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The Effect of Sulfur, Btu and Ash Content On the Price of Electric Utility Coal

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As a consequence of the Clean Act Amendments of 1970, electric utilities have been required to reduce their emissions of sulfur dioxide in many localities. Since many utilities consider stack gas scrubbers to be an unproven or unreliable technology, they have increasingly searched for low sulfur fuel. As a result, one expects low sulfur fuel to command a premium over high sulfur fuel. In addition, many coal contracts specify minimum Btu levels, and some include a penalty clause for low Btu coal, so we should expect coal price to be a function of Btu content. Finally, we might predict that low ash coal would command a premium over high ash coal.

In recent years, a number of economists have made use of hedonic price indexes. A hedonic price index is used when it is hypothesized that the price of a specific commodity is related to various quality attributes of the commodity and that variations in price can be explained by variations in quality. Hedonic price indexes have been used to study the impact of

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quality on the price for such goods and services as automobiles and housing rental or sales price. 1/

In the present study we hypothesize that the price of coal is negatively related to the percent sulfur content of the fuel. In addition, we also hypothesize that the price of coal is positively related to the Btu content of the coal and negatively related to the ash content.

The price data used were the delivered price of coal for a cross section of steam electric generating plants. The delivered price of coal varies with transportation costs which are a function of the distance the coal is shipped. Since we wish to observe variations in coal price due to variations in sulfur, Btu and ash content while holding other variables constant, we would like to include a variable which measures transportation costs. Since we did not have a direct measure of the distance over which the fuel was shipped, we used instead a series of dummy variables for five of the Federal Power Commission geographic regions in which the generating plants were located. We expect, for example, that the East South Central Region which is relatively close to coal supplies would have relatively low transportation costs and thus a relatively small coefficient for its regional dummy variable.

Finally, because we might expect spot and contract fuel prices to behave somewhat differently with regard to sulfur, Btu and ash content, we have estimated the equations separately for spot and contract coal. For example,

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1/ See for example: Zvi Griliches, "Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change," In Price Indexes and Quality Change Studies in New Methods of Measurement, edited by Zvi Griliches, (Cambridge, Mass.: Harvard University Press, 1971), pp. 55-87; Thomas F. Hogarty, "Price-Quality Relations for Automobiles: A New Approach." Applied Economics, 7(1975), pp. 41-51; Jack E. Triplett, "Automobiles and Hedonic Quality Measurement.: Journal of Political Economy, 77(1969), pp. 408-417; Brian J.L. Berry and Robert St. Bednarz, "A Hedonic Model of Prices and Assessments for Single-Family Homes: Does the Assessor Follow the Market or the Market Follow the Assessor?" Land Economics, 51 (1975), pp. 21-40; and Robert F. Gillingham, "Place-to-Place Rent Comparisons Using Hedonic Quality Adjustments Techniques," Bureau of Labor Statistics Staff Paper 8, 1975.

large long-term contracts might be to be more or less sensitive to Btu and sulfur content than smaller short-term contracts.

We assume that:

(1) $P = f(B,S,A,D_2,D_3,D_4,D_5,D_6)$

where P = the delivered price of coal in dollars per ton.

B = Btu content per lb. of coal.

S = percent sulfur content by weight of the coal.

A = percent ash content by weight of the coal.

D_2,D_3,D_4,D_5,D_6 = dummy variables equal to 1 if the electric utility plant is located in that region, and 0 otherwise.

We hypothozize that:

$$\frac{\partial P}{\partial B} > 0 \quad \frac{\partial P}{\partial S} < 0 \quad \frac{\partial P}{\partial A} < 0$$

Hedonic price indexes have usually been estimated using the log of price and untransformed independent variables, although there appears to be no theoretical reason to prefer the untransformed linear form of the independent variables to the log form. 2/ In the present study, price, Btu content, percent sulfur and percent ash were all transformed into logs. The regional dummy variables were not transformed.

Thus, the equations actually estimated were of the following form:

(2) $\log(P) = c_0 + c_1 \log(B) + c_2 \log(S) + c_3 \log(A) + c_4D_2 + c_5D_3 + c_6D_4 + c_7D_5 + c_8D_6 + e$

where e = the error term, and the other variables were defined perviously. In these equations c_1 may be interpreted as the elasticity of coal price with respect to Btu content, c_2 may be interpreted as the elasticity of coal price with respect to the percent sulfur, and c_3 may be interpreted as the elasticity of coal price with respect to the percent ash.

2/ See Griliches, op. cit., pp. 57-59.

The Data

The data were obtained from a copy of the Federal Power Commission tape of its records on FPC form 423. The particular tape used lists every separate receipt of fuel by every steam electric plant with an installed capacity of 25 megawatts or more of electricity for each month from July 1972 to March 1975. Since January 1975, the tape has also included power plant units used for peaking purposes. In some cases there were hundreds of separate deliveries to a plant listed in a single month. In order to decrease the size of the data sample, the data were aggregated and the weighted average spot and contract price, Btu content, sulfur content and ash content were calculated for each month for each plant in the sample. The directions on FPC form 423 require utilities to list spot and contract deliveries separately, but do not define the difference between spot and contract deliveries. However, most people in the industry assume that spot refers to any short-term delivery with a duration of one year or less, and contract refers to any long-term delivery commitment with a duration of greater than one year.

Six regressions were run for two different cases: spot coal and contract coal. The six regressions represented six different months: September 1972, March 1973, September 1973, March 1974, September 1974, and March 1975. Dummy variables were used for five FPC geographical regions. 3/

3/ The regions were as follows: D2, Middle Atlantic (New York, Pennsylvania, New Jersey); D3, East North Central (Wisconsin, Michigan, Illinois, Indiana, Ohio); D4, West North Central (North Dakota, South Dakota, Minnesota, Nebraska, Iowa, Kansas, Missouri); D5, South Atlantic (West Virginia, Virginia, Maryland, Delaware, North Carolina, South Carolina, Georgia, Florida); D6, East South Central (Kentucky, Tennessee, Mississippi, Alabama).

The Regression Results

Tables 1 and 2 present the regression results. In every case the Btu content coefficient has the predicted positive sign and is statistically significant at the .01 level. Also, in every case the percent sulfur coefficient has the predicted negative sign and is significant at the .01 level (or in one case at the .05 level). However, the percent ash never is statistically significant with a negative sign. In nine cases it would be statistically significant with a positive sign in a two-tail test.

The Btu coefficients or elasticities are greater than 2.0 in every case but one. That means that a one percent increase in Btu content is associated with a two percent increase in price. For example, in March 1974, the average price of contract coal was $10.63 and the average Btu content of all coal was 10,992 Btu's per pound. 4/ Since the Btu coefficient or elasticity was estimated to be 2.7560, a one percent increase in Btu content or increase of 109.92 Btu's would therefore be associated with approximately 2.7460 percent or a 29¢ per ton price increase.

The sulfur coefficient or elasticities vary from -.0926 for spot coal in March 1975 to -.2787 for spot coal in March 1974. Although they are all statistically significant, none has an absolute value as large as .3. In March 1974, the average spot price of coal was $22.54 and the average sulfur content of all coal was 2.3 percent. 5/ A coefficient of -.2787 implies that a 10 percent increase in sulfur content (from 2.3 to about 2.5 percent sulfur coal) would be associated with a 2.787 percent price decrease, or a decrease of about 63¢ per ton.

4/ U.S. Federal Power Commission, "Monthly Fuel Cost and Quality Information, March 1974," News Release No. 20445, June 28, 1974.

5/ Ibid.

Table 1

Regression Results for Spot Coal

Date						N	$\bar{R}^2$
72/9	P = -20.2798	+2.3399B** (11.57)	-.1575S** (-5.22)	+.2035A (6.50)	+.1348D2 (1.05)	160	.529
		+.2804D3* (2.21)	+.5662D4** (4.20)	+.1710D5 (1.39)	-.0379D6 (-.29)		
73/3	P = -16.9513	+2.0230B** (10.18)	-.1624S** (-4.99)	+.1027A (3.17)	+.0908D2 (.58)	163	.361
		+.2130D3 (1.34)	+.3834D4* (2.36)	+.1261D5 (.83)	-.0438D6 (-.27)		
73/9	P = -15.3067	+1.8476B** (10.03)	-.1225S** (-3.51)	+.1513A (4.31)	+.0021D2 (.01)	172	.461
		+.1195D3 (.75)	+.2279D4 (1.40)	+.0875D5 (.58)	-.1434D6 (-.89)		
74/3	P = -18.8255	+2.2787B** (6.95)	-.2787S** (-5.04)	+.2347A (3.59)	-.0253D2 (-.15)	200	.425
		-.0512D3 (-.31)	-.1032D4 (-.59)	+.2545D5 (1.55)	-.0779D6 (-.43)		
74/9	P = -26.2741	+2.9528B** (10.56)	-.2123S** (-5.22)	+.3830A (6.80)	+.9388D2** (3.03)	197	.577
		+1.1850D3** (3.87)	+.9354D4** (3.00)	+1.2877D5** (4.17)	+1.1439D6** (3.65)		
75/3	P = -17.4616	+2.1264B** (7.21)	-.0926S* (-2.35)	+.1556A (2.38)	+.4091D2* (2.08)	182	.353
		+.4360D3* (2.26)	+.5007D4* (2.58)	+.4538D5* (2.34)	+.4383D6* (2.23)		

** Indicates the S coefficient is significant at the .01 level in a 1-tail test; or the dummy variable coefficient is significant at .01 level in a 2-tail test.

* Indicates the S coefficient is significant at the .05 level in a 1-tail test; or the dummy variable coefficient is significant at .05 level in a 2-tail test.

N is the number of observations.

$\bar{R}^2$ is the coefficient of determination, adjusted for degrees of freedom.

The numbers in parentheses are the t-ratios.

Table 2

Regression Results for Contract Coal

Date						N	$\bar{R}^2$
72/9	P = -19.1270	+2.2524B** (18.83)	-.1478S** (-5.97)	-.0434A (-1.15)	+.4181D2** (5.77)	285	.677
		+.5414D3** (8.63)	+.5358D4** (8.40)	+.3966D5** (6.31)	+.3277D6** (4.64)		
73/3	P = - 9.4490	+2.2830B** (18.12)	-.1645S** (-6.36)	+.0277A (.87)	+.3596D2** (4.93)	288	.658
		+.4795D3** (7.49)	+.4882D4** (7.61)	+.3266D5** (5.00)	+.3231D6** (4.40)		
73/9	P = -21.7746	+2.5260B** (19.24)	-.1731S** (-7.05)	+.0488A (1.69)	+.3945D2** (5.60)	295	.663
		+.5266D3** (8.36)	+.5475D4** (8.52)	+.3388D5** (5.23)	.3603D6** (5.07)		
74/3	P = -24.0029	+2.7460B** (14.92)	-.2337S** (-6.35)	+.2228A (5.89)	+.5203D2** (5.41)	284	.583
		+.5444D3** (6.10)	+.4997D4** (5.68)	+.4965D5** (5.64)	+.3025D6** (3.01)		
74/9	P = -24.2173	+2.7850B** (13.58)	-.2478S** (-5.90)	+.1608A (2.60)	+.8366D2** (7.51)	288	.581
		+.7831D3** (8.06)	+.6999D4** (7.22)	+.7769D5** (8.02)	+.5956D6** (5.41)		
75/3	P = -23.8787	+2.8000B** (14.36)	-.1265S** (-3.11)	+.0137A (.19)	+.7809D2** (7.59)	286	.643
		+.7398D3** (8.21)	+.6999D4** (7.72)	+.7813D5** (8.56)	+.5978D6** (5.69)		

** Indicates the B, S or A coefficient is significant at the .01 level in a 1-tail test; or the dummy variable coefficient is significant at .01 level in a 2-tail test.

* Indicates the B, S or A coefficient is significant at the .05 level in a 1-tail test; or the dummy variable coefficient is significant at .05 level in a 2-tail test.

N is the number of observations.

$\bar{R}^2$ is the coefficient of determination adjusted for degrees of freedom.

The numbers in parentheses are the t-ratios.

In nine out of 12 equations the dummy variables for the East South Central Region, D6, had the lowest value of any of the dummy variables. In the other three cases it had the third or second lowest value. This reflects the relatively low delivered price of coal in that region. In six out of 12 equations the West North Central Region, D4, had the highest value, reflecting the relatively high delivered price of coal in that region.

The values of the adjusted R^2 ranged from .352 to .677, which means that variation in Btu, sulfur and ash content and region "explain" from about one-third to two-thirds of the variation in price.

It should also be noted that the values of the adjusted R^2 are significantly higher for the contract equations than for the spot equations. This reflects the fact that the t-statistics for the Btu and sulfur coefficients are significantly higher for the contract equations than for the spot equations. In other words, not surprisingly, contract prices are more closely related to Btu and sulfur content than are spot prices.

As a furthur test, the same equations were run again except that instead of using five regional dummy variables, from 26 to 38 state dummy variables were used. Those regressions, not reported here, resulted in substantially higher values of the adjusted R^2, ranging from .493 to .760, with six out of 12 equations having values of adjusted R^2 greater than .70.

Conclusions

These results definitely show that the Btu content and sulfur content do affect the price of coal. This conclusion may be contrasted with a recent report to the Federal Energy Administration which, on the basis of a simple nonregression analysis of FPC Form 423, suggested that sulfur content did not have any impact on the price of coal. 6/ Evidently, that report

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6/ U.S. Federal Energy Administration, Analysis of Steam Coal Sales and Purchases, (Washington, D.C.: Government Printing Office, 1975), p.18.

was incorrect. On the other hand, the percent ash content of coal never had the predicted sign and was statistically significant, and in nine out of 12 equations it would have been statistically significant with the wrong sign in a two-tail test.