The Role of Transaction-Specific Capital and Market Structure in Contracting: Evidence from Japan's Overseas Coking Coal Procurement

by

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ABSTRACT

Coking coal procurement by Japanese steel firms takes place within a framework of long-term contracts. We specify the determinants of price in a long-term contract and use an econometric model to investigate the effect of transaction-specific capital and market structure on contract price. The key finding is that both buyer concentration and transaction-specific capital have a significant impact on coking coal prices. Japanese steel firms also paid a price premium for contracts with larger dedicated quantities and longer duration. In contrast to previous studies, the empirical analysis shows that coking coal prices are significantly affected by coal quality attributes.

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Coking coal procurement by Japanese steel firms takes place within a framework of long-term contracts. We specify the determinants of price in a long-term contract and use an econometric model to investigate the effect of transaction-specific capital and market structure on contract price. The key finding is that both buyer concentration and transaction-specific capital have a significant impact on coking coal prices. Japanese steel firms also paid a price premium for contracts with larger dedicated quantities and longer duration. In contrast to previous studies, the empirical analysis shows that coking coal prices are significantly affected by coal quality attributes.

I. INTRODUCTION

Trade in energy resources often takes place within a framework of long-term contracts. A growing body of literature has provided theoretical and empirical analysis of long-term contracts between U.S. coal, petroleum, and natural gas producers and U.S. consumers.[1] This analysis of long-term contracts has, however, rarely been extended to international trade in energy. This paper investigates factors determining the use of long-term contracts in the coking coal trade between Japanese steel mills and their foreign suppliers and examines empirically the determinants of transaction prices in coking coal contracts in force during 1986 and 1989.

The coking coal contracts of Japanese steel firms are of particular interest for a number of reasons. First, Japan is the world's largest importer of coking coal, and Japanese steel firms have made extensive use of long-term contracts for importing coking coal. Second, although there has been extensive analysis of Japan's coking coal procurement practices, empirical studies based on contract-specific data have not been undertaken. Third, while information on long-term contracts is a commercial secret in many industries, fairly detailed information on coking coal procurement contracts exists for the Japanese steel industry. Finally, this data set enables us to investigate whether the determinants of price in long-term **international** contracts differ from the determinants of price in long-term **domestic** contracts.

II. AN OVERVIEW OF JAPAN'S COKING COAL IMPORTS

Coal can be roughly divided into coking coal and steaming coal; coking coal is used to produce steel while steaming coal is used to generate electric power. Japan is the world's largest importer of coking coal as well as of steaming coal; its total imports account for, respectively, 35 percent and 17 percent of world trade in 1989 (DOE/EIA, 1991). Steaming coal was excluded from this study because published information on Japan's steaming coal procurement contracts is unavailable. The distinguishing characteristics of coking coal are its superior caking properties. They allow the coal to be converted into a coke suitable for use in modern large blast furnaces. The coke is used to support the blast furnace charge and to generate the heat and gases necessary to produce pig iron. To work well, the coke should resist abrasion, be uniform in size and permeability, be strong at high temperatures, and be chemically pure to provide the necessary carbon for combustion.

The world's leading coal producers are China, the United States, and the (former) U.S.S.R.; they are followed at a considerable distance by Poland, South Africa, India, Australia, and Canada. Because coal is a product characterized by a low value-to-weight ratio and is not exported extensively by some of the leading producers, the relative rankings associated with coal export are quite different. In 1989 Australia was the largest exporter in the world, followed by the U.S., South Africa, the (former) U.S.S.R, Canada, and Poland.

The world's significant coal-importing countries are located in East Asia and Western Europe. Apart from Japan, South Korea, and Taiwan are important importers in Asia. They have three major coal suppliers: Australia, Canada, and the United States. Table 1 shows coking coal trade flows to Asia in 1989. Japan's coking coal imports accounted for 74 percent of total Asian imports, while the combined imports of South Korea and Taiwan accounted for only 18 percent.[2] On the supply side, the combined exports of Australia, Canada, and the United States accounted for about 82 percent of the total coking coal supplied to Asia.

Japan's coal imports have expanded considerably over the last three decades. Until the second round of OPEC price increases in 1979, its coal imports were almost exclusively coking

Table 1. Asian Coking Coal Trade Flows in 1989

Exporters	Importers				
	Japan	S. Korea	Taiwan	Others	Total
Australia	30.0	4.0	3.3	5.0	42.3
Canada	18.8	3.8	1.0	0.4	24.0
U.S.A.	11.6	3.0	0.7	0.1	15.4
U.S.S.R.	5.5	0.0	0.0	0.9	6.4
China	1.4	0.0	0.0	0.0	1.4
S. Africa	3.5	0.9	0.0	0.5	4.9
Others	2.7	0.9	0.0	1.8	5.4
Total	73.5	12.6	5.0	8.7	99.8

Sources: Derived from DOE/EIA (1991), *Annual Prospects for World Coal Trade*; International Energy Agency (1991), *Energy Prices & Taxes*; The Tex Report (1990), *Coal Manual*. Adjustments have been made to correct statistical discrepancies. The trade flows between countries are expressed in million tons.

coal. Coking coal is primarily used for steel production, and about 94 percent of Japan's coking coal imports is taken by steel mills.[3] Therefore, the demand for coking coal is closely related to the performance of the steel industry. In 1989 Japan was the second-largest producer of crude steel in the world after the former U.S.S.R. (DOE/EIA, 1991). Since the mid-1980s, because of the sharp appreciation of the *yen* in world financial markets and competition from steel companies in developing countries, conditions in Japan's steel industry have been stagnant. Since 1978, Japan's crude steel production has varied between 97 million tons and 112 million tons. As a result, Japan's annual coking coal imports have also not grown appreciably, fluctuating between 65 and 75 million tons during the 1980s.

There are six major steel firms in Japan, of which Nippon Steel Corporation alone accounted for about 40 percent of production in 1989. Coking coal imports for Japanese steel mills are handled by importers who act on behalf of the steel mills to coordinate their purchases. There are about 40 Japanese importers involved in the coking coal trade; most importers have been involved in the trade for many years. A substantial majority of these importers have dealings with all supplying countries except for a few relatively new suppliers. Two importers, Mitsui & Co. and Mitsubishi Corp., were responsible for about 50 percent of total imports in 1989.

Because Japan's domestic coal resources are almost exhausted, its steel mills rely heavily on coking coal imported from foreign suppliers; imported coking coal accounts for more than 90 percent of total consumption. On the other hand, those foreign suppliers have also been highly dependent on the Japanese market, as their exports to Japan account for significant proportions of their production and total exports. Table 2 reports the supplying countries'

Table 2. Supplying Countries' Coking Coal Output, Exports and Exports to Japan in 1989

Countries	Output	Total Exports	Exports to Japan
Australia	63.2	55.6	30.0
Canada	28.3	26.7	18.8
U.S.A.	96.3	59.1	11.6
U.S.S.R.	121.5	27.3	5.5
China	84.6	1.4	1.4
S. Africa	-	4.9	3.5

Sources: Derived from International Energy Agency (1990), *Coal Information*; The Tex Report (1990), *Coal Manual*. Output is expressed in millions of tons.

coking coal production, total exports, and exports to Japan in 1989. In 1989 Australia exported 88 percent of its coking coal production, and 54 percent of its exports went to Japan; comparable figures for Canada were 94 percent and 70 percent, respectively. South Africa and China exported only a small fraction of their coking coal production, but most of their exports went to Japan. In contrast, the United States and the former U.S.S.R. sent only a small proportion of their coking coal exports to Japan.[4]

III. REVIEW OF RESEARCH ON JAPAN'S COKING COAL PROCUREMENT

The coking coal trade between Japan and its suppliers has been the subject of intense political and economic debates. A fundamental issue concerns whether Japanese steel mills use collective purchasing practices to exercise monopsony power in their coking coal procurement. Some researchers have alleged the existence of a conspiracy among Japanese government ministries, steel mills, and coal importers. Two studies (D'Cruz 1979 and Anderson 1987) have concentrated on identifying the impact of market structure and the transaction environment on coking coal prices specified in the long-term contracts negotiated by Japanese steel firms.[5]

D'Cruz investigated the determinants of coking coal prices. He defined the concept of "quasi-integration" as a nexus of long-term contracts, logistical linkages, equity participation, and technological changes and examined the relationship between coking coal price and the existence of quasi-integration. His empirical analysis showed that coking coal prices were largely determined by product quality and the supplier's country of origin. Quasi-integration linkages were shown to have a small, but statistically significant impact on prices. D'Cruz's analysis anticipates more recent literature (Williamson, 1983, 1985; Crocker and Masten, 1991; Hubbard and Weiner, 1991) which specifies the more fundamental conditions inducing D'Cruz's "logistical linkages." D'Cruz's study did not, however, distinguish long-term contracts from other forms of quasi-integration and is limited by the use of aggregate rather than contract-specific data in its empirical analysis.

Anderson synthesized two rather polarized views on the coking coal procurement policies of Japanese steel mills: the "conspiratorial" and the "anti-conspiratorial" views. After extensively reviewing existing literature and analyzing Japan's coking coal procurement policy towards Australia and Canada, Anderson concluded that Japanese steel mills exercised oligopsonistic power in the Asia-Pacific coking coal trade. While Anderson's analysis advanced the literature by nesting alternative hypotheses within a single model, his work, like the D'Cruz study, did not utilize contract-specific data.

IV. SPECIFIC ASSETS IN THE COKING COAL AND STEEL INDUSTRIES

Long-term contracts are usually defined as contracts for sales and purchases with a duration exceeding five years. A contract for as short as a one- to five-year period is still regarded as a long-term contract, if the contract has been "rolled over" on a routine basis and therefore can be regarded as "evergreen".[6] Although evergreen contracts contain no renewal commitment, continuation of these contracts is very common.

One major rationale for two firms to enter into a long-term contract is to protect transaction-specific capital.[7] When one party has made an investment which has a higher yield when it is used with a specific partner, i.e., it generates quasi-rents, the partner has an incentive to engage in opportunistic behavior to influence the distribution of the resulting quasi-rents. Williamson (1985, pp. 95-96) identified four distinct types of asset specificity: (1) Site Specificity, where the two parties locate immobile assets contiguously to minimize inventory and transportation expenses; (2) physical asset specificity, in which the asset is specific to the other contracting party and has a lower value in alternative uses; (3) dedicated assets, which "represent a discrete investment in generalized ... production capacity that would not be made but for the prospect of selling a significant amount of product to a specific customer" (p. 95); and (4) human asset specificity, in which one party's human capital is specific to the other contracting party and has a lower value in alternative uses. Masten, Meehan, and Snyder (1991) expanded Williamson's original four-way classification by identifying a fifth category of transaction-specific assets: temporal specificity. They (p. 9) argued that:

> Where timely performance is critical, delay becomes a potentially effective strategy for exacting price concession. Knowing that interruptions at one stage can reverberate throughout the rest of the project, an opportunistic supplier may be tempted to seek a larger share of the gains from trade by threatening to suspend performance at the last minute.

The notion of "dedicated assets" essentially captures cases in which a supplier relies heavily on particular buyers. If the contract between them is terminated prematurely, it would leave the supplier with significant excess capacity for a period of time. As discussed previously, because coking coal is a bulky product, its value is limited by long distance transportation; therefore, some regional suppliers are highly dependent on imports by Japanese steel firms, as Japan is the dominant importer in Asia. Japanese buyers purchase over 80 percent of their coking coal from firms in the three largest supplying countries: Australia, Canada, and the United States. Five major coal shipping ports have been developed to supply coal to the Japanese steel industry: the Roberts Bank and Neptune Terminals in British Columbia, Canada; the Hay Point port in Queensland, Australia; the Richards Bay port in South Africa; and the McDuffie Terminals in Alabama. Cancellations by Japanese steel firms would leave substantial unused capacity at these ports and at coal mines delivering to the ports.

Joskow (1987, p. 170) has also argued that buyers face similar incentive problems because of their large investment in dedicated assets.

> A buyer that relies on a single supplier for a large volume of an input may find it difficult and costly to quickly replace these supplies if they are terminated suddenly and effectively withdrawn from the market and, as a result, a large unanticipated demand is suddenly thrown on the market.

These losses are, however, likely to be small, as since the early 1980s, several countries, in particular Australia and Canada, have had excess capacity in their coal industries. Firms with excess capacity are likely to take the initiative to service quickly any unanticipated demand placed on the market.

Masten, Meehan and Snyder's (1991) temporal specificity may also be relevant to Japan's coking coal trade. On the one hand, because coking coal is a large volume input in steel production, it is costly for steel mills to arrange sufficient storage capacity to guarantee supply for a long period of time. Thus, buyers may be frequently under the threat of delivery delay. On the other hand, because of the lead time required to find new customers, buyers' delay in accepting delivery could also cause substantial losses for producers.

We conclude that the coal trade between Japanese steel mills and their suppliers involves significant transaction-specific capital.[8] In the presence of transaction-specific capital, trade organized through spot exchange is prone to frequent and costly renegotiation, and parties have incentives to evade performance in order to seek quasi-rents. Long-term contracts can guard against such opportunistic behavior and promote efficiency by ex ante specification of contractual choice variables. It is unsurprising that a majority of the coking coal imported by Japanese importers came from suppliers with whom importers had long-term contracts. Table 3 displays

Table 3. Japanese Import Volume by Contract Type

Year	Long-Term	Evergreen	Annual	Spot	Total
1986	35.52	10.25	20.99	2.93	69.69
1989	33.06	16.11	19.00	5.28	73.45

Sources: Derived from The Tex Report (1987, 90), *Coal Manual*. Output is expressed in millions of tons.

Japan's coking coal import volumes by contract type.[9]

Another option which the two parties can choose to protect quasi-rent streams from appropriation is to fully or partially vertically integrate (Williamson, 1985, pp. 85-130; Pisano, 1989). A steel firm would then have less incentive to appropriate quasi-rents from a supplier as its incentives are more closely aligned with the incentives of its coal supplier. Opportunistic threats by a steel firm generate fewer potential benefits, as such threats reduce the value of the firm's equity position in the coal supplier. A direct equity position in a coal firm does not, however, eliminate opportunistic behavior, as the majority share holder in the coal firm still bears most of the costs stemming from opportunistic behavior.

Because the capital requirements of Japan's postwar reconstruction period placed heavy demands on domestic savings, it was difficult for Japanese steel mills to own foreign-based captive mines or even engage in substantial equity participation until the early 1970s (Rodrik, 1982). However, Japanese steel firms have made extensive equity investments in their foreign coking coal trading partners since the early 1970s. Such equity participation gives Japanese steel firms' representation on the management board, assuring better information for contract negotiations and more closely aligned incentives to find the market price of coal. Japanese steel firms have, however, normally restricted themselves to an equity position between 10 percent and 35 percent so as to minimize the impact of foreign direct investment on the political and economic environment of the host countries (Anderson, 1987).

Partial vertical integration between the steel and coal industries serves as a substitute for a fully-specified long-term contract specifying all elements of future transactions. The fully-specified long-term contract is replaced by a more flexible long-term relational contract which is characterized by an ongoing process of negotiation over the terms of trade. Consequently, as we shall see below, long-term contracts in the coking coal industry can be structured to approximate spot market conditions more closely.

V. FACTORS AFFECTING RENEGOTIATED PRICES IN LONG-TERM CONTRACTS

Long-term contracts can increase the overall value of exchange to both parties by specifying ex ante the terms of trade over future years. Prespecified contract prices can, however, cause problems when market conditions change dramatically. Since the early 1970s, the world coking coal market has experienced considerable price volatility. This was due to volatile world oil prices and increased competition in the world steel industry stemming from new steel mills built in developing countries. Coking coal prices increased more than three times from the early 1970s to the early 1980s, and then decreased over 50 percent by 1987. As a result, prespecified price escalation provisions were abandoned in a majority of long-term contracts. Instead, the Japanese steel mills, importers, and coking coal producers held annual conferences to examine prices and other contractual terms in light of current market conditions. Virtually all long-term contracts were perceived as open for adjustments. Long-term contracts in the coking coal industry represent, therefore, a commitment by the two parties to exchange, but their terms are only a baseline from which renegotiation begins when market conditions change. While these annual renegotiations have, in general, been tough but successful,[10] an interesting question concerns the determinants of the renegotiated prices.

Renegotiated price in a relational long-term contract can be affected by a number of factors.[11] First, market structure may affect prices if either buyers or sellers possess market power. For example, if a buyer has monopsony power, the price will be lower in this market than in other markets. Second, transaction-specific investments can affect prices. A coal firm's investment in additional coal-mining capacity represents a dedicated asset that allows a steel firm to earn rents by contracting for a secure supply of coal. The steel firm can reduce the probability that the coal firm will not supply coal by sharing a portion of the security rents with the coal firm. Such sharing takes the form of a higher contract price.[12] Finally, because coking coal is a product with a wide range of quality specifications, its price should reflect the attributes of the particular type of coal specified in the contract. Therefore, it is expected that the following relationship holds:

$$P = f(M, T, Q) \tag{1}$$

where P is contract price, M is a vector of market power variables, T is a vector of specific-capital proxies, and Q is a vector of product attributes. Based on (1), a reduced-form model is constructed to test the impact of different factors on contract prices.

Market structure is of particular interest because there have long been allegations of consumer monopsony or oligopsony in Japan's coking coal procurement.[13] A typical outcome of monopsony power, a transaction situation in which a single buyer faces a large number of independent sellers, is the mark-down of prices.

Japanese steel mills' coking coal procurement takes place in the following primary areas: the United States, Canada, New South Wales and Queensland in Australia, China, and the former USSR. The geographic market boundaries are defined asymmetrically for buyers and sellers. While Japanese firms are able to procure coal from firms in a variety of countries, exporters are heavily constrained by the very large size of the Japanese market. Transportation costs also separate producers into geographic markets; coking coal prices are specified in all contracts as FOBT prices.[14]

The outcome of individual transactions is significant in the coking coal trade because of the way transactions are organized. As discussed before, a majority of coking coal is traded under the framework of long-term contracts. There is no well developed spot market, therefore no widely quoted market price. The price and nonprice provisions specified in each contract are the outcomes of bilateral negotiations. Because of specific capital investments made by both buyers and sellers, there are gains to repeated dealings over an extended period and to specifying a contractual framework which protects each party's investment in specific capital. Direct measures of the extent of some transaction-specific assets have, however, not yet been established; and available information on Japanese overseas coking coal procurement transactions makes it impossible to measure all types of relevant transaction-specific capital. In the absence of direct measures, we use contract quantity and duration as proxies for transaction-specific capital to examine their effects on contract prices.

Contractual quantity is closely related to the concept of "dedicated assets".[15] If a buyer and a seller sign a long-term contract which requires a large quantity of coal to be delivered, a breach by either party would make it difficult for the other party to dispose quickly of unanticipated surplus at a compensatory price (if the buyer breaches), or to replace supplies at a comparable price (if the seller breaches).[16] The two parties have an incentive to share the security rents such that the wealth of the two parties is maximized (Hashimoto, 1979).

If the buyer of large quantities reneges, the supplier is left with excess capacity. Therefore, suppliers of large quantities would demand a higher price to compensate for costs incurred from the delay in finding a new buyer. On the other hand, buyers of large quantities also would incur significant losses if a seller reneges, as the steel plant must cut back on its output until it arranges for new deliveries. Buyers demand a lower price to compensate for the interruption in operations. Thus specification of the rental shares depends on which party is most likely to renege on the contract and their ability to find a new buyer or seller. Neither argument presupposes a risk premium; risk neutral suppliers and buyers who have made specific capital investments have incentives to incorporate a price premium in their contracts to maximize their joint wealth.

The duration of a contract is also related to the extent of investment in transaction-specific assets. Presumably, suppliers with longer-term contracts often have larger specific capital investments, such as exploration activities to guarantee proper reserve/output ratios, investments in improved delivery facilities, etc. From the buyers' point of view, long-term contracts also secure a supply of inputs for facilities that are specific to the input. Joskow (1988, pp. 66-67) analyzed the potential effect of contract duration on the initial base contract price. He argued that if the buyer or the seller tried to use the level of the base price as a "financial hostage," rather than relying on variations in the term of the agreement to amortize relationship-specific investments, the base price could vary systematically with the negotiated term of the agreement. Joskow also included a duration variable in his renegotiated price regressions and found that it was always insignificant. We include two duration variables in our renegotiated price regressions, as they represent additional, albeit imperfect, measures of investment in specific capital.

Coking coal prices should presumably vary directly with product quality. Anderson (1987) found that Japanese steel mills offered a wide range of prices for coking coals of similar quality and concluded that the price variation reflected monopsony power; the variation in prices may, however, reflect variation in coal attributes that Anderson's study did not consider.[17] There are two important quality criteria for coking coal that are widely used in the steel industry: "caking properties" which allow the coal to be converted into a coke suitable for use in large modern blast furnaces and "carbon content" which facilitates the conversion to carbon monoxide gas so as to reduce iron ore to iron.

VI. EMPIRICAL TESTS OF DETERMINANTS OF CONTRACT PRICES

A. The Data

The contract data used in this study are from the *Coal Manual.*[18] It provides information on all long-term contracts (including annual contracts) between Japanese coking coal importers and producers in supplying countries. A brief abstract for each contract specifies the importer, producer, date, duration, price, quantity, quality specifications, price escalation clause, penalty, loading port, delivery schedule, etc. The data used in the empirical analysis include contract samples for 1986 (65 contracts) and for 1989 (70 contracts), yielding a pooled sample with 135 observations.[19]

B. Variables associated with market structure

One proxy for market power is a concentration index, a summary statistic reflecting the distribution of firms in an industry. Three concentration indexes, the Herfindahl index, the 2-firm concentration ratio, and the 4-firm concentration ratio, are employed to measure the market power of Japanese importers. Table 4 reports concentration levels for Japanese importers in each of eight markets for 1986 and 1989, respectively.

Concentration indexes for producers are not incorporated in the empirical analysis. First,

Table 4. Buyers' Market Concentration Indexes

	1986			1989		
Market	Herfindahl	C2	C4	Herfindahl	C2	C4
U.S.A.	0.149	0.489	0.651	0.192	0.578	0.738
Canada	0.177	0.471	0.768	0.164	0.438	0.741
New South Walse	0.188	0.331	0.585	0.113	0.353	0.559
Queensland	0.280	0.726	0.858	0.247	0.674	0.831
China	0.072	0.245	0.419	0.073	0.267	0.441
USSR	0.136	0.437	0.634	0.150	0.458	0.674
S. Africa	0.438	0.752	1.000	0.480	0.823	1.000
Others	0.292	0.750	0.882	0.327	0.786	1.000

calculation of concentration indexes for producers in some planned economies (such as China or the former Soviet Union) involves difficult conceptual problems. Second, there is an implicit assumption in the previous literature that coal suppliers do not possess market power. The lack of price-setting power for producers is not surprising. Since the early 1980s, overcapacity has been present in some major exporting countries, particularly Australia and Canada.[20] Producers in other markets who took action to increase prices by limiting supply would find the supply reduction offset by additional output from Canada and Australia or from new facilities in the Soviet Union and China aggressively pursuing opportunities to earn hard currency.

C. Variables associated with transaction-specific capital

Contractual quantity (*QNT*) and contract duration (*LTD*, *EGD*) serve as proxies for the importance of specific capital. Hubbard and Weiner in their study of contracting in the U.S. natural gas industry considered contract quantity to be a measure of cost, as they assert the presence of economies of scale in transmission of natural gas. In our study *QNT* could also be picking up economies of scale in coal transportation as well as the presence of specific capital. In addition, Hubbard and Weiner (p. 43) consider contractual quantity to be an exogenous variable as "gas wells, once sunk, produce at maximum sustainable yield because of transmission-cost considerations and the common-pool problem." Coal quantity is, however, more likely to be an endogenous choice variable, as coal mining has neither a common pool problem nor the transmission cost economies peculiar to natural gas; most importantly, mine owners can adjust quantity in response to renegotiated prices. Thus, in addition to an OLS specification of the price equation, we also experiment with an instrumental specification for the quantity variable.

Contracts are divided into three groups which are based on the length of the buyer-seller relationship: long-term contracts, evergreen contracts, and annual contracts. Two dummy variables are constructed to capture their difference: dummy *LTD* with a value of 1 if the duration of the contract is longer than or equal to 5 years and dummy *EGD* with a value of 1 if the contract is evergreen. Thus, the base case is the annual contract. While the initial contract price and contract duration are set simultaneously, contract duration is exogenous to the renegotiated price.

D. Quality-related variables

As discussed above, there are five quality specifications in the two contract samples: total moisture (*MST*), ash content (*ASH*), volatile matter (*VLM*), total sulfur (*SLP*) and crucible swelling number (*CSN*). The first three are actually indirect measures of the carbon content in a particular coal, because carbon content is calculated as a residual by subtracting the percentages of moisture, ash and volatile matter from one hundred. Moisture consists of free water and is lost when the coal is heated in the coke oven. Coals with high moisture content yield less fixed carbon in the coke than other coals. Ash consists of all inert substances that remain behind when the coal is completely burned. The higher the percentage of ash, the lower the amount of available fixed carbon. Volatile matter consists of the organic chemical compounds that escape as gases when the coal is heated in a vacuum. Coals with high volatile matter lose more mass when heated in the coke oven; thus the coke yield of fixed carbon is low for such coal. Therefore, it is expected that the price of coking coal is negatively related to the presence of moisture, ash, and volatile matter. Total sulphur is also related to carbon content; but since its magnitude is rather small compared with the first three quality measures, it is more important as an environmental indicator. Crucible swelling number is one of the most common, simple caking tests. Its value ranges from 0 (no caking characteristics at all) to 9 (superior caking properties). So as the crucible swelling number increases, the contract price should also increase.

E. Additional dummy variables

Finally, two additional dummy variables are introduced. Dummy variable *EPC* is used to distinguish the transaction prices of fixed-price contracts and those of escalating price contracts. While this variable is endogenously determined with the initial price when the contract is executed, it is exogenous to the determination of renegotiated prices. The dummy variable YRD is used to distinguish the contracts in force in 1986 and 1989. Definitions and summary statistics for all variables are reported in Table 5.

F. Regression Specifications and Estimated Results

The primary interest of the empirical analysis is in estimating the effect on contract prices of the market-structure factors, the transaction-specific factors, and coal attributes. If only one group of factors matters, the estimated coefficients on all other variables are expected to be zero. The three groups of variables are, however, not necessarily exclusive, and their separate effects on coking coal prices are reflected in the magnitude and significance of the estimated coefficients.

The reduced-form price equation is specified as follows:

$$P_{ijk} = \alpha + \beta M + \gamma T + \eta Q + \theta D + \epsilon \qquad (2)$$

where:

i, j, k: denote buyers, sellers, markets respectively;

Table 5. Variable Definitions and Summary Statistics

Variables	Descriptions	Mean	St.Dev.	Minimum	Maximum
P	Nominal transaction price in dollars/ton	47.31	8.48	32.00	74.50
BHI	Buyers' Herfindahl index	0.19	0.09	0.07	0.48
BC2	Buyers' 2-firm concentration ratio	0.50	0.17	0.25	0.82
BC4	Buyers' 4-firm concentration ratio	0.71	0.15	0.42	1.00
QNT	Quantity dedicated in a contract (10^6 ton)	0.88	0.95	0.01	5.10
LTD	Dummy equals 1 if long-term contract		47 Observations		
EGD	Dummy equals 1 if evergreen contract		51 Observations		
MST	Total moisture (%)	8.07	1.33	2.40	10.00
ASH	Ash content (%)	8.62	2.19	2.00	25.00
VLM	Volatile matter (%)	28.96	6.19	17.00	42.00
SLP	Total sulphur (%)	0.65	0.25	0.30	1.60
CSN	Crucible swelling number	5.66	2.30	0.50	9.00
EPC	Dummy equals 1 if escalating price contract		14 Observations		
YRD	Dummy equals 1 if 1986 observation		65 Observations		

P: the transaction price in a contract between the *i*th buyer and *j*th seller in the *k*th market;

M: $M \in$ {*BHI, BC2, BC4*}, variables measuring market structure;

T: *T* = (*QNT*, *LTD*, *EGD*), variables measuring transaction-specific variables;

Q: *Q* = (*MST*, *ASH*, *VLM*, *SLP*, *CSN*), variables measuring coal quality attributes;

D: *D* = (*EPC*, *YRD*), dummy variables used for contract types and transaction year.

Equation (2) is estimated with OLS, and results are reported in Table 6. The three market structure variables produce three different specifications.[21] Each specification yields similar results in terms of the signs and significance of the estimated coefficients, indicating that the analysis is robust to the different measures of market power.

The estimated coefficients on the Japanese importers' concentration ratio (*BC2* and *BC4*) and the Herfindahl index (*BHI*) are negative and statistically significant, implying that the more concentrated are the Japanese importers, the lower the transaction prices of coking coal, other things equal. These results are consistent with the popular, yet much debated, view that Japanese importers exercise market power in procuring coking coal.

The estimated coefficients on the group of transaction-specific variables (*QNT*, *LTD*, *EGD*) have the expected positive signs and are statistically significant, indicating that the prices of larger-quantity contracts, long-term contracts, and evergreen contracts are significantly higher than those of annual contracts. These estimates suggest that coal producers who sign larger quantity supply contracts or longer-term contracts succeed in obtaining higher prices. In both cases, producers have invested in additional specific capital, while Japanese steel mills are provided with a more stable supply of coking coal. The small difference between the estimates of *LTD* and *EGD* reveals that prices in long-term contracts are not significantly different from

Table 6. OLS Estimates of the Contract Price Determination Equation

Variable	P	*t*-value	P	*t*-value	P	*t*-value
BHI	-15.718	(-3.03)	..	..	..	..
BC2	..	..	-7.517	(-2.53)	..	..
BC4	..	..	..	..	-9.237	(-2.74)
QNT	2.010	(3.82)	1.926	(3.64)	2.012	(3.79)
LTD	3.024	(2.52)	3.266	(2.70)	3.405	(2.82)
EGD	2.522	(2.34)	2.725	(2.51)	2.889	(2.68)
MST	-0.085	(-0.26)	0.007	(0.02)	-0.073	(-0.22)
ASH	-1.040	(-4.53)	-1.042	(-4.40)	-1.055	(-4.48)
VLM	-0.333	(-3.44)	-0.331	(-3.33)	-0.348	(-3.47)
SLP	2.720	(1.29)	2.581	(1.20)	2.497	(1.18)
CSN	0.639	(2.69)	0.770	(3.35)	0.695	(2.96)
EPC	12.867	(8.27)	12.758	(8.11)	12.726	(8.15)
YRD	0.447	(0.54)	0.348	(0.42)	0.392	(0.47)
Constant	58.836	(10.01)	58.173	(9.66)	62.470	(9.29)
N	135		135		135	
Adjusted R^2	0.7044		0.6980		0.7005	

those in evergreen contracts.[22]

The estimated coefficient of the dummy variable *EPC* is positive and significant, indicating the average price negotiated in escalating price contracts is \$12-\$13 dollars per ton more than in fixed-price contracts. This result stems from the imperfect nature of most price adjustment clauses: they usually do not replicate the market price of the good. Significant differentials between the spot price of the good and the specified "adjusted" price may arise; the party which is most susceptible to breach when the contract and spot prices diverge will be willing to pay a premium to prevent the breach.[23]

The estimated coefficient of the dummy variable *YRD* is very small and insignificant, suggesting that average prices were approximately the same in 1986 and 1989.

The five variables measuring coking coal attributes produce interesting results. While three of them (*ASH, VLM, CSN*) have the expected signs and are statistically significant in all three equations, the other two (*MST, SLP*) often (4 of 6 times) have the wrong sign yet are always insignificant at the five percent level. The estimated coefficients on *ASH, VLM* and *CSN* indicate, as expected, that the higher the content of ash and volatile matters, the lower the coking coal price, and that the higher the crucible swelling number, the higher price for the coking coal.

As noted before, the measurements of *MST*, *ASH*, and *VLM* together reflect one of the two important quality indicators of coking coal -- carbon content. It is interesting to examine the relationship between carbon content and contract price. Carbon content as a percentage is calculated as follows:

$$CBN = 100 - MST - ASH - VLM \qquad (3)$$

Equation (2) was reestimated by replacing *MST*, *ASH*, and *VLM* with *CBN*. Results are reported in Table 7.

While the estimated coefficients on other variables do not vary appreciably across the two models, both the estimated coefficients on *CBN* and on *CSN*, which are the two most important coal attributes, are significant and have the expected signs. It is noteworthy that the estimated coefficient on *SLP* has the wrong sign and is statistically significant. Sulphur content is, however, a relatively minor property of coking coal. Since Japanese steel mills typically use 16 or more coals in a particular blend, they are able to adjust for these minor properties by choosing from a large variety of available coal. Therefore, steel mills are relatively insensitive to these quality variations and are willing to purchase coals within a wide range of specifications over minor properties. They concentrate instead on the two major properties of coal - the fixed carbon content and the caking property.[24] Our estimated results show that the major attributes of coking coal are important determinants of its price.

From the early 1980s through 1987, the average price of coking coal decreased due to expanded coking coal supplies and lower demand resulting from the contraction of the steel industry in Japan and other industrial countries. The price has rebounded since 1987 largely because of increased demand from a buoyant world's steel industry (DOE/IEA, 1991). It is assumed that the balance of bargaining power would rest with Japanese importers during a period of decreasing prices, and with the coal producers during a period of increasing prices. Thus, an interesting question is whether the estimated relationships in the pooled sample are stable across both periods. To examine this issue, the model was run separately for contract data in 1986 and in 1989; estimated results are reported in Tables 8 and 9, respectively.

Table 7. Reestimates of the Contract Price Determination Equation

Variable	P	*t*-value	P	*t*-value	P	*t*-value
BHI	-12.119	(-2.31)	..	..	..	..
BC2	..	..	-4.832	(-1.65)	..	..
BC4	..	..	..	..	-6.636	(-1.96)
QNT	2.117	(3.91)	2.026	(3.73)	2.103	(3.85)
LTD	2.861	(2.07)	2.748	(2.21)	2.849	(2.30)
EGD	2.861	(2.80)	3.023	(2.71)	3.138	(2.82)
CBN	0.343	(3.54)	0.327	(3.32)	0.347	(3.48)
SLP	5.002	(2.48)	4.603	(2.25)	4.713	(2.33)
CSN	0.703	(2.88)	0.821	(3.48)	0.758	(3.14)
EPC	12.999	(8.56)	12.902	(8.33)	12.880	(8.44)
YRD	0.238	(0.28)	0.158	(0.18)	0.194	(0.23)
Constant	18.416	(3.75)	19.043	(3.86)	20.321	(4.16)
N	135		135		135	
Adjusted R^2	0.6829		0.6764		0.6972	

Table 8. OLS Estimates of the Contract Price Determination Equation, 1986

Variable	P	*t*-value	P	*t*-value	P	*t*-value
BHI	-15.330	(-1.56)	..	..	..	..
BC2	..	..	-7.248	(-1.27)	..	..
BC4	..	..	..	..	-7.518	(1.18)
QNT	2.600	(2.84)	2.499	(2.73)	2.550	(2.74)
LTD	3.423	(1.63)	3.490	(1.65)	3.818	(1.81)
EGD	4.063	(2.00)	4.129	(2.02)	4.430	(2.05)
MST	-0.034	(-0.05)	0.073	(0.12)	0.070	(0.11)
ASH	-1.059	(-3.13)	-1.064	(-3.05)	-1.053	(-3.01)
VLM	-0.564	(-3.17)	-0.574	(-3.16)	-0.577	(-3.15)
SLP	2.737	(0.71)	2.735	(0.70)	2.412	(0.62)
CSN	0.421	(0.87)	0.574	(1.24)	0.489	(1.00)
EPC	12.971	(4.21)	12.748	(3.99)	12.150	(4.04)
Constant	65.665	(6.27)	65.042	(5.97)	67.309	(5.45)
N	65		65		65	
Adjusted R^2	0.7110		0.7068		0.7056	

Table 9. OLS Estimates of the Contract Price Determination Equation, 1989

Variable	P	*t*-value	P	*t*-value	P	*t*-value
BHI	-17.870	(-3.28)	..	..	..	..
BC2	..	..	-9.656	(-3.00)	..	..
BC4	..	..	..	..	10.898	(-3.10)
QNT	1.708	(3.17)	1.672	(3.07)	1.657	(3.06)
LTD	2.631	(2.16)	3.204	(2.58)	3.046	(2.47)
EGD	1.513	(1.47)	1.874	(2.82)	1.921	(1.88)
MST	-0.096	(-0.28)	0.023	(0.07)	-0.081	(-0.24)
ASH	-1.278	(-4.04)	-1.297	(-3.99)	-1.323	(-4.06)
VLM	-0.189	(-1.93)	-0.185	(-1.85)	-0.210	(-2.05)
SLP	1.988	(0.95)	1.945	(0.92)	1.885	(0.90)
CSN	0.574	(2.62)	0.679	(3.18)	0.670	(3.15)
EPC	10.948	(5.69)	10.534	(5.31)	11.558	(6.03)
Constant	58.914	(9.27)	58.691	(9.02)	63.449	(8.73)
N	70		70		70	
Adjusted R^2	0.7249		0.7178		0.7204	

As can be seen from Tables 8 and 9, the estimated results are similar in most respects to the estimated results of the pooled model. The signs of all significant coefficients are identical in the pooled model and the individual models. Both individual models indicate that the basic determinants of coking coal price are consistent. One interesting difference between the individual models is that the estimated coefficients on market structure variables (*BHI, BC2* and *BC4*) are insignificant at the ten percent level in 1986 and significant at the five percent level in 1989. This result is consistent with our interpretation that the buyer's market structure is less important in price determination in a period when the average price is declining.

We also ran a model specification in which we corrected for possible simultaneity bias with respect to the quantity variable. Adjustments in the coking coal price could theoretically have substantial effects on the quantity of coking coal supplied. To correct for this simultaneity bias we substitute predicted values of the quantity variable from the reduced form estimation of this variable.[25] Results are reported in Table 10. Comparison with results (using the *BC2* concentration specification) from Tables 6, 8, and 9 reveals that the sign and significance of estimated coefficients does not change in the instrumental specification.

VII. CONCLUSIONS AND DISCUSSIONS

A majority of coking coal trade between Japanese steel mills and coal producers around the world takes place within a framework of long-term contracts. We hypothesized that transaction-specific assets are important factors determining the use of long-term contracts in the coking coal trade. For example, many coal mines and shipping facilities in supplying countries are dedicated to the Japanese coking coal trade. There are many special purpose ports, carriers, and bulk loading equipment built to minimize inventory and transportation expenses.

Table 10. 2SLS Estimates of Contract Price Determination Equations
With Quantity Instruments

	pooled		1986		1989	
Variable	P	*t*-value	P	*t*-value	P	*t*-value
BC2	-8.335	(-2.79)	-7.631	(-1.31)	-9.668	(-2.94)
QNT	2.335	(3.66)	2.710	(2.52)	1.605	(2.49)
LTD	2.845	(2.36)	3.448	(1.60)	2.600	(2.03)
EGD	2.545	(2.39)	4.400	(2.11)	1.243	(1.21)
MST	0.056	(0.17)	0.069	(0.11)	0.089	(0.24)
ASH	-1.027	(-4.31)	-1.028	(-2.90)	-1.321	(-3.94)
VLM	-0.331	(-3.32)	-0.526	(-2.82)	-0.216	(-2.14)
SLP	3.115	(1.43)	2.940	(0.74)	2.225	(1.00)
CSN	0.757	(3.27)	0.552	(1.17)	0.729	(3.34)
EPC	12.710	(8.05)	12.264	(3.82)	11.635	(5.85)
YRD	0.475	(0.56)	..	..	..	..
Constant	58.914	(9.27)	58.691	(9.02)	63.449	(8.73)
N	135		65		70	
Adjusted R^2	0.6967		0.7012		0.7003	

Our principal empirical findings can be summarized as follows. First, Japanese importers appear to exercise monopsony power in their coking coal procurement, as coking coal prices tended to be lower in markets where Japanese importers have higher concentration indexes. Second, transaction-specific capital (as indicated by contract quantity and contract duration) has a significant impact on coking coal price determination; Japanese steel mills paid a price premium for contracts with larger quantity or with longer duration. Third, though we find empirical evidence that Japanese steel mills are insensitive to some minor coal properties, the price of coking coal is strongly related to coking coal's two major quality attributes - fixed carbon content and caking property.

The results for the contract duration variables and the quantity variable contrast sharply with Joskow's (1988) estimates. He used contract duration as one of the independent variables in his regression analyses of base prices and transaction prices in long-term steaming coal supply contracts between coal mines and power plants in the United States. His empirical results showed that duration had no effect on base prices or on renegotiated transaction prices. He also found that "there does not appear to be a contract-quantity effect either" (p. 69, footnote 45).

The contrasting results are not particularly unexpected considering the different legal environments in which the respective firms are imbedded. A coal mine in the U.S. selling to a steel firm in the U.S. can appeal to the U.S. federal and state court system to enforce the provisions of a long-term contract. By contrast when the coal firm and the steel firm are located in two different countries, both firms may encounter higher costs of settling a dispute in the other country's court system and a lower probability of prevailing in the dispute. Two substitutes for court adjudication of disputes are to structure contracts such that they are more adaptable to circumstances and to make them self-enforcing (Telser, 1981; Klein and Leffler, 1981). The contracts between Japanese steel mills and foreign coal mines appear to embody both features. The yearly conference to renegotiate prices ensures a secure supply/demand for both parties without allowing transaction price to deviate substantially from the spot price. And the price premium, as reflected in the positive coefficients on the duration and quantity variables, binds the two parties to the contract by reducing the probability that either party will terminate the contract if there is a temporary price change (Hashimoto, 1979). In lieu of access to low-cost enforcement in the courts, the two parties have structured their long-term contract to ensure maximization of joint wealth.

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ENDNOTES

1. Joskow conducted a series of research projects on long-term coal supply contracts by using data from the U.S. steam coal market. See Paul Joskow, Vertical Integration and Long-Term Contracts: the Case of Coal Burning Electric Generating Plants, J. of Law, Econ. and Organ. 1 (1985); Contract Duration and Relationship-Specific Investment: Empirical Evidence from Coal Markets, AER. 77 (1987); Price Adjustment in Long-Term Contracts: the Case of Coal, J.of Law & Econ. 31 (1988); The Performance of Long-Term Contracts: Further Evidence from Coal Markets, Rand J. Econ. 21 (1990). Several authors analyzed long-term contracts in the U.S. petroleum industry and natural gas industry. See, for example, Crocker and Masten, Pretia ex Machina? Prices and Process in Long-Term Contracts, J. of Law & Econ. 34 (1991); Goldberg and Erickson, Quantity and Price Adjustment in Long-Term Contracts: A Case Study of Petroleum Coke; J. of Law & Econ. 30 (1987); Hubbard and Weiner, Efficient Contracting and Market Power: Evidence from the U.S. Natural Gas Industry, J. of Law & Econ. 34 (1991).

2. In the European market, import shares are more evenly distributed.

3. The remaining six percent is taken by chemical and other industrial firms.

4. The U.S. producers have access to a large, though declining, domestic market, and their remaining sales can go to Europe and other regions.

5. Smith wrote a series of articles on long-term contracts between firms in Japan and Australia. His work, though not directly targeted on long-term contracts in coking coal trade, provides information on how long-term contracts are structured in international trade. See, for example,

Ben Smith, Long Term Contracts in Resource Goods Trade, 1976; and Long-Term Contracts and Financial Arrangements for Mineral Development, 1980, Center for Resource and Environmental Studies, The Australian National University.

6. A similar definition is used by Rogers and Robertson who examined long-term contracts in the world's raw iron markets. Not surprisingly, this definition is somewhat arbitrary. Japanese steel mills define a long-term contract as a contract with a duration longer than one year. See Rogers and Robertson, Long Term Contracts and Market Stability: the Case of Iron Ore, Resources Policy, 13 (1987).

7. Other reasons for the use of long-term contracts have also been suggested, such as risk aversion, information lags and income effects; see, for example, Hart and Holmstrom, The Theory of Contracts, 1987.

8. Physical asset specificity may also be important in the coking coal trade, as coking coal is a product with several important attributes. It varies in terms of its caking characteristics, carbon content, ash, sulphur and so on. Steel mills are designed to produce a particular mix of products, with different processes requiring a particular mix of the coking coal. To find an optimal mix, steel mills usually experiment with different mixes for several years and only then commit to full capacity operation. Once the mill operates near capacity, substitution between alternative coal sources is limited and involves substantial cost penalties.

9. While evergreen contracts are conceptually considered to be long-term contracts in this study, they are separated into an individual group for expository reason. In calculations for Table 3 and in our empirical analysis, an evergreen contract is defined as a contract with a duration from

two to five years and annual contracts which follow the expiration of a contract with a duration of over 5 years.

10. Perhaps the only exception is the 15-year contract of Quintette coking coal of Canada. Because of unfavorable financial conditions, the Canadian mine refused a price reduction requested by the Japanese steel mills. The contract dispute finally developed into such an unprecedented case that the Japanese steel mills appealed to a court of arbitration in British Columbia province.

11. Several empirical studies looked at the issue of pricing in long-term contracts. For example, Joskow (1988) analyzed price adjustments in long-term contracts in the U.S. steam coal market, and Hubbard and Weiner (1991) examined the determinants of contract prices in the U.S. natural gas industry; *supra* note 1.

12. This analysis does not require that either firm be risk averse. In addition, investment in a specific asset does not imply a lower marginal cost of production. The rents are generated by reducing the uncertainty encountered by both buyer and seller. Hashimoto discussed how a cooperative buyer and seller can set rental shares to maximize joint wealth; see Hashimoto, Bonus Payments, On-the-Job Training, and Lifetime Employment in Japan, JPE, 87 (1979).

13. While Anderson concluded that Japanese steel mills exercised monopsony power in their coking coal procurement, D'Cruz just assumed that Japanese steel mills were colluding, i.e., that they "operated as a single customer unit". See Anderson, An Analysis of Japanese Coking Coal Procurement Policies, Ontario, Canada: Center for Resource Studies, Queen's University, 1987; and D'Cruz, Quasi Integration in Raw Material Markets, Unpublished D.B.A. Dissertation,

Harvard University, 1979.

14. Areeda and Turner defined a market's boundaries by the following criterion: "a firm or group of firms, which if unified by agreement or merger, would have market power in dealing with any group of buyers". See Areeda and Turner, Antitrust Law III, Boston: Little, Brown, 1978 (p. 347). Presumably there would be a similar definition with respect to buyer market power. Landes and Posner defined market power as "the ability of a firm (or a group of firms, acting jointly) to raise prices above the competitive level without losing so many sales so rapidly that the price increase is unprofitable and must be rescinded." See Landes and Posner, Market Power in Antitrust Cases, Harvard Law Rev., 94 (1981), p.937.

15. In his pioneering work, Joskow (1987, *supra* note 1) employed contract quantity as a proxy for dedicated assets in his empirical analysis of the relationship between transaction-specific assets and contract duration.

16. Given producer overcapacity in Canada and Australia, a breach by a buyer may have more impact than a breach by a seller.

17. For example, Anderson (1987, p. 72, *supra* note 13) stated that "perhaps the strongest evidence to support the allegations that the Japanese steel mills exercise significant market power is their current practice of paying widely varying prices for coal of similar quality."

18. The *Coal Manual* is published regularly by The Tex Report, Ltd.

19. Contracts in force in 1986 differ from contracts in 1989 because over this three-year period, the average coking coal price rebounded.

20. There are two views on how this over-capacity situation was created. The conspiratorial view contends that the situation was deliberately created by Japanese government and Japanese steel mills. The proponents of anti-conspiratorial theory do not dispute the existence of over-capacity during the 1980s but suggest that most of the problems were caused by an unanticipated decline in the long-term demand for steel. For some detail, see Anderson, *supra* note 13.

21. Specifications of equation (2) passed Ramsey's test for residual non-linearities. In this test, the dependent variable is regressed on the model's prediction and the square of the prediction. If there are no residual non-linearities, then the coefficient on the predicted variable should be insignificantly different from 1.0, while the coefficient on the squared predicted variable should be insignificantly different from zero. See Ramsey, Classical Model Selection through Specification Tests, 1974.

22. The null hypothesis that the estimated coefficients on *LTD* and *EGD* are equal can not be rejected by a t-test at the five percent significant level.

23. Escalating price contracts were mostly used in contracts with Canadian mines.

24. For a more detailed discussion of Japanese steel mills' preferences concerning coking coal quality, see Matsuoka, Requirements for Coals in Japanese Coking Blends, 1975.

25. For instruments we used all of the variables in the price regression as well as the market share of the seller in the particular market.