CAPTIVE SHIPPERS AND THE SUCCESS OF RAILROADS IN CAPTURING MONOPOLY RENT

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I. Introduction

The issue of "captive shippers" goes back to the early history of the railroads. It concerns the ability of railroads to extract monopoly rents from shippers or receivers who have no other alternative for shipment of their products or receipts of their inputs.

In spite of its long history there appears to be little progress made towards its ultimate resolution. The main reasons for this lack of success are the conceptual and measurement difficulties encountered in defining and identifying "captive shippers." One possibility is to define a "captive" shipper as one served by a single railroad. This condition, however, is not sufficient to allow the railroad to extract monopoly rents because intermodal competition is not taken into account. Intermodal competition is likely to be effective in reducing the railroad's ability to raise rates for all but bulk commodities.

However, even for shipments of bulk commodities, several forms of intrarailroad competition may be present. According to Levin

> When one or more connecting railroads are potential participants in the traffic, the threat of short-hauling may constrain the market power of the originating road. Where this threat is absent, the market power of the originating railroad may be nevertheless constrained by the shipper's ability to send his goods to a different destination where more favorable rates can be obtained. Moreover, for many commodities, railroads not serving the shipper directly may compete for traffic by offering inter-modal services. Finally, product market or "source" competition among shippers may constrain a railroad from raising the rates of its "captive shippers" for fear of pricing them out of the product market.(1)

In addition, there are measurement difficulties. The currently available statistical methods are not suitable for estimation of the shipper's elasticity of demand for rail services for bulk commodities, and the estimation of costs is complicated by the importance of joint and common costs in the railroad cost structure. It is not surprising, therefore, that past efforts to develop operational criteria to identify "captive shippers" have not been successful.(2)

In spite of these conceptual and measure difficulties there appears to be some agreement that shipments of coal are the most likely candidates for the title of "captive traffic." Thus, if the railroads have been successful in exploiting their monopoly power coal traffic is most likely to supply the necessary evidence. Previous research efforts are another reason for selecting coal shipments, and unit-train coal shipments, in particular, for a detailed examination.

In the past the availability of alternative energy sources has imposed constraints on the level of railroad coal rates. Zimmerman(3) argues that in early 1970s these constraints have been largely eliminated by the shortages of natural gas, the increase in oil prices, and the concerns with nuclear power. This has resulted in both an increase in the demand for coal and a decrease in elasticity of that demand. Thus, the potential economic rents associated with coal shipments have increased considerably during the 1970s. Since in many areas there is no alternative but rail, and in many areas there is only one possible railroad to carry coal, railroads should have been able to capture an increased share of this economic rent. Zimmerman argues further that the concurrent development of Western coal fields has provided the railroads serving those areas the opportunity to develop pricing structures which were not tied to past practices. These railroads, therefore, should have had more success in exploiting the potential economic rents on the Western coal traffic.

Zimmerman estimated that prior to 1973, the railroads were able to capture approximately 20% of the potential economic rent. Since the potential rent was measured as the difference between the mine-mouth price of coal and the delivered price of alternative fuel less the cost of providing rail service, after 1973 it became undefined because of the shortages of alternative fuels. Therefore, for the post-1973 period Zimmerman examined freight rate increases and found that although rates on all coal shipments have increased substantially, those on Western coal shipments have increased considerably more than those on previously established routes. Thus, his findings suggest that the railroads enjoyed a substantial success in exploiting their potential monopoly power on the Western coal traffic.

Friedlander et. al.,(4) however, argue that it is not possible to make inferences concerning the expropriation of the potential economic rents from the behavior of rates without the knowledge of the absolute magnitude of these rents. It is quite possible that rate increases may actually be accompanied by a lowered share of the potential economic rents if the absolute magnitude of the potential rents increases sufficiently.

Since the late 1970s several events had a significant impact on the issue at hand. One of these was the Staggers Rail Act of 1980 which gave the railroads greater flexibility to raise rates and, thus, other things being equal, should have allowed them to capture a larger share of the potential rent. Another one was the tightening of the emission standards particularly for sulfur dioxide (SO_2). This has increased the demand for low sulfur Western coal and, thus, increasing the potential rents railroads serving Western coal fields could capture.

One of the events with the opposite impact was the 1981-82 recession. It reduced the demand for electricity and, thus, the demand for coal. In fact, in 1982 for the first time in more than 30 years the net generation of electric energy in the U.S. actually decreased from the previous year.

The differences between the delivered price of coal and the delivered prices of alternative fuels continued to be large. In July 1983 the average cost of coal received by electric utility plants as 165.5¢/MBTU compared to 466.9 and 359.¢/MBTU for heavy oil and natural gas, respectively.(5) The supplies of fuel oil as well as natural gas were more abundant. However, given the interfuel price differentials there was no incentive for any coal burning facility to switch to an alternative fuel although several utilities shifted from fuel oil to natural gas. In addition, there may have been institutional constraints on switching from coal to natural gas. It is not clear, therefore, if conceptually the potential economic rent was defined. However, if that was indeed the case, the empirical results should show that the price of alternative fuel was not an important determinant of rail freight rates.

The purpose of this paper is to test the hypothesis that railroads, and railroads serving Western coal fields, in particular, in the post-Staggers Act period were successful in capturing an increased share of the potential economic rents. In order to accomplish this task, the next section reestimates the model Zimmerman used to estimate the share of rents captured by railroads prior to 1973. As it was pointed out above, in this model the potential rent was defined as the difference between the mine-mouth cost of coal and the delivered price of alternative fuel, less the cost of providing rail services; and natural gas was assumed to be the alternative fuel. However, not all power plants can substitute natural gas for coal. Some can use fuel oil, but others are limited to burning coal. Thus, in section III the model is reestimated for a sample of power plants that can use alternate sources of fuel. In section IV the revised model is estimated in which the potential economic rent is defined as the difference between the mine-mouth price of Western coal and the delivered price of Midwestern or Eastern coal (adjusted for cost differences in their use, _if_ appropriate), less the cost of providing rail services. In the revised model it is assumed that railroads in setting rates on Western coal shipments take rates on shipments of Eastern/Midwestern coal as given. In section V the model is reestimated to jointly estimate rates on all coal shipments and the final section summarizes the conclusions.

The results suggest that the railroads in negotiating rail rates do not perceive alternative energy sources as viable substitutes for coal. However, if in estimation of the potential rent it is assumed that the next best alternative to Western coal is Eastern or Midwestern coal and not natural gas or fuel oil, then railroads serving Western coal fields were able to capture about 1/4 of the potential rent. This is considerably less than what one would expect if the utilities using Western coal were indeed "captive."

II. Reestimation of Zimmerman's Model

Unit-train rates are established through bargaining between a railroad and an electric utility. Since in many cases the railroad is the only means of transporting coal and the utility typically posseses some monopsony power, the rate that emerges is the result of a bilateral monopoly bargaining process which, from the modeling standpoint, is indeterminate.

To deal with its stochastic nature, Zimmerman models the bargaining process in the following way. Let $\hat{t}$ be the true cost of hauling coal. Let PGD be the difference between the price of gas delivered to the electric utility and the mine-mouth cost of coal, expressed on an equivalent basis. Then the rate that emerges lies somewhere between $\hat{t}$ and $\hat{t} + (PGD - \hat{t})$.

Let the fraction of $(PGD - \hat{t})$ captured by the railroad be β. Then, the rate t is:

$$t = \hat{t} + \beta(PGD - \hat{t}). \quad (1)$$

Since β depends upon the outcome of an indeterminate bargaining situation, β itself is a random coefficient. Equation (1) can be rewritten as:

$$t = \hat{t} + (\bar{\beta} + \eta)(PGD - \hat{t}), \quad (2)$$

where $\overline{\beta}$ is the expected value of β, or the mean outcome of the bargaining process. The term η reflects the stochastic behavior, or the indeterminacy of the bargaining process. Rewriting equation (2) yields:

$$t = \hat{t}(1 - \overline{\beta}) + \overline{\beta}(PGD) + \eta(PGD - \hat{t}) \qquad (3)$$

The true cost, $\hat{t}$, is simply a linear function of miles shipped, 1/annual volume shipped, loading and unloading time, a constant, and a random disturbance term, i.e.,

$$\hat{t} = \alpha_0 + \alpha_1 M + \alpha_2 IMAT + \alpha_3 L + \varepsilon, \qquad (4)$$

where

M = miles shipped one-way;
IMAT = 1/minimum annual tonnage required for the rate in thousands;
L = loading and unloading time in hours;
ε = a random disturbance.

Miles shipped reflects line-haul costs. Loading time influences rates since faster loading and unloading of cars means better rates of capital utilization and hence lower capital costs. IMAT is the reciprocal of tonnage required to get the rate specified, expressed in thousands. The rate charged is an average per ton charge. Higher volumes mean that fixed cost arising from initiation of the service expressed per ton are lower, thus yielding lower average charge. The PGD variable measures the difference between delivered gas prices and the mine cost of coal. Substituting (4) into (3) yields the following equation to be estimated:

$$t = \alpha_0(1 - \overline{\beta}) + \alpha_1(1 - \overline{\beta})M + \alpha_2(1 - \overline{\beta})IMAT + \alpha_3(1 - \overline{\beta})L + \overline{\beta}(PGD)$$
$$+ \{\eta(PGD - \alpha_0 - \alpha_1 M - \alpha_2 IMAT - \alpha_3 L - \varepsilon) + (1 - \beta)\,\varepsilon\}. \qquad (5)$$

Zimmerman assumes that η is distributed normally and is independent of ε and estimates (5) by maximum likelihood techniques simultaneously estimating all seven parameters.

Equation (5) was reestimated using samples of freight rates in effect on July 1, 1983 for unit-train movements of steam coal from mines in the Eastern and Midwestern U.S., and from mines in the Western U.S. to power generating plants of various utilities.(6) However, only the freight rates at which coal actually moved in July 1983 were included in the samples, i.e. the so-called "paper rates" were excluded.

The main source of data on tonnage of coal shipped from various mines to utilities is the Federal Power Commission Form 423 submitted monthly by each power plant. In addition to tonnages the same source provides information on the quality of coal received (i.e. its BTU, sulfur and ash content) and the delivered price in ¢/MBTU and in $/ton.

The conceptually correct definition of rent is the difference between the delivered price of natural gas (PNG) and the sum of mine cost of coal (PC) and t. However, the data on mine costs are not available. Following Zimmerman, therefore, we have used FOB mine price of coal as a proxy for mine costs. This creates two potential problems. First, in the above specification of the model the PGD becomes a function of two prices, PNG and PC, which may be jointly determined with t and with each other. That is, PNG, PC and t may be an oligopoly price vector. If these prices are in fact endogenous variables, additional equations would have to be included in the model to explain their determination. However, since the coal market is highly competitive, and since the price of natural gas is regulated, it is reasonable to treat both prices as exogenous to rail rate setting decision.

The second problem pertains to the upward bias in the estimates. The mines could capture a share of the rent by increasing FOB mine prices. Other things being equal, the share of rent captured by an individual mine would equal the difference between its mine costs and those of the marginal mine. Thus, the substitution of the FOB mine prices for mine costs underestimates the total rent (i.e. measured rent is net of the rent captured by the mine) and overestimates the share of potential rent captured by the railroads. Data are not available to estimate the magnitude of the bias.

The FOB mine prices were obtained by subtracting freight rates from the delivered prices reported in the above source. This estimation process was complicated by the increased use of shipper-owned cars. In these cases the freight rate excludes car rental charges. Zimmerman had limited his sample to shipments in railroad-owned cars. At present, however, eliminating shipments in shipper-owned cars would have reduced the samples significantly. Instead, therefore, a dummy variable was added for movements in shipper-owned cars. However, even with this change it was necessary to combine Eastern and Midwestern coal shipments in order to increase the number of observations.

The average price of natural gas (and later fuel oil) paid in July 1983 by all utilities in the state in which the particular plant was located was used as a proxy for the price actually paid by that plant.(7) In some cases several freight rates are shown in the tariff depending on the annual volume shipped. In these cases the freight rate applicable to the volume of coal burned in 1983 was used.

Although it would have been desirable to include the same variable as those used by Zimmerman, the allowed loading and unloading time is not specified in the tariff for a large number of shipments. This variable, therefore, had to be omitted. However, it was significant in only one of the two equations estimated by Zimmerman and is less likely to be important when coal is transported in shipper-owned cars. For these reasons the specification error resulting from the omission of the allowed loading and unloading time is expected to be minor.

Following Zimmerman we used maximum likelihood techniques to estimate all seven parameters (α_0, α_1, α_2, α_3, β, σ_n, σ_e) of (5) simultaneously, assuming that n is distributed normally and independently of e. Equation (5) assumes that transportation costs are a linear function of miles, the reciprocal of the minimum annual volume required for the rate, and a dummy variable for shipper owned cars. The linear cost function, however, may be a poor proxy for the true cost function. To test this we employed the test for non-linearity suggested by Savin and While.(8) Their procedure uses a likelihood ratio statistic to test for the existence of Box-Cox class of non-linearities. The test indicated that the hypothesis of linearity should be rejected at the 1 percent level of significance. However, when miles-squared (M^2) was added to the model, the test indicated that a hypothesis of linearity should not be rejected.(9) A likelihood ratio test also indicated that miles-squared added significantly to the relationship. The revised equation is

$$t = (1-\beta)*(\alpha_0+\alpha_1*M+\alpha_2*IMAT+\alpha_3*SC+\alpha_4 M^2)+\beta*PGD$$
$$+ \{\eta(PGD-\alpha_0-\alpha_1 M-\alpha_2 IMAT-\alpha_3 SC-\alpha_4 M^2-e)+(1-\beta)e \qquad (6)$$

The examination of equation (6) estimates revealed that the parameter σ_n was never significant. As noted by Zimmerman, the above specifications are heteroscedastic, and the heteroscedasticity is particularly troublesome as it is a function of unknown parameters. However, the unknown error term is specified as a linear function of the exogenous variables. This suggests that one test for heteroscedasticity would be to regress the absolute value of the residuals from the maximum likelihood estimate of (6) on the independent variables. A significant relationship would then indicate the presence of heteroscedasticity.(10) This procedure indicated that heteroscedasticity was present in all the equations. Equation (6) was then respecified as

$$t = (1-\beta)*(\alpha_0+\alpha_1*M+\alpha_2*IMAT+\alpha_3*SC+\alpha_4 IM^2)+\beta+PGD+u \qquad (7)$$

where u_i is assumed to be distributed normally with zero mean and variance equal to $\sigma^2 w_i$. Estimates of the w_i were obtained by first regressing t on all the independent variables in (7) and computing the residuals. Note that this yields the same estimated equations as (7) but the variances of all the coefficients cannot be identified. Next, the absolute values of the residuals were regressed on the independent variables in (7). Estimates of the weights (w_i) were then obtained as the squares of the predicted absolute residuals. Equation (7) was then estimated using maximum likelihood procedures assuming that u_i was distributed and normally with zero mean and variance equal to $\sigma^2 w_i$.

Table 1 presents the parameter estimates for the sample of Western coal shipments (equation #1) and for the combined sample of Eastern and Midwestern coal shipments (equation #2). The asymptotic standard errors and t-ratios are shown below each coefficient. The likelihood ratio test was used to test the hypothesis that all of the slope coefficients and one of the variance estimates are equal to zero. The summary statistic for this test is -2*ln (likelihood ratio) and this statistic is distributed as a chi-square statistic with K-1 degrees of freedom where K is the number of parameters estimated. According to this test both equations are significant at the 0.001 level.

Two out of four cost coefficients in the equation #1 are significant at the 0.05 level but one of these coefficients (M^2) has an incorrect sign. All four cost coefficients in the equation #2 are significant at the 0.01 level and have expected signs. However, the β coefficient is statistically significant at the 0.05 level in the equation #1 but is not statistically significant in the equation #2 suggesting that the variable PGD is a significant determinant of the rail freight rates for shipment of Western coal but not for shipments of Eastern/Midwestern coal. But even on shipments of Western coal, according to β coefficient in the equation #1, the railroads were able to capture 5.8 percent of the potential rent which is a much smaller share than what railroads were able to capture on Midwestern coal shipments in 1970.

Friedlaender et. al. have pointed out that it is possible that although the share of rent may have decreased, the potential rent may have increased so much that the railroads may have been able to appropriate a larger absolute amount.(11) In the 1970 sample of Midwest coal shipments used by Zimmerman the average value of (PGD - $\hat{t}$) was $1.69. For this potential rent, a 95 percent confidence interval for the rent captured by railroads was 38¢ ± 25¢ per ton. In the current sample of Western coal shipments the average value of (PGD - $\hat{t}$) was $32.97 per ton and the average rent captured by the railroads was $1.92 per ton. These results are consistent with the Friedlaender et. al. hypothesis. There appears to have been a very larger increase in the potential rent and the railroads were able to capture a larger absolute amount but not a larger share of this rent.

III. Exclusion of Plants Unable to Use Alternate Fuels

An implicit assumption of the model is that natural gas could be

Table 1

EMPIRICAL RESULTS

Equation	Region	Const.	Miles	IMAT	SC	$Miles^2$	$\bar{\beta}$	LR	N
#1	W	1.997	1.057	1.345	-1.493	.032	.058	62.3	39
			.316	.353	1.136	.014	.028		
			3.348	1.345	-1.314	2.242	2.069		
#2	E/MW	-.210	3.286	1.624	-1.831	-.168	.002	44.0	33
			.558	.440	.560	.067	.041		
			5.888	3.688	-3.272	-2.487	.051		
#3	W	-1.433	1.478	2.183	-1.417	.012	.017	39.9	21
			.267	.743	.997	.013	.015		
			5.531	2.938	-1.420	.956	1.079		
#4	E/MW	2.369	3.395	.245	-3.858	-.254	.006	14.1	14
			1.259	.448	.767	.160	.017		
			2.696	.548	-5.030	-1.593	.327		
#5	W	-13.339	2.989	4.737	-.627	-.048	.188	28.6	20
			1.144	.974	1.304	.042	.121		
			2.614	4.865	-.481	-1.127	1.551		
#6	W	-17.845	3.334	4.989	-1.794	-.053	.255		
			1.168	.793	.950	.053	.135		
			2.855	6.289	-1.889	-1.007	1.893		
#7	E/MW	-.453	3.383	1.763	-1.598	-.178	.014	81.3	53
			.393	.504	.797	.044	.042		
			8.600	3.495	-2.005	-4.069	.344		

Miles are in units of 100 miles
IMAT has been scaled by multiplying by 1000

Table 2

DISTRIBUTION OF PLANTS BURNING WESTERN COAL BY ALTERNATE ENERGY SOURCE

Alternate Energy Source	Number of Plants
None	18
Natural Gas	12
Fuel Oil(1)	8
Natural Gas and Fuel Oil	1
TOTAL	39

(1) All weights

Source: DOE/EIA-0095 1981, 1982 & 1983 issues easily substituted for coal and vice versa. In reality, however, substitution among different fuels may be somewhat limited. The DOE requires each power plant to specify the primary and the alternate energy source. Although the specific definition of "alternative energy fuel" is not provided the discussion in the report suggests that the emergency switching of fuel in the event of fuel shortages caused by interruptions in supply was the main motivation for requesting this information.(12) Thus, the alternative energy fuel is probably defined by the ability to substitute fuels in the short-run, i.e., substitution of fuels involving boiler modifications are excluded.

The distribution of plants by specified alternate energy source in the sample of plants burning Western coal is shown in Table 2. According to these data almost half of the plants specified "none" as an alternative energy source, and thus, presumably are unable to substitute alternate fuels for coal. These plants, therefore, were excluded and the model was reestimated for the remaining sample. For plants citing fuel oil as an alternate fuel the price of fuel oil was substituted for the price of natural gas. One would expect that if the railroads perceive alternative energy sources as viable substitutes for coal these modifications should improve the statistical results.

The parameter estimates for the reduced samples of Western and Eastern/Midwestern coal shipments are also reported in Table 1 (equation #3 and #4). Equations are significant at the 0.01 and 0.02 level. However, in neither equation is the $\bar{\beta}$ coefficient statistically significant. Thus, these results suggest that the railroads do not perceive alternate energy sources as viable substitutes for coal.

IV. Estimation of the Revised Model

It is plausible to assume that competition from coal supplied from other sources may provide a more binding constraint on the increase of freight rates than does the price of alternate fuels. That is, at some point, plants burning Western coal would shift to Eastern or Midwestern coal or vice versa. In this specification of the model the potential economic rent is defined as the difference between the mine-mouth price of Western coal and the delivered price of Midwestern or Eastern coal (adjusted for cost differences in their use, if appropriate), less the cost of providing rail transport services.

The empirical estimation of this version of the model presents a number of problems. First, it is necessary to estimate what the delivered price of Midwestern or Eastern coal would be if it were to replace the currently used Western coal. This, in turn, requires an estimation of the FOB mine price for Midwestern or Eastern coal and an estimation of freight rates. In order to estimate freight rates, at a minimum, it is necessary to know the distance, which requires identification of a specific mine that would supply the plant.

The procurement practices of the electric utilities make this task exceedingly difficult. Upon expiration of the current contract to supply coal, a utility would probably solicit bids for a new contract. A plant contemplating a shift to Midwestern or Eastern coal would presumably utilize the bidding process to secure a new contract. Thus, the estimation of the delivered price would require a prediction of the winning bid, clearly an impossible task.

As a simplification one could assume that the plant would be supplied from the production region nearest to it. According to this assumption all but three plants in the sample would be supplied by the Illinois mines. The remaining three would be supplied by the Indiana mines.

This assumption would be plausible if FOB mine prices were the same, and coal were a homogenous commodity. In that case one would want to minimize transportation costs. However, this is not the case. Coal varies not only in price but also in its BTU, sulfur and ash content. For example, Powder River coal typically has a low BTU content (8,000-9,000 BTU/lb) but also a low sulfur content (typically 0.6%). The Illinois coal has a higher BTU content (10,000-12,000 BTU/lb) but a relatively high sulfur content (2.5-3.0%). Thus, a plant contemplating a shift from low sulfur Western coal to a higher sulfur Midwestern coal may have to retrofit its boiler(s) with a flue-gas desulfurization (FGD) system in order to meet sulfur emission regulations.

In the real world, therefore, the choice of coal source would depend not only on transportation costs but also on the variation of FOB mine prices, coal attributes, and the differences in scrubbing costs. In order to make the estimation manageable two types of Illinois and two types of Eastern Kentucky coal were selected to represent the range of available Eastern and Midwestern coal. The specifications of selected coal and their contract prices are shown as Type #1 through #4 in Table 3.

The sulfur emission regulations in effect in 1983 for each power plant are provided by the Environmental Protection Agency.(12) Using the estimates developed by DRI, shown in Table 4, the scrubbing costs which would have to be incurred in order to meet the sulfur emission regulations were estimated for each plant in the sample and for each type of coal. The cost estimates shown in Table 4 are for installation and operation of a new boiler. The capital and operating cost of scrubbers for plants not originally designed for FGD systems can be significantly higher than those incurred in new units. Therefore, following DRI practice for existing units a 25% cost premium was added to the new facility costs identified in Table 4.

The next task was to estimate the delivered price of Eastern or Midwestern coal to each plant. In order to accomplish this task, the two following rate functions were estimated from the tariff rates for the two origins:

ILLINOIS

$$\underset{}{RATE} = \underset{(.46748)}{1.8639} + \underset{(.0012648)}{0.01648\ M} + \underset{(237.76)}{1218.4\ IMAT} - \underset{(.37630)}{1.2918\ SC}$$

$$R^2 = 0.8468 \qquad N = 41$$

EASTERN KENTUCKY

$$RATE = \underset{(.87671)}{3.8394} + \underset{(.0019647)}{0.01962\ M} + \underset{(360.09)}{689.73\ IMAT} - \underset{(.52409)}{.70329\ SC}$$

$$R^2 = 0.7591 \qquad N = 36$$

where RATE is in $/ton, SC is the dummy variable for shipper-owned cars, and other variables are as defined above.

RATE was estimated for each origin to each plant, and the FOB mine price (and the scrubbing cost, if appropriate) was added to obtain the delivered price for each type of coal. The coal with the lowest delivered price was taken as the closest substitute for the Western coal and its price replaced the price of natural gas or oil in forming the variable PCD.

Table 3

CONTRACT MARKET COAL PRICES BY TYPE, JULY 1983(1)

Type #	Producing District	BTU/lb.	Sulfur%	Ash%	Contract Price
1	(10) Illinois	10,500	3.5	13.0	$24.50
2	"	11,700	2.5	8.5	29.50
3	(8) Eastern Kentucky	12,200	1.6	13.0	31.00
4	"	13,000	0.7	9.0	38.00
5	(16) Colorado	10,700	0.5	9.1	20.00
6	"	11,600	0.5	9.0	24.00
7	(19) Wyoming	10,500	0.6	8.5	16.50
8	"	8,100	0.5	6.0	7.50
9	(20) Utah	11,500	0.6	9.0	26.00
10	(22) Montana	8,600	0.7	8.0	9.75
11	"	9,300	0.4	6.0	10.00

(1) According to Coal Week "marker" prices reflect state-of-trade and don't necessarily represent actual transactions. They are derived from confidential discussions with buyers, sellers, traders and brokers for coal of the marker's specifications.

Source: Coal Week, Vol. 9, No. 27, July 4, 1983, p. 5

Table 4

ESTIMATED SCRUBBING COSTS, 1983
(Current dollars per MBTU)

	Scrubbing Effectiveness (%)			
Sulfur Content (%)	50	70	80	90
0.0 - .64	.61	.66	.74	.83
.65-1.04	.63	.67	.76	.85
1.05-1.84	.66	.70	.79	.88
1.85-2.24	.67	.72	.81	.89
2.25-3.04	.75	.75	.84	.93
3.05-	.75	.79	.88	1.00

Source: John W. Dean, Scrubbing Costs: New Projections Amidst Controversy. Coal Review Update, Fall 1983, p. 23.

To estimate the revised model the sample of power plants was reduced for three different reasons. First, five plants burn both Western and Midwestern coal. Inclusion of the blending option would have made the model too complex. These plants, therefore, were excluded from the sample. Second, in terms of the BTU content and price, Colorado, Utah and New Mexico coal is similar to low sulfur Eastern coal (Table 3). However, it faces a significant freight cost disadvantage. As far as this coal is concerned, there is little potential rent (as defined in this version of the model) to be captured by the railroads. Therefore, shipments of Colorado, Utah and New Mexico coal were also excluded from the sample. Third, for 7 plants in the sample the estimated potential rent was negative, i.e., the delivered price of Eastern/Midwestern coal was already lower than the delivered price of Western coal the plant was currently burning. One possible explanation for negative rents is a lag in contract price adjustments, i.e., the market price of Eastern/Midwestern coal has decreased more rapidly than a renegotiated contract price of Western coal. Alternatively, the negative rents may simply be due to estimation errors.(14)

All the plants with negative rents were also excluded from the sample. These plants are located at the edges of the area Western coal was able to penetrate and the potential rent for shipments to these plants should have been close to zero. Their exclusion, therefore, should result in only a slight overestimate of the average share of the rents railroads were able to capture.

The results are reported in equation #5, Table 1. As before, the equation is statistically significant at the 0.001 level and two out of four cost coefficients are significant at the 0.01 level but the $\overline{\beta}$ coefficient is significantly only at the 0.10 level. According to this estimate of $\overline{\beta}$, the railroads serving Western coal fields were able to capture 18.8 percent of the potential rent. Since the average value of the (PCD - $\hat{t}$) variable in this sample was $11.67 the average absolute value of captured rent was $2.19 per ton.

V. Simultaneous Estimation

The model estimated in the previous section assumes that Western railroads in setting their rates take the existing rates on shipments of Eastern-Midwestern coal as given. Another possibility is that all rates on coal shipments are jointly determined. In this situation the model for Western coal rates would be

$$t^w = \hat{t}^w + \beta(MM^e + \hat{t}^e - MM^w - \hat{t}^w - C^{we}) \tag{8}$$

and the model for Eastern/Midwestern coal would be

$$t^e = \hat{t}^e + \beta(MM^w + \hat{t}^w - MM^e - \hat{t}^e - C^{ew}) \tag{9}$$

where MM^i is the mine-mouth cost of coal in region i and C^{ij}, is the cost of converting to the use of coal from region j when the plant is set up to use coal from region i.

The above equations can be estimated simultaneously by combining the samples and estimating

$$\begin{aligned} t = {} & [(1 - \beta^W)d^W + \beta^E d^E][\alpha_0^W + \alpha_1^W M^W + \alpha_2^W IMAT^W + \alpha_3^W SC^W + \alpha_4^W (M^W)^2] \\ & + [(1 - \beta^E)d^E + \beta^W d^W][\alpha_0^E + \alpha_1^E M^E + \alpha_2^E IMAT^E + \alpha_3^E SC^E + \alpha_4^E (M^E)^2] \\ & + \beta^W dM^{WE} + \beta^E dM^{EW} + u \end{aligned} \tag{10}$$

Here d^1 is a dummy variable taking on a value of one when the dependent variable is the rate for coal from region i, and dM^{ij} is the difference in the mine-mouth cost of coal between region j and i including any cost of converting to the alternative coal.

In order to estimate equation (10) it was assumed that if plants currently burning Eastern/Midwestern coal were to switch to Western coal, this coal would originate in the Power River Basin.(14) It was further assumed that the value of IMAT and SC for shipments of Eastern/Midwestern coal to plants currently using Western coal would be equal to the average value of current shipments of this coal and vice versa for shipments of Western coal. This corresponds to an assumption that railroads in one region are cognizant of the typical shipments in the other region.

The equation (10) was estimated in the same fashion as the previous equations, i.e., using the maximum likelihood procedure and assuming that u was distributed normally. The same procedure as before was used to take into account the heteroscedasticity.

All cost coefficients have the expected signs and all but one (M^2 for Western coal shipments) are statistically significant at 0.01 level or better. The estimated share of the rent captured by the railroads on Western coal shipments increases to 25 percent and the estimate is significant at the 0.01 level. The estimate of the average potential rent ($MM^{we}+\hat{t}^e-\hat{t}^w$) is now \$17.58 and the average absolute amount of rent captured is \$4.39 per ton. The estimate of $\bar{\beta}$ for Eastern/Midwestern coal shipments, however, is not statistically significant.

The results suggest that the railroads serving Western coal fields in negotiating their rates take into account the prices of alternative coal and the cost of delivering it to power plants and were successful in capturing about 25% of the potential rents.

VI. Summary and Conclusions

The purpose of this paper was to test the hypothesis that railroads, and particularly railroads serving Western coal fields, in the post-Staggers Act period were successful in capturing an increased share of the potential economic rents. As the first task the model used by Zimmerman (1979) was reestimated using 1983 data on shipments of coal from mines to power plants. In this model the potential rent is defined as the difference between delivered price of natural gas and the mine-mouth cost of coal and the cost of providing transport services. The results suggest that the railroads serving Western coal fields were able to capture a smaller share but a larger absolute amount of the potential rent than the Midwestern railroads did in 1970. For the combined sample of shipments from Midwestern and Eastern mines the coefficient of ($PDG - \hat{t}$) variable is not statistically significant. No conclusion regarding these shipments, therefore, can be drawn.

Almost half of the power plants included in each sample are not able to substitute alternate fuels for coal. When these plants were excluded, the $\bar{\beta}$ coefficients of the reestimated model for both samples were not statistically significant. These results suggest that the railroads in negotiating rail rates do not perceive alternate energy sources as viable substitutes for coal.

For the next task the potential rent was redefined as the difference between delivered price of coal from the next best alternative source and the FOB mine price of Western coal and the cost of providing transport services. With this definition of rent the empirical results show that railroads serving Western coal fields were able to capture slightly less than 20% of the potential rent.

In this specification of the model it was assumed that Western railroads in setting their freight rates take the existing rates of Eastern/Midwestern coal shipments as given. As the final task the model was respecified to assume that all rates are determined simultaneously. The statistical quality of empirical results for this model is better than for all previous models. They suggest that railroads in negotiating rates on Western coal shipments do take into account the prices and delivery costs of alternate coal and were successful in capturing about 25% of the potential rents.

If the utilities using Western coal were indeed "captive" one would expect railroads to capture all of the potential rent, i.e., the coefficient of $(PD - \hat{t})$ variable to be close to one. The Staggers Act Specified a revenue-to-variable-cost ratio of 160% as the test for "market dominance" and this ratio is to rise between 170 and 180% in 1985 (Section 202). The mean $t/\hat{t}$ ratio in the sample is 1.33 (based on model #6). If the market dominance test were applied, only in one case would the railroad be judged to have market dominance. Of course, the ratio has to exceed 1 if railroads are to cover their total costs.

There is a number of possible reasons for railroads lack of success in appropriating a larger share of the potential rents. It is possible that geographic competition provides an effective constraint to the exercise of their monopoly power or that the monopsony power of utilities dominates the monopoly power of the railroads. Further studies will be required to test these hypotheses.

FOOTNOTES

1. Richard C. Levin, Railroad Rates, Profitability, and Welfare Under Deregulation, 12 Bell J. 1 (1981). "Short-hauling" refers to the practice of routing rail shipments so as to minimize the distance these shipments move on the track of originating carrier. It is intended to reduce the share of revenue earned by the originating carrier. 2. For review of these efforts see Walter Miklius, Assessment of Previous Efforts to Develop Operational Criteria to Identify "Captive Shippers" (August 1984) (Working Paper No. 84-01, Office of Industry Policy, DOT). 3. Martin M. Zimmerman, Rent and Regulation in Unit-Train Rate Determination, 10 Bell J. 217 (1979). 4. Ann F. Friedlaender, William L. Ferguson and James Sloss, The Rate Structure of Unit Coal Trains in the 1970s, 28 J of Industrial Economics 269 (1980). 5. Electric Power Monthly, DOE/EIA-0226 (83/08). 6. List of all power plants included in the samples is provided in the Appendix. The freight rates were obtained from Coal Tariff Report: Unit Train/Annual Volume Shipments published quarterly by Pasha Publications, Arlington, Virginia. 7. Average prices of natural gas and fuel oil were obtained from Electric Power Monthly, DOE/EIA-0226 (83/08). 8. Eugene N. Savin and Kenneth J. White, Estimation and Testing for Functional Form and Autocorrelation, A Simultaneous Approach, 46 Econometrica 59 (1978). 9. Another variable, the minimum train tonnage, was also tried but was not significant in any of the equations. 10. This is essentially the procedure suggested in Herbert Glejser, A New Test for Heteroscedasticity, 64 J. Am. Statistical Assoc. 316 (1969). 11. Ann F. Friedlaender, _et. al._, _supra_ note 4. 12. The source of this information is Inventory of Power Plants in the United States, Annual, DOE/EIA-0095, 1981, 1982 and 1983 issues. 13. Sulfur emission regulations for each plant are reported in Cost and Quality of Fuels for Electric Utility Plants. 1983, DOE/EIA-0191(83). 14. The negative rents, however, cannot

be attributed to overestimation of scrubbing costs because only in case of one plant the higher sulfur coal and installation of FDG system was the lowest cost substitute for the Western coal. 15. The following equation was used to estimated rail mileage

$$\ln(\text{Rail Miles}) = \underset{(.1463)}{.2979} + \underset{(.02764)}{.95851} \ln(\text{Highway Miles})$$

$R^2 = .96$
N=49

where Highway Miles are from Sheridan, Montana to each plant burning Eastern/Midwestern coal.

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APPENDIX

List of Utilities and Power Plants

Company	Power Plant
Arkansas Power & Light	White Bluff
Cajun Electric Power Coop	Big Cajun #2
Central Illinois Light	Edwards
Central Louisiana Power	Rodemacher
Central Power & Light	Coleto Creek
Commonwealth Edison	State Line
Consumers Power	Campbell
Dairyland Power Coop	Alma
Detroit Edison	River Rouge
Detroit Edison	Trenton
Detroit Edison	Monroe
Duke Power	Belews Creek
Georgia Power	Mitchell
Georgia Power	Wansley
Hoosier Energy	Merom
Houston Lighting & Power	Prish
Illinois Power	Wood River
Interstate Power	Kapp
Iowa-Illinois Gas & Electric	Louisa
Iowa Power & Light	Council Bluffs
Iowa Public Service	Neal
Iowa Southern Utilities	Burlington
Iowa Southern Utility	Ottumwa
Kansas City Power & Light	Hawthorne
Kansas City Power & Light	Tatan
Kansas City Power & Light	LaCynne-Linn
Kansas Power & Light	Jeffrey
Kansas Power & Light	Tecumsen
Louisville Gas & Electric	Mill Creek
Louisville Gas & Electric	Cane Run
Minnesota Power & Light	Clay Bosswell
Mississippi Power	Daniel
Nevada Power	Gardner
Northern Indiana Public Service	Mitchell
Oklahoma Gas & Electric	Sooner
Omaha Public Power	North Omaha
Public Service of New Hampshire	Row
Public Service of Oklahoma	Northeastern
Salt River Project	Coronado
San Antonio Public Service	Deely
Sikeston Light & Water	Sikeston
South Carolina Electric & Gas	Canadys
South Carolina Electric & Gas	Urquhart
South Mississippi Electric	Morrow
Southwestern Electric Power	Flint Creek
Southwestern Electric Power	Welsh
Southwestern Public Service	Harrington
Sunflower Electric	Holcomb
Tampa Electric	Gannon
Toledo Edison	Bayshore
Union Electric	La Badie
Union Electric	Rush Island
Union Electric	Sioux
Western Farmers Electric Coop	Hugo
Wisconsin Electric Power	Pleasant Prairy
Wisconsin Electric Power	Oak Creek
Wisconsin Power & Light	Columbia
Wisconsin Public Service	Weston