AN APPLICATION OF THE HEDONIC APPROACH TO ESTIMATING PRICES FOR STEAM COAL CONTRACT TERMS

by

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The purpose of this paper is to apply the hedonic approach to estimating the average market price of contract terms in United States steam coal markets. In other words, this paper examines the implicit prices which steam coal markets assign to the major quality characteristics of steam coal purchased under agreements of one year or more in length, and the implicit prices assigned to major non-quality terms of those agreements. Steam coal is examined separately from coal in general because metallurgical coal is valued for different reasons. For example, low volatility is preferred over high, which is the opposite of the case for steam coal. In addition, all met coals must have high energy and low sulfur contents, which is not true for steam coal. The U. S. is divided into four major steam coal markets. For two of these, the eastern and central markets, sufficient data exists in a test year to employ regression analysis. Data on nearly all steam coal purchases under contract for deliveries to electric utilities in 1978 is analyzed.

Steam coal is used as a fuel in the production of process steam which drives turbines in the generation of electricity and other industrial processes. Electric utilities and the non-steel industries consumed about eighty-nine percent of total 1978 national coal consumption. Steam coals include the bituminous, subbituminous, and lignite types as opposed to anthracite and coking coal. About seventy percent of annual steam coal purchases are made under agreements of at least a year in length.[1] These are commonly referred to as contract purchases. These contracts typically contain price adjustment clauses for changes in production costs and/or changes in the market value of like coals. Spot agreements are for less than one year and are usually carried out with a price fixed for the full term except for possible adjustments for coal quality variations, e.g. energy and molecular contents. Contract purchases also typically carry such quality provisions, along with price adjustment clauses for changes in labor costs, other operations costs, laws and regulations, and other factors. Estimating the average market price of these provisions and how they vary across markets will be the focus of this study.

If prices are determined by trade conditions in markets, then a preliminary duty in a study of price structure is to define the markets. The markets for given products must be defined in terms of the nature of the product and the geographic boundaries of the market. A product market

[1] U.S. Deparment of Energy, "Cost and Quality of Fuels for Electric Utility Plants" (Washington, D.C.: 1979), p. 112.

contains all goods and services for which there is a high degree of similarity in the utility characteristics they provide.[2] In the case of steam coal, it is logical to include all types of coal which are purchased to generate electricity in the market. However, these coals can have significant differences in their major quality characteristics, i.e. heat, sulfur, ash, and moisture contents. For example, the British thermal units (Btu) in American steam coals range from less than 6,500 Btu per pound to more than 13,000. Yet all boilers are designed to burn a range of quality differences, and are usually designed concurrently with the signing of the first coal contracts and to burn the coals which are most regionally abundant and least costly for delivery. Therefore, given sufficient lead time, a particular utility can use any type of steam coal that is purchased by other utilities. The exceptions to this rule are utilities which chose to meet 1970-78 particulate emissions regulations for coal plants by purchasing low sulfur (less than 1.2 pounds of SO_2 per million Btu) coal instead of installing emissions control equipment. As a generating plant under these regulations become older, it becomes increasingly less economical to build scrubbers.

[2]Alfred Marshall, Principles of Economics (New York: Random House, 1974), V, pp. 324-29.

Consequently, such plants find it most economical to continue purchasing low sulfur coal. Approximately twenty percent of coal purchases in 1978 were for compliance coal.[3] However, low sulfur coal is purchased for many plants without regard to emissions standards because it is locally inexpensive.

The geographic boundaries of steam coal markets, as opposed to definition of the product, are more difficult to determine. The subject of market delineation methodology has received considerable attention in Economics literature and in writings on coal markets. However, there is less than complete agreement on either methodology or boundaries. With regard to methodology, a review of the literature indicated two major approaches to delineation: price uniformity and shipments patterns. Writings on coal markets included findings of as many as seven regional markets to as few as one national market in the U.S.

The price uniformity methodology that has received the most attention is that developed by Ronald Shrieves.[4]

[3] Unpublished responses to an interrogatory on electric utilities 1978 fuel purchase practices by the Federal Energy Regulatory Commission.

[4] Ronald E. Shrieves, "Geographic Market Areas and Market Structure in the Bituminous Coal Industry," The Antitrust Bulletin, 23 (1978) p. 18.

Shrieves' methodology was built on the premise that market prices tend to uniformity with allowances for transportation costs. The methodology is two phased: a determination of common supply sources and a test for price similarity. The first phase includes two or more States in the same geographic market if over fifty percent of their coal purchases come from common coal producing States, and if over five percent of a producing State's coal production is sold in the consuming State(s). All intersecting State(s) that meet the above criteria are combined in the same market. The second phase of the methodology requires the adjustment of delivered coal prices for coal quality characteristics, contract terms, and transportation costs. Once the average adjusted FOB mine price for each State is found, the prices are subjected to a one-way analysis of variance for testing hypotheses of price equivalence among States grouped together in the shipments test. The results are used as a test for the validity of the shipments test findings, and the final market shapes are then determined.

One weakness of the Shrieves shipments methodology is that the test percentages are arbitrary. Shrieves used various combinations of shipments test percentages to delineate seven regional coal markets in the U.S., using prior knowledge of geography and transportation costs as guides. Shrieves left six States as single markets because they imported or exported little coal. Seven others were not classified as belonging to markets because they consumed little coal. Changes in the percentages would arbitrarily increase or decrease these numbers.

Another market delineation methodology using the price uniformity criterion is that discussed by Areeda and Turner in their massive work Antitrust Law.[5] They claimed that two kinds of data are normally sufficient for delineating geographic and product boundaries: price relationships over time and sales-purchasing patterns. Price relationships are the best single guide to geographic market delineation. The absence of price similarity and similar price movements among products indicates that they are in separate markets. A producer cannot maintain a higher delivered price than other producers without losing sales. Substantial transportation costs can prevent similarly priced products from being in the same market. Close price relationships can reflect similar conditions in different markets. However, sales and purchasing patterns should indicate markets where pricing patterns are ambiguous, especially when there is a shift in relative prices. The size of markets can be verified by the distance of shipments by suppliers. If a significant number of suppliers

[5]Phillip Areeda and Donald F. Turner, Antitrust Law, an Analysis of Antitrust Principles and their Application (Boston: Little, Brown and Company, 1978), II, pp. 331-67.

from one area ship to another or to other markets similar distances away, they are part of the same market. Actual shipments do not have to occur for areas to be in the same market.

The major problem in using the Areeda-Turner philosophy to market delineation is its subjectivity. The authors prescribed no numerical or statistical techniques for determing price similarity nor interconnecting shipments patterns. Like the Shrieves methodology, the Areeda-Turner philosophy is not a pure price uniformity test, but depends ultimately on a shipments test. The fact that similar prices can exist coincidentally in different markets because of similar demand-supply conditions create practical problems using price similarity alone as a basis for delineating markets. Also, neither Shrieves nor Areeda-Turner allow for the possibility that trade-offs between product characteristics and price can keep highly substitutable products with different prices in the same market, which appears to be the case with steam coal. The use of average State-wide prices and State boundaries for markets is a simplistic approach, but apparently the most practical one.

The most reknowned and employed geographic market delineation methodology using the shipments approch is that developed by Elzinga and Hogarty, which they applied to 1975 steam coal data as an example.[6] Elzinga and Hogarty based their methodology on the Marshallian premise that a market includes the primary demand and supply forces which determine the price of a product. The authors opposed the idea that price uniformity should set the geographical limits of a market because of possible like prices in different markets owing to coincidental demand-supply equilibria. Also, different prices may occur in the same market if it is not a competitive one.

The Elzinga-Hogarty methodology consists of a test for few exports and imports for an area using shipments data. A starting point for measuring imports and exports is selected on the basis of informed judgment about the likely center of a market. For steam coal, West Virginia and Kentucky were considered a logical starting point by the authors. A little out from inside (LOFI) test is performed first to include all neighboring States for which ninety percent of the goods produced within the area are consumed therein. A little in from outside (LIFO) test is then performed to include all States for which ninety percent of the goods consumed within the area are produced there.

[6]Kenneth G. Elzinga and Thomas F. Hogarty, "The Problem of Geographic Market Delineation in Antimerger Suits," The Antitrust Bulletin, 22 (Spring 1973), Elzinga and Hogarty, "The Problem of Geographic Market Delineation Revisited: The Case of Coal," The Antitrust Bulletin, 23 (Spring 1978).

States that meet both the LOFI and LIFO tests at the ninety percent levels are included in the same market area. While the use of the ninety percent levels resulted in some overlapping of markets in the case of coal, the authors believed this to be characteristic of reality. All demand and supply factors that affect price also affect shipments. Therefore, shipments data is all that is required to estimate geographic market areas "in most cases."

The weakness of the Elzinga-Hogarty approach include the arbitrariness of the 90% test figure; potential market overlaps and gaps; and the use of State boundaries as market boundaries. These problems are to a great extent interrelated and would have to be solved by educated guessing and arbitrary determination.

In addition to the Elzinga-Hogarty methodology, there have been numerous other geographic market delineation methodologies or philosophies based on shipments. Weiss believed markets might best be delineated by the maximum distance a product could be profitably shipped or the geographic dispersion of output.[7] The Weiss method is to delineate markets as a circle, with the radius being the

[7] L. Weiss, "The Geographic Size of Markets in Manufacturing," Review of Economics and Statistics, 54 (1972), pp. 245-57.

distance from a manufacturing center within which eighty or ninety percent of shipments occur based on national averages. This approach is too simplistic and considers only the supply side of the market. The problem with the geographic dispersion alternative is that it assumes goods are produced everywhere at the same cost, which eliminates the possibility that lower cost goods can be competitively shipped into a higher cost region, as in the case of coal.

A number of reports published by government and private industry have used some form of shipments methodology to delineate energy markets.[8] Two of these four studies used the Elzinga-Hogarty methodology. A comparison of coal markets delineated by Shrieves and the Elzinga-Hogarty methodology showed that Shrieves delineated seven regional coal markets in the U.S. versus four for Elzinga-Hogarty. Shrieves left six States as single markets because they imported or exported little coal, and seven other States were not placed in markets because they consumed little coal. The Elzinga-Hogarty method left six States outside

[8]U.S. Federal Trade Commission, "Concentration Levels and Trends in the Energy Sector of the U.S. Economy" (Washington, D.C.: GPO, 1974).

Thomas Duchesneau, Competition in the U.S. Energy Industry (Cambridge: Ballinger Publishing Company, 1975).

General Accounting Office, "The State of Competition in the Coal Industry" (Washington, D.C.: GPO, 1977).

U.S. Department of Justice, "Competition in the Coal Industry" (Washington, D.C.: GPO, 1978).

any market but no States were considered to be single markets. Two of the single State markets using the Shrieves test were Colorado and Wyoming, which were market center States using the Elzinga-Hogarty method because they export most of their coal production to neighboring States.

It does not seem logical that States which export most of their coal production to neighboring States are not part of the same market as those States. To say they are not is to say that supply forces do not play an important role in forming market areas. The Shrieves approach essentially ignores supply side factors and, when applied, results in market areas which are troublesome intuitively. In addition, there may be factors which influence prices in one area but not another, such as different costs of production and transportation per unit, differing business laws and regulations, and different industry and general economy organization. There can also be price discrimination by a monopolist for only some customer classes within a market. Because prices can be tending toward equality but not be so for many reasons, the Elzinga-Hogarty methodology of including the major forces which determine prices in the same market seems to be most logical. It is also the most widely accepted methodology in coal market delineations and is relatively simple to employ.

The Elzinga-Hogarty methodology resulted in four coal market regions when applied to 1978 State of orgin-destination coal shipments data.[9] These regions are shown in Figure 1 on the following page. All of the States fit decisively in the markets as shown except Illinois which was virtually a toss-up for Markets 1 or 2. While Illinois is shown in Market 1, it was included in both 1 and 2 during the regression analysis. States not shown in a market consumed virtually no steam coal with the exception of Oregon, which has two captive coal mines (owned by the consumers), and no coal trade with other States. These results compare favorably with the results Elzinga and Hogarty achieved with 1975 data from the same source. They also compare favorably to the generally accepted belief that coal markets center around the major coal basins, which are shown in Figure 2. The major deviation from this belief when using the Elzinga-Hogarty methodology is Market 2, which encompasses both the Interior basin and the Powder River Basin. This deviation is due to the large amounts of Powder River Basin coal which are transported east because of its low sulfur content and its low mining costs relative to those of Interior and Appalachian basin coal.

[9]U.S. Department of Energy, "Cost and Quality of Fuels for Electric Utility Plants" (Washington, D.C.: GPO, 1979).

FIGURE 1

COAL MARKET REGIONS

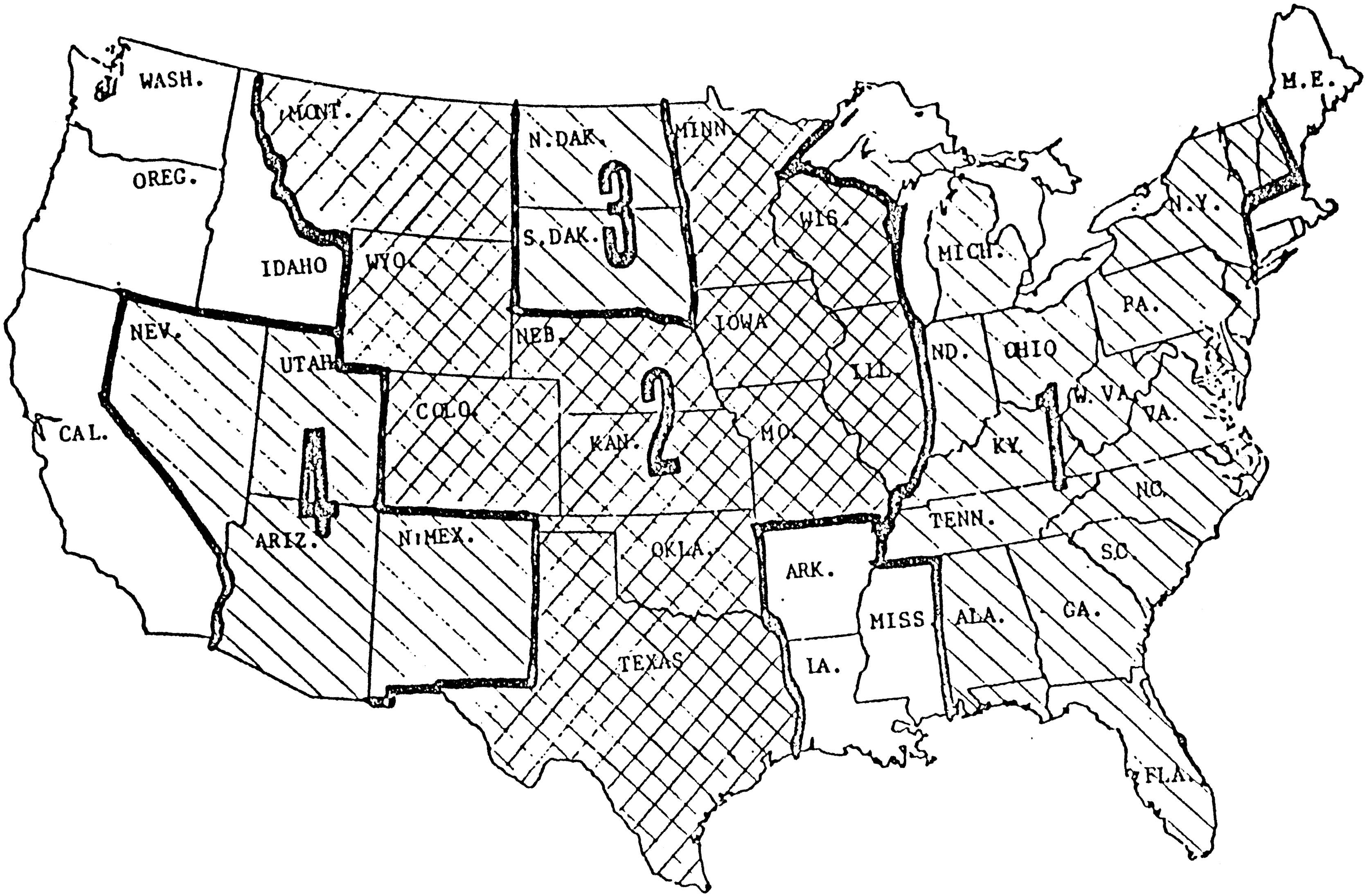
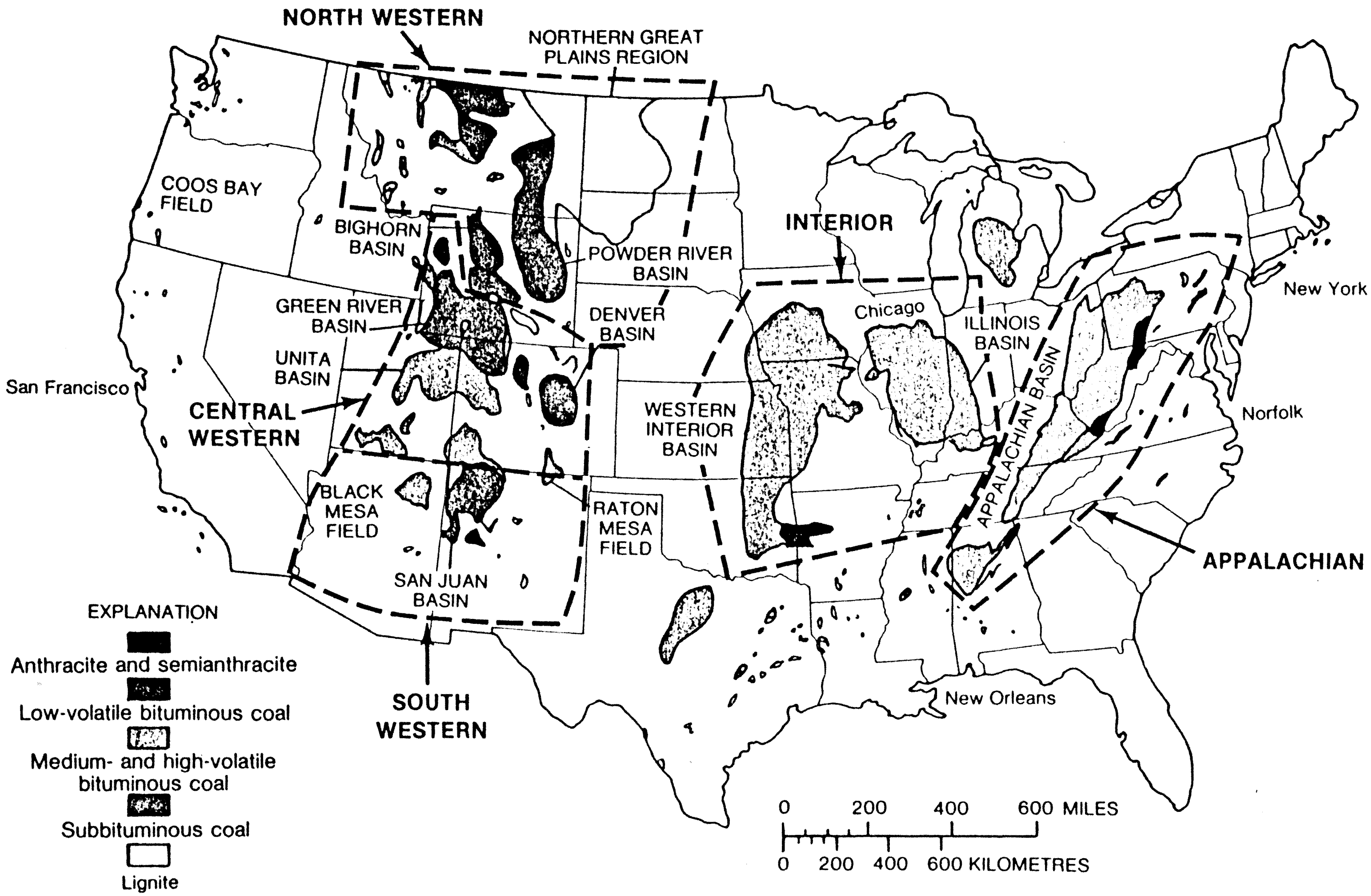


FIGURE 2

Coalfields of the Conterminous United States



SOURCE: P. Averitt, *Coal Resources of the United States, Jan. 1, 1974,* U.S. Geological Survey Bull, 1412, at 5 (1975).

The structure of steam coal contract prices that is examined here is not the cost structure but rather the amount of utility which markets attach to various aspects or characteristics of a contract steam coal purchase. This type of analysis is based in part on the theoretical contribution of Lancaster, who proposed that properties or characteristics of goods, rather than the goods themselves, are the direct objects of utility.[10] Utility or preference orderings rank collections of characteristics directly, and rank goods indirectly. The theory assumes that properties possessed by goods are identical for all consumers, who must choose between collections of characteristics, and do not assign properties to goods. While the demand for steam coal is driven by the demand for electricity and other industrial goods, the exact type of coal and its contract terms are selected from many alternatives based on buyer preference. Thus once the type of coal is selected, the quantity required is determined by the electricity or other good's production function. However, the coal selected is first subject to the multidimentional indifference map of the buyer which accounts for all of the quality and contract

[10]Kelvin J. Lancaster, "A New Approach to Consumer Theory," Journal of Political Economy, 74 (1966), pp. 132-56.

terms of coal and the supply agreement, respectively.

Lancaster's theory was adopted by a number of economists working with price indexes, who began to refer to it as the theory of hedonic prices. Triplett wrote probably the longest treatise on the theory of hedonic prices, and said that economic measurement of quality differences in products when measuring price changes "deals" with different levels of quality.[11] Levels of quality are measured by differences in preference levels by some criteria. The system of measurement should be systematic according to grade, desirability, or usefulness if it is to be a measurement of economic welfare. Quality levels can be based on consumer preferences where the consumer's preference function is the quality criterion. Goods are a source of services that are demanded. Those goods which provide more services, or have higher levels of the characteristics of a good, are more in demand than goods that provide less.

According to Triplett, while market transactions are not usually conducted in terms of the qualities of the goods, there is an implicit price for each characteristic of a good. Therefore, the price of a good represents the sum of all of the prices of its characteristics. The criterion

[11]Jack E. Triplett, The Theory of Hedonic Quality Measurement and Its Use in Price Indexes (Washington, D.C.: GPO, 1971), p. 312.

for determining the appropriateness of an element as a quality characteristic is whether or not it enters the consumer's indifference curve. If two like products have different characteristics, the consumer is essentially faced with choosing between two bundles of goods. Variations in product quality are actually variations in the quantities of the different characteristics of the product. There is a great amount of literature suggesting that consumers are greatly ignorant of quality levels in the goods they purchase. However, economic theory begins from the point that consumers are capable of acquiring quality information, through price shopping if nothing else, and that it is to their advantage to do so. Mistakes in quality measurement probably balance each other out.

In reality, of course, each consumer has a unique price that he is willing to pay for any given characteristic. What can be inferred from Triplett is that there is an average implicit market price, which is the object of this study to determine. Implicit price differences among consumers occur because of differences in their indifference curves, lack of information, and variations in bargaining power. The statement that mistakes in quality measurement probably balance each other out is not empirically substantiated but seems intuitively acceptable across all purchases of a given type. Quality measurement accuracy is only important for this study to the extent that average market price is desired as an estimate of true value.

Triplett and Griliches were primarily interested in hedonic quality measurement for its use in constructing price indexes. According to Griliches, the hedonic or characteristics approach to price index construction is based on the hypothesis that the many varieties of a product are different in only a small number of basic attributes.[12] The existence or absence of these attributes in similar products is what causes price differences. A determination of a product's prices are empirical matters. Triplett saw the hedonic technique in price indexing as involving the isolation of the quality level determining characteristics in a cross-section analysis, and adjusting for changes in them in time series analyses to determine changes in prices of goods with like qualities. The price index should be adjusted for only those elements that have a market price.

The purpose of this paper, then, can be likened to the preliminary stage of price indexing using the Griliches-Triplett method. The objective is to conduct a cross-sectional analysis of steam coal prices to determine what characteristics of the good have a market price and what their impacts on the market price for coal are. Steam coal contract purchases lend themselves to hedonic quality

[12] Zvi Griliches, Price Indexes and Quality Change, Studies in New Methods of Measurement (Cambridge: Harvard University Press, 1971), p. 183.

measurement very well. A major study on coal prices noted that coal is a heterogeneous commodity, referring to its quality variations, with users placing values on its various attributes.[13] Moreover, most steam coal supply agreements specify the quality characteristics of the coal to be delivered, along with terms of delivery such as the quantity of coal and the length of the agreement, which all can be objects of utility to the buyer.[14] Such contract characteristics are important to steam coal consumers because of generating equipment and emissions constraints, and the life and size of generating units.[15] Such properties are nearly identical for all steam coal consumers because all existing electricity generation technology takes these factors into account. What seems to remain for discussion, then, is what characteristics of contract steam coal purchases were selected for examination of their impacts on coal prices and the results of the regression runs.

The characteristics of contract steam coal purchases selected for examination of their impacts on coal prices

[13]Charles River Associates, Coal Price Formation (Cambridge: Charles River Associates, 1977), p. 73.

[14]U.S. Department of Energy, "Coal Competition: Prospects for the 1980's" (Washington, D.C.: GPO, 1981), p. 343

[15]Ibid

in this study, as in all studies of this type, were as much a function of data availability as they were theoretically considered to influence the price of steam coal purchased under long-term contracts (at least one year in length). All of the data on prices and characteristics examined was extracted as part of this study from electric utilities' responses to an interrogatory on their 1978 fuel purchase practices issued to all jurisdictional utilities of the Federal Energy Regulatory Commission (FERC).[16] The interrogatory requested information on the contract terms of coal delivered under each long-term contract the utility was party to as of the date of the interrogatory. Thus, the only steam coal contracts for which no interrogatory information was available were for those of industrial and retail steam coal consumers, about ten percent of the utility total, and non-jurisdictional utilities, less than ten percent of utility consumption.[17] However, the information required for examination was obtained by letter from the Tennessee Valley Authority, the largest non-Federal coal consumer. Therefore, this study examined over eighty-five percent of all contract steam coal purchases in 1978.

[16]Commission Order, Docket No. IN79-6. April 15, 1979.

[17]National Coal Association Economics Committee meeting, October 20, 1981.

The characteristics examined here for their impacts on contract steam coal prices include controlling interest in the mining operation by the utility; the average annual tonnage to be delivered over the life of the contract; the year in which the first delivery was made under the contract; the length of the contract; the contracted sulfur content of the coal to be delivered; the contracted ash content; the contracted Btu content; the cost of transporting the coal from the mine to the consuming plant or plants; the location of the mine; the constraints and buying practices of the utility party to the contract; the various transformations and variations of the above. The coal prices for which the above characteristics were examined included separately, the actual delivered and mine prices. The reasons for examining the impacts of these characteristics are discussed below.

The major chemical characteristics of coal affecting its burning qualities and emissions include Btu, sulfur, ash and moisture content.[18] The measurement of these characteristics are the most important elements of the proximate analysis of coal, or the analysis before burning,

[18]Charles River Associates, Coal Price Formation (Cambridge: Charles River Associates, 1977), p. 79.

which is the basis on which the quality of coal is usually specified in coal contracts. This was evident from reading dozens of coal contracts and the interrogatory responses. Most coal contracts, and nearly all of those signed in the last few years, are written with price adjustment clauses for variations in these quality characteristics from target values. Inadequate price adjustments for quality variations result in excess profits or losses to buyers and sellers. It is the average of the price adjustment clauses which this study aims to determine.

Most contracts also contain quality parameters outside of which the buyer has the right to refuse receipt of the coal. Less important coal characteristics for electricity generation include volatility, fixed carbon, grindability, and ash fusion temperature. These characteristics are less likely to have a significant impact on the price of steam coal. Unfortunately, this hypothesis could not be tested because of the absence of data on most of the available coal contracts. Most unfortunate was the frequent absence of data on moisture content for most of the contract, which precluded on examination of its impact on price.

The importance of Btu content in coal has its roots in the simple fact that Btu content is the energy resulting from combustion. The more Btu content, the more heating value per ton of coal. As stated earlier, the Btu content of steam coal ranges nationally from less than 6,500 Btu per pound to over 13,000. The more Btu per ton of coal, the less a buyer must pay for transporting the Btu to the plant and for the other characteristics (per Btu) which the buyer pays for. Boilers used in generating electricity are designed to operate most efficiently by burning coals with Btu contents within specified ranges. The range is usually set concurrently with the signing of a long-term contract or in accordance with the coals the utility is most likely to buy. The range is typically about ± 500 Btu, with adjustment costs set to equal the cost of purchasing the Btu variation.

The sulfur and ash content of coal influences its value because increases in their content detract from the heating value of the coal, and because lower levels of their content are less expensive to dispose of after burning and are less harmful to boiler equipment. Sulfur content is not a serious detractor from heating content as its range in steam coal is from 0.4 - 4.0%, with the average in 1978 delivered utility coal being 1.8%.[19] However, sulfur content is very important to utilities that burn low sulfur coal to meet particulate emissions regulations

[19] U.S. Department of Energy, "Cost and Quality of Fuels for Electric Utility Plants - 1978" (Washington, D.C. : GPO, 1979(, p. 27.

under the Clean Air Act. As stated earlier, about twenty percent of all steam coal purchases in 1978 were compliance coal. Sulfur content is also important because it is expensive to remove if scrubbing of high sulfur coal (over 1.0%) is chosen to meet emissions regulations. Ash content is a more serious detractor from heating content because it ranges up to 30% by volume in steam coal. It also must be removed from boilers and disposed of after burning. As in the case of Btu content, boilers are constructed to burn coals with sulfur and ash content within specified ranges. The sulfur range is usually $\pm$ 0.5%, the ash $\pm$ 5%, with cost adjustments in the contracts to reflect affects on equipment.

Transportation costs must theoretically rank near the top of any list of factors affecting the price of coal. In 1979, about 65% of all U.S. coal was shipped by rail at an average cost of 1.9 cents per ton mile.[20] The remaining transportation of coal was nearly totally provided by truck and barge. These forms of coal transportation are respectively more and less expensive than rail. Regardless of which type of transporation is used to haul coal, transporation costs can add significantly to the delivered price of coal. For example, the cost of transporting western coal to the Mid-West by rail is about twenty dollars

[20]Eugene Guccione, "Coal and Rails: A Strained Partnership," Coal Mining and Processing, (June, 1980) pp. 48-51.

per ton at a rate of one million tons per year.[21] The average transportation cost in 1978 derived from the sample data was $4.97 in Market 1, and $6.83 in Market 2. The average delivered price for contract coal was about $22.19 per ton in 1978, ranging from an average of $9.52 per ton in the West to $30.09 in the North East.[22] Therefore, transporation costs would seem to significantly affect the price a utility is willing to pay for coal at the mine. The greater the costs of transporting coal from a particular source, the less the buyer is willing to pay for the coal at the mine ceterus paribus. On the other hand, the less costly it is to transport a coal to a given plant, the more a producer can charge for his coal FOB mine relative to coals more costly to transport. Naturally, greater transportation costs are expected to positively impact delivered price, as opposed to their negative impacts on mine prices. Distant suppliers must set their FOB mine price lower if they are more distant than other suppliers, ceterus paribus. Most coal prices are negotiated FOB mine, with transportation costs a given.

Contract terms that theoretically would impact coal prices and are common to all contracts include the annual average tonnage to be delivered over the life of the

[21]Unpublished Interstate Commerce Commission tarriff rates.

[22]U.S. Department of Energy, "Cost and Quality of Fuels for Electric Utility Plants - 1978" (Washington, D.C.: GPO, 1979), p. 41.

contract; the year of first delivery under the contract; and the length of the contract. The annual tonnage was thought to be an important factor because larger tonnage usually comes from larger mines which should enjoy economies of scale in production. Larger tonnages should also enjoy a discount because of the sales volume they offer suppliers. Longer contracts should also result in lower prices for the same reason. Coal prices under contracts signed in earlier years should be lower than prices under later contracts because the former should include lower capital and fixed costs per ton as a result of subsequent inflated costs for newer mines.

Of the remaining coal purchase characteristics examined, the one likely to have the most significant impact on prices is the location of the coal mine. This characteristic was examined because of the knowledge that coal mining costs are substantially lower at some locations within a given market because of thicker seams, thinner overburden etc. The examination of this characteristic may seem to be at odds with the theory that delivered prices tend toward equality within a given market, because it would seem that producers could extract rents from buyers when they have lower costs of production. Yet two considerations support its examination. First, theory has it that delivered prices within a given market tend toward equality. It does not state that they must be equal. Prices will be equal in a perfectly competitive market only if the market is in long and short run equilibrium, which is rare for any market. Imperfect markets can yield equal prices as a result of collusion and perfect monopoly or monopsony power, but these conditions are theoretically short term. Because of the ever changing constraints on steam coal markets and their imperfect structure, equal prices are unlikely except in short run equilibrium. Steam coal markets are competitive enough to prevent collusion or market dominance by a single party.

Second, examination of coal prices within the delineated Markets reveals that delivered prices of coals from some sources show consistently higher or lower than market average tendencies and that higher and lower prices are correlated with higher and lower production costs, respectively. The areas with lower production costs seem to form "submarkets" in which the tendency is for local buyers to import very little if any coal because of lower local prices. However, sellers in the low production cost areas export amounts of coal significant enough for these submarkets to be included in a large market using the Elzinga-Hogarty methodology. Therefore, within the large market areas delineated by the Elzinga-Hogarty methodology, some source locations of coal should have significant impacts on mine prices and delivered prices.

The remaining two characteristics examined for their impacts on contract steam coal prices are the impacts of the electric utility party to the contract and the existence of a controlling interest in the mining operation by the utility. The buying utility will have an impact on price if it has monopsony power in a market, superior or inferior buying practices to those of other utilities, distinctly differing regulatory oversight conditions, or other constraints peculiar to its location. A controlling interest in the mining operation or significant parts of coal production, such as ownership of the reserves, can result in the economies of vertical integration or technical inefficiencies because of inexperienced management of the coal operations.

The regression analysis of the above characteristics on steam coal prices was performed using the Statistical Package for the Social Sciences, which uses ordinary least squares to calculate a multiple regression model. Initial models were calculated for each coal Market Region delineated using the average 1978 mine and delivered price under each contract as dependent variables. Delivered price is of most concern to buyers and it is significantly affected by transportation costs, which in some cases amount to more than fifty percent of total delivered price. The mine price is of most concern to suppliers, unless they are also providing transportation, which is rarely the case. Both prices are important to regulators of electricity prices in determining fair market value, particularly when part of the mining or transportation is controlled by a utility.

The delivered price has been the price of main consideration in past studies because it is the total coal price to the buyer and delivered price data is readily available. However, transportation costs are usually negotiated with a vendor other than the coal supplier, and they affect the mine price the buyer is willing to pay. The mine price and transportation costs are negotiated simultaneously, and are both of major concern to the buyer. Therefore, because the mine price information was available along with the characteristics described above for perhaps the first time, the mine price was also examined. It was believed that the same coal characteristics would influence mine prices as well as delivered although probably to different extents. The prices were initially examined in both cents per million Btu and dollars per ton. Cents per million Btu is considered by some to be the most important price form because it allows for comparison of what is generally regarded as the most important coal characteristic: the price of the energy content. Many previous studies of coal prices have used ¢/MMBtu as its sole basis for analysis. However, it is more likely that dollars per ton is of greater importance to a coal buyer because he is not simply purchasing heat content, but all of the other characteristics discussed above as well. For example, transportation costs, handling costs, and royalties are all dependent on the weight of coal, not its heat value. Unfortunately, most of the price data used in this study was reported in ¢/MMBtu form only. Therefore, $/ton had to be estimated by using the Btu/lb. figures. This is problematical for reasons discussed next.

Btu content was entered into the data base in the traditional Btu/lb. form. This is the form in which it is negotiated for all coal contracts, as well as being the form in which it was reported in the interrogatories. Unfortunately, the Btu figures were reported for most contracts in the average contracted form as opposed to the average received form. The average received form is preferred because coal prices are adjusted for variations in received Btu content. Using the contracted Btu content instead of actual will lose the effects of changes in Btu content from the contracted amount on the final coal price. The price for energy content will be somewhat, although not greatly, distorted in the model which will decrease its accuracy. However, the distortion is expected to be small because delivered Btu content is usually within a few percentage points difference from contracted Btu.

Sulfur content is stipulated in the model in the familiar percent of volume form. This is the manner in which it is described in most coal contracts, and in which it is referred to in nearly all discussions of coal prices. As with Btu content, the sulfur data used is the contracted content rather than delivered, so the data and its impacts on the model are only reasonably accurate. However, the accuracy loss in the sulfur case is not as significant as with Btu because contracts usually stipulate sulfur content as a maximum rather than an average as in Btu. Therefore, deviations from contracted sulfur specifications are only on the downside. Moreover, these deviations are usually very small because premiums paid for lower than contracted sulfur content are typically less than the cost to suppliers to reduce it. Suppliers will minimize coal washing and blending and attempt to hit the maximum sulfur content, and sell lower sulfur coal to another customer at higher premiums.

Sulfur content stipulated in pounds of sulfur dioxide per million Btu is uncommon, but it is occasionally done for utilities whose sulfur emissions standards are stipulated in that way. Usually, however, the maximum percent sulfur allowable is backed out of the lbs. of SO_2/MMBtu requirement for contract purposes. Entering the data in this form may improve modeling accuracy when the dependent variable is stated in ¢/MMBtu. However, because most of the sulfur data is in percentages, transforming it to lbs. SO_2/MMBtu requires utilizing the inaccurate Btu content data. Nevertheless, the transformation to lbs. SO_2/MMBtu was made and tested on some of the regression runs.

Ash content is always stipulated in contracts as percent of unit volume, so it was entered into the data base as such. The average annual tonnage delivered over the life of the contract was entered in thousands of tons. The year in which the first delivery was made under the contract was entered in its full form. The length of the contract was entered in years.

The cost of transporting the coal from mine to plant was entered in dollars per ton or cents per million Btu to match the form of the dependent variable. As in the case of coal prices, intuitively dollars per ton is a more accurate measure of transportation costs in cents per million Btu may reflect the Btu content per ton of coal as well as the transportation charge. This is because buyers should be willing to pay higher prices per Btu for higher Btu coals because it is less expensive to transport. In addition, transportation rates are contracted for in dollars per ton.

Dummy variables were assigned to describe the existence of the remaining characteristics for each coal contract entered into the data base. In the Market 1 analysis, a dummy was assigned for coal mined in Indiana, Illinois and western Kentucky to differentiate it from the coal mined in the Appalachian basin (see coalfields map). The Illinois basin coal is more frequently surface mined and therefore less costly. In the Market 2 analysis, a dummy was assigned for coal emanating from Wyoming or Montana; Illinois; and the remaining States in the Interior basin. Powder River Basin coal lies in very thick seams which are immensely less costly to mine than any other coals in Market 2. The remaining States in the Interior basin have coal from a different field than Illinois. All coal produced in Market 3 comes from the same basin so no dummies were assigned. In Market 4, a dummy was assigned for coal mined in Utah because all of this coal is mined underground at a considerably higher cost than the surface-mined coal elsewhere in the Market. A dummy was also assigned for Colorado coal because of its unique coal fields and costs of production. Dummy variables were also assigned for each utility and for each case in which the utility had a controlling interest in the mining operation.

The first step in the regression analysis was to analyze FOB mine and delivered prices in all Markets in both dollars per ton and cents per million Btu. The following independent variables were included in all of these regression runs; tons delivered per year; start year of the contract; % sulfur, % ash, and Btu content of the coal; the Powder River Basin dummy; transportation costs; and length of contract. Depending on the form of the dependent variable, there were eleven observations or less for each regression for Market 4, and five observations or less for Market 3. Therefore, Markets 3 and 4 were not analyzed any further. Markets 1 and 2 had up to 331 and 107 observations, respectively, so the analysis could proceed with sufficient degrees of freedom.

For Market 1, the highest R^2 values and lowest standard errors obtained for both the mine price and the delivered price was when they were analyzed in terms of dollars per ton. The mine price in dollars R^2 was 0.336; the delivered price was 0.396. Their respective R^2 values in cents per million Btu were 0.187 and 0.240. For Market 2, again the equations in dollars per ton achieved higher R^2 values and lower standard errors. The mine price in dollars R^2 was 0.718; the delivered price was 0.649. Their respective R^2values in cents per million Btu were 0.602 and 0.624. The conclusion from the above results was that the regression analysis supported the theory that dollars per ton is the best form of coal price for analysis of price structure and variation. The signs (+ or -) of all the independent variables matched theoretical expectations in both the \$/ton and ¢/MMBtu runs, so they were all retained in the following runs.

The next set of regression runs was essentially devoted to a number of variable transformation and combinations. Values for sulfur content, transportation cost and ash content were squared because of evidence from plotting coal price against the variable values that as their values increased, the corresponding coal price increased at a faster rate. The values for sulfur and ash content were multiplied because both characteristics are undesirable and it was believed that their total value may be more so. The inverse value of transportation cost was examined because plots of price against the variable were convex to the orgin. The values of tons per year and the length of each contract were multiplied to see if an estimate of expected total tonnage delivered over the contract's life was significant. Ash and sulfur content were multiplied separately with transportation cost because high costs of transporting these characteristics are very undesirable. Ash and sulfur content were divided separately by Btu content because the former two characteristics displace Btu content, which is undesirable. However, none of these transformed variables were found to have greater impacts on price than their untransformed counterparts. Taking the log linear form of the equations to test for exponential relationships resulted in lower R^2 values and higher standard errors.

The following regression runs were made on observations broken down into sets or categories as follows: contracts signed in 1978 only; contracts signed after 1976; contracts signed after 1973; and contracts signed after 1970. Such groupings were made to determine if regression results were better for later years as a result of more precise coal contracts and better representation of contemporary conditions. Indeed, the later categories yielded consistently higher R^2 and lower standard error values than earlier ones. Groups of runs were also made for contracts specifying sulfur contents yielding greater than 1.2 lbs. of SO_2 per million Btu when burned and less than 1.2 lbs. of SO_2. This split was made because coal emitting less than 1.2 lbs. of SO_2 is in full compliance with Federal air pollution regulations, and therefore may be a separate type of coal. Regression results were not conclusively different than for all contract runs.

The next regression runs were made dividing the observations into the following categoreis: all contracts; those with less than 1.2 lbs. of SO_2 emitted per million Btu; those with greater than 1.2 lbs. SO_2; and contracts signed in 1978. Dummies for all producing regions and for each buyer were included for the first time. The general results were that categorizing by lbs. of SO_2 yielded poorer results than not; analyzing 1978 contracts resulted in higher R^2 and lower standard error values than for all years; utilizing the production region and utility dummies yielded better results than not; and some of the production region and utility variables had significant impacts on coal price. Expressing sulfur content in lbs. of SO_2 per million Btu as an independent variable proved to have a lesser impact on R^2 than when expressed as percent of volume. The sign of the ash content variable was found to be inconsistent. Investigations disclosed that ash content is usually negotiated simultaneously with moisture content, with tradeoffs to arrive at a total figure. Higher ash content may be associated with higher prices if moisture content is acceptable. Therefore, lacking moisture content information, ash content was dropped from the analysis.

The final regression runs yielded the following results. For Market 1 with delivered price as the dependent variable:[23]

[23]See Appendix I for list of variables.

All Years (335 cases)

$$DP = -207.82 + \underset{(0.00)}{0.00295X_{11}} + \underset{(0.07)}{0.78X_{20}} + \underset{(0.78)}{3.41D_{45}} - \underset{(0.25)}{1.18X_9} + \underset{(1.06)}{2.09X_2} - \underset{(1.54)}{5.25D_{48}} - \underset{(2.09)}{7.64D_{23}} - \underset{(1.70)}{4.62D_{36}} - \underset{(1.95)}{7.41X_{17}} - \underset{(0.79)}{1.72X_{29}} - \underset{(1.65)}{3.78D_{37}} + \underset{(4.85)}{10.45X_{28}} - \underset{(1.48)}{2.75D_7} - \underset{(2.10)}{4.17D_{21}} + \underset{(2.68)}{4.93D_{39}} + \underset{(0.04)}{0.087X_{21}} + \underset{(0.05)}{0.10X_6}$$

$R^2 = 0.602$ standard error = 4.484

1978 Only (77 cases)

$$DP = 34.36 + \underset{(0.00)}{0.0058X_{11}} - \underset{(1.78)}{9.90D_{48}} + \underset{(0.00)}{0.0036X_5} + \underset{(3.17)}{19.95X_{26}} - \underset{(0.50)}{2.17X_9} - \underset{(3.75)}{10.59D_{31}} - \underset{(3.48)}{7.38D_{23}} - \underset{(2.44)}{3.85X_{17}} + \underset{(3.45)}{5.65D_1} + \underset{(1.46)}{2.27X_{29}} + \underset{(3.44)}{5.35D_{43}}$$

$R^2 = 0.733$ standard error - 3.384

As would be expected with fewer observations, more of the variation in price is explained using 1978 data as opposed to all years, with a lower variance. In both models, Btu content has the greatest explanatory power.[24] However, transportation cost is disturbingly absent from the 1978 model. While the ordering of the utility variables is understandably different, note also that tons

[24] See Appendix II for tabular comparison of market results.

surprisingly accounts for more of price variation in 1978 than sulfur content. This may be related to the higher importance of the Colorado variable than sulfur. Much low sulfur Colorado coal was purchased in the later years of the study period because of regulations under the Clean Air Act. Market 1 contracts for Colorado coal would necessarily be large to be economical. Other differences in the two models are probably due to short or long run changes in market conditions. However, the model for all years appears to be more intuitively correct for long run equilibrium because of the explanatory variables it includes and the R^2 change they account for. The sign of the coefficient for length of contract was surprisingly positive, probably because buyers were required to pay a premium for supply security. For 1978, the sign for the tons coefficient was surprisingly and unexplainably positive. The sign for the Interior coefficient was probably positive because of higher transportation costs. Variables extant in the model for all years not found in the 1978 model may have been victims of insufficient degrees of freedom.

For Market 2 with delivered price as the dependent variable:

All Years (97 cases)

$$DP = -13.85 - \underset{(0.06)}{0.20}X_{21} + \underset{(0.00)}{0.0033}X_{11} + \underset{(0.11)}{0.75}X_{20} + \underset{(1.21)}{1.76}X_{29} +$$

$$\underset{(2.59)}{6.78}D_{56} - \underset{(2.16)}{5.93}D_{69} - \underset{(4.51)}{11.50}D_{64} - \underset{(3.23)}{5.66}D_{65} - \underset{(2.60)}{4.73}D_{66} - \underset{(2.26)}{3.86}D_{75} +$$

$$\underset{(2.10)}{3.32}D_{50}$$

R^2 = 0.808   standard error = 4.31

Unfortunately, insufficient observations existed for running regressions on 1978 data alone. In comparing the Market 2 model to the Market 1 model for all years, the most important difference is the appearance of length of contract as accounting for the greatest R^2 change for Market 2 delivered prices. This can be intuitively supported by the fact that coal industry development in the West has been a recent phenomenon in response to population growth there and the Clean Air Act. Because coal in the West is frequently mined in larger quantities for more isolated mine-mouth or distant buyers than Eastern coal, suppliers require longer contracts to assure demand reliability. Another noticeable difference in the Market 2 model is the absence of the sulfur content variable. This is surprising because while most of the coal purchased in this Market is low sulfur Western, which does not vary much in sulfur content, a large portion of Market 2 coal purchases are high sulfur Mid-Western coal. The sulfur information may have been picked up in other significant variables.

Aside from contract length, Btu content and transportation costs play the most important role in explaining price movements in Market 2, while they were most dominant in Market 1. The Powder River Basin variable is also surprisingly absent from the Market 2 model.

For Market 1 with mine price as the dependent variable:

All Years (340 cases)

$$MP = -\ 243.48 + \underset{(0.00)}{0.0031}X_{11} + \underset{(0.79)}{3.17}D_{45} - \underset{(0.27)}{1.31}X_{9} + \underset{(1.08)}{1.78}X_{2} -$$

$$\underset{(2.10)}{8.24}D_{23} - \underset{(1.70)}{5.07}D_{36} - \underset{(1.56)}{5.68}D_{48} - \underset{(0.09)}{0.22}X_{20} - \underset{(1.66)}{4.15}D_{37} - \underset{(0.76)}{1.41}X_{29} -$$

$$\underset{(1.50)}{3.06}D_{7} - \underset{(3.22)}{5.53}D_{26} - \underset{(2.11)}{4.42}D_{21} + \underset{(2.69)}{4.25}D_{39} - \underset{(1.68)}{2.85}D_{12} - \underset{(3.24)}{5.22}D_{6} -$$

$$\underset{(0.04)}{0.11}X_{21} + \underset{(0.05)}{0.12}X_{6} - \underset{(0.00)}{.00063}X_{5}$$

$R^2 = 0.467$ standard error = 4.50

Comparing the above results to those for delivered price, all years, in Market 1, the standard errors are nearly identical. There are lower impacts for Btu content, transportation cost, and length of contract in the mine price model, and the absence of the Powder River Basin and Utah variables because those regions do not figure in Market 1 mine price analyses. Variables accounting for greater R^2 change in the mine price analysis than for delivered price included sulfur content, captive relationship, the Interior coal source, and start year of the contract. Average annual tons delivered was significant in the mine price model but not for delivered price. The mine price model did, however, have more explanatory variables than the delivered price model.

1978 Only (74 cases)

$$MP = -56.77 + \underset{(0.00)}{0.0075}X_{11} + \underset{(1.22)}{1.87}D_{45} + \underset{(0.09)}{0.17}X_{21} + \underset{(3.61)}{8.54}D_{1} - \underset{(2.21)}{8.61}D_{48} - \underset{(0.17)}{0.65}X_{20} - \underset{(0.56)}{1.72}X_{9} + \underset{(1.58)}{4.16}X_{29}$$

$R^2 = 0.731$ standard error = 3.42

As expected with fewer cases, the R^2 for 1978 data is higher than for all years. The standard error is also lower. Btu content, length of contract, transportation cost, sulfur content, and the Interior variable all have greater impacts on mine prices in 1978 than for all years. Another important difference in the 1978 model is that length of contract accounts for a much higher R^2 change. The market probably placed greater importance on this factor in 1978 because excess mine capacity depressed coal prices. Suppliers were, therefore, reluctant to sign long agreements without price compensation. Nonutility variables absent from the 1978 model that were significant for all years included utility controlling interest, the starting year of the contract, and annual delivery tonnage. The starting year variable was not entered into the regressions because all observations started in 1978. The tonnage variable was a victim of insufficient degrees of freedom. The sign for the transportation cost coefficient was inexplicably negative.

For Market 2 with mine price as the dependent variable:

All Years (108 cases)

$$MP = 5.35 + \underset{(0.00)}{0.0019}X_{11} + \underset{(1.02)}{7.44}X_{24} + \underset{(1.88)}{9.34}D_{56} - \underset{(1.53)}{4.50}D_{74} -$$

$$\underset{(0.04)}{0.0086}X_{21} + \underset{(1.63)}{4.03}D_{58} + \underset{(2.35)}{5.44}D_{72} + \underset{(1.45)}{3.35}D_{52} + \underset{(1.58)}{4.54}X_{26} + \underset{(1.63)}{2.24}D_{51} +$$

$$\underset{(1.67)}{2.64}D_{50} - \underset{(1.87)}{2.83}D_{66} - \underset{(2.31)}{4.21}D_{65} - \underset{(1.82)}{3.32}D_{69} - \underset{(0.08)}{0.12}X_{20}$$

$R^2 = 0.841$ standard error = 3.09

Comparing the Market 2 models for mine price and delivered price, the standard error for the mine price model is significantly lower. Btu content and transportation cost have lower impacts on mine prices per unit change than on delivered. The Btu impact is probably lower because there is less variation in mine prices than delivered within the market. The mine price rents attributable to transportation costs are apparently much less than the costs of delivery as evidenced by the absence of the transportation independent variable. Length of contract has a higher impact per unit change on mine prices but accounts for a smaller percent of R^2. The higher coefficient probably occurs because of a drop in the coefficient values of other variables such as transportation cost. The Illinois variable is more important in the mine price model because production costs in that area are significantly higher than the average for Market 2.

Comparing the mine price models in Markets 1 and 2, Btu content has a lower impact per unit change in Market 2, probably because of greater variations in mine prices within the Market. Sulfur content is not a significant variable in

Market 2, probably because most of the coal produced there is of the low sulfur variety, so premiums are not necessary to obtain it. Utility control of the mining operation is not a factor in the Market 2 mine price model for probably the same reason as for delivered price. The starting year of the contract is not a significant variable probably because there were no real increases in mining costs caused by reserve depletion. This region had many surface mineable reserves which were of equal cost to mine but were not touched until the 1970's. Improvements in surface mining technology may have offset inflated nominal dollars. However, insufficient degrees of freedom may be a factor. Tons delivered is also not a factor probably because most contracts are for coal mined from very large surface mines with little production cost variation from mine to mine. The Illinois and Colorado coal source variables has a positive impact on price as expected because of higher costs of production than in the Powder River Basin, which accounts for most of the coal production in the Market.

Conclusions

The conclusions which can be drawn from the above analyses are that first, the various characteristics which have the greatest impacts on contract steam coal prices vary from market to market and from year to year. Differences in coal production costs, the proportion of low sulfur coal mined in a Market, and the nature of doing business account for most of the variations across markets. Changes in market conditions such as excess mine capacity or environmental regulations account for some variation in the impacts of characteristics from year to year, but these variations are less than they are across markets. Indeed, the delineation of the markets themselves has major implications for the results of this analysis.

Second, Btu content is usually the most important characteristic in explaining coal price variations in a given market for both delivered and mine prices. Length of contract is more important than any variable other than Btu in Market 2 and for Market 1 mine prices. This can probably be explained for Market 2 by the smaller size of spot market than in Market 1 and the larger average size of generating plants. Sulfur content and transportation cost were found to be frequently higher than other variables in their impacts on coal prices, but were not consistently so. Some locations of coal were found to be significant in each model, but were rarely highly important. This indicates that coal prices in the Markets examined tend toward equality but either the Markets are incorrectly delineated or there are noncompetitive constraints.

Third, some utilities buying practices and/or other constraints on their purchasing behavior had significant impacts on coal prices in each model, and in some situations the impacts were profound. This occurence, along with that of the mine location variables, precluded testing for the equality of regression coefficients across models. As in the case of the coal location impacts, the utility impacts may indicate noncompetitve constraints. Where utility variables had negative coefficients, the reason may have been utility bargaining power or better procurement practices. Where the coefficients were positive, the case could have been supplier bargaining power or poor procurement practices. Other reasons could have included specific regulations or State regulatory practices, such as fuel adjustment clauses or higher rates of return.

As mentioned previously, there are some factors not included in this analysis which undoubtedly have significant market-wide impacts on coal prices. One major consideration not addressed previously is that steam coal is traded in a derived demand market. The demand for electricity and the prices for factors of production other than coal, along with the price of coal, determine the quantity of electricity that will be generated by coal. Coal is only one input in a production function for electricity. The marginal productivity of a given type of coal is determined by a production function for electricity and the fixed quantity of the nonvariable inputs. The value of the marginal productivity in electricity production determines the demand function for coals in competitive markets. It must be said, then, that the prices of the hedonic characteristics or properties of coal are for the most part determined as a result of their impacts on the marginal productivity of coal in electricity production. In noncompetitive markets, the marginal revenue productivity of coal replaces the value of marginal productivity as determinant of the demand function for coal.

Another potential major factor influencing coal prices is the practice of price discrimination by electric utilities in the electrice rates they charge. It is well known that utilities charge different prices to residential, industrial, and wholesale buyers, and for different quantities of electricity. A utility's account portfolio therefore influences the price it can pay for coal at various quantities. Along these same lines, the rates a regulatory body allows a utility to charge and the return to investors also influences prices for coal a utility will pay. Consequently, some of the price differences which are attributed in the models to differences in the properties of coal or other measured variables may in fact be attributable to other technical or economic characteristics of the markets for steam coal or electricity.

Appendix I

Independent Variables

Variable	
X_2	utility controlling interest in mining operation
X_5	average annual tons delivered
X_6	start year of the contract
X_9	sulfur content (%)
X_{11}	Btu content (per pound)
X_{17}	Powder River Basin coal source
X_{20}	transportation cost
X_{21}	length of contract
X_{24}	Illinois basin coal source
X_{26}	Colorado coal source
X_{28}	Utah coal source
X_{29}	Interior coal source in Market 1
D_1	Alabama Power Co.
D_3	Appalachian Power Co.
D_4	Atlantic City Electric
D_6	Cardinal Operating Co.
D_7	Carolina Power and Light
D_{12}	The Dayton Power and Light Co.
D_{21}	Indianapolis Power and Light
D_{23}	Kentucky Power
D_{26}	Metropolitan Edison

Variable	
D_{31}	Ohio Edison
D_{36}	Philadelphia Electric
D_{37}	Potomac Electric Power
D_{39}	Public Service Electric and Gas of New Jersey
D_{43}	Tampa Electric
D_{45}	Tennessee Valley Authority
D_{48}	West Penn Power
D_{50}	Central Illinois Public Service
D_{56}	Iowa Electric Light and Power
D_{58}	Iowa Public Service
D_{64}	Missouri Public Service
D_{65}	The Montana Power Co.
D_{66}	Northern States Power
D_{69}	Public Service Co of Colorado
D_{72}	St. Joseph Light and Power
D_{74}	Union Electric
D_{75}	Wisconsin Electric Power
D_{51}	Commonwealth Edison

Independent Variable Coefficients *

Independent Variable	Market I all years DP	Market I 1978 DP	Market II all years DP	Market I all years MP	Market I 1978 MP	Market II all years MP
X_{11}	0.00295	0.0058	0.0033	0.0031	0.0075	0.0019
X_{20}	0.78	-	0.75	-0.22	-0.65	-0.12
X_{9}	-1.18	-2.17	-	-1.31	-1.72	-
X_{2}	2.09	-	-	1.78	-	-
X_{17}	-7.41	-3.85	-	-	-	-
X_{29}	-1.72	2.27	1.76	-1.41	4.16	-
X_{28}	10.45	-	-	-	-	-
X_{21}	0.087	-	-0.20	-0.11	0.17	-0.086
X_{6}	0.10	-	-	0.12	-	-
X_{5}	-	0.0036	-	0.0063	-	-
X_{26}	-	19.26	-	-	-	4.54
X_{24}	-	-	-	-	-	7.44

*1% level of significance

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AN APPLICATION OF THE HEDONIC APPROACH
TO ESTIMATING PRICES FOR STEAM COAL CONTRACT TERMS

by

Michael A. Fletcher

(ABSTRACT)

The hedonic approach involves determining the characteristics of a good or service that have a market price. Simultaneously, estimates of those prices are made using regression analysis. Both delivered and FOB mine prices are examined in regional U.S. markets.

The steam coal contract terms examined include Btu, sulfur, and ash content; transportation cost, average annual tons delivered, start year of the contract, length of contract, buyer controlling interest in the mining operation, coal mine locations, and the individual buyers. Data for about eighty-five percent of all 1978 steam coal deliveries is utilized.

The major findings were that coal price structure varies substantially across markets, from year to year, and for delivered prices and FOB mine prices. Btu is usually, but not always, the most important characteristic in explaining coal price variations. Length of contract is occasionally more important. Transportation cost and sulfur content are usually of high importance. Some buyers have a

substantial impact on price because of market imperfections and poor buying practices. The regression results were robust.