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THE ECONOMIC IMPACT OF THE COAL BOOM AND BUST*

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In this paper, we examine the impact of the coal boom in the 1970s and the subsequent coal bust in the 1980s on local labour markets in Kentucky, Ohio, Pennsylvania, and West Virginia. We address two main questions in our analysis. How were non-mining sectors affected by the shocks to the mining sector? How did these effects differ between sectors producing local goods and those producing traded goods? We find evidence of modest employment spillovers into sectors with locally traded goods but not into sectors with nationally traded goods.

Assumptions about the effects of shocks on local labour markets strongly influence local economic policies. Communities often bitterly oppose plant closures believing that closures will create devastating ripple effects throughout the local economy. Similarly, local and state governments often provide a variety of incentives, such as tax breaks and loans, to encourage businesses to locate in their area, hoping that in addition to the direct economic benefits of a new facility, existing local businesses will also benefit from the additional economic activity generated by the new employment. Indeed, the business press trumpets these 'spillover' effects as an important benefit of a firm's location decision. Despite these widespread beliefs and government actions, relatively little is known about the indirect impact of local economic shocks. It is difficult to quantify the effect of a shock to the local labour market because the counterfactual (what would have happened in the absence of the shock) is missing.

In this paper we take advantage of an economic shock that induced a substantial exogenous shift in the demand for labour in certain local labour markets. We examine the impact of the coal boom in the 1970s and the subsequent coal bust in the 1980s on local economies in the four-state region of Kentucky, Ohio, Pennsylvania, and West Virginia. During the 1970s, regulatory changes and the Organisation of Petroleum Exporting Countries (OPEC) oil embargo drove up the price of coal and generated an enormous boom in the coal economy. There was a tremendous long-term infusion of mining jobs into areas with coal reserves as new mines were opened and existing ones were expanded. The coal boom lasted for more than a decade. By 1983, however, oil prices had declined, alternative mines had opened in the western US, and improvements in mining technology had reduced the demand for coal workers. The coal boom collapsed into a bust.

The coal boom and bust primarily affected counties that had large coal industries. By comparing counties in this region that have large coal industries to counties that have no coal to mine, we measure the effect of the coal boom and

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bust on a variety of economic outcomes. We address two questions in our analysis. How were non-mining sectors affected by the shocks to the mining sector? How did these effects differ between sectors producing local goods and those producing traded goods? While it is often argued that new jobs in one sector will increase demand for local goods, the potential negative impact on other sectors is often ignored. Local firms that trade their goods nationally or internationally do not experience an increase in demand for their products. To the extent that they must now pay higher wages to compete for local workers, these increased labour costs might cause them to reduce employment and output in the local area.

Our results indicate there are in fact modest employment spillovers into the local goods sectors. One mining job created during the boom generates 0.174 local sector jobs and one mining job lost during the bust destroys 0.349 local sector jobs. There is no evidence of positive spillovers into the traded goods sector. On the other hand, there is little evidence to suggest negative spillovers either, so it does not appear that the coal boom crowded out other industry in these areas.

The magnitude of wage increases generated by the increased demand for local labour, and the extent to which the existing local population benefits from the new jobs, will depend in large part on the extent to which migration into the area absorbs the increased demand. We therefore investigate the migration response to the coal shocks. We find that the population response to the bust was substantially larger than that experienced during the boom, potentially explaining the larger employment spillovers experienced during the bust. We do find evidence that the coal boom reduced out-migration of prime-aged men and generated return-migration of prime-aged men who had previously left the region. We also find that the boom increased wages, and reduced both the level and rate of poverty in coal areas, suggesting that the existing residents did benefit from the coal boom.

In Section 1, we review the literature and, in Section 2, we describe the coal boom and bust. In Section 3, we present our empirical findings. In Section 4, we provide a brief summary and conclusions.

1. Literature Review

There are several different literatures that examine how local or regional labour markets respond to demand shocks. Topel (1986), Bartik (1991), Eberts and Stone (1992), Blanchard and Katz (1992), and Montgomery (1993) measure how wages, employment and migration respond to local aggregate shocks. In general, these studies estimate structural models of supply and demand and then simulate out the effect of changes in employment or wages. As such, they do not identify the specific shocks that generate these employment or wage changes and hence cannot address the issue of spillover effects. Blanchard and Katz perform additional analysis in which they identify employment shocks due to defence spending or changes in industry-specific employment at the national level but do not address the issue of spillovers. Eberts and Stone study spillovers in a very rough sense by separating the economy into goods and services sectors and allowing interaction effects but do not identify specific shocks to either sector. Bartik does not identify specific shocks but estimates spillover effects between less-educated and more-educated male and female workers.

In contrast, there are several literatures that identify a specific shock and attempt to measure its effects on the local labour market. For example, one line of research studies the effect of enterprise zones on local economic outcomes. Enterprise zones encourage business development in very specific geographic areas with a variety of incentives, such as property tax abatement and wage and capital subsidies. The hope is that spillovers from new businesses will also increase employment in existing businesses. Studies such as Erickson and Syms (1986), Papke (1993, 1994), Boarnet and Bogart (1996), Dowall (1996), Engberg and Greenbaum (1999), Greenbaum and Engberg (2000), and Bondonio and Engberg (2000) that have compared labour and housing market outcomes in zone areas to non-zone areas, however, find little or no impact of enterprise zone policies. As zone areas appear to have no faster aggregate employment growth even with the addition of new businesses, this suggests that new business development may be 'crowding out' employment in existing businesses. Viewed this way the enterprise zone literature suggests that spillovers may be negative, not positive, on existing firms; see Bartik (2003) for a critique of these evaluations.

Military base closings are another government-generated local employment shock. Dardia *et al.* (1996), Krizan (1998) and Hooker and Knetter (1999) attempt to measure spillover effects in connection with the Base Realignment and Closure Commission (BRAC) recommendations in the late 1980s. All three papers find that the economic impacts of the base closings are surprisingly modest, and in some cases are even positive. Both Dardia *et al.* and Krizan find evidence that retail sales increased after base closing. The authors attribute this seemingly paradoxical result to the increased spending of military retirees in the local economy as the base's Post Exchanges (PXs) and Commissaries (food stores) close. As with enterprise zones, it appears that government induced employment often crowds out other local employment. In a clever paper, Greenstone and Moretti (2004) measure the performance of the local economy that wins the bidding for a large plant by comparing the performance of the county that wins the bidding for the plant compared to the counties that were the major competitors for the plant. They find evidence that obtaining the plan increases labour earnings and property values in the winning county.

Our approach is most similar to that of Carrington (1996), who in an influential paper examines the impact of the construction of the Trans-Alaskan Pipeline System (TAPS) from 1974 to 1977. TAPS injected a very large number of high-paying jobs into a relatively small economy and then removed those jobs from the area. Rather than differentiating between areas specifically affected by the construction of TAPS and those that are not, Carrington uses state-wide employment and earnings data. Yet, because TAPS created 50,000 new jobs each summer in an economy that had only 95,000 jobs in 1970, Carrington is able to identify significant impacts on the Alaskan economy, relying solely on the large time series variation from the construction boom. Carrington finds evidence of strong positive spillovers into most sectors, with the exception of manufacturing and government.[1]

Like Carrington, we analyse the effect of employment shocks to a specific economic sector generated by a specific exogenous source, in this case, the increase in demand for coal generated by the OPEC oil embargo. Our work also differs from Carrington's in some notable ways. First, we construct a cross-sectional comparison group rather than rely solely on time-series analysis. Second, the construction of TAPS was short term, 1974–77, and seasonal due to the intensity of Alaskan winters. The coal boom was much longer in duration and provided year-round employment. Third, TAPS required substantial skilled labour, almost all of which was imported from Texas and Oklahoma. The large and organised migration of labour to Alaska might not reflect the change in employment opportunities that typically occurs when the local populace can at least partially fill newly created positions. Coal mining, at this time, was a low-skilled occupation. Almost any prime-aged male in the local area would have been qualified to work as a miner.

2. The Coal Boom and Bust

In this Section, we describe the boom and bust in the coal industry that occurred during the 1970s and 1980s.[2] Our analysis of the coal economy will focus on the states of Kentucky, Ohio, Pennsylvania and West Virginia, all of which contain counties that are intensive in coal mining. To indicate the magnitude of these demand shocks, in Figure 1 we first plot the real price of coal over time.[3] We can see that up until 1969 the price of coal was relatively stable. Then regulatory changes caused the real price of coal to increase 28% between 1969 and 1970, and the OPEC oil embargo caused the real price of coal to increase 44% between 1973 and 1974. In the graph, we can see that the price of coal stabilised for about five years. Then during the 1980s, the price of coal began to fall.

In Figure 2, we plot the trend of real earnings for the coal mining industry. The graph shows that mining earnings increased steadily from 1969 to 1977, increasing about 150%. The regulatory changes and OPEC oil embargo clearly generated a tremendous boom in the coal economy. Coal earnings levelled off between 1977 and 1982, and then declined drastically during the mid and late 1980s. These economic shocks were not felt equally in all counties in the four-state region. In Figure 3, we plot the total amount of coal reserves in each county on a map of the four-state region. We can see that some counties have substantial coal reserves and will benefit tremendously from a boom in the coal industry. More than half of the

[1] Carrington hypothesises that the lack of spillovers into the manufacturing sector is due to the fact that manufacturing is geographically isolated in the panhandle of Alaska, away from the TAPS construction.

[2] Black *et al.* (2002) examine the impact of the coal boom and bust on disability payments. Black *et al.* (2003) study its impact on AFDC receipt and family formation.

[3] We define the real price of coal to be the ratio of the Producer Price Index for coal to the Current Price Index. The CPI-U series also serves as our measure of the general price level. The CPI-U series covers all urban consumers and is somewhat broader than the wage earner and clerical workers series, CPI-W, although for this time period the correlation between the two indices is 0.9999. All nominal values in this paper are deflated by the CPI-U. The base year is 1983 for the index. We use the July index values of each year for all data.

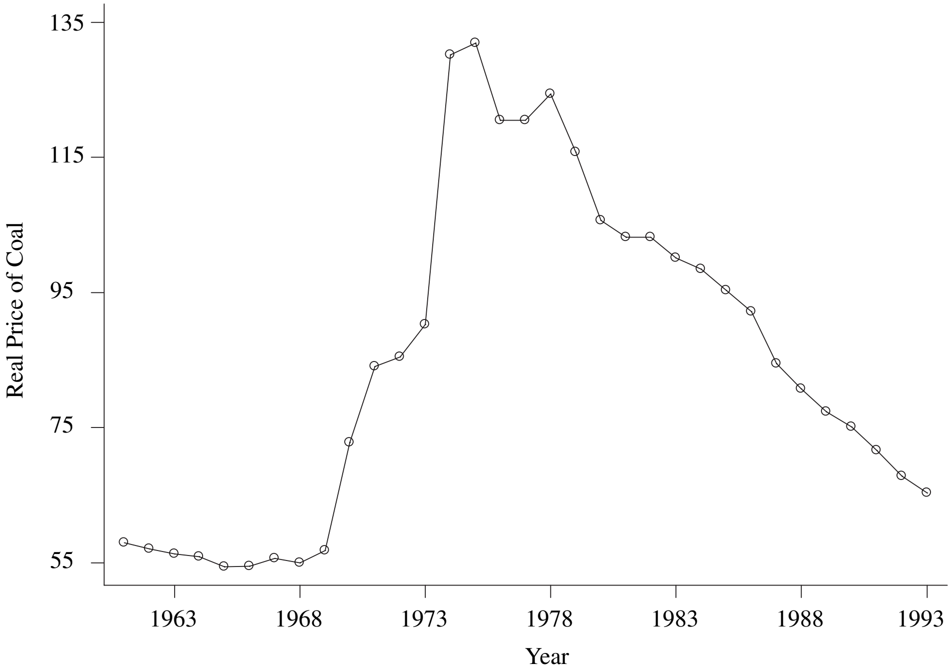

Fig. 1. *The Real Price of Coal,* 1961–93

Notes: Authors' calculations, consumer price and producer price indices data. This Figure plots the ratio of the producer price index for bituminous coal to the CPI

counties in this region, however, have almost no coal reserves, and therefore will be substantially less affected by the coal boom and bust.

Our strategy is to use the increased growth during the 1969 to 1977 period and the reduced growth during the 1982 to 1989 period to identify any potential spillover effects. If the growth of the non-mining sector of counties with coal during the coal boom is faster than in the regions without coal, we take this as evidence of spillover effects, that the rapid growth in coal mining generates jobs in other sectors. Correspondingly, if the growth of the non-mining sector of counties with coal during the coal bust is slower than in regions without coal, we take this as evidence that decline in the coal sector spilled over into other sectors of the economy.

3. Direct and Indirect Effects of the Coal Shocks

3.1. *Testing for Direct Effects*

In this Section, we investigate the direct impacts of the coal boom and bust. Because we are interested in studying those counties that were greatly affected by the shock, we limit our sample of coal-producing counties to those counties that derived at least 10% of their total earnings from the coal industry in 1969. This results in a sample of 32 counties, with a median fraction of earnings from the coal industry of 25.3% (the mean fraction is 30.4%). Fourteen of the

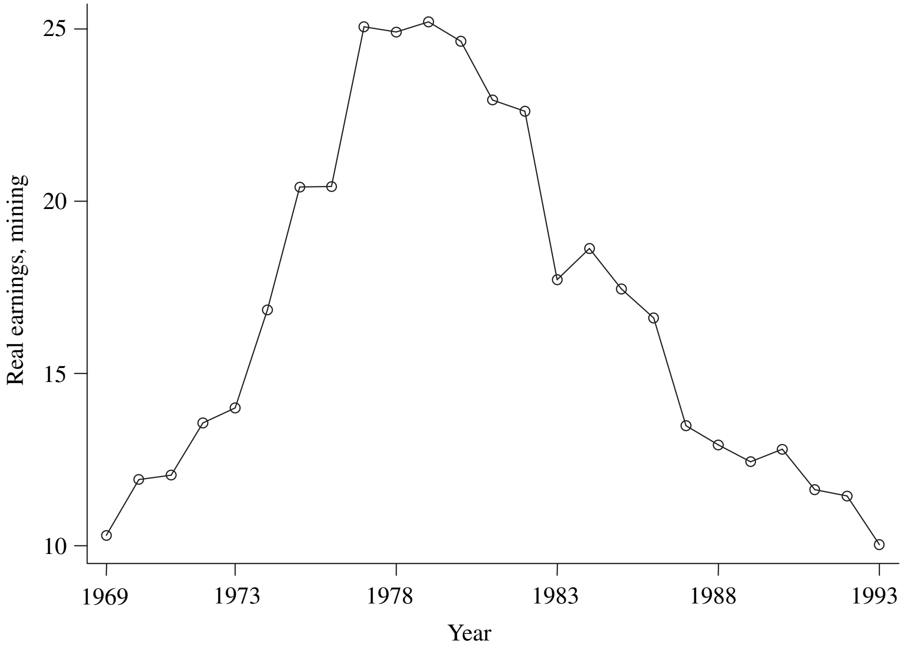

Fig. 2. *Total Real Earnings in the Mining Industry,* 1969–93
Notes: Authors' calculations, REIS data. Graph reports earnings from the coal mining industry for Kentucky, Ohio, Pennsylvania, and West Virginia, mining earnings reported in US $million.

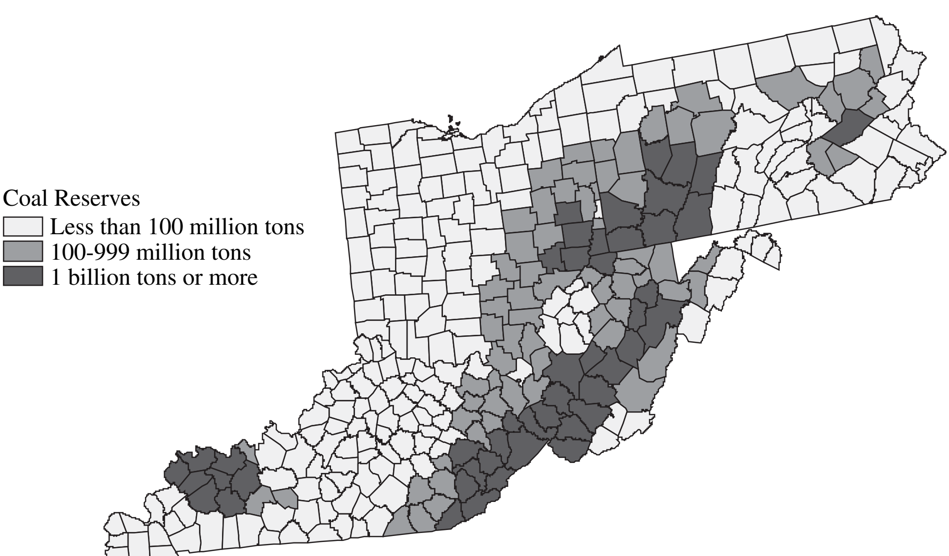

Fig. 3. *Coal Resource by County*

counties are in Kentucky, 12 are in West Virginia, 4 are in Pennsylvania and 2 are in Ohio. See Appendix for a list of the counties. Because these counties had large coal industries, we refer to them as the 'treatment' counties which are treated first with a large positive demand shock and then a large negative demand shock.

In Table 1, we measure the size of the boom and bust for these 'treatment' counties, using data on employment, earnings and earnings per worker for the mining sector. Our data on earnings and employment by sector and county are from the Regional Economic Information System (REIS) data provided by the Bureau of Economic Analysis (BEA, US Department of Commerce 1969–99). These data contain annual county-level tabulations of total employment and total earnings by sector from employer reports of wage and salary disbursement on tax forms. Through out this paper, we do not weight the data to account for differential size of the counties, preferring instead to treat each county as a separate observation in our quasi-experiment.

For Table 1, we calculate the average annual change in the logarithm of mining employment, mining earnings, and earnings per worker for three separate periods: the boom (1970–7) period in which the price of coal rises rapidly, the peak (1978–82) in which the price of coal stabilises, and the bust (1983–9) in which the price of coal declines. During the boom, mining employment in our treatment counties

Table 1

Growth in Mining Employment, Earnings, and Earnings per Worker; Treatment Counties, 1970–89

Average annual growth in:	Treatment (coal area)
Mining employment ($N = 640$)	
Boom period, 1970–7	0.068
	(0.009) [0.000]
Peak period, 1978–82	−0.008
	(0.010) [0.410]
Bust period, 1983–9	−0.078
	(0.010) [0.000]
Mining earnings ($N = 640$)	
Boom period, 1970–7	0.123
	(0.012) [0.000]
Peak period, 1978–82	−0.017
	(0.016) [0.155]
Bust period, 1983–9	−0.086
	(0.010) [0.000]
Earnings per mining worker ($N = 640$)	
Boom period, 1970–7	0.055
	(0.006) [0.000]
Peak period, 1978–82	−0.008
	(0.003) [0.027]
Bust period, 1983–9	−0.007
	(0.005) [0.137]

Notes: Authors' calculations, REIS data. Table reports average annual differences in the logarithm of mining earnings, mining employment and earnings per mining worker. Huber-White standard errors are reported in parentheses and p-values are reported in brackets. There are 32 treatment counties, which have greater than 10% of earnings from coal mining in 1969.

grew an average of 6.8% per year and real mining earnings grew 12.3% a year on average.[4] During the bust, mining employment declined an average of 7.8% per year in our treatment counties and real mining earnings declined an average of 8.6%. While mining earnings and employment declined during the intermediate peak years, these changes were not statistically significant. These effects on earnings and employment are quite large in magnitude. For instance, at a 12.3% average growth rate, real earnings in the coal industry would have been over 2.5 times their 1969 level by 1977.

As the BEA data do not contain a direct measure of mining wages, we divide earnings by employment to obtain a measure of earnings per mining worker. This is obviously an imperfect measure of wages, because an increase in earnings per worker could reflect an increase in hours per worker, or a change in composition if industries within a sector that pay high wages are growing faster than industries that pay lower wages.

We find that there was 5.5% growth on average in earnings per worker during the coal boom. The 0.7% decrease in earnings per worker during the bust is very small and statistically insignificant. This most likely reflects the substantial increase in the skills of coal miners during the 1980s as automated mining practices were introduced. For example, the fraction of coal miners in the four-state region with less than a high school education dropped from 67.8% to 29.8% between 1970 and 1990. The corresponding decrease for all workers in the four-state region was from 37.4% to 17.6%. Therefore, the decline in demand for coal workers during this period is being offset by an increase in the human capital of the average miner. There is also a very modest, but statistically significant, 0.8% decline in earnings per worker during the peak period.

In order to attribute these observed changes in economic outcomes for the coal counties rightfully to the actual coal shocks, we need an appropriate comparison group. We must avoid comparing our treatment counties to counties that had smaller coal industries, which presumably would have also benefited from the coal boom. We therefore limit our comparison group to counties without coal reserves.[5] Counties without coal to mine should be relatively unaffected by the coal shocks.[6] We also make sure that our comparison group counties are roughly comparable in population size to the treatment counties. Counties with large coal mining activity tend to be relatively rural counties. We therefore do not want to include large urban areas in our comparison group. The treatment counties had populations in 1970 that ranged from about 9 to 212 thousand, so we limit our comparison sample to counties whose population ranged from 8 to 225 thousand.

[4] We will somewhat casually interpret the logarithmic difference as the percentage change, which is exact only about zero.

[5] Data on coal reserves are obtained from a variety of sources. The data for Kentucky are from the Kentucky Geological Survey's (KGS) Kentucky Coal Resources Information; the data for Pennsylvania are from Edmunds (1972), Table 3; the data from Ohio are from the Internet at [http://www.dnr.state.oh.us/odnr/geo_survey/ogcim/coalgrp/counres.htm]; data for West Virginia are from Webber (1996).

[6] In contrast, if we had selected our comparison group based on fraction of earnings from mining, then the comparison group might have included some counties with coal reserves that had little mining activity before the boom but opened up mines in response to the demand shock.

The resulting comparison group contains 139 counties: 58 in Kentucky, 53 in Ohio, 17 in Pennsylvania, and 11 in West Virginia. These counties are in the same four-state region and are subject to the same state laws and regional influences as the coal economies. The Appendix provides a list of counties in the comparison group as well.

Figure 4 plots comparison and treatment counties on a map of the four-state region. By comparing Figure 4 to Figure 3, it is clear that all of our treatment counties sit on major coal seams and have substantial coal reserves. Because we do not use the counties with moderate coal industries in either the treatment or comparison group, this creates a 'trough' around the treatment counties. Therefore, we can feel more confident that our comparison counties are not experiencing geographic spillovers from the coal counties.

In Table 2, we report the difference in annual growth in total employment, total earnings, and earnings per worker between comparison and treatment counties by estimating:

$$\Delta \ln(Y_{ist}) = \sum_{j=1}^{3} \beta_j (T_i P_{jt}) + (\mathbf{State}_s \mathbf{Year}_t)\boldsymbol{\phi} + \varepsilon_{ist} \tag{1}$$

where $\Delta \ln(Y_{ist}) = \ln(Y_{ist}) - \ln(Y_{ist-1})$ and Y_{it} is employment, earnings or earnings per worker for county i in state s in year t. T_i is an indicator variable for whether the county is in the treatment group. P_j is an indicator for the time period where $j =$ *boom, peak, or bust.* Therefore, β_1, β_2 and β_3 measure the difference in average growth between the treatment and comparison counties during the boom, peak and bust respectively. $\mathbf{State}_s$ is a vector of state indicator variables and $\mathbf{Year}_t$ is a vector of year indicator variables. These state-year effects therefore control for anything that varies over time at the state level.

By any measure, the treatment counties grew much faster than the comparison counties during the coal boom, and the treatment counties grew much slower than

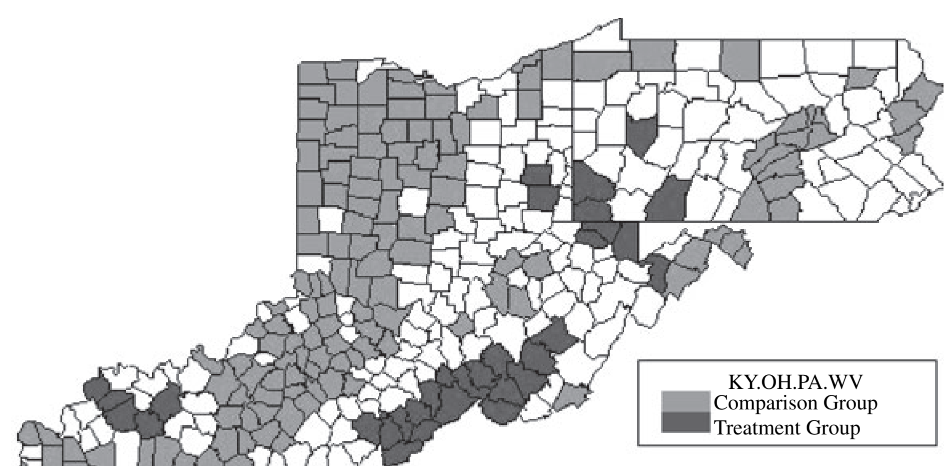

Fig. 4. *Comparison and Treatment Counties*

Table 2

Growth in Employment, Earnings and Earnings per Worker, Treatment and Comparison Counties, 1970–89

Average annual growth in:	Difference (Treatment − Comparison)
Total employment ($N = 3{,}420$)	
Boom, 1970–7	0.020
	(0.004) [0.000]
Peak, 1978–82	−0.001
	(0.004) [0.877]
Bust, 1983–9	−0.027
	(0.004) [0.000]
Total earnings ($N = 3{,}420$)	
Boom, 1970–7	0.050
	(0.007) [0.000]
Peak, 1978–82	0.005
	(0.007) [0.525]
Bust, 1983–9	−0.055
	(0.006) [0.000]
Earnings per worker ($N = 3{,}420$)	
Boom, 1970–7	0.030
	(0.004) [0.000]
Peak, 1978–82	0.005
	(0.004) [0.211]
Bust, 1983–9	−0.028
	(0.004) [0.000]

Notes: Authors' calculations, REIS data. Table reports the difference in average annual changes in the logarithm of total earnings, total wage and salary employment, and earnings per worker between treatment and comparison counties. Regressions include state-year dummy variables. Total earnings are based on place of work rather than place of residence. Huber-White standard errors are reported in parentheses while p-values are reported in brackets. There are 171 counties, with 32 of these counties in the treatment group.

the comparison counties during the coal bust. Employment grew 2.0% faster during the boom and 2.7% slower during the bust in the treatment counties. Earnings grew 5.0% faster during the boom and 5.5% slower during the bust. Finally, earnings per worker grew 3.0% faster during the boom and 2.8% slower during the bust.

During the peak, there are no statistically significant differences between the growth in earnings and employment of the treatment and comparison groups. This suggests that, without a coal shock, there are no underlying differences in economic growth between the treatment and comparison counties.[7]

In Table 3 we pause to consider how economic growth in counties with smaller coal industries compares to the growth in the treatment counties. For Table 3, we estimate the following model:

$$\Delta \ln(Y_{ist}) = \sum_{j=1}^{3} \beta_j (T_i P_j) + \sum_{j=1}^{3} \delta_j (M_i P_j) + \sum_{j=1}^{3} \gamma_j (L_i P_j) + (\mathbf{State}_s \mathbf{Year}_t)\boldsymbol{\phi} + \varepsilon_{ist} \quad (2)$$

[7] This is a specification test in the spirit of that recommended by Heckman and Hotz (1989). Heckman and Hotz check the validity of their comparison groups in a training programme evaluation by testing for differences between the treatment and comparison groups in earnings in the pre-programme period. In this case, we test for differences in growth in the period with stable coal prices.

Table 3

Growth in Employment, Earnings and Earnings per Worker, Treatment, Medium and Low Coal Counties, 1970–89

		Non-treatment counties	
Average annual growth in: (relative to comparison counties)	Treatment counties	Medium (>100 million tons reserves)	Low (Some reserves, <100 millon tons)
Total employment ($N = 5{,}500$)			
Boom, 1970–7	0.020	0.006	0.008
	(0.004) [0.000]	(0.002) [0.009]	(0.004) [0.025]
Peak, 1978–82	0.000	−0.000	0.000
	(0.004) [0.999]	(0.003) [0.961]	(0.003) [0.986]
Bust, 1983–9	−0.028	−0.011	−0.009
	(0.004) [0.000]	(0.002) [0.000]	(0.003) [0.006]
Total earnings ($N = 5{,}500$)			
Boom, 1970–7	0.048	0.010	0.008
	(0.007) [0.000]	(0.002) [0.000]	(0.005) [0.113]
Peak, 1978–82	0.006	0.004	0.005
	(0.004) [0.135]	(0.003) [0.168]	(0.004) [0.233]
Bust, 1983–9	−0.028	−0.019	−0.017
	(0.003) [0.000]	(0.003) [0.000]	(0.005) [0.000]
Earnings per worker ($N = 5{,}500$)			
Boom, 1970–7	0.028	0.010	−0.000
	(0.004) [0.000]	(0.002) [0.000]	(0.003) [0.979]
Peak, 1978–82	0.006	0.004	0.005
	(0.004) [0.135]	(0.003) [0.168]	(0.002) [0.039]
Bust, 1983–9	−0.028	−0.019	−0.009
	(0.003) [0.000]	(0.003) [0.000]	(0.002) [0.000]

Notes: Authors' calculations, REIS data. Table reports the difference in average annual changes in the logarithm of total earnings, total wage and salary employment, and earnings per worker between treatment and comparison counties. Regressions include state-year dummy variables. Total earnings are based on place of work rather than place of residence. Huber-White standard errors are reported in parentheses while p-values are reported in brackets. There are 139 comparison counties, 32 treatment counties, 73 medium coal counties and 31 low coal counties.

where T is a treatment county indicator and P_1–P_3 are period indicators for boom, peak and bust as defined above. M is an indicator for medium coal counties, defined as counties with greater than 100 million tons of coal reserves, but less than 10% of earnings from coal in 1969. L is an indicator for low coal counties, defined as counties with positive coal reserves but less than 100 million tons of coal. Medium and low coal counties are only included in the analysis if they meet the population limits defined for the comparison group above. The β, δ and γ coefficients therefore measure the average annual growth in treatment, medium and low coal counties relative to comparison counties for each period. The results in Table 3 show that there is a fairly monotonic relationship between coal intensity and the effect of the shock.

The differential growth rates in economic outcomes between the comparison and treatment groups observed in Tables 2 and 3 may have been solely the consequence of growth in the coal industry rather than growth in both the mining and non-mining sectors. We next examine whether the coal boom and bust affected non-mining sectors of the treatment counties.

Table 4

Testing for Spillover Effects into the Non-mining Sector, 1970–89

Average annual growth in:	Difference (treatment − comparison)
Non-mining employment ($N = 2{,}821$)	
Boom, 1970–7	0.007
	(0.003) [0.060]
Peak, 1978–82	0.004
	(0.003) [0.233]
Bust, 1983–9	−0.009
	(0.003) [0.002]
Non-mining earnings ($N = 2{,}947$)	
Boom, 1970–7	0.012
	(0.004) [0.003]
Peak, 1978–82	0.005
	(0.004) [0.295]
Bust, 1983–9	−0.020
	(0.005) [0.000]
Earnings per non-mining worker ($N = 2{,}751$)	
Boom, 1970–7	0.005
	(0.003) [0.054]
Peak, 1978–82	−0.001
	(0.003) [0.752]
Bust, 1983–9	−0.010
	(0.003) [0.006]

Notes: Authors' calculations, REIS data. Table reports difference in average annual changes in the logarithm of employment, earnings, and earnings per worker for the non-mining sector between treatment and comparison counties. Earnings are calculated based on place of work, not place of residence. Regressions include state-year dummy variables. Huber-White standard errors are reported in parentheses while p-values are reported in brackets. There are 171 counties, with 32 of these counties in the treatment group.

3.2. *Testing for Spillover Effects*

In Table 4, we report the difference between the treatment and comparison counties in growth rates for employment, earnings, and earnings per worker in the non-mining sector, again using the specification described in (1).[8] The results indicate that the non-mining sector in treatment counties grew faster in the boom and slower during the bust than the non-mining sector in comparison counties, although the results for employment and earnings per worker are only marginally significant during the boom.

During the boom, non-mining employment grew 0.7% faster, non-mining earnings grew 1.2% faster, and non-mining earnings per non-mining worker grew 0.5% faster in the treatment counties compared to the comparison counties. During the bust, non-mining employment grew 0.9% slower, real non-mining earnings grew 2.0% slower and non-mining earnings per non-mining worker grew 1.0% slower in the treatment counties compared to the comparison counties. These findings suggest that the coal boom spurred economic growth in the non-

[8] Some of the comparison counties do report some mining earnings. Most of this mining activity is in the oil and gas or non-metal (e.g. stone) sectors. There is also some administrative activity for the coal mining industry located in the comparison counties. The mining sectors combined account for less than 0.8% of total earnings in the comparison counties.

mining sectors of the treatment counties and that the coal bust dampened economic growth in the non-mining sectors of the treatment counties. Furthermore, the fact that the difference in growth rates for all three measures is small and statistically insignificant during the peak years again suggests that the comparison and treatment counties do experience comparable economic growth in years without a coal shock.

The growth in the non-mining sector during the coal boom and the contraction during the coal bust could mask a great deal of heterogeneity in the impact of the coal shocks on local economies. In Table 5 we therefore repeat the analysis from Table 4 separately for the construction, service, retail and manufacturing sectors.[9] The construction, service and retail sectors largely produce local goods. We expect the coal boom to generate an increase in demand for these local goods, which should generate both increases in wages and employment in these sectors. Likewise, the bust should generate a decline in wages and employment in these sectors. The results for these sectors are reported in the first three columns of Table 5.

The results indicate that employment increased during the boom in the construction and services sector and decreased during the bust for all three local sectors. For earnings per worker, the results do not indicate a statistically significant increase during the boom for any of the local sectors. Earnings per worker do, however, decrease in all three sectors during the bust. The results from the boom could indicate that there was no wage effect of the coal boom, or they could reflect the fact that earnings per worker are an imperfect measure of wages.[10] We will return to this issue below. In addition, the difference in growth rates for earnings per construction worker are statistically significant during the peak, which suggests that there could be some underlying differences in construction wages between the treatment and comparison groups.

In the final column of Table 5, we report the results for the manufacturing sector. The manufacturing sector largely produces traded goods. The coal boom should not generate an increase in demand for these goods. Local manufacturing firms, however, have to compete with other local sectors for workers. If the coal boom drives up wages for local workers, this increase in labour costs could generate a reduction in local manufacturing employment.

[9] Unfortunately, confidentiality requirements force the BEA to suppress some reports on these industries. Therefore, we do not observe sector specific employment in all counties in all years. The rate of suppression varies from a high of 1.7% of all observations for the service industry to no suppression for the retail industry. To test whether or not there is selection into those counties for whom sector-specific information is suppressed, we estimated the selection correction model due to Heckman (1979). To identify the suppression equation, we used a quadratic time trend and a cubic in the logarithm of a county's population. Because the Heckman procedure is sensitive to the assumption of normality of the error terms, we also implemented a 'control function' correction (Heckman and Robb, 1985). We used a logit model with a quadratic time trend and a cubic in the logarithm of a county's population to predict whether a county's earnings or employment in a sector was suppressed. We then used the quadratic of the predicted probabilities as our control function. The resulting 'control function' estimates were quite similar to the OLS estimates on a sample that dropped the missing values.

[10] In addition, these results could reflect a compositional change in the labour market if lower-skilled individuals are being drawn into employment by the boom. In our wage analysis using the PUMS that is reported in Table 7 below, we are able to restrict our analysis to a sample of prime-aged men and comparison for some individual characteristics, which reduces the effect of compositional changes on our estimates.

Table 5

Spillover Effects for Employment and Earnings per Worker by Sector, 1970–89

	Difference (Treatment − Comparison)			
Average annual growth in:	Construction	Retail trade	Services	Manufacturing
Employment				
Boom, 1970–7	0.023	0.016	−0.001	−0.005
	(0.011) [0.045]	(0.005) [0.001]	(0.008) [0.877]	(0.010) [0.616]
Peak, 1978–82	−0.016	0.005	0.003	−0.038
	(0.012) [0.196]	(0.005) [0.365]	(0.006) [0.543]	(0.014) [0.007]
Bust, 1983–9	−0.043	−0.019	−0.014	−0.012
	(0.010) [0.000]	(0.004) [0.000]	(0.004) [0.001]	(0.013) [0.329]
N	3,380	3,420	3,362	3,416
Earnings				
Boom, 1970–7	0.023	0.018	0.004	0.004
	(0.014) [0.112]	(0.003) [0.000]	(0.007) [0.562]	(0.014) [0.833]
Peak, 1978–82	0.002	0.004	0.009	−0.032
	(0.018) [0.889]	(0.005) [0.482]	(0.006) [0.086]	(0.053) [0.053]
Bust, 1983–9	−0.080	−0.027	−0.025	−0.019
	(0.016) [0.000]	(0.004) [0.000]	(0.005) [0.000]	(0.015) [0.196]
N				
Earnings per worker				
Boom, 1970–7	0.000	0.002	0.005	0.011
	(0.006) [0.987]	(0.003) [0.496]	(0.004) [0.199]	(0.004) [0.009]
Peak, 1978–82	0.018	−0.001	0.006	0.005
	(0.009) [0.039]	(0.003) [0.773]	(0.004) [0.071]	(0.008) [0.578]
Bust, 1983–9	−0.037	−0.008	−0.011	−0.007
	(0.008) [0.032]	(0.003) [0.002]	(0.004) [0.003]	(0.008) [0.406]
N	3,380	3,420	3,362	3,404

Notes: Authors' calculations, REIS data. Table reports differences in average annual changes in the logarithm of employment, earnings, and earnings per worker between treatment and comparison counties, by sector. Regressions include state-year dummy variables. Huber-White standard errors are reported in parentheses while p-values are reported in brackets. There are 171 counties, with 32 of these counties in the treatment group. For earnings, the suppression rate is 1.6% for services, 1.1% for construction, 0.3% for manufacturing and zero for retail. The suppression rates for employment are similar.

We have some concerns about using manufacturing in the comparison counties as a control for manufacturing in the treatment counties. The retail, services and construction sectors are of similar sizes in the comparison and treatment counties. For example, in 1969, the retail sector provided 14.6% of earnings in comparison counties and 14.8% of earnings in treatment counties.[11] The manufacturing sector, however, provided 27.7% of earnings to comparison counties in 1969, but only 14.6% of earnings to treatment counties. This is because the coal industry provides more than half of earnings from heavy industry in the treatment counties, so that coal is to some extent displacing manufacturing.[12] With these cautions in mind

[11] The corresponding numbers for services are 14.5% in comparison counties and 14.9% in treatment counties. For construction they are 5.3% and 4.6%, respectively.

[12] We checked whether or not the composition of the manufacturing industry differed substantially between the treatment and comparison counties. There were some differences, but they were not substantial. For treatment counties, 74% of manufacturing is in durable goods, compared to only 67% for comparison counties. This difference is mainly due to heavier concentrations of primary metals (steel) and stone manufacturing in treatment counties.

concerning the comparability of these manufacturing sectors in mind, we proceed with our analysis.

During the boom, there is a statistically significant increase in earnings per manufacturing worker. There is a modest, but statistically insignificant, decrease in employment. These results are broadly consistent with the argument that higher wages in the traded goods sector will drive down employment, but only suggestive. The estimates for the coal bust indicate that wages and employment both fell in manufacturing during the bust but both estimates are statistically insignificant. There is a statistically significant decline in manufacturing employment during the peak, which suggests that there are some underlying differences in employment growth in this sector between the treatment and comparison counties.

3.3. *Estimating the Magnitude of the Spillover Effects*

In this Section, we measure the magnitude of spillovers from the mining sector into the traded and local sectors. Specifically, how many local sector jobs are created for each mining sector job created? How many traded sector jobs are destroyed for each mining sector job created?

We estimate the spillovers into the local sector using IV analysis. The main regression equation is:

$$\Delta \ln(Local\_Emp_{ist}) = \beta_0 + \beta_1[\Delta \ln(Mine\_Emp_{ist}) W_{ist}] + (\mathbf{State}_s \mathbf{Year}_t)\boldsymbol{\phi} + \varepsilon \qquad (3)$$

where *Local_Emp* is total employment in the local goods sector, defined as construction, retail and services. *Mine_Emp* is total mining employment and $W_{ist} = Mine\_Emp_{t-1}/Local\_Emp_{t-1}$, the ratio of mining employment to local employment in the previous year. As

$$\Delta \ln(Mine\_Emp_{ist}) \approx (\Delta Mine\_Emp_{ist})/Mine\_Emp_{ist}$$

and as

$$\Delta \ln(Local\_Emp_{ist}) \approx (\Delta Local\_Emp_{ist})/Local\_Emp_{ist},$$

this weighting of the independent variable allows us to interpret β_1 as the number of local jobs created for each new mining job.

The instruments for the weighted change in logarithm of mining employment are TP_1, TP_2, and TP_3, where T is an indicator variable for treatment county and P_1, P_2 and P_3 are indicator variables for the boom, peak and bust periods, as defined above.

The spillovers into the traded sector, defined as the manufacturing sector, are estimated through an IV regression analogous to (3). The dependent variable is the change in log manufacturing employment and the independent variable, mining employment, is weighted by the ratio of mining to manufacturing employment in the previous period.

The IV results are reported in the first column of Table 6. The first two rows report the results using all data from 1970–89. We find that each additional mining job generates 0.246 local sector jobs and essentially no traded sector jobs.[13] We further break the results out into the boom and bust. We find that each additional mining job created during the boom generated 0.174 local sector jobs and each mining job lost during the bust cost the county 0.349 local sector jobs. In both periods, the impact on traded sector jobs was negligible.

One concern about the IV results reported in the first column is that the mining employment in the comparison counties is not an appropriate counterfactual for the mining employment in the treatment counties. In the second column, we set mining employment equal to zero for all comparison counties. This simply attributes all of the changes in mining employment in the treatment counties to the coal boom and bust, rather than differencing out changes in mining

Table 6

Instrumental Variables Estimates of Spillover Effects

	Employment multiplier: jobs created in traded or local sector per job created in mining sector		
	Using mining employment in comparison counties	Mining employment = 0 for comparison counties	Including 'medium' and 'low coal' counties
All years, 1970–89			
Traded sector	0.002	0.004	0.003
	(0.009) [0.832]	(0.009) [0.632]	(0.008) [0.706]
N	2,819	3,416	4,778
Local sector	0.246	0.265	0.212
	(0.058) [0.000]	(0.058) [0.000]	(0.053) [0.000]
N	2,761	3,325	4,692
Boom, 1970–7			
Traded sector	−0.008	−0.006	−0.006
	(0.014) [0.545]	(0.013) [0.671]	(0.013) [0.658]
N	1,135	1,366	1,925
Local sector	0.174	0.193	0.137
	(0.094) [0.066]	(0.089) [0.031]	(0.083) [0.102]
N	1,119	1,344	1,901
Bust, 1983–9			
Traded sector	0.010	0.011	0.009
	(0.013) [0.456]	(0.013) [0.375]	(0.012) [0.460]
N	964	1,195	1,634
Local sector	0.349	0.375	0.356
	(0.094) [0.000]	(0.088) [0.000]	(0.087) [0.000]
N	934	1,144	1,590

Notes: Authors' calculations, REIS data. Dependent variable is annual change in logarithm of local or traded employment. Independent variable is annual change in logarithm of mining employment multiplied by ratio of mining to local or traded employment in previous year. Instrument is a set of interactions of treatment dummy and dummy variables for boom, peak and bust period. Regressions include a set of state-year dummy variables. Huber-White standard errors are reported in parentheses while p-values are reported in brackets. For the results in columns 1 and 2, there are 171 counties; 32 are in the treatment group. The analysis in column 3 includes 104 additional counties: 73 medium coal counties and 31 low coal counties. The local sector contains services, retail and construction. The traded sector contains manufacturing.

[13] The first-stage partial F-statistic on the instruments was 31.4 for the traded sector regression and 78.6 for the local sector regression.

employment that occur in the comparison counties. The results of this exercise are reported in the second column of Table 6. This modification has a relatively small effect on the results.

In the final column of Table 6, we include medium and low coal counties, as defined in Table 3, in the IV analysis. The instrumental variable set is expanded to include M and L interacted with $P_1 - P_3$. We do not set mining employment in comparison counties to zero as was done in column 2. While the magnitude of the boom impacts are somewhat smaller, this change in sample and specification did not have a very large effect on our spillovers estimates. The overall traded sector multiplier is 0.003 and the overall local sector multiplier is 0.212.[14]

Overall the results of Table 6 suggest that the coal boom and bust did generate employment spillovers in the local sectors, albeit modest ones. As expected, the coal boom and bust do not appear to have generated positive spillovers into the manufacturing sector. On the other hand, there is little evidence to suggest that the coal boom actually drove out other industrial employment.

The multiplier effect of the bust is almost twice the size of the multiplier effect of the boom.[15] There is no reason to expect the effects to be symmetric, given the changes in the local population and the economy between the two periods. Changes in transportation and communication costs and the overall integration of the economy might have made it easier for jobs to leave the local area. In other work, we have documented that the coal boom affected the human capital, fertility, family structure and labour force participation decisions of the local population (Black *et al.*, 2003). Therefore, even ignoring migration, the local population that experiences the bust is substantially different from the population that experiences the boom. One likely reason for the larger bust effects is that, as documented below in Table 8, the migration effects of the bust were substantially larger than those of the boom. This would have generated a larger employment response to the bust.

We performed two other robustness checks of the results in Table 6. In the first, we dropped all counties in the comparison group that border on counties with coal reserves. This produced a comparison group that was less likely to experience geographic spillovers from neighbouring counties that were directly affected by the coal boom. In the second, we included comparisons for three measures of initial conditions in the regressions: population in 1969, per capita income in 1969 and fraction employed in manufacturing in 1969. Because the model is estimated in differences, this allows the time trend in the dependent variable to vary based on these initial conditions. The IV results were relatively robust to each of these changes in specification. The local job multiplier for the boom was 0.131 in the

[14] In adding the medium and low coal counties, the first-stage F-statistic for the traded sector drops from 31.4 to 21.5 and the first-stage F-statistic for the local sector drops from 78.6 to 36.5, indicating that the interactions of M and L with $P_1 - P_3$ are weak instruments. The standard errors in column 3 are similar in magnitude to those in the first two columns because a 67% increase in sample size counteracts the use of weaker instruments.

[15] It is easy to believe that the bust effects would be larger than the boom effects for the construction industry. When the economy declines, the stock of housing and buildings created during the boom still exist. The construction industry results in Table 5 also suggest that the asymmetry between the boom and bust is largest for construction. Even after removing construction from the analysis in Table 6, however, the asymmetry in spillover effects still exists.

first case and 0.225 in the second. The local job multiplier for the bust was 0.436 in the first case and 0.425 in the second. The traded job multipliers remained, by comparison, small and insignificant.

To compare our results to findings in the literature, we consider the analysis of spillovers between the goods and services sectors performed by Eberts and Stone (1992). In their analysis, the goods sector is defined as manufacturing and construction and the services sector is transportation, wholesale, retail, services, FIRE and government. Estimating lagged models of wages and employment for each sector and simulating out the effect of a 1% increase in goods sector employment, they find a 0.1% increase in service sector employment after two years and a stable long-run 0.2% increase in service sector employment after four years. Because, by their definition, the service sector is approximately 3 times the size of the goods sector during the years of their study, this suggests a spillover of approximately 0.6 service sector jobs for every 1 goods sector job created. For comparison, we re-estimate our spillovers model using 5-year differences in mining and local sector employment and estimate a local sector multiplier of 0.72 for the boom and 1.10 for the bust. So our local sector multipliers are larger than those obtained by Eberts and Stone.[16]

Eberts and Stone also simulate out the effect of a 1% increase in service sector employment and find no effect on goods sector employment for the first four years, an approximately 0.05% decrease in the fifth year and a long-run decrease of 0.4% reached by the tenth year. Using 5-year differences in our model, we find a traded sector multiplier of −0.106 for the boom and 0.100 for the bust, but both are very imprecisely estimated.

3.4. *Wage Effects*

The IV results in Table 6 suggest that the boom and bust did generate employment spillovers into local sectors, albeit modest ones. This leaves unsettled the wage effects of the coal boom and bust. The earnings per worker results in Table 5 are inconclusive. Unfortunately, wage data are not available at the county level for the coal-producing areas. Because coal-producing areas are rural, the sample sizes at the county level in most available micro-level panel data sets are extremely small. The one data set with sufficient sample sizes in rural areas, the Public Use Microdata Sample (PUMS), does not identify county of residence in rural areas. Therefore, in Table 7, we use the 1970, 1980 and 1990 PUMS data to measure wages by industrial sector at the county group or Public Use Microdata Area (PUMA) level. Fortunately for us, the 1970 Census was at the beginning of the boom, the 1980 Census was during the peak, and the 1990 Census was at the end of the bust, so the PUMS data sets are well-timed for the purpose of studying the coal boom and bust.

For Table 7, we select county groups or PUMAs with at least 40% of their population residing in treatment counties and designate these as treatment county groups. We select county groups with greater than 75% of the population residing

[16] Although this could in part reflect that the service sector used in Eberts and Stone is narrower than our local sector category.

Table 7

Wage Growth by Sector, 1970–80 *and* 1980–90

	Difference (Treatment PUMAs) − (Comparison PUMAs)	
Average wage growth in:	1970–80	1980–90
Mining	0.273	−0.093
	(0.068) [0.000]	(0.040) [0.020]
N	4,930	6,870
Non-mining	0.058	−0.097
	(0.013) [0.000]	(0.009) [0.000]
N	75,746	134,154
Local sector:		
Construction	0.147	−0.043
	(0.044) [0.001]	(0.026) [0.093]
N	7,654	14,563
Retail trade	0.121	−0.134
	(0.046) [0.009]	(0.028) [0.000]
N	6,345	12,484
Services	0.096	−0.081
	(0.040) [0.017]	(0.023) [0.001]
N	10,115	20,199
Traded sector:		
Manufacturing	0.060	−0.126
	(0.018) [0.001]	(0.014) [0.000]
N	31,819	50,974

Notes: Authors' calculation of sector-specific wages for men 25–55 years old calculated from the 1970, 1980 and 1990 PUMS by dividing total wage and salary earnings by (weeks worked last year × average hours per week). County Groups or PUMAs in which 40% or more of the population resides in treatment counties are compared to those in which 70% or more reside in comparison counties. Regressions also compare for age, race (black, white), education (less than high school degree, high school degree, some college, college, advanced degree), and marital status. Standard errors are reported in parentheses while p-values are reported in brackets.

in comparison counties and designate these as comparison county groups.[17] Because the county groups change over time, a county that is in a treatment county group in one census could be in a comparison county group the next. This is a weakness of our analysis of wage effects, and the reason we prefer to use the BEA data to analyse employment and earnings outcomes.

The wage measure we use in Table 7 is total wage and salary earnings divided by hours of work, which is obtained by multiplying weeks worked last year by average number of hours worked per week.[18] Thus, if workers worked more overtime and received an overtime premium, then we will measure an increase in their wages even if their base wages did not change. We use the percentage change in wages from 1970 to 1980 to measure the wage effect of the coal boom, and the percentage change in wages from 1980 to 1990 to measure the wage effect of the coal bust. We limit our analysis to the wages of men who are 25 to 55 years old so that the observed wage changes are less likely to be caused

[17] For 1970, we use county groups with at least 70% of the population residing in comparison counties as comparison county groups. We also include a West Virginia county group with 36% of the population residing in treatment counties as a treatment county group. This is necessary so that West Virginia will have a treatment county group in 1970.

[18] 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, as our measure of labour supply.

by compositional changes in the labour force and more likely to reflect changes in demand for workers.

We use the following specification to analyse the sample of workers from 1980 and 1970:

$$\ln(Wage_i) = \beta_1 Coal_i + \beta_2 P_{80} + \beta_3 (Coal_i P_{80}) + \mathbf{X}_i \boldsymbol{\beta}_4 + \varepsilon_i \tag{4}$$

where $\mathbf{X}$ contains controls for age, age-squared, four education dummy variables (high school diploma, some college, college degree, advanced degree), two race indicators (white and black), and marital status.[19] *Coal* is a binary indicator that equals one if the worker is in a treatment county group. P_{80} is an indicator variable for 1980. Therefore, β_3 is interpreted as the differential wage growth during the boom between the treatment and comparison county groups. An analogous regression is estimated on the sample of workers from 1990 and 1980 to estimate the differential growth rate during the bust.

The results indicate that wages increased substantially during the coal boom and decreased during the coal bust in treatment county groups relative to comparison county groups. During the boom, mining wages increased 27.3% and wages for all non-mining sectors increased an average of 5.8%.[20] When the wage increases are broken out for the construction, retail, services and manufacturing sectors, we see that the wage increases were fairly proportional across these sectors, with the largest increase, 14.7%, occurring in construction and the lowest increase, 6.0%, occurring in manufacturing.

During the bust, mining wages declined by 9.7% and non-mining wages decline by 9.3%. The sector-specific non-mining wage declines range from a low of 4.3% in construction to a high of 13.4% in retail. The results in Table 7 provide convincing evidence that wages in both mining and non-mining sectors were affected by the coal boom and bust, and that migration did not completely eliminate the wage impacts. The fact that the 1980 and 1990 wages still show the effects of shocks that started early in each decade suggest that labour markets were not exceptionally quick to adjust to these shocks. Finally, while mining wages did decline in the coal bust, the magnitude of the decline was much smaller than the corresponding increase in the coal boom. This suggests that not only did coal mines begin to employ more educated miners, but these miners also accumulated more human capital while on-the-job, making them relatively more productive than their counterparts in the 1970s even after controlling for differences in formal education.[21]

[19] Because 1970 county groups cross state lines, the 1970 PUMS sample includes workers in neighbouring states of the four-state region. Because we cannot determine state of residence for most of the workers in our PUMS samples, we cannot control for state fixed-effects in this analysis.

[20] It is surprising that the wage effect for mining is so much larger than the wage effect for non-mining. We initially suspected that the likely cause was an increase in overtime work among coalminers. We estimated the change in hours of mining workers using the PUMS and did not find evidence of an increase in average hours that would support this theory.

[21] At the suggestion of a reviewer, we attempted to replicate our REIS analysis with the Census data. Unfortunately, the geographical areas change between the three Censuses, we are not sure about the quality of the estimates. With that caveat, however, we find a surprising agreement between the Census and REIS estimates. These results are available from the authors upon request.

3.5. *Impact on Migration and Poverty*

In this Section, we use aggregate county-level data from the 1970, 1980 and 1990 Census Summary Tape Files (STF) data to examine the impact of the coal shocks on migration and on poverty. The STF data report county-level statistics generated from the Decennial Censuses, providing us with county-level demographic information not available in the BEA data. In Table 8, we estimate the differential growth in the size of prime-aged cohorts, by gender, as well as changes in cohort-specific gender ratios. The equation for population change from 1970 to 1980 is:

$$\ln(Pop_{cis80}) - \ln(Pop_{cis70}) = \beta_1 T_i + \mathbf{State}_s \boldsymbol{\phi} + \varepsilon_{ist} \tag{5}$$

where Pop_{cis} is the population for cohort c in county i in state s, for the three prime-aged cohorts: population ages 10–19, 20–29 and 30–39 in 1970 (therefore 20–29, 30–39 and 40–49 in 1980). We estimate population changes by gender and then estimate the change in the ratio of men to women in each cohort. The results for the change from 1980 to 1990 are estimated using an analogous regression and those cohorts that are 10–19, 20–29 and 30–39 in 1980.

The results in Table 8 suggest that the population increases during the boom are mainly concentrated among the cohort that is 20–29 years old in 1970. The results also indicate that the population of men increased relative to women for both the 20–29 and 30–39 year olds. In the 1970 Census, 97.3% of all employees in the coal industry in the four-state region were men, so one might expect to see a gender-specific population response. Surprisingly, the results indicate that the 10–19-year-old cohort lost men relative to women during the boom. The results for the bust are substantially different; they indicate that population loss during the bust was larger and more broad-based across age and gender categories than the population changes during the bust.

The larger population response to the bust might suggest that leaving these remote mining areas is easier than moving to them. They also might reflect the fact that there is some up-skilling of the population during the coal boom that makes it easier for them to migrate to jobs in the outside economy. The population loss of women during the bust also might reflect the higher marital formation during the boom.[22] This larger population response could also be responsible for the larger employment spillovers of the bust reported in Table 6.

A few features of the prime-aged male migration during the boom are interesting. Using the 1980 PUMS and once again dividing county groups into comparison and treatment areas as described in the wage analysis above, we calculated the fraction of men aged 20–49 in 1980 who had lived in the same county five years prior. For men in the treatment county groups, 80.7% had lived in the same county five years ago, compared to only 73.8% in comparison county groups. This suggests that the population growth among prime-aged men might actually reflect in large part a decline in out-migration from the previously economically depressed coal areas,

[22] See Black *et al.* (2003) for evidence of marriage effects of the boom.

Table 8

Population Growth by Gender, 1970–80 *and* 1980–90

	Difference (Treatment − Comparison)		
Average population growth for:	Women	Men	Men/women
Cohort ages 10–19 in base year			
1970–80	−0.024	−0.051	−0.040
	(0.027) [0.376]	(0.031) [0.101]	(0.036) [0.263]
1980–90	−0.180	−0.224	−0.046
	(0.028) [0.000]	(0.033) [0.000]	(0.017) [0.007]
Cohort ages 20–29 in base year			
1970–80	0.056	0.091	0.048
	(0.031) [0.073]	(0.040) [0.024]	(0.027) [0.075]
1980–90	−0.145	−0.163	−0.017
	(0.023) [0.000]	(0.026) [0.000]	(0.012) [0.166]
Cohort ages 30–39 in base year			
1970–80	−0.012	0.031	0.041
	(0.016) [0.431]	(0.020) [0.111]	(0.011) [0.000]
1980–90	−0.107	−0.114	−0.008
	(0.015) [0.000]	(0.017) [0.017]	(0.006) [0.179]

Notes: Authors' calculations, Decennial Censuses STF files data. Columns 1 and 2 report the difference in changes in the logarithm of population measures from one census to the next between treatment and comparison counties. Column 3 reports the difference in changes in the gender ratio. Regressions are estimated separately for 1970–1980 and 1980–1990 and include state dummies dummies. Huber-White standard errors reported in parentheses while p-values are reported in brackets. There are 171 counties, with 32 of these counties in the treatment group. Every coefficient reported in Table 8 is estimated from an individual regression using these 171 counties.

rather than substantial in-migration.[23] Among those men who did report that they had lived in a different state five years ago, 48.9% of the men in treatment county groups had been born in their current state of residence, compared to only 34.8% of men in comparison county groups. Therefore, the in-migration that did contribute to population growth appears to substantially be return-migration among prime-aged men who had previously left these areas due to the poor job prospects.[24]

While our analysis has documented relatively large changes in earnings and wages during the coal boom and bust, we know little about the distributional aspects of the coal boom and bust. To gain some insight into the impact of the coal boom and bust on the poor, in Table 9 we analyse the effect of the coal boom and bust on poverty. We use both the fraction of families in poverty and the number of families in poverty as dependent variables. By using both poverty levels and rates, we can determine whether or not changes in the poverty measures are being driven by composition changes due to migration, or whether they reflect true changes in the well being of existing residents. For example, during the coal

[23] This also suggests that the negative population growth during the boom for the youngest male cohort might reflect the fact that the treatment areas were already experiencing out-migration of young men relative to the comparison areas. We do not, however, have pre-1970 data to confirm this.

[24] Indeed, the out migration has been noted in the region's popular culture. For instance, in his 1987 compact disc *Hillbilly Deluxe*, Dwight Yoakam includes a song entitled 'Readin', Rightin', and Route 23'. Route 23 is the highway that leads from Appalachian Kentucky to the industrial cites of Cincinnati, Columbus and Toledo, Ohio, and Detroit and Flint, Michigan. The song chronicles the out-migration of the region's residents for the economic opportunities of the northern cities.

Table 9

Poverty Effects of Coal Boom and Bust

	Difference (Treatment − Comparison)		
Average growth in:	1970–80	1980–90	N
Number of families in poverty	−0.224 (0.029) [0.000]	0.196 (0.038) [0.000]	342
Fraction of families in poverty	−0.246 (0.031) [0.000]	0.310 (0.045) [0.000]	342
Number of families with children in poverty	−0.218 (0.035) [0.000]	0.170 (0.046) [0.000]	342
Fraction of families with children in poverty	−0.269 (0.038) [0.000]	0.285 (0.051) [0.000]	342

Notes: Authors' calculations, Decennial Censuses STF files data. Table reports the difference in changes in the logarithm of population measures from one census to the next between treatment and comparison counties. Regressions include state-year dummies. Huber-White standard errors reported in parentheses while p-values are reported in brackets. There are 171 counties, with 32 of these counties in the treatment group.

boom, if families migrating into coal areas are less likely to live in poverty than those already living in the coal areas, then the fraction of families in poverty could decrease, even without any change in well being among the existing residents. If, however, the number of families in poverty decreases in coal areas at the same time the population is increasing, this is solid evidence that the existing residents are being made better off by the coal boom.

In Table 9, we find strong evidence that poverty decreased during the coal boom and increased during the coal bust. During the boom, the number of families in poverty in the treatment counties declined, even though the population in these counties grew. During the bust, the number of families in poverty increased, even though population in these counties declined. When we repeat the analysis using only families that have children, we find very similar results. Thus, poverty declined substantially during the boom and grew substantially during the bust, suggesting that the poor benefited from the expansion associated with the coal boom.

3.6. *Replicating Carrington*

Carrington (1996) analysed the impact of a temporary shock to an isolated economy. Our shock, while also to a relatively isolated economy, persisted for much longer than the construction of the Alaskan pipeline. An obvious question arises: 'How did the more persistent coal shock compare to the temporary Alaskan Pipeline shock?' In Table 10 we estimate several of Carrington's empirical specifications with our data and compare them to his results. In the first three columns, we regress first-differences of the logarithm of employment, the logarithm of population and the employment population ratio on first-differences of the log of earnings, which has been instrumented with the coal instruments used in the first two columns of Table 6, and state-year effects. These are compared to Carrington's results obtained using quarterly data to regress log employment, log population and the employment-population ratio on log earnings, instrumented with a

Table 10

Comparison of Employment and Population Responses to Carrington (1996)

Independent variable:	Dependent variable: log (employment)	log (population)	Employment-to-population ratio	log (mining employment)	log (construction employment)
Four-state coal region, 1970–89:					
log(Earnings) IV with coal shock	0.448 (0.029)	0.160 (0.020)	0.108 (0.013)	–	–
log(Mining earnings)	–	–	–	0.556 (0.030)	–
log(Mining earnings) IV with coal shock	–	–	–	0.907 (0.116)	
Alaska, 1968–81:					
log(Earnings) IV with TAPS	0.683 (0.033)	0.161 (0.042)	0.194 (0.036)	–	–
log(Construction Wages)	–	–	–	–	0.738 (0.388)

Notes: Results for Alaska obtained from Tables 2 and 3 of Carrington (1996). Regressions for the coal region are at the county level using annual data and include state-year effects. Regressions for Alaska are at the state level using quarterly data and include a time trend and AR(1) error structure. Standard errors are reported in parentheses. Coal estimates are obtained using first-differences to eliminate county fixed-effects. Carrington's estimates are in levels as he only uses a single time series.

triangular pulse that represents the effect of TAPS on labour demand, and time trend.[25] Our employment effect of 0.448 is smaller than Carrington's estimate of 0.683. Our population effect of 0.160, however, is almost identical to Carrington's estimate of 0.161.

In the fourth column we report the results of regressing the logarithm of mining employment on the logarithm of mining earnings and state-year effects. We compare this result to Carrington's from the regression of the logarithm of construction employment on the logarithm of construction hourly wages and a time trend. We estimate an elasticity of 0.556, compared to Carrington's of 0.738. Our right-hand side variable, however, is total annual earnings. Thus, our measure includes the hours worked response to the coal shocks while Carrington's hourly wage variable does not. Carrington does not report the results obtained by instrumenting the construction wage with the triangular TAPS pulse. Using our instruments for mining earnings yields a coefficient of 0.907.[26]

[25] Carrington's results are from columns 2, 6 and 8 of Table 2. We do not, as Carrington does, estimate an AR(1) error structure. Carrington's triangular pulse instrument is simply a linear trend that starts at zero in the winter of 1974, increases to 2.5 in the summer of 1996 and returns to zero by the fall of 1978. This triangular pulse is intended to approximate the actual time series for Alaskan employment during this period.

[26] Carrington also regresses the logarithm of sector-specific earnings for retail, services, transportation, FIRE, manufacturing and government on the logarithm of mining earnings. When we estimate similar specifications with our data, we find that the OLS first-differences results show very small effects, much smaller than Carrington's. When we use our coal shock instrument, however, the coefficient estimates are more in line with Carrington's estimates. For example, Carrington obtains an elasticity of 0.108 for retail; our estimate is 0.135. Our estimates for services and manufacturing are smaller than Carrington's estimate but our estimate for FIRE is larger.

Overall, our results in Table 10 are similar to those of Carrington. The smaller coefficient on earnings in the first column does suggest slower labour market adjustment in the case of the coal shock compared to the TAPS project. This probably reflects in part the fact that TAPS was seasonal and took advantage of the addition of college students to the labour market during the summer.

4. Conclusions

We analyse the effects of a boom and bust in the coal industry during the 1970s and 1980s on counties in Appalachia with substantial coalmining activity. The coal-producing counties in the four-state region are, with the exception of those in Pennsylvania, geographically isolated from large metropolitan areas. Thus, one suspects that spillovers from the coal shocks would be greater in this region than in areas located in urban areas. Consumers in Eastern Kentucky had long drives if they wished to do their shopping in Lexington or Cincinnati, so an increase in demand for goods and services as a result of the coal boom should have resulted in increased demand in the local economy. Yet, for each 10 jobs produced in the coal sector during the boom, we estimate that fewer than two jobs were produced in the local goods sectors of construction, retail and services. While the positive spillovers into the local sectors were smaller than some might have expected, the good news is that the negative spillovers into the traded sector were smaller than we might have expected as well. There is little evidence that the coal boom crowded out manufacturing employment in the coal areas.

The spillovers from the coal bust were larger. During the coal bust, we estimate that for each 10 jobs lost in the coal sector, 3.5 were lost in the construction, retail and services sectors. This asymmetry in the impact of the boom and bust may reflect the larger population losses that were experienced during the bust, which are probably due in part to the improved educational attainment of residents in the coal area during the 1970s and 1980s.

For areas that are economically depressed as the coal towns of our four-state region were in 1970, our results suggest that attracting industrial employment can help the area retain prime-aged men, increase local wages and reduce poverty without crowding out existing industrial employment. They also suggest, however, that employment spillovers into other sectors will be modest, and should not be overestimated in determining the generosity of tax holidays and subsidies used to lure new business.

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Appendix: Counties Used in this Study

In this Appendix, we provide a list of the treatment counties, with the fraction of total earnings derived from coal mining in 1969, and counties in the comparison group.

Counties in Treatment Group

County	Fraction of earnings from coal mining, 1969
Washington County, PA	0.100
Somerset County, PA	0.103
Armstrong County, PA	0.104
Preston County, WV	0.131
Knott County, KY	0.145
Belmont County, OH	0.152
Leslie County, KY	0.160
Monongalia County, WV	0.167
Marion County, WV	0.199
Union County, KY	0.221
Mingo County, WV	0.222
Hopkins County, KY	0.228
Webster County, KY	0.242
Martin County, KY	0.242
Perry County, KY	0.243
Fayette County, WV	0.247
Clay County, KY	0.259
Grant County, WV	0.269
Raleigh County, WV	0.280
Floyd County, KY	0.292
Ohio County, KY	0.300
Muhlenberg County	0.341
Harlan County, KY	0.347
Pike County, KY	0.415
Greene County, PA	0.459
Letcher County, KY	0.513
Harrison County, OH	0.521
Logan County, WV	0.531
Nicholas County, WV	0.534
Boone County, WV	0.558
Wyoming County, WV	0.585
McDowell County, WV	0.628

Counties in Comparison Group

Kentucky counties	Kentucky counties	Ohio counties	Ohio counties	Pennsylvania counties	West Virginia counties
Adair	Jessamine	Adams	Logan	Adams	Berkeley
Allen	Kenton	Allen	Madison	Crawford	Cabell
Anderson	Larue	Ashland	Marion	Cumberland	Hampshire
Ballard	Lewis	Ashtabula	Medina	Franklin	Hardy
Barren	Lincoln	Auglaize	Mercer	Juniata	Jackson
Bath	Logan	Brown	Miami	Mifflin	Jefferson
Boone	McCracken	Butler	Morrow	Monroe	Monroe
Bourbon	Madison	Champaign	Ottawa	Montour	Morgan
Boyle	Marion	Clark	Paulding	Northampton	Ritchie
Breckinridge	Marshall	Clermont	Pickaway	Northumberland	Roane
Bullitt	Mason	Clinton	Portage	Perry	Wood
Calloway	Meade	Crawford	Preble	Pike	
Campbell	Mercer	Darke	Putnam	Potter	

Counties in Comparison Group

Kentucky counties	Kentucky counties	Ohio counties	Ohio counties	Pennsylvania counties	West Virginia counties
Carroll	Metcalfe	Defiance	Richland	Snyder	
Casey	Monroe	Delaware	Ross	Union	
Clark	Montgomery	Erie	Sandusky	Warren	
Estill	Nelson	Fairfield	Seneca	Wyoming	
Fayette	Oldham	Fayette	Shelby		
Fleming	Pendleton	Fulton	Union		
Franklin	Rowan	Geauga	VanWert		
Fulton	Russell	Greene	Warren		
Garrard	Scott	Hancock	Williams		
Grant	Shelby	Hardin	Wood		
Graves	Simpson	Henry	Wyandot		
Green	Taylor	Highland			
Hardin	Todd	Huron			
Harrison	Trigg	Knox			
Hart	Washington	Lake			
Henry	Woodford	Licking			

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