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# The Impact of the Clean Air Acts on Coal Mining Employment in Kentucky

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**Abstract.** This article provides empirical evidence that environmental legislation affecting coal mining employment passed in 1977 had different effects on Western Kentucky, where the coal is of higher sulfur content, compared to Eastern Kentucky, where coals are of lower sulfur content, while the 1990 amendments to the Clean Air Act had no statistically significant impact in either region. The 1977 law generated a statistically significant reduction in West Kentucky employment. In addition, it appears that coal employment in Kentucky is correlated with coal mining employment in the US.

## 1. Introduction

In 1963, Congress passed the Clean Air Act, but it was not until 1970 that Congress provided the Environmental Protection Agency the authority to set uniform air standards (Rosenbaum 1991). The new source performance standards imposed by the 1970 Act limited emissions from plants built after 1971 (Tietenberg 1992). This standard could be met by burning low-sulphur coal. In 1977, Congress amended the Clean Air Act with a provision that required that sulfur emissions had to be cut by 90 percent. Now all new plants would require scrubbers. This reversed the incentive to rely on low-sulphur coal to meet air quality standards, and again allowed high-sulphur coal as a viable alternative. One important political force pushing for these amendments came from high-sulphur coal producers who felt the earlier law restricted their market potential. Thus the 1977 amendments were aimed, in part, at redressing the balance. Also in 1977, a surface mining reclamation bill was passed that effectively raised the cost of surface mining. Money had to be set aside to provide for reclamation. In 1990, the Clean Air Act was amended again. This landmark legislation provided for pollution permits where emissions would be allowed up to the number of permits a utility had.

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Permits were initially granted to the utilities, and a market for permits was also established.

In this article we examine the effects of theses laws on coal mining employment in Kentucky. Kentucky is of interest because Kentucky is home to two different quality coal beds. In the East, the coal has a higher BTU and lower sulfur content than the coals in the West that are higher in sulfur and lower in BTUs. One of the concerns about the laws that were passed was that they could have different regional impacts due to the way the sulfur content of the coal was handled in the law. We wish to see if this purpose of the law was realized.

The article is laid out as follows. The next section is devoted to a model of fuel choice by a utility. The second section discusses the data and variables used in the analysis. In the third section, we provide the empirical results, and the summary is found in the fourth section.

## 2. A Model of Utility Fuel Choice

There are three markets of interest: The market for electricity, the market for coal, and the market for coal miners. The environmental law affects the utility's choice of technology for producing electricity. The impact of the law is then carried through to the coal market and then on to the demand for miners. Our expectation is that a law reducing sulfur emissions for utilities will likely reduce the coal mining employment. We expect, however, that the impacts will not be similar for the two types of coal. We start with a model of fuel choice for a utility.

Consider a utility, producing electricity from some combination of low-sulphur coal (l), high-sulphur coal (h), and oil (o). The utility must satisfy a pollution emission requirement. To start, the firm can meet the pollution requirements with some form of scrubbing technology, which, we assume, the firm has chosen, and some combinations of low and high-sulphur coal. There is a scrubbing technology for each type of coal, (scrubh) for high-sulphur and (scrubl) for low. The price of electricity, $P_e$, will be assumed to be set by an independent regulatory agency, and the utility accepts the price as a parameter. The utility is assumed to purchase coal and oil on a long-term contract so that the prices of these inputs are also treated parametrically. In addition to the above, the utility is assumed to be a common carrier and is required to provide sufficient electricity to meet demand, (ebar). We assume that the scrubbing technology for both high and low-sulphur coal has been chosen and is not a variable in this analysis.

We will need some additional notation. $P_h$ is the price of high-sulphur coal; $P_l$ is the price of low-sulphur coal; $P_o$, is the price of oil; $C_h$ is the cost function for scrubbing high-sulphur coal which depends on the scrubbing technology chosen, (scrubh); $C_l$ is the cost function for scrubbing low-sulphur coal which depends on the scrubbing technology chosen. Electricity is produced according to a production function, $f_h$ is the production function for electricity from high-sulphur coal which depends on the quantity of high-sulphur coal and the scrubbing technology, $f_l$ is the production function using low-sulphur coal, and $f_o$ is the production function using oil. The quantity of electricity produced is $e_h$ from high-sulphur, $e_l$ from low-sulphur, and $e_o$ from oil . Pollution is produced by a production function $g_h$ for high-sulphur depending on the quantity of high-sulphur coal burned and the scrubbing technology. There is a similar function for low-sulphur coal. The amount of pollution produced is the sum of the pollution from each kind of coal. In the formulation given below, the possibility that oil also pollutes is included. The firm may not pollute more than the some upper limit, (pbar).

The firm's objective is to maximize profit. We have the following Lagrange expression.

$$\begin{aligned} &-C_h(\text{scrubh}) - C_1(\text{scrubl}) - C_o(\text{scrubo}) \\ &+ \mu_1[\text{pbar} - g_h(h, \text{scrubh}) - g_1(1, \text{scrubl}) - g_o(o, \text{scrubo})] \\ &+ \mu_2[f_h(h) + f_1(1) + f_o(o) - \text{ebar}] \end{aligned} \tag{1}$$

The first order conditions are as follows (again, we are treating scrubh, scrubl, and scrubo as parameters so that the functions f and g are functions of one variable).

$$\frac{\partial\psi}{\partial h} = P_e f_h{}' - P_h - \mu_1 g_h{}' + \mu_2 f_h{}' = 0 \tag{2}$$

$$\frac{\partial\psi}{\partial 1} = P_e f_1{}' - P_1 - \mu_1 g_1{}' + \mu_2 f_1{}' = 0 \tag{3}$$

$$\frac{\partial\psi}{\partial o} = P_e f_o{}' - P_o - \mu_1 g_o{}' + \mu_2 f_o{}' = 0 \tag{4}$$

$$\mu_1[\text{pbar} - g_h(h; \text{scrubh}) - g_1(1; \text{scrubl}) - g_o(o; \text{scrubo})] = 0, \mu_1 \geq 0 \tag{5}$$

$$\mu_2[f_h(h; \text{scrubh}) + f_1(1; \text{scrubl}) + f_o(o; \text{scrubo}) - \text{ebar}] = 0, \mu_2 \geq 0 \tag{6}$$

The question we propose to examine is what happens to the use of high and low-sulphur coal as the regulatory process changes. In the period we are studying, the pollution permit market was introduced. The question is whether this will cause the relative use of high vs. low-sulphur coal to change compared to the case where there is a limit on the amount of pollution allowed. To address this question, the above model will be altered to bring in the permit process. We will observe that the conditions governing the choice of coals will be very similar to the case of emissions control. The primary difference in the two outcomes is due to the different level of pollution. Hence, we may find how the coal use changes as the institutional setting changes by looking at how coal use changes as the level of allowable emissions changes in the original model.

In the case of pollution permits, the firm must keep its pollution level below the number of permits they have or purchase more permits. There is an initial allocation of permits, $P_o$, and permits may be purchased or sold in a market for permits; $P_{per}$ is the price of the permits. Using the notation given above, we may now state the Lagrange and first order necessary conditions for this problem.

$$\psi = P_e[f_h(h,scrubh) + f_1(1,scrub1) + f_o(o;scrubo)] - P_h h - P_1 1 - P_o o - P_{per}(Per - P_o) - C_h(scrubh) - C_1(scrub1) - C_o(scrubo) + \mu_1[Per - g_h(h, scrubh) - g_1(1, scrub1) - g_o(o, scrubo)] + \mu_2[f_h(h) + f_1(1) + f_o(o) - ebar] \tag{7}$$

$$\frac{\partial\psi}{\partial h} = P_e f_h' - P_h - \mu_1 g_h' + \mu_2 f_h' = 0 \tag{8}$$

$$\frac{\partial\psi}{\partial 1} = P_e f_1' - P_1 - \mu_1 g_1 + \mu_2 f_1' = 0 \tag{9}$$

$$\frac{\partial\psi}{\partial o} = P_e f_o' - P_o - \mu_1 g_o' + \mu_2 f_o' = 0 \tag{10}$$

$$\frac{\partial\psi}{\partial Per} = -P_{per} + \mu_1 = 0 \tag{11}$$

$$\mu_1[Per - g_h(h; scrubh) - g_1(1; scrub1) - g_o(o, scrubo)]0, \mu_1 \geq 0 \tag{12}$$

$$\mu_2[f_h(h; scrubh) + f_1(1; scrub1) + f_o(o;scrubo) - ebar] = 0, \mu_2 \geq 0 \tag{13}$$

First note that the first order conditions for the two problems are very similar. The impact of the alternative formulation in terms of the marginal analysis will be due to the size of pbar compared to Per. There is no reason to think that the initial regulation of the quantity of emissions would be equal to the number of permits that the firm would choose. There may be an efficiency gain if the firm can alter the amount of pollution it generates and pollution is shifted to those who can afford the permits.

The question we wish to address, what happens to the quantity of each kind of coal used as the regime changes from the emission limit to permits, can be examined by looking at the impact of a change in the amount of pollution allowed, pbar, on the quantity of each type of coal used looking in the model where emissions are capped. The question of how h and l change as the number of permits, Per, changes cannot be answered by comparative statics as all three of these variables are endogenous.

Comparative statics will tell us the impact on h and l of a change in pbar. We assume that both constraints are binding. By the usual comparative statics process, we obtain the following.

$$\frac{\partial h}{\partial pbar} = \frac{-f_1' a_{33}(g_1' f_h' - g_h' f_1') - f_o' a_{22}(f_h' g_o' - f_o' g_h')}{(g_1' f_h' - g_b' f_1')^2 a_{33} + (g_o f_1' - g_1' f_o')^2 a_{11} + g_o' f_1'(g_o' f_1' - g_1' f_o') a_{11} - g_h' f_o'(g_o' f_h' - g_h' f_o') a_{22}} \quad (14)$$

where

$$a_{11} = (P_e f_h'' - \mu_1 g_h ?'' + \mu_2 f_h''), \quad (15a)$$

$$a_{22} = (P_e f_1'' - \mu_1 g_1'' + \mu_2 f_1''), \quad (15b)$$

and $$a_{33} = (P_e f_o'' - \mu_1 g_o'' + \mu_2 f_o''). \quad (15c)$$

The denominator is negative. The numerator is of undetermined sign. However, if the heat rate of the coal is nearly the same regardless of the sulfur content (i.e., if the marginal MMBTU content of the two coals is about the same, $f_h' = f_l'$), if $g_l' > g_h'$, and if $f_h' g_o' - f_o' g_h' > 0$, then the numerator is positive, and this derivative is negative. Under similar conditions, the MI/M pbar> 0 will hold. This result is what we would expect. As the requirement for less pollution becomes more strict, the firm, which cannot adjust its scrubbing alternatives, is forced to move to the lower polluting sources of energy, low-sulphur coal and oil. Thus we would expect that as the requirements for cleaner air get tighter, the market for low-sulphur coal should improve and the market for high-sulphur coal should get worse. Of course, coal prices will adjust to some extent to reflect these changes in demand.

Based on this model, we would have mixed expectations concerning the impact on demand of stronger clean air acts. For firms that reduced the amount of pollution they were generating, we would expect that the demand for high-sulphur coal would be reduced. Firms that increased the amount of pollution they produced might increase their demand for high-sulphur coal.

In 1971, the law could be satisfied by burning low-sulphur coal. That would suggest that there would be a relative decrease in coal mining employment in areas where high-sulphur coal is found. Later, in 1977, when all new plants had to include scrubbers regardless of the kind of coal they burned, some of the incentive to move away from high-sulphur coal was removed and we would expect to see a relative growth or slowing of the decline of coal mining employment in areas with high-sulphur coal. In 1990, when permits were introduced, as argued above, it is unclear what impact we might find. If the 1977 law had relatively favored high-sulphur coal compared to what would have held under permits, then we would expect a movement toward low-sulphur coal.

# 3. Data and Variable Choice

The applied research pursued here provides some empirical evidence concerning what happened to coal mining employment in the two areas of Kentucky from 1975 through 1997. Our analysis includes the economic variables one would generally expect. Mining employment represents all mining employees covered by workman's compensation. We included only the counties where coal is found. A description of the data and the adjustments made is found in the appendix.

From the model given above, we know that the utility's demand for coal depends on the price of electricity, the marginal product of coal in producing electricity, the price of alternative fuels, and the marginal product of coal in producing pollution. The demand for coal is then the basis for the demand for coal miners. Profit maximization suggests that the demand for coal miners depends on the price of coal and the marginal product of labor. We expect the quantity of labor hired will depend on these factors. The supply of miners will also affect the quantity of miners hired. Thus we are looking at coal mining employment as a function of the price of coal, an index of the price of bituminous coal as found in the Producer Price Index, the price of a substitute fuel (we used residual oil, also an index found in the Producer Price Index), and other employment opportunities for the miners. The coal price for East Kentucky is the Southern Appalachian coal price, a region that includes East Kentucky, and the price for the West is the Midwestern coal price. There is not one particular alternative job that the miners might have taken rather than mine coal, so we include non-coal mining employment in the region as a proxy for what the available alternatives might have been. It is not clear, however, which way the direction of causation goes here. It may be, if the region is highly dependent on coal mining, that increases in coal mining employment cause increases in non-mining employment. Or it may be that coal mining has become a relatively less important employment source because of diversification that has occurred, and the two kinds of employment are substitutes.

One important driver for mining employment is the demand for energy. As the demand for energy rises, we would expect the coal market to improve and mining employment to rise. To capture this, we include U.S. employment. We presume that as total U.S. employment rises, there is a greater need for energy.

While it may be true that the two regions are different from each other, it is also useful to see which, if either, has an experience that is different from the rest of the mining population. The standard is how coal mining employment in each region has fared compared to national coal mining trends. Thus we include U.S. coal mining employment to capture how the region is similar to the nation as a whole and the extent to which the national coal trends affect the region.

Because there were nine strikes in the period, we also include a dummy for each of the strikes. To account for seasonal patterns, we included a dummy for each quarter. We also include dummy variables to represent the laws. In this study, there are two laws included as our quarterly data starts in 1975:1 and goes through 1997:3. We have a dummy for the 1977 law and one for the 1990 law. The 1977 dummy actually stands for two laws that were passed within days of each other, the Surface Reclamation Act and the Amendments to the Clean Air Act. It is not possible to separate the effects of these laws. We would generally expect both to make coal a more expensive proposition and decrease employment in coal mines (McDermott 1997). If reclamation work requires more labor than without reclamation, then it is not clear whether the law would increase or decrease employment. We do not believe that the laws would have an immediate impact so we modeled the dummy as a gradual change from zero to one. There are an infinite number of possible ways this could happen and a variety of time horizons over which the effect could be felt. We chose to use a dummy that took on values giving a shape similar to a cumulative standard normal over a two year period. In addition to Kentucky, we also examined total U.S. coal mining employment.

The data are quarterly and were first converted to logarithm and then differenced. We checked each series for unit roots using a Dickey-Fuller test and found none (Engle and Yoo 1987; Lasage 1990; Fuller 1976). We then ran seemingly unrelated regressions; standard OLS gives very similar results. Our results are provided in Table 1.

## 4. Empirical Results

The 1977 law is statistically significant at the 5 percent level in East Kentucky (and the coefficient is negative), but the coefficient is negative and not statistically significant in the West or in the U.S. as a whole. The 1990 law is not statistically significant at conventional levels in any case.

These results suggest the following comments. Normally, any law mandating utilities to produce less sulfur would be expected to drive up the cost of coal, which would cause coal to become relatively less attractive as an energy source, and thus cause coal employment to fall. The 1977 law should have had a positive influence on mining employment in Western Kentucky as the law made burning high-sulphur coal more attractive.

For both the U.S. as a whole and Western Kentucky, the 1977 law dummy is negative but not statistically significant. There are a variety of reasons. First, the dummy represents two laws. The laws, a surface mining reclamation act and amendments to the Clean Air Act, may have opposite impacts and thus wash out. This could account for the lack of statistical significance. The puzzle is that the sign of the coefficient in the case of Western

Kentucky is negative. The negative impact of the law may have been caused by the fact that even when the low-sulphur coals are scrubbed, they are more cost effective than high-sulphur coal. Thus the high-sulphur coals of Western Kentucky lost market share to the less expensive low-sulphur coals of the Powder River Basin (PRB). Again, one aim of the 1977 Clean Air Act Amendments was to keep Eastern and Midwestern high-sulphur coal from being punished because of environmental laws (Ackerman and Kassler 1981; Stanton 1989). The fact that mining employment in the high-sulphur coals of West Kentucky did not show a statistically significant impact may suggest that the effort to not hurt high-sulphur coals was mildly successful. The law was statistically significant in the East, and the coefficient was negative suggesting that the effects of the Clean Air Act on employment were likely more powerful in the East than the impact of the reclamation law. This latter result may also suggest that in an effort to protect high-sulphur coal, the law hurt the lower sulfur coals of East Kentucky. As an alternative, even given the law, the low-sulphur PRB coals may have been cheaper than the low-sulphur coals of East Kentucky, and the PRB coals replaced the East Kentucky coals in the market.

**Table 1:** Regression Coefficients

| | U.S. 1976:2-1997:3 | East Kentucky 1976:2-1997:3 | West Kentucky 1976:2-1997:3 |
|---|---|---|---|
| Coal Price | 6.8025* | 0.4589* | 0.1235 |
| | (6.17) | (2.00) | (0.41) |
| Oil Price | -0.0647 | 0.0156 | -0.0557 |
| | (-0.55) | (.59) | (-1.11) |
| U.S. Coal Emp | | 0.2085* | 0.6762* |
| | | (13.06) | (16.51) |
| U.S. Emp | 2.9556 | 1.5501* | 1.3089 |
| | (1.87) | (4.12) | (1.61) |
| E Ky non coal employ | | 0.2118 | |
| | | (1.61) | |
| W Ky non coal employ | | | 0.4370 |
| | | | (1.08) |
| Law 90 | 0.2534 | -0.0287 | 0.00006 |
| | (0.96) | (-0.47) | (0.0006) |
| Law 77 | -0.0338 | -0.1876* | -0.1736 |
| | (-0.13) | (-2.92) | (-1.52) |
| Box-Ljung Q(27) | 13.16 | 22.74 | 29.73 |
| $\overline{R}^2$ | .5391 | .8002 | .8872 |
| DW | 2.10 | 2.13 | 2.48 |

t statistics in parentheses
* significant at the 5% level
strike and quarter dummies are not reported in any equation

The 1990 laws do not appear to have an impact on employment. Again, it is difficult to know *a priori* what the likely impact of the 1990 law might be. Because the main impact of the laws was to establish marketable pollution permits, we would expect the price of the permits to adjust the price of coal so that sulfur content of the coal would not be an important determinant of use. While there was not a statistically significant impact, 1990 law had a negative coefficient in both the West and East, but a positive coefficient for the U.S. as a whole. The positive coefficient could reflect the fact that the permit system improved efficiency of coal use and therefore boosted overall coal mining.

We turn now to how the economic variables have affected employment. The regression analysis suggests the following.

1) Coal employment in the United States is statistically significant at the 5 percent level in both the East and West. In both cases the coefficient is positive.
2) Total U.S. employment is statistically significant in the East, but not the West or in the US as a whole. Again the coefficient is positive in all cases.
3) No other economic variables are statistically significant at conventional levels.

We have no *a priori* expectation for the sign of the coal price coefficient. For example, if the demand for coal increases causing the price of coal to rise, the demand for coal mining labor will also rise and, all else equal, employment will rise. This would yield a positive coefficient. On the other hand, if there is an increase in supply of coal caused by some technological factor, the price of coal would fall. Whether mining employment would rise or fall would depend on whether the impact of the coal price on employment demand was larger or smaller than the impact of the change in the marginal product of labor (due to the new technology). In both the West and in the U.S., coal price has a positive sign and is statistically significant. The sign suggests that increases in coal demand have been more important than change in supply in determining coal mining employment.

Mining employment in both the East and West is connected in a statistically significant way at the 5 percent level with U.S. coal mining employment. Thus mining employment patterns in the East and West are related to nationwide mining employment trends. Hence, the experience of the Kentucky miner is similar to that of miners across the U.S. On the other hand, the experience is not exactly the same. If we test whether the coefficients on the U.S. coal employment variable are equal to one, the hypothesis is rejected. It is likely that other regions are gaining employment at least relatively compared to Kentucky. In the East, but not the West, there is a statistically significant relationship with U.S. total employment. As the U.S. economy gains speed, there will be relatively more important spillovers in the East than in the West. So the well being of the U.S. economy matters more for the East than the West.

Non-mining employment is not statistically significant in either the East or West, and the coefficients are positive in both cases. We summarize the expected sign and the actual sign obtained for each variable in each equation in Table 2.

This analysis is supported by the work of Ellerman *et al* (Ellerman et al 1998) who argue that the falling rail rates and low price of coals from the Powder River Basin, which are exceptionally low in sulfur, caused the replacement of higher sulfur Midwest coals with the PRB coals. They argue that this happened and would have happened even without the environmental laws. In other words, the decrease in employment found in Kentucky was due primarily to the fact that they did not compete well on a dollar per BTU basis with the coals of the PRB. In this case, we would not expect that the laws would have much impact in Kentucky.

Overall, the statistical analysis indicates that the two regions are reasonably similar, but there are differences. The East was affected by the 1977 Law, but the West was not. The two regions demonstrate different relationships with U.S. level employment variables; both are correlated with U.S. coal employment but the West is not correlated with U.S. total employment while the East is. On the other hand, no economic variable affects either region. The 1990 law does not have a statistically significant impact in either region. Neither region is affected by regional non-coal mining employment in a statistically significant way.

**Table 2.** Actual and Expected Signs for Each Variable in Each Region [2]

| | Sign of the variable in the equation for: | | | | | |
|---|---|---|---|---|---|---|
| | US | | East Kentucky | | West Kentucky | |
| Variable | Expected | Actual | Expected | Actual | Expected | Actual |
| Coal Price | pos | pos | pos | pos | pos | 0 |
| Oil Price | pos | 0 | pos | 0 | pos | 0 |
| U.S. Coal Employment | | | ? | pos | ? | pos |
| U.S. Employment | pos | 0 | pos | pos | pos | 0 |
| E. Kentucky non-coal Employment | | | ? | 0 | | |
| W. Kentucky non-coal Employment | | | | | ? | 0 |
| 1990 Law | ? | 0 | pos | 0 | neg | 0 |
| 1977 Law | ? | 0 | neg | neg | Pos | 0 |

# 5. Summary

Two hypotheses concerning coal mining employment in Kentucky were examined in this paper. They are:

[2] When 0 is reported in the case of the actual coefficient, we mean that the coefficient was not significantly different from zero in the statistical sense at the 5% level. When pos (neg) is reported for an actual coefficient, we mean that the sign is positive (negative), and significantly different from zero in the statistical sense at the 5% level. When a ? is reported for and expected sign, we mean that arguments can be made to make the sign of either sign, and we do not hold *a priori* expectations of the sign.

1. Have the laws had different effects upon coal mining employment in the regions?
2. Have the laws had a different impact on coal mining employment in the state compared to the nation as a whole?

Our results suggest that the 1977 law had a statistically significant impact on the East but not on the West or the U.S. as a whole. The 1990 law had no statistically significant impact on any of the mining employment variables. It is also true that the experiences of coal miners in Kentucky were similar to the experience of coal miners generally in the U.S.

Earlier work by Hoag (1995) suggested that the 1977 laws had no impact on coal mining employment in either Ohio or Illinois. Based on that work, we would expect that the laws should have no statistical impact in West Kentucky; the coals of West Kentucky are contiguous with the coals of Illinois. However, the coals of Ohio are not in the same bed as those of East Kentucky. In fact, the coals of Ohio are more similar in sulfur content to the coals of West Kentucky/Illinois. Thus the results found here are consistent with the earlier work. When the 1977 law was passed, the hope was to improve the market position of high-sulphur coals that would have a positive impact on coal mining employment in regions where high-sulphur coal is found, such as West Kentucky. The evidence presented here is that the law had no statistically significant impact on West Kentucky, but did reduce employment in East Kentucky where coal is generally of lower sulfur content. In that sense, the law did not have an even effect on all regions. Nor did the law have the impact it was intended to have: to remove some of the onus of using high-sulphur coal. The point of this work is this: When a legislature passes a law with a particular goal, the law may not achieve the goal the legislature set out to achieve.

# Appendix

The employment data is from the Kentucky Department of Human Resources and includes all miners covered by workman's compensation each quarter in each county. The data does not distinguish the kind of mining the person does. Thus mining employment includes coal and other kinds of mining. To overcome this problem, we removed from the data set counties where coal mining employment was non-existent or was not in an area where coal is found. Using information provided in Kentucky Coal Facts (Governor's Office for Coal and Energy Policy and the Kentucky Coal Association 1997), we identified the counties that produced coal in 1990. We then looked to see if there were other counties that produced coal in other years. Some counties were dropped out of the sample because of missing observations. In the East, we used data from Bell, Carter, Clay, Floyd, Harlan, Johnson, Knott, Knox, Laurel, Lawrence, Lee, Leslie, Letcher, Magoffin, Martin, Perry, Pike, Pulaski, and Whitely. In the West, we included Breckinridge, Caldwell, Daviess, Henderson, Hopkins, Muhlenberg, Union, and Webster. In three quarters, data were missing for all counties. However, we did know the total mining wages in each of those quarters. We were able to estimate employment by dividing total wages by earnings per miner from a previous month. Other missing observations were filled with the average of contiguous months.

We were concerned that our data did not reflect what was happening in coal mining. We did have annual data from 1979 through 1996 for East and West Kentucky provided in Kentucky Coal Facts (Governor's Office for Coal and Energy Policy and the Kentucky Coal Association 1997), a publication of the Governor's Office for Coal and Energy Policy and the Kentucky Coal Association. We then averaged our quarterly data and ran a regression with the actual data as the dependent variable and our estimates from quarterly data as the independent variable for both the East and the West. The results are reported below.

Appendix Table 1

| | Regression Coefficients | |
|---|---|---|
| | East Kentucky | West Kentucky |
| Constant | -57.77 | 5527.4009 |
| | (-.11) | (0.899) |
| Coefficient | 1.0219 | 0.9828 |
| | (0.019) | (0.083) |
| $\overline{R}^2$ | .9939 | .8911 |

We test the hypothesis that the coefficient is one. For the East, we do not reject the hypothesis at conventional levels of significance. For the West, the hypothesis is rejected. This suggests that a significant portion of the variation is captured by these variables. While the levels of employment we use are not the same as the levels for coal mining employment in Kentucky, our data does show a strongly similar pattern of behavior.

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