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Evaluation of risk strategy and market efficiency in the international coal market: A case study of the Japanese coking coal market

Wang, Tianchi, Ph.D.

The University of Arizona, 1992

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EVALUATION OF RISK STRATEGY AND MARKET EFFICIENCY IN THE INTERNATIONAL COAL MARKET —— A CASE STUDY OF THE JAPANESE COKING COAL MARKET

by

Tianchi Wang

A Dissertation Submitted to the Faculty of the

DEPARTMENT OF MINING AND GEOLOGICAL ENGINEERING

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY
WITH A MAJOR IN MINERAL ECONOMICS

In the Graduate College

THE UNIVERSITY OF ARIZONA

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As members of the Final Examination Committee, we certify that we have read the dissertation prepared by Tianchi Wang

entitled Evaluation of Risk Strategy and Market Efficiency in the International Coal Market -- A Case Study of the Japanese Coking Coal Market

and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Dorcot Philosophy

DeVerle P. Harris — Date 5/13/92

Michael Rieber — Date 5/13/92

Richard Newcomb — Date 5/13/92

Lester Taylor — Date 5/13/92

Date

Final approval and acceptance of this dissertation is contingent upon the candidate's submission of the final copy of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Dissertation Director
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ABSTRACT

Market efficiency and buyers' risk strategy in the Japanese coking coal import market are examined. The Japanese coal market is found to be inefficient, Japanese buyers traditionally have purchased coals from the United States at a high price and, since the second half of the 1980's, have paid the highest average price to Canadian producers. Given the abundant low cost Australian coals, this purchasing pattern does not meet the cost minimization criteria for efficiency. This is explained mainly by the buyers' risk management strategy.

To more accurately examine price differentiation, the complexity of coal quality is considered first. A statistical method is used to estimate the quality premium as a cost component in price formation. Next a comparison of supply regions and a detailed investigation on market conduct is based on quality-adjusted prices, which are assumed to represent the prices of homogenous coals. Although various reasons are used by researchers to explain Japanese buyers power, this study finds vertical integration of the Japanese companies to be the most important factor creating that power. A detailed survey of vertical integration is made.

Finally, a monetary value of the risk premium is estimated by using the partial elasticity of substitution. Total payments by Japanese coking coal buyers for risk premiums are estimated. These represent the extra dollars paid by the Japanese to US and Canadian coal producers for purchasing their coals instead of Australian coals.

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1. INTRODUCTION

1.1 Statement of the Problem

For researchers interested in international mineral commodity markets, coal trade market is an excellent case study. As a widely traded mineral commodity, coal is distinguished from most other minerals by its complex quality and the large cargo volumes traded. As in crude oil trade, natural differences among producers are created by coal quality and geographic location. These natural differences combine with some economic conditions, such as prices, and non-economic conditions, such as reliability of shipping, to provide different levels of advantage or disadvantage for each producer. In the coal market, especially the coking coal market, market equilibrium and purchasing decisions are based on combinations of these advantages and disadvantages. Most prior research focuses on one or two aspects of the market and ignores or over simplifies others. The contribution of this dissertation is to include all of these aspects in order to more comprehensively realistically explain the Japanese coking coal market.

Compared with other research, the emphases of the present dissertation are on a careful, detailed market and business survey, an intensive study and evaluation of coal quality, and finally, an analysis of the risk management strategy of Japanese buyers, which determine market shares of producers. Hopefully, this study will be beneficial to these people who are interested in the international coal market and businessmen who actually trade with the Japanese.

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Most previous research concerning this coal market was done before 1988. Therefore, there are many hypotheses about why the US coals are expensive, but few systematic works investigating how Canadian coal has become expensive and what was the initiation of this new phenomenon. Another contribution of this dissertation is a rationalization of the Canadian coal mines, prices, and trade with Japan.

A conventional way to analyze trade patterns is to assume perfect competition, certainty, and rational behavior. Failure to explain trade patterns requires modifying these assumptions or introducing new methods. Much work has been done comparing the competitiveness of each coal supplier to the Japanese market. These include the cost comparisons between US coal mines and Australian, Canadian and South African coal mines by the US Bureau of Mines. Instead of studying supply, this study takes the view of consumers in order to understand how Japanese buyers make purchasing decisions under given supply and other market conditions and how import shares are distributed among coal producers for a given market condition.

Consider the prices and shares of each of the suppliers that ship coal to the Japanese coking coal market. If the market is efficient, the share of each supplier would be determined by the minimum cost solutions for given prices. If the least cost allocation differs significantly from observed data, there must exist an implicit cost or benefit which is not represented in the simple model. (Figure 1.1).

The major regions supplying the Japanese coal market are the United States, Canada, Australia, the Republic of South Africa, Russia, and China. Among these countries, Australia has taken the place of the United States in the last 15 years,

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becoming the largest supply region. Although the market share of US coal exported to Japan has declined over the years due to its higher delivered price, the US is still the third largest supplier to Japan during the recent, long period of overcapacity. The latest phenomenon is that since 1985 Canada has taken over the US position as the most expensive coal supplier to the Japanese coking coal market.

Figure 1.1 shows CIF prices per ton of coal at the Japanese import ports. It can be divided into two periods; prior to 1985 and after: (1) Until 1985, average US coal prices were substantially higher than the prices of other producers - most previous research examined this period of market practice; (2) after 1985, Canada took the US position of the highest cost supplier to the Japanese coking coal market. This phenomenon is seldom mentioned by researchers since most of their studies of this market were done before 1988.

Simply stated, this study seeks to understand why the Japanese continuously purchase coking coal from the US and Canada in large quantities at prices that appear to be above those paid for coking coals from other supply regions. Given the practice of blending coals to meet the requirements of coking ovens and the availability of large coal resources close to Japan, why does Japan continue to purchase coking coals from the high cost regions? How can one explain this apparently inefficient choice?

Possible explanations include the following: The higher prices paid to the US producers are due to their higher coking quality. If so, can these purchases and prices be justified by quality differences? When quality differences are accounted for in the purchases made by the Japanese steel mills, the purchasing shares should be consistent

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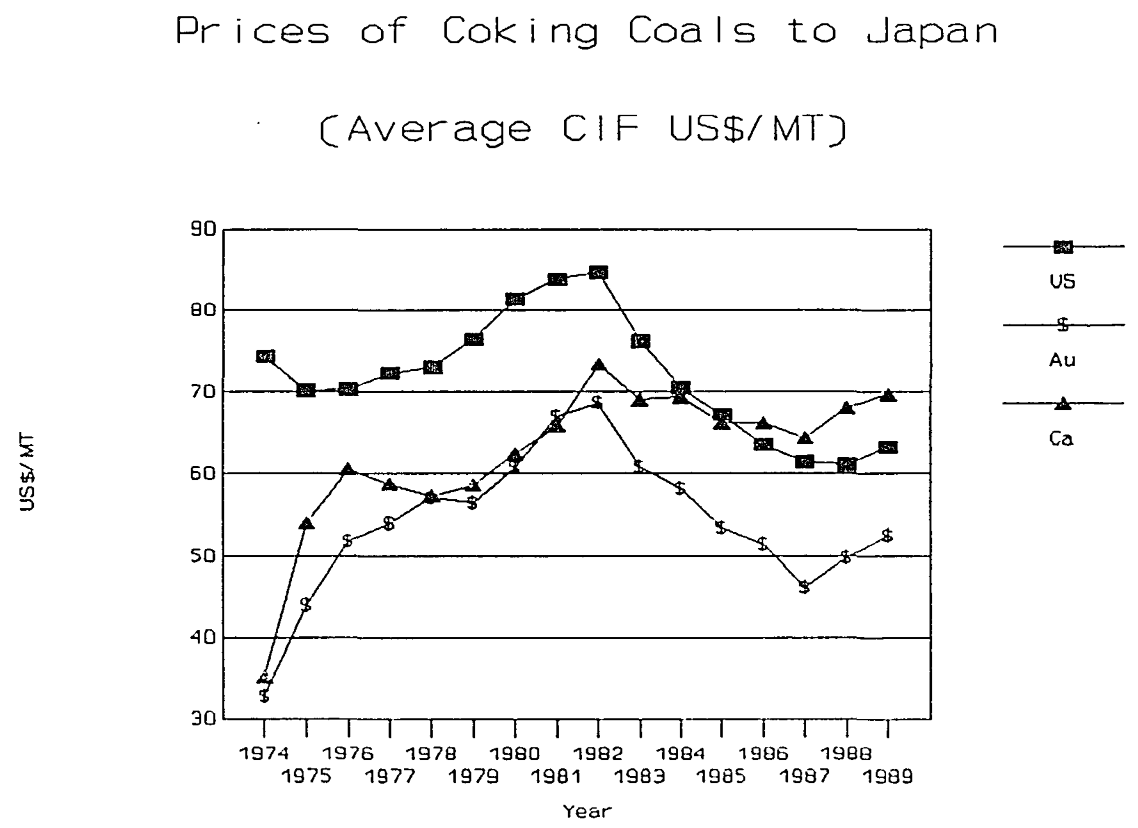

Figure 1.1 CIF Prices of Coking Coal to Japan From Three Large Producing Countries

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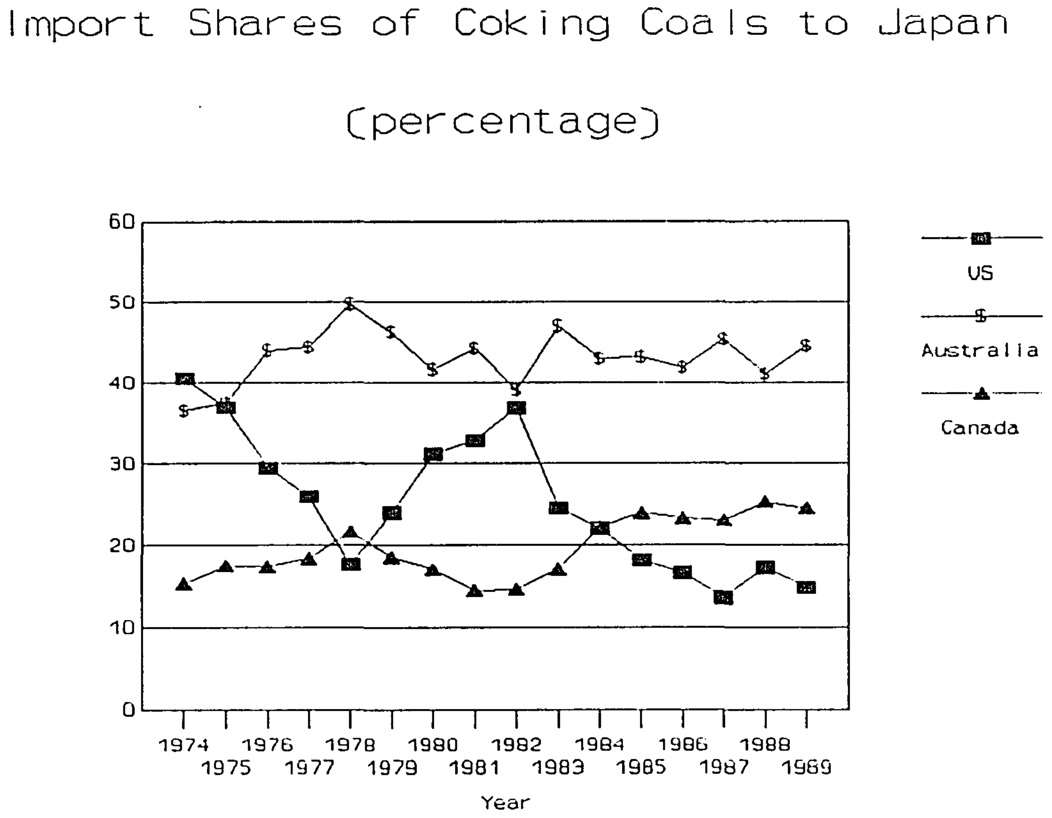

Figure 1.2 Import Shares of Coking Coal to Japan From Three Large Producing Countries

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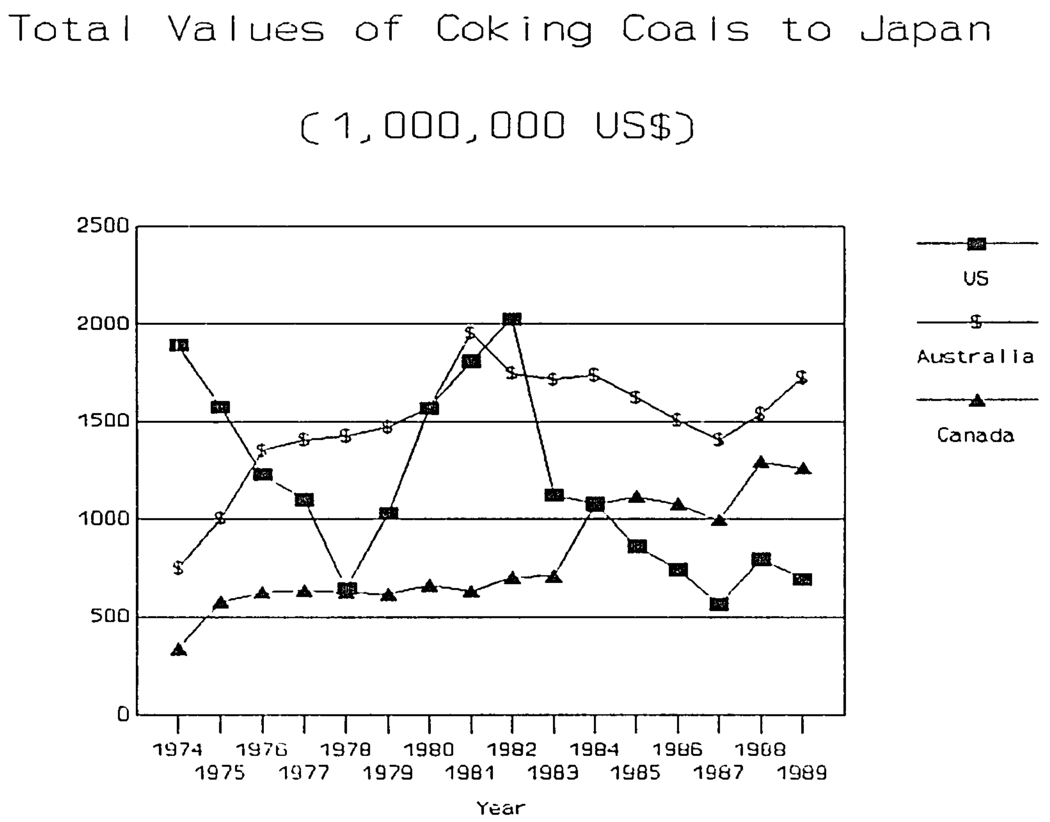

Figure 1.3 Total Values of Coking Coal to Japan From Three Large Producing Countries

with a minimum cash cost solution, provided that quality differences, transportation costs, and coal costs are adequately represented. This argument is especially mentioned by businessmen.

Second, to assure coal supply with the required qualities is always the top priority of the Japanese decision makers. In other words, the decision made by the steel mills includes risk as well as quality features of the coal from each supply region. Some research supports this argument, but explanation are divided concerning as to how this is achieved by the Japanese.

The third possibility is that purchases are " tied " to other political or economic activities. In this paper, the forming of a vertically integrated industry is considered an essential factor.

1.2 Literature Review

1.2.1 Market Structure and Efficiency

Relevant literature is reviewed in detail in chapter 4; consequently, the review provided here is general and brief.

Some researchers (Baylis, 1984; etc.) considered the world coal trade market to be a competitive market and believed that it would remain competitive. Other researchers have alternative views of the market conduct of world coal trade (Kolstad and Abbey 1984, Wolak and Kolstad 1991, etc.). They try to explain the world coal market by a non-competitive market model or by risk diversification behavior. However, most of these works are partial analyses and suffer some deficiencies.

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Kolstad and Abbey (1984) pointed out that simple competitive market models failed to explain most of the cases in the coal and grain markets. They also criticized those works which use institutional factors.

Wolak and Kolstad (1991) limited their work to the Japanese steam coal market. The focus of their work was mainly on quantitatively demonstrating how Japanese buyers make their decisions based on a risk minimization strategy. The imperfection of the coal market is assumed as given or proven.

Many people complain that the Japanese play an unfair game by forming a buyers' cartel and by acting as one buyer with the government assisting in the coking coal import market. Especially, they think this institutional factor plays a very important role in assisting the Japanese gain of and exercise of market power. The Japanese government, primarily through the activities of MITI (Ministry of International Trade and Industry), has long promulgated the collective purchasing of raw materials (D. Rodrik, 1982;C.Johnson, 1983; D'Cruz 1985; and O'Grady 1985; D.Anderson 1987; etc.). David Anderson systematically investigated the institutional issues: his well written paper is based on numerous materials.

1.2.2 Methodology

To take quality into consideration, Henderson (1958) and Kolstad (1991) used a very simple method to modify data which are based only on weight. Both of them used Btu content to replace the weight of coal before doing any economic analysis. Bennett (1975) did much intensive research to convert the quality parameters to a cost

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component. (See Chapter 3).

To test market efficiency, linear and quadratic programming are commonly used. An early study by James Henderson (1958) analyzes the competitiveness of the US coal industry with a linear programming model. His linear programming model was used to test the efficiency of the US coal market. Noticing that there is almost no ideally competitive industry and that the conditions of perfect competition are violated in the real world, instead of analyzing whether the industry is in perfect competition, Henderson studied "how closely" its competitive conditions. Since an homogeneous assumption for coal quality cannot satisfy real data and consumers do not judge coals on the basis of weight, quality differentiation was considered in a simple manner. Henderson used Btu as an output quality index for coal, and converted all cost data from that based on weight to that based on Btu content.

Opportunity cost is another interesting idea used by Henderson in his paper to define the delivery cost (including transportation cost) differentials between different supply regions to each of the demand regions. The way he described opportunity cost implied that there is no price discrimination in a demand area. In the present study these differences are explained differently.

The static linear model is limited, as it is a short run model which is constrained by fixed total demand, capacity and costs. The variation from the optimum solution was explained by two sources of inefficiencies: secular inefficiency which persists year after year with little or no prospect of elimination through the automatic workings of the market. Overcapacity seems to be the major reason for secular

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inefficiency. Cyclical inefficiency, on the other hand, is primarily a result of temporary interruptions. Total demand shifts due to changes in the final demands of energy or steel or labor strikes could cause a cyclical inefficiency.

Using programming, Kolstad (1984) tested four different models representing different market conduct in the world steam coal trade. To determine which was the best model, two measures, the Theil (1961) inequality coefficient and the Spearman rank correlation coefficient (Conover, 1980), are used. The analysis showed that the simple competitive model failed to yield the observed trade patterns. (Chapter 4)

To estimate risk, various methods have been introduced. Some of them measure the risk attitudes of persons (Arrow, 1971 and Pratt, 1964). Others measure the monetary values of risk premiums. Arrow and Pratt compared an individual's von Neumann and Morgenstern (1947) utility function to actuarial behavior to derive the measure of risk attitude. If we denote an individual's von Neumann-Morgenstern utility function as u(x), then the Arrow-Pratt measure of risk is defined as

$$r(x) = - u''(x)/u'(x)$$

Dyer and Sarin (1982) used a measurable value function to measure an individual's strength of preference for alternatives in the absence of stochastic risk. This function can be assessed using difference equations.

No commonly accepted theory has been developed on how to obtain risk premiums; consequently, the estimates are often obtained by applying other theories, and the monetary values of risk premiums are commonly estimated by the deviations from equilibrium.

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1.3 Structure of This Dissertation

Chapter Two investigates current metallurgical coal market conditions and business practice. The current situation of each stage of coal trade, from mining, transportation, trading to consumption, is reviewed. Specifically, a detailed survey is made of coal contracts.

Chapter Three discusses the quality factor of coal in trade. A technical background review of, coal blending and its impact on quality requirements for coal is provided first. Then, the quality premium is estimated through regression analysis of observed market data. After these quality premiums are obtained, prices are adjusted to reflect the approximate prices of coals with an homogenous quality, which is crucial in subsequent study.

Chapter Four studies market structure and focuses on vertical integration. The purpose of this chapter is to disclose the Japanese long term strategy of securing natural resource supply as a means to answering the question: why do the Japanese continue to buy Canadian coal at high prices?

Chapter Five uses partial elasticity of substitution to estimate the monetary values of the risk premiums and discusses the reasons for two opposite trends of risk premiums for the US and Canada. Although estimated risk premiums in these countries trend in opposite directions, they both are the results of Japanese risk management strategy.

Chapter Six concludes the study.

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2. MARKET SURVEY

2.1 Market Condition Review

Amount of coal shipped across oceans increased rapidly in the 1970s in response to rapid economic growth. The technological improvements of increasing size of vessel and depth of ports made this possible. Before these technological improvements, the coal flow was basically intra continental.

In the 1980s, coking coal trade remained relatively flat, and steam coal trade started to increased dramatically. In this study, we are going to examine the coking coal market during the 1980's.

At the end of the 1980's, 381.7 Mmt (Million metric ton) of coal were traded in the world coal market. Japan, as the largest single importer, accounted for 27% of this trade. Though metallurgical coal takes 48.3% share of the world market, it takes 68% of the Japanese coal import market and amounts to 68.7 million metric tons in that year (19% of world coal trade).

The basic characteristics of the world coal market in most of the 1980's can be described in one word, oversupply. Over supply has dominated the market for a long period.

Short term supply/demand imbalance can be caused by difference in supply and demand expansion: demand usually increases in a series of small steps, while supply increases usually are "lumpy" and of large scale. For instance, a utility plant rarely consumes more than 1 Mmt of coal per year, while a newly developed open pit coal

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mine may produce 3-5 Mmt per year. But, the supply surplus that occurred in the 1980's was a long term supply effect, which was caused mainly by inaccurate prediction of demand expansion and world wide development of supply capacity there after.

In 1979, the energy crisis caused coal price to rise sharply. Demand of coal was predicted to increase continuously due to economic growth, particularly due to steel production increase and change in composition of energy consumption. Since Japanese-owned natural resources are scarce, the Japanese are very vulnerable to this kind of change and to shortfall of supply. In order to secure stable supply and meet the increasing demand, the Japanese started to invest in coal mines and facilities, primarily in Australia and Canada; United States, as swing producer, also invested in its port facility. As a result of these developments, supply capacity quickly expanded in all supply regions. On the other hand, the production of steel was lower than predicted due to economic recession and the high cost of energy, and energy consumption did not shift from oil to coal as predicted, since oil price remained low. As a result, production over capacity has existed in all world producing regions since late 1982. Jack Morrish, President, Fording Coal, was cited in the *Northern Miner* (1985) :

> As a result, the entire capacity of all the new projects has become redundant, according to Mr. Morrish. In other words, this over contracting has resulted in an annual oversupply of approximately 20 million tones of coking coal or about 30 percent of the requirements of the Japanese steel industry.

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The result of this over capacity was a sharp decrease in the price of coking coal from 1983 to 1988.

Although closing of inefficient mines and increasing steam coal demand partially released the pressure on producers in recent years, over supply capacity is still the dominate factor in coal market.

In this chapter and the following chapters, I am going to examine how consumers and producers reacted to this supply surplus.

2.2 Consumption

2.2.1. Coking Coal Versus Steam Coal Consumption

Coal consumption is classified by final use as metallurgical/coking coal or thermal/steam coal. The trends in coal consumption are different in these two sectors. The consumption of steam coal, as energy, is consistent with economic development. Thus steam coal consumption is highly related to GNP. The demand for coking coal is derived from the production of iron and steel. Thus, consumption of coking coal is cyclical, reflecting the cycle of demand for durable goods (Michael Elliot-Jones, 1984).

Long term trends of these two types of coals consumed in the Japanese market are shown in Figure 2.1. Coking coal still dominates the market, although consumption has been at a relatively stable level for the last 15 years. In contrast, steam coal consumption has risen sharply.

Steam coal is a relatively new and booming sector in the Japanese coal import

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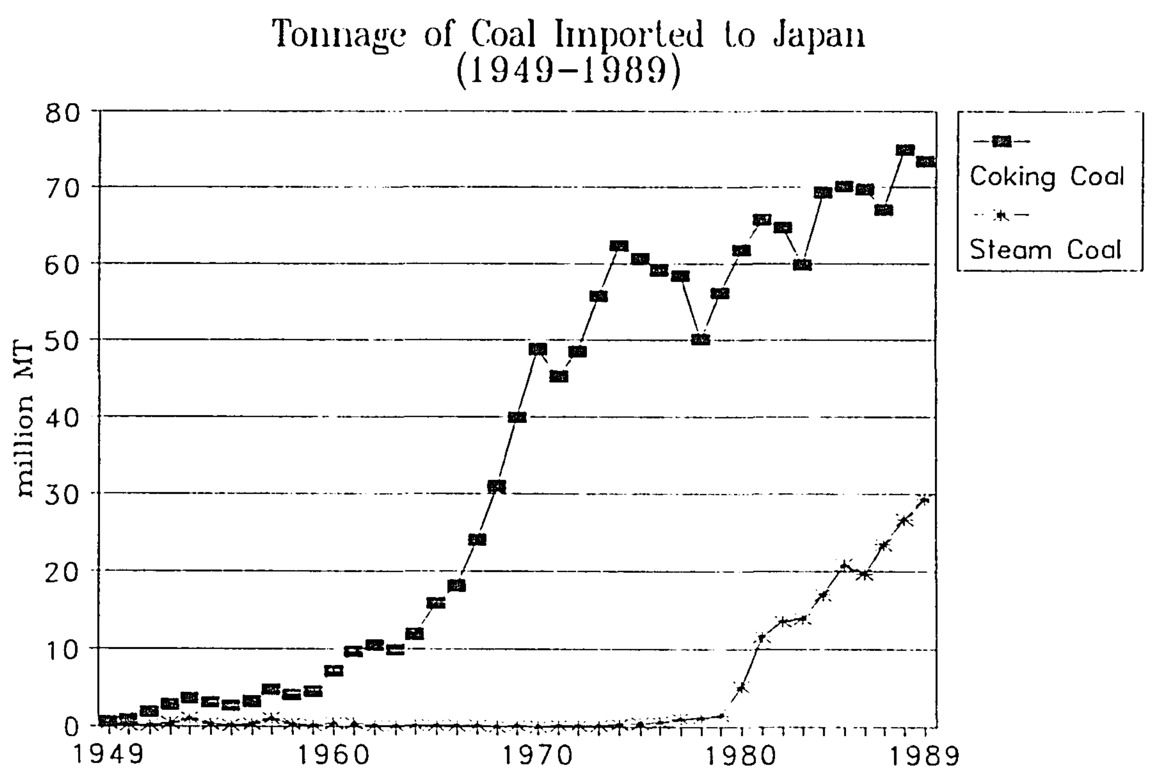

Figure 2.1 Tonnages of Coal Imported to Japan

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market. The large volume of steam coal import actually started in 1980. From 1980 to 1989, steam coal imports increased from about 5 Mmt to 29 Mmt, implying a 21% annual growth rate in tonnage and 34% annual growth rate in share. In the future, the steam coal imported to Japan is expected to continue to increase. The major consumers of steam coal in Japan are seven regional utilities, five other joint utilities, and four major cement companies.[1]

A plot of coking coal consumption in Japan in the last 40 years (Figure 2.1) shows a very slow demand growth from 1949 to 1965 followed by rapid increase from 1965 to 1974; then, growth slowed and became quite stable in the 1980's. In contrast to the 21% annual growth rate of the steam coal, the growth rate of coking coal is small, only 1.9% from 1980 to 1989. And, the share of coking coal in total coal consumption dropped from 92% to 72% during that same period. This pattern mirrors the history of Japanese steel production, as coking coal demand is directly derived from steel production. Although steel production increased in a few developing and central planned countries, it remained slack in the developed countries. Steel productions peaked in the US, the EEC, and Japan, in the 1950s, 1960s and 1970s, respectively. The Japanese economy has grown slowly and undergone a transition from heavy industry to higher technology and service. Besides the slow growth in

---

1 The nine major regional utilities are: Hokkaido, Tohoku, Tokyo, Kansai, Chugoku, Shikoku, Kyushu, Chubu and Hokuriku, the last two are not coal burning facility (1986). The five utilities are E.P.D.C., Sakata Joint Electric, Joban Joint Electric, Toyama Joint Electric and Sumitomo Joint Electric. And four major cement companies are: Nippon Cement, Onoda Cement, Sumitomo Cement and Osaka Cement.

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demand, another reason for stagnant demand for coal is technological change. First, improving productivity of the basic oxygen furnace (BOF), in which coke is needed to produce pig iron from raw iron ore, leads to less coke consumption per ton of pig iron. Second, the amount of scrap used in steel making has increased. To melt the scrap, an electric arc furnace (EAF) is in use which does not need coke. Therefore, coking coal consumption per ton of steel has declined. Last, through coal blending, more steam grade coals replace conventional coking coal to be used in coke making, which also has a strong negative impact on demand for traditional coking coals.

2.2.2 Coal Flow Between Two Markets

Under certain conditions, coals are exchangeable between two final use sectors. There are two ways coals can flow between the coking and steam coal markets: (1) some low quality and cheaper coking coals flow into the steam market stimulated by the higher environmental requirement (Dr. M. Rieber 1975); or (2) some high quality steam coals flow into the coking coal market through coal blending to further reduce the cost. To examine the direction of the coal flow in the Japanese coking coal market, the actual differences between the imported and exported tonnages of coking coal and steam coal will be examined.

All data are obtained from official publications by the International Energy Agency (IEA). The first group of data show how much imported coal is accounted as coking coal or as steam coal at the Japanese ports. The coal referred to as coking coal

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Table 2.1

Coking and Steam Coal Tonnage Based On Import Statistic And Export Statistic

<u>Coking Coal</u>

(1,000 MT)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
United States										
Import	19256	21568	23911	14719	15317	12794	11659	9176	12990	10923
Export	19914	19869	20288	14626	14060	12613	9506	9172	10991	10387
D=Imp-Exp	-658	1699	3623	93	1257	181	2153	4	1999	536
Australia										
Import	25783	29130	25410	28176	29830	30351	29235	30465	30839	32783
Export	25579	28685	23572	29316	29503	29251	27728	27464	28980	29925
D=Imp-Exp	204	445	1838	-1140	327	1100	1507	3001	1859	2858
Canada										
Import	10583	9554	9536	10262	15421	16820	16272	15481	18990	18055
Export	10711	9434	9420	10148	15452	17026	15670	15026	18069	17981
D=Imp-Exp	-128	120	116	114	-31	-206	602	455	921	74
Sum Coking	-582	2265	5577	-934	1553	1076	4262	3460	4779	3467

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Steam Coal

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
United States										
Import	289	2119	1630	930	485	957	516	80	417	1297
Export	1014	3545	3087	1580	749	1331	808	881	1819	2173
D=Imp-Exp	-725	-1426	-1457	-650	-264	-374	-292	-801	-1402	-876
Australia										
Import	3529	5676	6344	7647	10866	13608	12739	16364	18641	20265
Export	3581	5655	5934	7442	11727	15256	14774	19257	21518	23508
D=Imp-Exp	-52	21	410	205	-861	-1648	-2035	-2893	-2877	-3243
Canada										
Import	328	1140	1302	555	680	784	1268	1343	1475	1276
Export	412	1052	1337	697	1091	1516	1879	2038	1928	1758
D=Imp-Exp	-84	88	-35	-142	-411	-732	-611	-695	-453	-482
Sum Steam	-861	-1318	-1082	-587	-1536	-2755	-2937	-4388	-4732	-4601
Grand Sum	-1443	947	4495	-1520	17	-1679	1325	-928	47	-1134

Sources:
(1) Import: "Energy Price and Taxes, 1st quarter 1990"./IEA
(2) Export: "Coal Information, 1990"./IEA

in these statistics is defined by final receivers. These data are obtained from "Energy Price and Taxes (quarterly)"[2]. The second group of data show how much exported coal to Japan is account for as coking coal or as steam coal at the ports of supply regions. Here coking coal is defined by quality. These data were obtained from another IEA official publication -- "Coal Information (annual)". Comparison will made for each major supply region.

Since the definitions of coking coal are different in these two statistics, the actual tonnages of import and export show substantial gaps in the data from 1980-1989 (see Table 2.1 and Figure 2.2). Taking the difference (*D*) between the imported tonnage and the exported tonnage:

$D_i(coking) =$ *Imported coking coal from* i^{th} *country*

- Exported coking coal from i^{th} *country to Japan.*

$D_i(steam) =$ *Imported steam coal from* i^{th} *country*

- Exported steam coal from i^{th} *country to Japan.*

Where, $i = US, AU, CA$

Summing up these differences by type of coal gives the total differences of coking and steam coal in that year, *D(coking)* and *D(steam)* respectively,

---

2 Actual data used here are from "Energy Price and Taxes, 4th quarterly, 1989. (Table 16, pp.20).

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$$D(coking) = \sum D_i(coking)$$
$$D(steam) = \sum D_i(steam) \qquad (1)$$

These sums show an over-account on coking coal and an under-account on steam coal in the Japanese market. Adding up these two gaps, the grand sum of the differences becomes much closer to zero after 1982 (Table A.1, Appendix, and Figure 2.2). The, the net coal flow is from steam coal to coking coal in Japan. Namely, the Japanese steel mills import coals defined as steam coal by their quality and use them in coking coal blending. Figure 2.2 also shows that the gaps are increasing. If we assume the other factors are held unchanged, this increasing trend could lead to more low quality coals going to the Japanese steel mills. Every thing else being equal, this would reduce the quality premium paid for better US coals.

2.3 Production and Producers

2.3.1 Domestic Supply versus Import and Government Intervention

Japan's coal reserves are very small and expensive to develop. Most of the operating mines are underground mines, and the costs of mining are very high. The record high production was 56,300,000 ton in 1940. Output of production reached a second peak, 55,413,493 ton, in 1961, but after that, production declined to the current level of about 10,000,000 tons. As a highly developed industrial country having very little nature resources, Japan is highly dependent on foreign coal import. For example, the domestic coking coal supply, in fiscal year 1988, was 678,000 tons,

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which is only about 1% of total coking coal supply.

Table 2.2 Average Prices of Domestic and Imported

Average Prices of Domestic and Imported
in Selected Years (CIF U$/MT)

Year	Domestic Price	Imported Price
1975	49.98	56.16
1980	97.56	67.24
1985	107.63	58.68
1986	145.32	56.27
1987	167.41	52.43
1988	180.07	56.35

Source: Coal Manual, 1989

The Japanese coal mining industry has been under government intervention. The government institutes eight programs -- "countermeasures" through 1958 to 1986. Except for the first and last one, they all provided some kind of subsidy to the coal mining industry to prevent unemployment or to keep a certain amount of domestic coal production as part of a national strategy of securing supplies of natural resources. The Japanese government's policies also directly reflect the coal market condition and buyers' view of risk. For example, the 7th program issued in 1981 stated that domestic steam coal was valuable to stabilize supply and that there was no alternative to this coal for inland consumption, thus 20 million tons of production was necessary for harmony between supply stability and economy. The minimum production rates, with the quota system set to support this minimum production, caused a dramatic price

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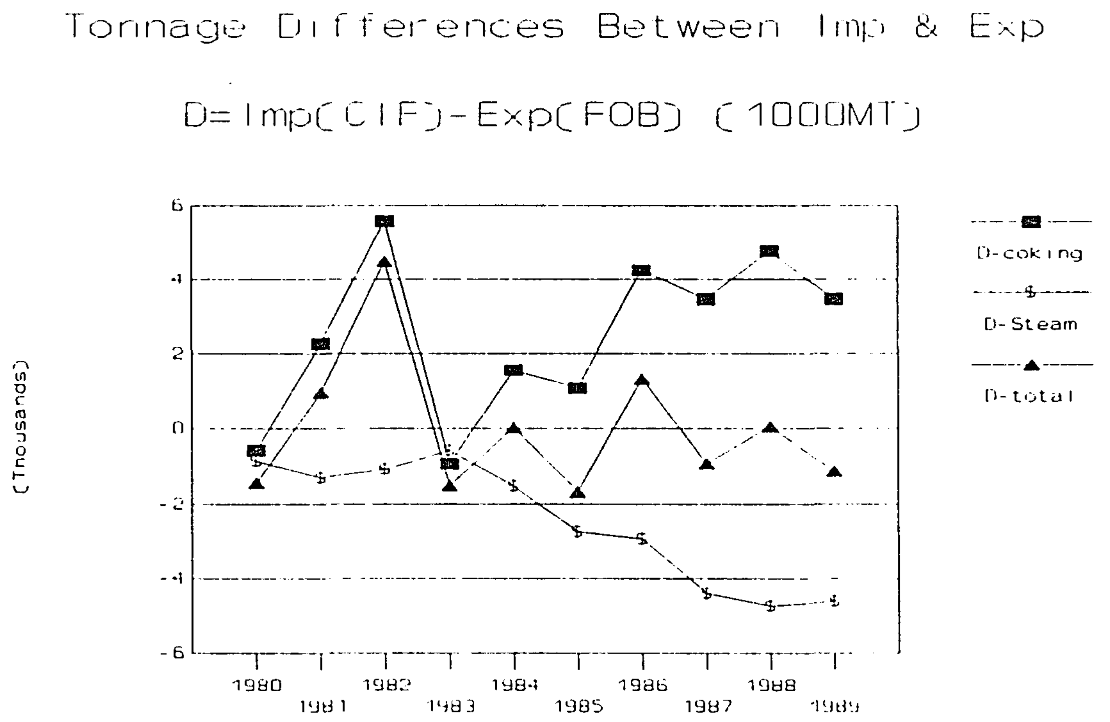

Figure 2.2 Differences Between Import And Export Tonnages

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increase of domestic coal (Table 2.2). While world wide supply over capacity has been dominated in this market, the risk of coal shortage was very small. Consuming high cost domestic coal became less attractive and not necessary to Japanese consumers. Thus the 8th countermeasure issued in November 1986 is different from the previous ones. It is characterized and considered as a line of industrial structure rearrangement. Cutting cash cost became as important as securing supply. "It is said that the domestic coal supply should be about 10 million tons for five years and particularly on coking coal its supply should be zero in the same time."[3] As the result of this countermeasure, four large coal mines and a small mine had been closed by 1990. The domestic coking coal production is small enough to be ignored. The Japanese government also supports importing of natural resources by not imposing a tariff on coal imports[4]. Although there is a quantitative allocation system in use for importing coal, which requires the purchase of a certain amount of domestic coal before importing from abroad, it seems apply only to low grade coals. Coking coals with less than 23% volatile matter, less than 12% ash content, and more than 3 coke button index, and anthracite are exempted ([2]). Under the import quota system, in JFY 1988, the upper limit is 57.1 Mmt for coking coal and 28.5 Mmt for steam coal. The amount of low grade coking coal imported was much lower than that quota.

---

[3] "Japan's Coal Mining Industry Today, 1990", The Coal Mining Research Center, Japan. Tokyo, Japan.

[4] "Japan's Coal Mining Industry Today 1990", the Coal Mining Research Center, Japan.

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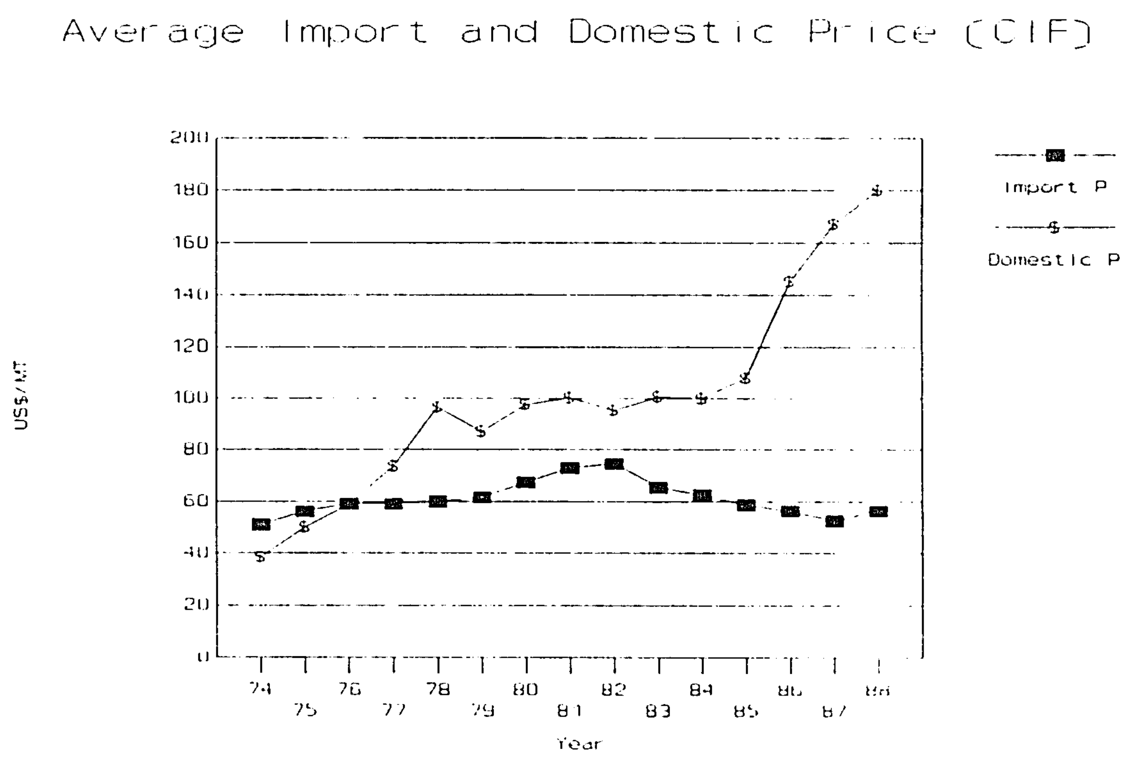

Figure 2.3 Average Import and Domestic Prices (CIF)

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2.3.2 Foreign Production Regions and Exporters[5]

This section provides basic information about producers, which may include producing regions, leading exporters, export with respect to total production and the dependence on the Japanese market, coal quality, railway and port conditions, estimated cost components if data are available, some special characteristics, and foreseen potential export capability.

The supply regions in order of their importance are: Australia, Canada, the United States, former USSR, South Africa, China and New Zealand (whose export is close to zero). The shares of the first six supply regions in selected years (1980 and 1989) are shown in the Figure 2.3 and 2.4.

The United States:

Around 10% of total U.S. production goes abroad, and about 13% of these

---

[5] The data in this section are cited from following publication, except otherwise stated:
[1] US Department of Commerce. *Asia Pacific Energy Series, Country Report, Australia.* Government Printing Office, Feb. 1988. (ASI:90 3406-6.4)
[2] US Department of Commerce, ITA. *Survey of Government Assistance for the World's Hard Coal Industries.* Government Printing Office, 1989. (C 61.2:C 63/5)
[3] Japanese Economic Institute. *JEI Report.*
[4] United Union, UNCTAD. *Japan's trade and Economic Co-operation with USSR and Other Socialist Countries of East Europe.*
[5] OECD/IEA. Coal Information (annual report).
[6] UN, International Energy Agency (IEA). *Energy Price and Taxes, quarterly report.*
[7] Chinese Ministry of Coal Industry. *Yearbook of Chinese Coal Industry 1989.*
[8] ??? *Economic Bulletin For Asia and Pacific.*
[9] Tex Report Inc., Japan. *Coal Manual (annual).*

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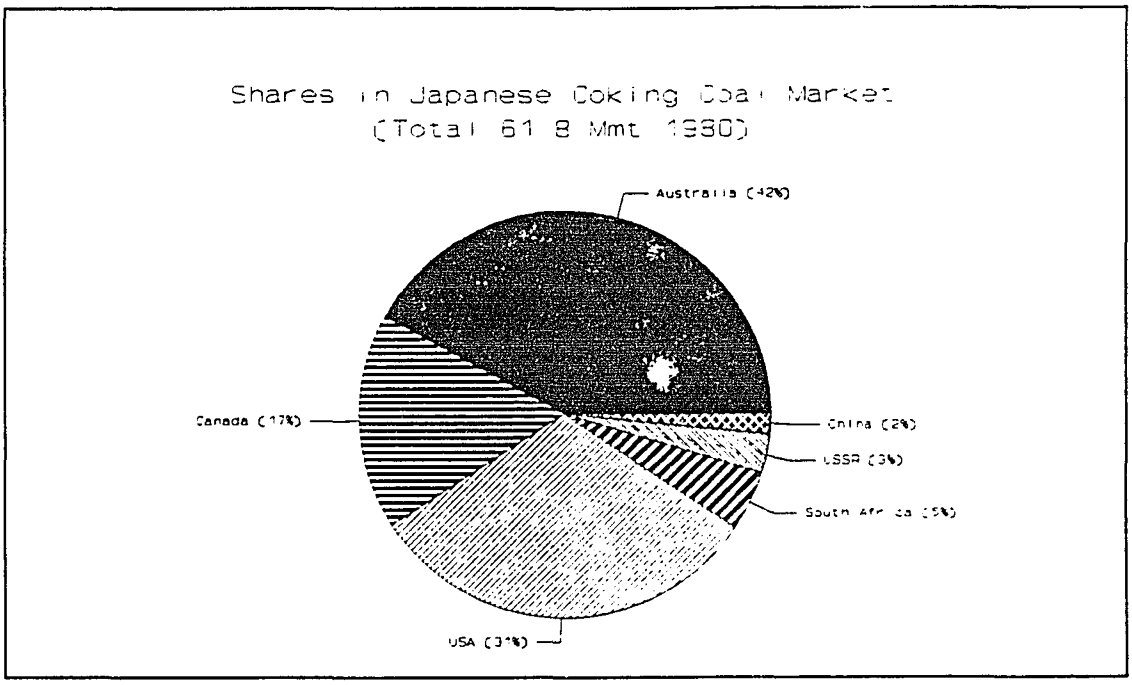

Figure 2.4 Producer Shares In Japanese Coking Coal Market (1980)

exports goes to the Japanese coking coal market, meaning that only a little over 1% of U.S. production was exported to the Japan in 1989. Though the dependence of the US producers on the Japanese market is very low, the absolute revenue can not be ignored. In 1988, the total revenue was about $600 million dollars: $525 million dollars from selling coking coal and $72.6 million dollars from selling steam coal. In 1982, US coal export to Japan increased to a peak due to the failure of Poland and Australian exports. Since then, US export has declined from 23.4 Mmt in 1982 to 12.6 Mmt in 1989. In 1982, as many as 104 trading brands had contracts with Japanese buyers, and now only about 20 US coal brands have survived. The supply has become more concentrated. Currently the leading exporters are Pittston (Pittston

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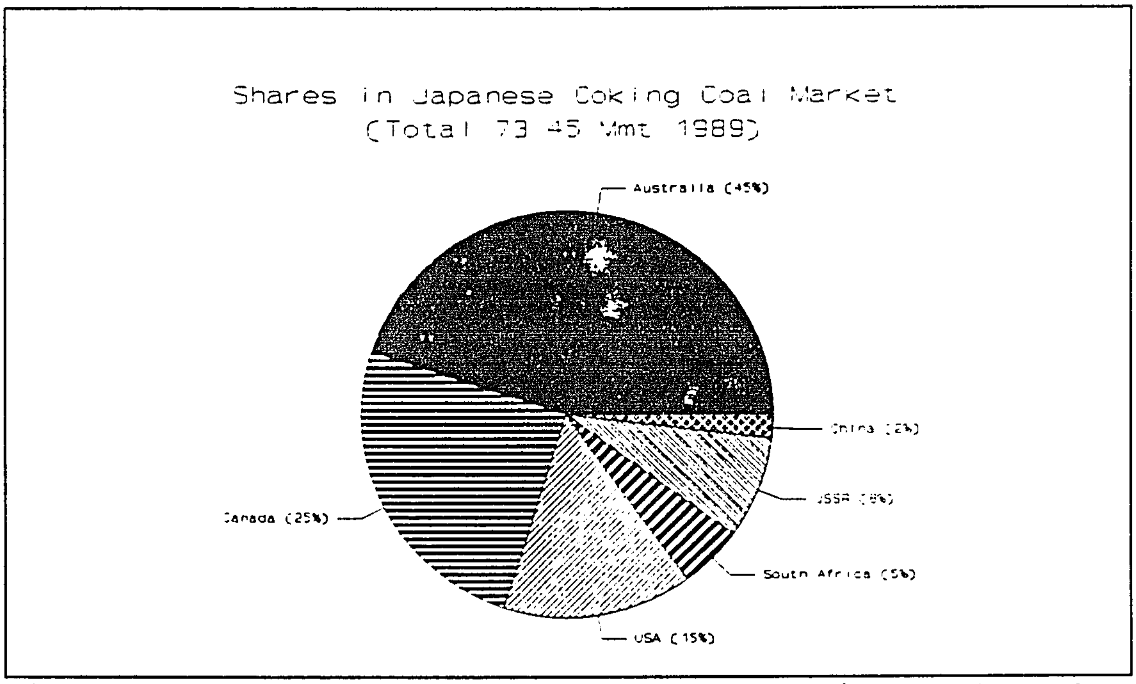

Figure 2.5 Producer Shares In Japanese Coking Coal Market (1989)

MV blending takes about 30% of total coking coals exported to Japan) and Jim Walter (Blue Creek takes about 23%).

All US coking coals come from Appalachia and are shipped through Hampton Road, Mobile, Baltimore, and New Orleans. The coking coal reserves in Colorado and Utah are 2% of total US reserves (Spearman, 1980. pp.5). In 1982, about 10% of coking coal export shipped from the west coast (Coal Manual, 1982). With the decrease in total US export, western coking coals are out of the market. Despite their closeness to the market, no western coking coals are currently exported to the Japanese market. Appalachia coal reserves are abundant and well known for their high coking quality and high cost. Most Appalachian coals are produced from deep underground mines. The average inland transportation distance is four hundred miles

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(Brown 1985). Moving export coal from mines to ports plays an important role in cost formation. Inland transportation cost is much higher than in other supply regions; this has been identified as the major cost barrier for US coal exporters. Railway freight was estimated at $18/ton in 1986 dollars, which accounts for about one third of coking coal costs at the port ($57.7/ton including capital cost) ([5]). Long distance ocean transportation makes prices even higher at the CIF level. Some other estimation shows that the inland transportation cost can be as high as three quarters of deliver price for some domestic utility plants.

Traditionally, Japan imported a large amount of US coal to take advantage of its high quality and supply stability in order to reduce risk. It has changed over the last decade. Low quality coals, even some steam coals, are used in coking coal blending to reduce the cost. The expectation of risk has been decreased by persistent current and expected oversupply. These trends press the US exporters to either cut price or give up market share.

Canada:

More than 95% of the Canadian coal is produced in the western provinces -- British Columbia, Alberta and Saskatchewan. Eastern Canada is the largest market for US coal. About 45% of Canadian coals is exported, 95% of them from British Columbia and Alberta. The Pacific Rim market absorbs about 85% of Canadian export. Therefore, the dependence of the Canadian coal industry on the Pacific Rim market is relatively high. Total participants of Canadian suppliers has increased from 4 brands in 1982 to 17 brands in 1990, after new coal mines started to operate.

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Currently, the largest exporters are Quintette, Greeg River and Westar (Balmer and Greenhills).

The three producing areas in Alberta are the Mountain Region, the Foothills Region, and the Plains Region. The Mountain Region produces metallurgical coal while the other two primarily produce steam coal. Almost all mines in B.C. produce metallurgical coal, or both metallurgical coal and steam coal. Canadian coals have better quality than the Australian coals, but are not as good as the US coals (see Table 3.4). The average distance from Canadian mines to the Pacific Ports, Roberts Bank and Neptune Terminals, is seven hundred miles. Three transcontinental railway systems, Canadian National (federally owned), Canadian Pacific (privately owned) and British Columbia Railway (provincially owned), compete in this market. Compared to most other North American railways, these rail networks are extensive and have the advantage of being able to handle coal movements from origin to destination without interchange to other carriers. Coal producers are heavily dependent on the transportation industry due to their remote location from the consuming market or ports (Brown, 1985). Most Canadian mines are open cut, and operating costs are low.

The newly developed mines in western Canada play a heavy role in exporting to Japan. They were stimulated by the Japanese steel mills efforts to diversify their coal supply and are still supported by long term contracts. These new mines carry high investment costs. The average capital recovery charge is 2.6 times that of US mines and 1.4 times that of Australian mines ([5]), which raises total costs and makes

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Canadian coal the most expensive coal for the Japanese buyers. For instance, Quintette, as the largest single coking coal exporter to Japan, by contract was supposed to ship about 5 Mmt at C$99.69 (U$84.18) in 1989, Greeg River to ship about 2.1 Mmt at price C$74.60 (U$63), and Bullmoose 1.7 Mmt at C$95.67 (U$80.79), which accounts for about 50% of total shipments of the Canadian coking coal to Japan. These three mines entered the market in 1983 and still use escalated prices to recover their investment and other costs. The Japanese companies are heavily involved in coal mine investment in Canada. These high cost mines are partly owned by Japanese companies: 38% of equity in Quintette, 40% in Greek River, and 10% in Bullmoose. If not, these contracts could be renegotiated or would have been terminated already. Besides these three mines, the Japanese have 33.4% of equity in Balmer (operated by Westar) and 22% in Greenhills (operated by Westar). These four large companies account for about three quarters of total Canadian shipment to Japan (11,320,000 MT in 1989). Since they are partly owned by the Japanese, they are expected to continue exporting to Japan, even though the prices may be high.

Canada is a very important coal supply region for the Japanese, and the Canadian government and industry recognize the importance of being a reliable supplier. They have carefully imposed some policy to encourage foreign investment and to improve the supply and export environment (Haglund (1989).

Australia:

Australia is the sixth largest coal producer in the world and has been the largest world coal exporter since 1984, except in 1989. In 1989, US export slightly

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exceeded Australian export due to the fast increase in steam coal sales. Australia is heavily dependent on exports, for about 70% of its salable coal is exported. About 85% of Australia's mines produce exclusively or predominantly for the export market ([2]). Around 90 percent of metallurgical coal produced in Australia is exported, three quarters of that goes to Japan. New South Wales and Queensland (especially Bowen Basin), are the primary producing and exporting regions of Australia. Together, they account for about 95% of Australian coal production and 100% of coal export. The largest company, BHP, is the leading exporter. BHP operates six of the top ten mines and produces about 17% of Australian coal.

The quality of Australian coal is relatively poor; 35% of the coals shipped to Japan in 1989 were semi-soft coking coals. By comparison, 6% of Canadian coal, less than 1% of the US coal, and 47% of South African coals are semi-soft ([9]).

The Australian producers are among the lowest cost producers in the world. Underground mining dominates in New South Wales, and open cut mining is widely used in Queensland. Most recent investment in Queensland's open cut mines are participated in by foreign partners, especially by the Japanese trading companies and steel mills.

The railways and port loading facilities are owned by state governments. The major loading ports are Gladstone, Hay Point, Dalrymple Bay, Kembla, Newcastle and Sydney. The inland transportation distance is short. On average, it is two hundred miles from mine to deep water port, which is far less than US (400 miles) and western Canada (700 miles). The rail rates are confidential. Thus, it is not clear whether state

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governments provide subsidy or levy a tax. One Australian study found that rates are two times operating costs ([2]). Thus, the government seems to indirectly tax the coal industry.

Currently, the Australian coal industry is experiencing cost increases and an appreciating Australian dollar versus the US dollar, which offsets some of their cost advantage. Also, the Australian coal industry is disturbed by its reputation for delayed shipping of export coal due to mine and railway strikes. Overall, Australian coal is very competitive in the Pacific Market due to its lower cost and closeness to market. The Australian coal industry is export oriented such that it tends to have a strong tie with customers.

The Republic of South Africa:

The Republic of South Africa is the third largest export region in the world. The large volume of exports actually started in 1975 and from 1975 to 1985 increased at 32% per year. A quarter of the production goes abroad (46.1 Mmt in 1989), of which 92% are steam coals, since South african coals have very poor coking quality. The amount of coal going to the Japanese coking coal market is limited, it accounts for only 5% of the Japanese coking coal market in 1989. The 85% to 90% of coal produced is from the Transvaal, which is 300 miles north of Richards Bay.

Basic transportation facilities are efficient. South Africa is the cheapest coal producer; since 1985 the CIF prices have been kept at least $5/ton cheaper than Australian coals and much cheaper than others. But, this $5 has been referred to as a "political discount" by Michael Hawarden, official of South Africa coal trading

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company JCI Co Ltd.. This discount, supported by government to help boost export, could disappear (Coal Outlook, Nov. 1990).

The disadvantages of South African coal exporters include: poor coking quality and unpredictable political disturbances. Since 1986, economic sanctions, enforced by the US and other western countries including Japan, prohibited or reduced coal shipping to those countries. In the Japanese steam market, the share dropped from 15% in 1986 to 5% in 1989, coking coal dropped too. South Africa can be a potential competitor in the Pacific market if the political situation is stabilized and low grade coal is more demanded by the Japanese steel mills. Actually, the US lifted sanctions in July 1991. Most other countries did also. If the Japanese buyers think the political risk has been reduced, they may be willing to buy more coal from South Africa; at least, they could count it as a cost reducer and buy coal on annual contract. Technological improvement could further favor this cheapest coal producer in the long run.

Although, South Africa is a market-economy country, the market conduct of their coal mining industry is different from the top three supply regions because of the concentration of producers and the determination of price. Most of the mines are privately own, and the concentration is high. The privately owned Anglo American's Amcoal is the largest producer and exporter in South Africa. It operate 13 mines with 40.9 Mmt output in 1986/1987[6] (23%). The second largest privately owned

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[6] The year starts from July 1, 1986.

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company,the Trans Natal, controls 14 mines with 38.9 Mmt coal produced in 1987 (22%). Rand Mines controls 10 mines and produced 30 Mmt (17%). Partially government owned Sasol Ltd. produced 35 Mmt (20%). These four companies controlled 82% of total production in 1987. South Africa uses a two-tier pricing system, domestic prices are controlled by the government and export prices are set by the world market, which is higher then domestic prices. The objectives of the government pricing policy are described in a US DOC' report ([2]) as: "(1) to give priority to supplying domestic energy requirements at a reasonable price; (2) to allow an acceptable return on capital invested in order to provide incentives for expansion; and (3) to avoid reaching a level of coal exports that would drive international prices down to South Africa's long run marginal cost, which would substantially reduce the country's economic rent." To do so, the government controls the volume of exports. The permit of annual shipments to each exporter is given by the government for the next 30 years in order to allow the producers to make long term plans. This export allocation is consistently increased as the export infrastructure improves. Therefore, South African exporters have the potential to keep the current low prices or to further reduce them.

Former USSR:

The former USSR is the fourth largest coking coal supplier to Japan, taking about 9% of the Japanese market. Coals exported to Japan come from two coal fields, Kuznetsky and Neryungrinsky in South Yakutsky, Siberia (Russia). These coals are high coking quality and low sulfur coals. The average CIF price of Yakutsky coal is

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the third highest after Canadian coals and the US coals. Considering its quality, Yakutsky coal may not actually be more expensive than Australian coals. The tie between these suppliers and the Japanese consumers is through Japanese investment with a long term trade agreement. The investment is supposed to be paid back from 1983 to 1990 and the trade agreement ends in 1999.

The disadvantage of the former USSR coals are: (1) although they are the neighbor of Japan only divided by the Sea of Japan, the inland transportation distances are as long as 2800 miles (4500 km) from Kuzentsky and 1580 miles (2550 km) from Neryungrinsky to the port of Vostochnyi. (2) The main reason for exporting is to get hard currency rather than to develop a consumption market for its existing capacity. The domestic energy shortage constrains the ability to export coal. (3) The recent political changes in Soviet Republics bring some political uncertainty at this moment. The future of this competitor is not clear.

The People's Republic of China:

China is the largest coal producer in the world with one billion tons of raw coal produced in 1990. The major producing and export regions are Shanxi, Hebei and Inner Mongolia. More than 95% of its production is consumed domestically. Most is used for energy or residential heating. Coking coal consumption was only 7.2 percent of total production in 1988. China exported 11.2 Mmt steam coal and 3.5 Mmt coking coal in 1989, while 1.2 Mmt coking coal went to Japan, which took only 1.2% of this market. The coking coal export mines are Kailuan (Hebei province), Zaozhuang (Jiangsu province) and Huaibei (Anhui province), which are about 70

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miles from Qinhuangdao port, 155 miles and over 200 miles from Lianyungang port, respectively. They are high ash coal with medium to high Free Swelling Index. Besides these mines, the Japanese invested in several other coking and steam coal mines and infrastructure projects to stimulate their export to Japan. But several factors obstruct coal exports : (1) Like the former USSR, the object of export is hard currency instead of selling extra production. Actually, domestic consumption is high, and there is a severe supply shortage, as three quarters of all energy is generated by coal. This situation will continue, and the amount of coal consumed domestically will increase to comply with Chinese economic growth. The structure of Chinese energy consumption will restrict a large volume increase of coal export; (2) railway transportation is a bottleneck to coal supply. The railways are inefficient and overloaded. Port facilities, while old and inefficient, do not seriously constrain coal movement. A new railway, specifically built for moving coal from mines in Shanxi to the largest export port, Qinhuangdao, is expected to be finished soon. Operating this railroad will relieve some pressure and increase mainly steam coal export capability. But it will be easily swamped by the increase in domestic consumption. (3) the quality of Chinese coal is not stable. Overall, the Chinese producers are not major competitors in the Pacific coal market. They have not yet built up their credit in the coking coal trade market because of the failure to deliver and because of poor quality.

It is meaningless to predict price or compare Chinese coal price with cost. As large mines are controlled by the central government, prices are set arbitrarily by the government. The price received from domestic consumers who are in the government

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quota system is even lower than the mining cost. Price paid by the consumers who are in the quota system was about $6.7 to $8.1/ton in 1986, while prices paid by other consumers were $26.8 to $32.2. Producing cost before transportation was estimated to be $12.10. Export prices are determined by world market price([2]).

2.4 Other Aspects

2.4.1 Stock/Inventory

Like all other natural resources, land is scarce in Japan. The high cost of storage limits the capacity for coal inventory. The Japanese have to find the optimal trade off of secure supply and coal cost, including cost of storage. Table 2.3 shows the ratios of consumption to stock in selected countries. In Japan, the ratio of imports to consumption is low in comparison to those of other countries. This low stock/consumption ratio actually put more stress on securing reliable coal deliveries to Japan.

2.4.2 Transportation

In the Japanese coal market all transactions are completed at export ports. Producers all accept FOBT prices, which includes inland transportation cost paid to shippers. The ocean transportation is charged to Japanese buyers. On contract, the transaction in European market may occur at different levels, such as at export ports and at import ports. Producers may be in charge of ocean transportation to Europe (interview with BHP-Utah and Mitsui).

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Table 2.3 Comparison of Consumption and Stock

Comparison of Consumption and Stock
(1,000 tones, in 1987)

	Consumption	Stock	Ratio
Japan			
Domestic Coal	12732	5008	0.39
Imported Coal	90859	259	0.003
Total	103591	5267	0.05
EEC Total**	261400	31647*	0.12
Spain**	28017	11185*	0.40
UK	115860	33157*	0.29
West Germany**	84305	18035*	0.21
US Utilities***	717978	170842	0.24
Canada	43835	13898	0.32

Source: International Coal Report's *Coal Year 1988*.

Note:
* Including colliery stock.
** Hard coal only.
*** Electricity Utilities only.

The alternative shippers include independent shipping companies, a fleet owned by Japanese consumers, and a fleet operated by buyers under long term contract.

Undoubtedly, ocean transportation costs are extremely important in price formation and relative competitiveness among producers. But, it is very difficult to get accurate estimates of these costs, because most of the freight rates are confidential and the shipping routines are changeable. For example, the Japanese may load one-half of their ship at the east coast of the US; then, instead of going through Panama Canal, they go to South Africa to load the rest, finally back to Japan through the Indian Ocean, as this route may be the cheapest one for them (Interview with Japanese

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trading company, 1991). One estimate is the spot rate estimated by Simpson, Spence & Young and published in "Coal Week International", which give rates between some selected ports. Some representative rates are estimated by private companies, such as Rodriguez Sons Company,Inc. (See Table 2.4).

Table 2.4 Single Trip Representative Ocean Freight Rates to Japan

Single Trip Representative Ocean Freight Rates to Japan

	Volume (MT)	1987 Rate ($/MT)
US		
Mobile	55,000	$13.00
NorFolk+Richards Bay	120,000	$10.00
Long Beach	55,000	$8.75
Canada		
Vancouver	55,000	$7.00
Australia		
Queensland	55,000	$7.00
	130,000	$5.00
New South Wales	55,000	$7.25
	130,000	$5.20

Source:Rodriguez Sons Company, Inc. Cited by "A Cost Comparison of Selected US & Australia Coal Mines", US DOC and US BOM, 1989.

As Discussed in Chapter 3, from the Japanese buyers viewpoint, the FOBT prices paid to each of the brands from the United States and Australia are almost perfectly consistent with their qualities. The differences in ocean transportation distances are used by the Japanese to collect rent from producers and to subsidize others. In chapter 4, this will be discussed further.

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2.4.3 Exchange Rate

Exchange rate, of course, plays a very important role in international trade, thus it is an important factor in price renegotiation.

The Yen exchange rate was greater than 200 per dollar in the first half of the 1980's, during 1986, Yen sharply appreciated in exchange value and remained low during the rest of the last decade. The appreciation of the Yen favors Japanese imports, for import prices in Japanese Yen have declined.

From the producers' viewpoint, appreciation of the Yen directly affects producers' profit/loss. For Example, Australian producers experienced loses in 1991, but they expect this year (1992) to be profitable due to devaluation of Australian dollars.

As this study's emphasis is on a relative comparison among producers and how market shares are distributed, the relative changes of exchange rates are important. The US dollar was relatively stronger than the Canadian and Australian dollars during the 1980's, especially in the first six years, for the Canadian and Australian dollars were continuously devalued.

2.5 Transaction

2.5.1 Form of Transaction -- Contracts[7]

1. Contract versus spot purchasing

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[7] All information was gathered from various issues of *Coal Manual*, published by Japanese Company TEX. Otherwise, the citation will be given.

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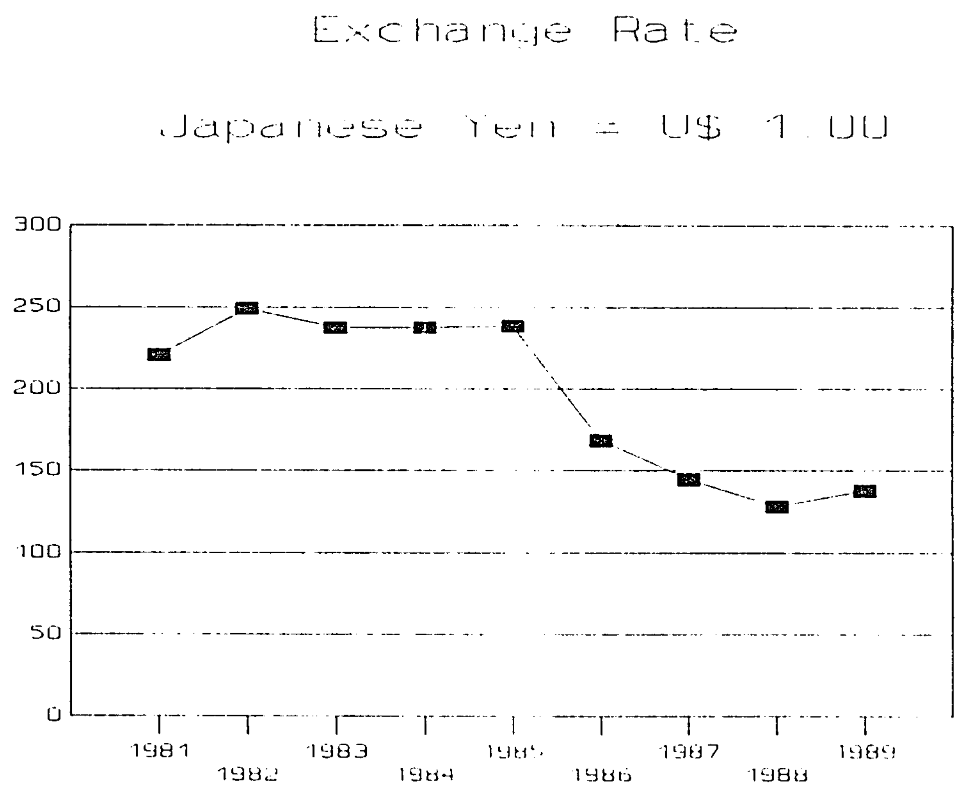

Figure 2.6 Exchange Rate (per Japanese Yen)

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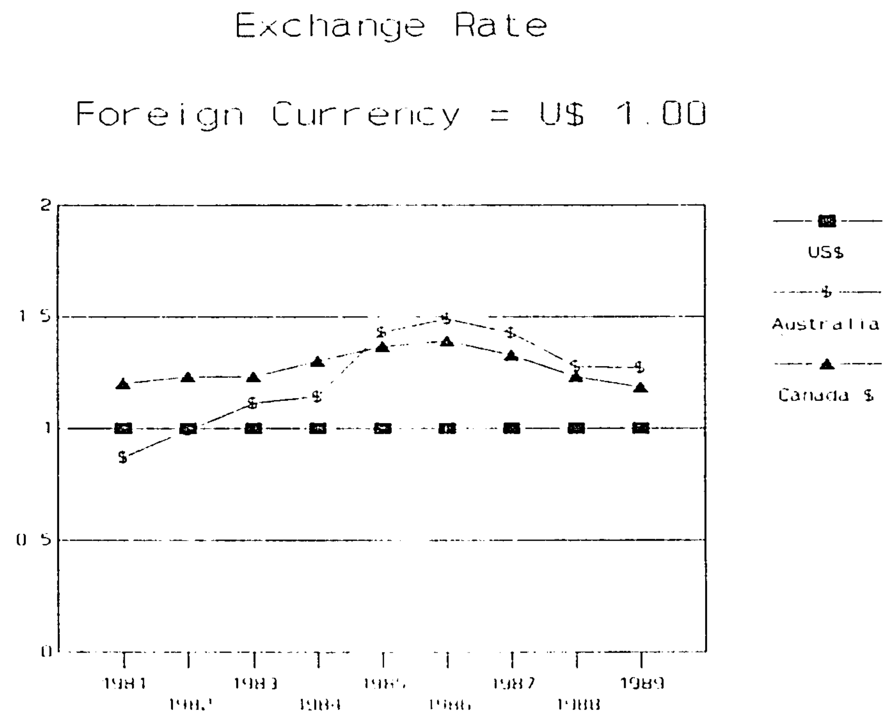

Figure 2.7 Exchange Rate (per US dollar)

There is no futures market for coal due to its heterogeneous quality. All coals are traded through contract or spot market transaction.

Purchasing coal on contract or spot is dependent on what the buyer's ability is to bear risk. In the cement industry, the penalty for a coal shortage is small. Thus, it is profitable for cement producers to buy coal on the spot market under the condition of supply surplus. Utilities continue to place a high premium on the supply security of long term contracts, but they partly purchase from the spot market. Steel companies, who incur the greatest economic penalties of coal supply shortfall, are wholly dependent upon contracts. (Elliot-Jones, 1986). Actually, most spot market transactions are by buyers who are building or reducing coal inventories.

The international coking coal market of the early post-WWII period, when only a small amount of coal flowed across oceans, was dominated by spot market transactions. However, this approach was undoubtedly unattractive to the Japanese buyers at a large volume base, because the spot price fluctuated and the quantity and quality of shipments were uncertain. It was also unattractive to suppliers. In the early years, the spot-market was dominated by US-based suppliers. Most of them were existing mines. Selling small amounts of coal on the spot market would not effect their production planning very much. As the amount of coal transported across the oceans increased, the importance of purchasing or selling by contract increased. Suppliers needed to plan their production and development. This is particularly true for those export oriented newcomers. Now, all coking coal exported to Japan is through contract (from an interview with the Japanese trading company Mitsui & Co (U.S.A.),

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Inc., New York). (Sometimes, yearly contract is also classified as spot purchasing by some people working in the domestic coal industry. But, we will not use that definition here). Captive mines were also widely utilized by many of the Japanese buyers; this usually leads to long term contracts between operators and the Japanese consumers. Since inside information is available to Japanese participants, captive mines virtually precluded collusive practice by suppliers and facilitated the transfer of some portion of deposit specific location and scarcity rents from producers to consumers (Anderson, 1987). Being involved in mine development was also part of the strategy to cut cost cutting and to secure supply long run supply.

2. Contract Components In The Current Situations:

In practice, there are many types of contracts in use. The basic components of a contract in the Japanese coking coal market includes shipping tonnage, price determination, contract terms, quality specifications, and a penalty clause for violating the guaranteed quality. Changes of these components reflect market situations and risk expectations.

Contract tonnage:

Specific *shipping tonnages* for the contract period are set at the time the contract is signed. Usually they are fixed in the first couple of years; they can be changed by renegotiation. Tonnages experienced large cuts during the long period of slack demand. "The 10% adjustment on tonnage on buyers option" is commonly used in today's contracts. Oversupply is resolved in various ways to cut down contract

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tonnage, which is an evidence of buyer's power (See chapter 4.4, for detailed discussion).

Price determination:

In the 1960s Japanese buyers arbitrarily switched from CIF price to FOBT price. Thus the Japanese took the risk and captured all ocean-transportation rent. Given subsequent events, this switch has been an important source of cost saving for the Japanese buyers (Anderson, 1987).

Local currency was more commonly used in the past. That means the buyers would take the exchange rate risk, and on the other side of the coin, they catch the profit. This settlement is in favor of the producers who do not have to a pay large amount of debt or dividends to foreigners to get a stable cash inflow in local currency. This phenomena has changed. In 1989, with the exception of four Canadian brands, all contracts are signed in US Dollars.

Two types of *price determination* currently used are fixed price and escalated price. Before 1982, the *Fixed price* could be pegged for a couple of years. Now, fixed prices, based on market price and coal quality, are negotiated annually or semi-annually. The determination of *escalated price* is more complex. Most new projects use a cost based escalated price to ensure the cash flow for paying back the debt. The items covered by price escalation clauses may include wages, materials and supplies, railway freight, and government charges such as royalties and exchange rate. These adjustments are calculated from the predetermined components multiplied by the rates of increases in the official indices announced every 3 or 6 months. Another type of

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escalation clause only concerns the change of the exchange rate. It is composed of a fixed proportion in US dollars and an escalated proportion adjusted by the change of the exchange rate. In this way, buyers and sellers share the risk of exchange rate variation. Generally speaking, exchange rate escalated price was used by existing mines. However, recent trends indicate that the escalated price determination has become less popular, as contracts with fixed price dominate. In JFY 1985, at least, 10 Australian brands and 4 Canadian brands used escalated prices. In JFY 1990, only three Canadian coal brands had escalated prices. Some other clauses have been used in contracts, such as equity review clauses and recession clauses. The equity review allows the price to be reviewed when this price is lower than the market level, such as during the oil price shock. The recession clause on behalf of the Japanese buyers allows the Japanese Steel Mills to cut up to 20% of the contract volume, subject to fair treatment with other suppliers, at the time of serious adverse economic conditions in Japan.

Who sets "world market price" ? The former USSR and China, and South Africa are basically price takers. Although escalated prices used by some Canadian mines reflect costs, they are exceptionally high, since they entered the market at a much higher cost than the long run marginal cost of existing mines as part of the buyers' risk diversification strategy. Including those prices to form the market price would draw the price above the costs of most mines. In this way, the producers would earn some economic rent. The reality is that those high cost producers are excluded from forming world market price. Namely, Japanese buyers are powerful

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enough to exert price discrimination. Actually, the reference coals brands used to determine the basic price once included US Pittston and Mettiki, Australian Moura, South Blackwater, German Creek (Coal Manual, 1987) ([9]). The settlements between these mines and the Japanese buyers strongly influence all export prices to the Japanese market. This suggest that the importance of individual suppliers varies. Most of them act as semi-price takers in the market, while a few suppliers have more influence on price determination than others.

Quality clause:

Quality specifications and penalties are discussed in Chapter 3.

Contract term:

The lengths of contract terms have declined substantially in response to market condition changes. The longer terms reflect the desire to secure supply and sale in the early 1980's. The shorter terms are the result of continuing supply surplus and buyers' power to manipulate the market.

Some observations and conclusions related to contract terms are: (1) The length of the contract term has decreased. Long term contract was dominate in early years.To the end of the last decade, a little less than three quarters of brands (56 out of 80 brands were traded) and 43% of tonnages are traded by yearly contract (*Coal Manual, 1989*). (See Chapter 4 for detailed discussion). (2) Small producers lost long term contracts and act as swing suppliers. With the combination of more price and tonnage cutting, small producers definitely get hurt most during the over supply period. (See Chapter 4 for detailed discussion). (3) The impacts on each country may

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be different (see Table 2.5) Australia seems at the least favorite position in terms of contract length, if over supply continues. It is unlikely that many Australian brands are going to be out of market due to their low cost, but less protection by longer term contracts can be used by Japanese negotiators to further cut their prices. Canadian suppliers seem to be in a much better position, as they are in "safe" long term contracts. But they also have experienced tough negotiations with Japanese buyers. These buyers complained about the high price contracts and went to court. When those long term contracts are terminated, western Canadian coal mines will have a rough time selling large volumes of coal at high prices. Some small US producers with yearly contract could face more loss of tonnage if the demand continues slack and prices of U.S. coals continues high.

Breaking a Contract[8]

Can contracts be broken? Reviewing of contracts was a common business settlement. When market conditions change substantially, renegotiation is carried on before one partner is completely out of business. Through tough renegotiation, the initial contracts are changed considerately. But, breaking a contract still can be very difficult, and sometimes it can not be resolved by buyers and sellers. An example is the law suit in British Columbia. In 1987, the Japanese steel mills called a review on

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[8] *International Coal Trade* , No. 762, May 31, 1990.
Coal Week -- International, July 3, 1990.
Coal Manual, 1988-1991.

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Table 2.5 Classification of Contracts By Their Terms (JFY 1988)

Classification of Contracts By Their Terms (JFY 1988)

Term(year)(*)	Long	Medium	Yearly	Total
(1) Numbers of brands				
US(**)	3	1	18	22
Canada	6	6	5	17
Australia	5	3	41	49
Sum	14	10	56	88
(2) Tonnages by contract term (1,000 MT)				
US	6710	203	4817	11730
Canada	11631	4898	2150	18679
Australia	5755	4200	18677	28632
Sum	24096	9301	25644	59041
(3) Percentage of tonnage by contract term				
US	57.2%	1.8%	41.0%	100%
Canada	62.3%	26.2%	11.5%	100%
Australia	20.1%	14.7%	65.2%	100%
overall	41.0%	15.6%	43.4%	100%
(4) Average price weighted by tonnages				
US(**)	50.75	58.07	46.81	
Canada	69.56	46.90	43.15	
Australia	45.35	46.69	40.25	
Average	58.93	47.05	41.36	

Source: Coal Manual, 1989
Note:
(*) Long - equal or more than 10 years.
Medium - 2 to 5 years.
(**) 8 US brands are excluded, as lack of full information.

the contract between the Japanese steel mills and Quintette Coal Ltd.. After the two sides failed to reach an agreement, the Japanese steel mills filed for arbitration on

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Nov. 17, 1987. At that time, the Japanese mills had required the price be lowered to C$57.85/t (US$48.82/t). After three year law suit, the British Columbia Supreme Court finally dismissed the Quintette appeal in July 1990. The price of Quintette coal was reduced to C$94.90/mt for the second quarter of 1990, then dropped to C$84.40/mt in second half of 1990, C$82.40/mt on January 1, 1991; the contract price was to be reviewed again in April 1991; and, Quintette would reimburse the Japanese steel mills approximately C$46 million (US$39 million) for their over charge. Although the Japanese steel mills won the suit, industry observers think that the decision was essentially a compromise. Initially, the Japanese steel mills asked to cut price to about the market price, C$57.85 (US$48.82). If this had happened, they would be reimbursed C$540 million (US$455 million), which is ten times the final settlement. The mine's operating cost appeared to be higher than its revenue at that time. The mines would have to close if the price were cut further. Quintette was 50% owned by Denison mines ltd. at that time, 38% owned by the Japanese steel mills, and 12% by Charbonnages De France. Therefore closing the mine was not a desirable solution for the Japanese.

2.5.2 Media of Transaction -- Trading Company

An important participant in Japanese coal transactions are the Japanese trading companies, also called trading firms or trading houses. These companies provide the interface between producers and consumers. They are always present in coal transactions. In the coal market, regardless of the type of transaction, all purchasing

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is done through trading companies or with their participation (Interview with the Japanese trading companies, Mitsui and Mitsubishi). After World War II trading companies were initially set up to help Japanese companies to trade internationally. At that time, foreign currency was scarce for Japan. The main functions of the trading companies were to coordinate foreign currency and to help Japanese companies to understand foreign markets and the regulations of international trade. These function have changed. Lack of foreign currency is no longer the reason for keeping trading companies. But, as specialists in trade, trading companies are still the key participants due to their experience, information and connections.

Acting as brokers, trading companies represent buyers and sellers simultaneously (Anderson, 1987, p.14). Trading companies with their offices in coal producing regions help to set up business between sellers and buyers, anticipate investment decisions, arrange long term contracts, and also help to set up annual negotiating sessions. Trading companies are well known for their knowledge and excellent information about the coking coal market. Therefore, most producers believe that these companies provide useful services.

Currently, about 39 Japanese trading companies are involved in coking coal trade, of which 11 have more than a 1% share. In total they control 91.8 % of the coking coal contract tonnage. Mitsui & Company, Inc. (U.S.A.) made about a quarter of coking coal transaction and stands as the largest trading company in coal market.

There is, however, some support for the proposition that the relationship is

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likely to be biased in favor of the Japanese steel mills (Anderson, 1987).[9] Anderson also questions the long run effect: "in long run, do trading houses facilitate the transfer of surplus from the producer to the consumer?" But, there is a lack of hard evidence on this issue, as has been mentioned by other investigators. Through my research on actual trading activity by trading companies, it is still hard to get a clear conclusion. The nature of a trading company is complicated. Some trading companies are subsidiaries of Japanese steel mills or other large consumers. The largest trading company, Mitsui Company, Inc., is a subsidiary of Mitsui Group. It is reasonable to believe that they represent their parent companies and use their knowledge and experience to make best purchases to maximize their parents company's profit. At the same time, there is some evidence showing that the tie between parent and subsidiary is loose. Like many subsidiaries, their business extends beyond the parent company. Trading companies independently import and export for all consumers. Furthermore, their parent companies do not purchase coals exclusively through their subsidiaries. For example, the contracts through trading company Mitsui (U.S.A.) involve all coking coal consumers in Japan. The purchase made by Mitsui (U.S.A.) for Mitsui Chemical was 153,500 tons, which was less than 1 % of the business for Mitsui (U.S.A.) in 1988. On the other hand, Mitsui Chemical purchased 3,342,200 tons by

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9 D. Anderson concluded this based on Peter Szabo, "Role and the Japanese Trading Company in Setting World Coal Prices"; and Jon P.B. Vinvient, "Australia's Mineral Resources: Rags or Riches?". But the publication were not given.

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contracts through 11 trading companies. Mitsui (U.S.A.) made only 4.5% of sales, ranking lower than six other trading companies. Actually, trading companies try to diversify their customers too. Table 2.7 gives the number of buyers and sellers involved by the top four trading companies. And, each consumer or producer deals with more than one trading company. The positive contribution of this independence to the market is that trading companies smooth transactions and make the whole market work fast. It is pretty obvious that trading companies are not a simple extension of their parents company. But, do they benefit Japanese industry as a whole? Simple cost minimization/profit maximization does not provide an answer to this broad question.

Table 2.6 Concentration of Japanese Trading Companies (1988)

Concentration of Trading Companies (1988)

Number of companies	Market Concentration
4	59.8%
8	84.9%
11	91.8%
39	100.0%

Source: Derived from *Coal Manual,* 1989. pp.99

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Table 2.7 Contract Distribution Among Countries By Major Trading Company

Contract Distribution Among Countries
By Major Trading Company

	Contract Brands				*share of*	*Major*
market¦*Consumer*	US	Canada		Aust.	Total (%)	
Importers:						
Mutsui Co.	4	8	16	28	24.5	12
Mitsubishi	4	3	12	19	17.1	13
C. Itoh & Co.	4	3	3	10	10.2	13
Tokyo Boeki	4	1	2	7	8.0	10
Total brands in that year	14	17	49	80		16(a)

Note
(a) including 8 steel mills and 8 major coke and chemical companies.

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3. QUALITY OF COAL AND ESTIMATION OF QUALITY COMPONENT OF PRICE

3.1 Technical Background

By their degree of product homogeneity we can generally classify mineral commodity markets into two types. In the "downstream market", an homogeneous product, such as a copper cathode with less than 0.1% impurity, is traded simply by quantity. In the "upstream market" heterogeneous commodities, such coal and crude oil, are traded not only by quantity, but also by quality. General economic theory can be applied directly to the market for an homogeneous product. To facilitate economic comparison for the heterogeneous good, quality requires special treatment.

In the heterogenous coking coal market price differentiation seems to exist. Figure 3.1 shows the plot of FOBT contract prices by coal brand.

As mentioned before there are two types of argument concerning price differentiation among supply regions in the Japanese coking coal market. One type of argument is that the higher price paid for the US coal by the Japanese is due to some non-market factors such as political pressure, risk premium, or the buyers' power to geographically discriminate among producers. Another type of argument suggests that the price differentiation is largely due to natural differences among coals, ie. a higher price is paid to US coal producers for their higher quality, so that the market is close to efficienT. Two factors identified in those discussions are "non-market" and "quality" factors. Including the conventional market factor, there are three major

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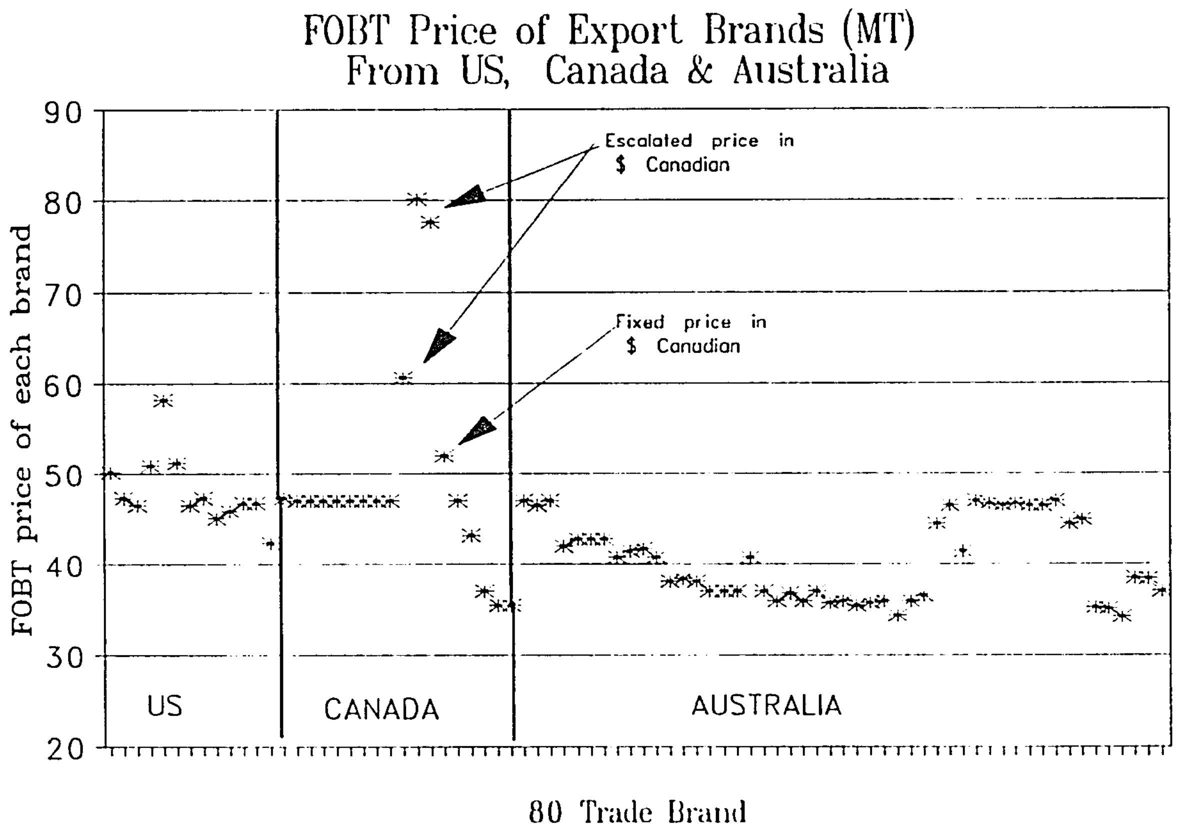

Figure 3.1 FOBT Contract Price by Brands (JFY 1988)

factors in market price determination. In mathematical form, price is a function of these factors:

$$P = F\ (M;\ NM;\ Q),$$

where,

M = market factors, such as supply, demand, contract, etc.

NM = non-market factors, such as buyers' power, risk aversion, etc., which mainly affect price differences among countries.

Q = quality or technical factors, which are the intrinsic properties of coal and are relatively independent of economic factors.

To study market efficiency and to determine if a non-market factor exists, the quality factor must be quantified to measurable terms of price or cost. Then, observed market prices are adjusted by this derived quality measure for further study of market efficiency. Here, the implicit assumptions are: the quality factor can be measured; the impact on price by the quality factor can be isolated from that by the non-market factors, and they can be studied separately. In this chapter, coal properties, coking properties, and coal classification are introduced first in order to help us understand the role of coal quality in price. Then relevant previous work is discussed. Finally, a statistical method is used to estimate the cost component, and a test for price differentiation is performed.

3.1.1. Properties of Coal and Coal Quality

As coals are rocks their qualities vary from mine to mine and from seam to

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seam. Consequently, different coals may be very different commodities. Ultimately, rather than paying for tons of materials, consumers basically pay for specific Btu content for thermal use or carbon content for metallurgical use, subject to premium or discount for other special qualities or impurities. In this study, coals of a specific trading brand[1] are viewed as a homogeneous product having a specific quality. The quality standard is maintained at the guaranteed level for a given period, which basically can be assured by coal preparation. Failure to meet this quality at shipment is penalized by buyers. Buyers can ask for cash penalty on extra amount of impurity, suspend shipment, or terminate the contract for severe failure to deliver coal with guaranteed quality.

Properties of Coal

Numerous physical and chemical properties of coal have been studied by researchers and engineers, and numerous parameters are used. Due to the complexity of coal quality there is no single set of parameters that is universally accepted. In this section, only the major, important properties are examined.

Chemical analyses are made in laboratories to study the relationships among the elements and the occurrence of mineral matter. Two methods are primarily used: ultimate analysis and proximate analysis. An ultimate analysis determines the

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1 A trading brand is provided by a producer/operator with guaranteed maximum impurities and minimum coking index, which may be produced from one mine or blended by several mine.

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quantities of carbon, hydrogen, oxygen, nitrogen, sulfur, chlorine, and phosphorus in dry coal; a proximate analysis determines the fixed carbon, moisture, ash content, and volatile matter. Proximate analysis is the most commonly used in coking coal evaluation.

Carbon content is the primary characteristic of coal and is positively related to *heating value* normally expressed in British thermal units (Btu). Coal with a high heating value is desired by all coal users.

The presence of moisture decreases the heat from coal combustion, as some heat is used to drive off the moisture. Coal with the lowest percent moisture is preferred. However, 4% moisture content is necessary for transportation (R. Bennett 1975). Therefore, in practice coals exported to the Japanese coking coal market have a moisture content of 4% to 11%. The weighted average moisture content of three major supply countries to the Japanese market in 1988 is 7.68%.

Sulfur content varies in bituminous coals from less than 0.5% to more than 4%. Sulfur is harmful whether coal is used in steam boilers or in the metallurgical sector where half of it will remain in the coke and become an impure matter in the blast furnace and subsequent steel. Therefore, coking coal has to be a low sulfur coal. The weighted average sulfur content from the three major supply countries to the Japanese market was 0.62% in 1988.

Ash is the residual of all unmeasured components remaining after coal burning. Usually ash consists of inorganic materials in raw coals, largely clay waste. This waste obstructs coal burning, requires residuals management and raises transportation

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costs. Low ash content is desired in both coking and burning processes.

Volatile matter consists of gases and vapors driven off during pyrolysis. All coking coals are bituminous. According to their volatile matter, they can be classified as low volatile, medium volatile or high volatile coals. Volatile matter, like moisture, displaces valuable carbon and needs heat for its removal. Generally speaking, low volatile coal is highly desired for coking coal because it usually exhibits high mechanical strength, which is the most important single characteristic of coke in blast furnace practice. For example, a study of coking coals in the US shows that the maximum microhardness occurs at about 83% carbon content of low volatile (LV) coals (R. Schmidt, 1979).

Some other factors, however, constrained low volatile (LV) coals to less than a 20% market share in 1988. These are reserve limitations and technical and economic factors. Technically, low volatile coals can create unacceptably high pressures in coke ovens, so coals with volatile matter below 16% (dry basis) are seldom cokeble. The optimum volatile matter is supposed to be between 22% and 30% and usually is obtained by blending coals having a wide range of volatile matter (R. Bennett, 1975). In the Japanese coking market in 1988, volatile matter is between 17% to 42%. Coal blending will be discussed below.

Evaluating Coking Quality

To be suitable for making coke, coal must ultimately satisfy four technical requirements: low ash, low sulfur, low coking pressure, and high coke strength (J.

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Leonard, 1988).

The three functions of coke in a blast furnace are as a source of fuel, a reducing agent, and a substance to maintain permeability in the furnaces, because a good liquid permeability allows iron tapping and slagging-off to take place. The last role is extremely important, for coke is the only solid present in the shaft bottom and lower zone of the furnace where the ore and the flux soften and melt. Coking strength is desired to secure uniform gas pressure throughout the large furnace diameter and good properties for iron tapping. Strength is the most important property in coking coal. A number of methods or tests are used to evaluate the quality of coking coals, such as the crucible swelling test, the Geiseler plastometer for determining plasticity, the Rhur and Audibert-Arnu dilatometer and the coke oven tests. The crucible swelling test is used to determine whether or not a coal has potential to be used for coke making. The amount of swelling is quantified by assigning a numerical value from 1 to 9, increments of 0.5, which is called the Crucible Swelling Number (CSN) or Free Swelling Index (FSI). The greater the CSN, the better the coal is assumed to be for coking. An increase in ash content reduces CSN. The numerical values obtained from the Ghastlier method are used with reflectance measurements to predict the behavior of not only a single coking coal, but also of a coke made by blending.

Petrographers use the mean maximum reflectance of vitrinite in oil ($\overline{R_0\text{max}}$) as the level of organic maturity. Reflectance can be used to rank coals because of the correlation between reflectance and carbon content, and it is closely

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related to volatile matter. Petrographic composition is also used by petrographers.

Among these tests, only the CSN data are available for further numerical analysis. The remaining tests are of use for illustrative purposes.

3.1.2 Coal Blending

Traditionally the Japanese have imported large volumes of low volatile U.S. coking coal to get optimum coal quality with premiums on coke strength. But the import share of low volatile American coals has dropped over the years from more than 20% at the beginning of the 1970's (Hiroshi Matsuoka, 1975) to about 1% in 1989 (Coal Manual, 1990). While the coal demand started to slow down in 1982, the New York Times (hershey, 1982) claimed that the low-volatile coal market had "disappeared".[1] The primary reason for this decline is coal blending.

From a metallurgical point view, very few American coal fields satisfy all of the requirements to produce premium coke. The necessity of blending in American practice arose from the fact that LV coals produces a high expansion pressure during carbonization. These, if not offset by coals with low expansion coefficients, can cause damage to the coke oven.

Taking US coal as an example, the reserves of high quality low volatile US coals are very limited. In the U.S., the large volume of low volatile coals with high coking strength yield unacceptably high pressure; thus, these have always been blended with other coals to yield low pressure in coke ovens. The reserve of medium volatile coals also yield high coke strength, but these are generally unacceptable

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because of high sulfur, ash and coking pressure. The large reserve of high volatile coals yields low coke strength. Table 3.1 shows the rank of coal, type of reserve and coking character for U.S. coals.

Table 3.1 US Coal Reserve By Type

US Coking Coal Reserve by Type

Rank of Coal	**Type of fields**	**Reserve**
Low-Volatile	Low-ash, Low-sulfur High-Strength High-Pressure	Large
Medium-Volatile	High-ash, High-sulfur Medium-High-strength Medium-High-pressure	(*)
High-Volatile	Low-Medium-ash Low-Medium-sulfur High-strength Low-pressure	Large

Source:Derived from "Evaluating Coking Coals", by J. W. Leonard, 1988 Keystone Industry Manual. pp 338.

Note: (*) not given by Leonard.

The high quality low volatile US coals are underground in seams that tend to be deep and thin, which make them high cost. On the other hand, volatile matter yields valuable coke oven by-products, such as gas, under certain technical conditions. This provides a bonus for higher volatile coal which, along with a lower price, makes high volatile coal economically more attractive. Coal blending and by-products have reduced dependence on LV coal. Consequently the price of LV coal no longer commands a substantial premium as in the past.

Indeed, coal blending has always been used in coking and steel making. For

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Japan, as a consumer dependent on outside coal suppliers, it is in its best interest to improve technology to reduce its dependence on a few high quality coals, to diversify supply sources, and to reduce coal cost. Coal blending practice has been refined and developed over the years to permit more medium and high volatile coals and other low volatile coals of lower quality to displace the traditional low volatile US coking coal in the market. The 1988 coal import contract tonnages and shares by volatile matter are shown in Table 3.2.

Table 3.2 Contract Tonnages by Volatile Matter (JFY 1988)

Import Tonnage By Volatile Matter and Countries

Tonnages Classified by Volatile Matter
(1000 MT)

	LV	MV	HV	Rest[a]	Total
US	862	7421	3383	385	12051
Canada	4383	13396	900	30	18709
Australia	5710	12155	10767	105	28737
Total	10955	32972	15050	520	59497

Shares Classified Among Three Countries[b]

	LV	MV	HV	Rest	Total
US	1.45%	12.47%	5.69%	0.65%	20.25%
Canada	7.37%	22.52%	1.51%	0.05%	31.45%
Australia	9.60%	20.43%	18.10%	0.18%	48.30%
Total	18.41%	55.42%	25.30%	0.87%	100.00%

Source: Derived from "Coal Manual 1989".

Note:
(a) Including trading brands without clear quality specification.
(b) Three countries comprise 84.25% of the total coking coal import market in Japan. The remaining exporters are the USSR, South Africa, China and New Zealand.

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Although LV Canadian and Australian coals constitute about 17% of the three countries' total exports to Japan, the coking qualities of those substitute coals are not as good as American coals, as determined by microscopic examination. For example, the crucible swelling numbers (CSN) of LV American coals are all above 8. One LV Canadian coal has a CSN equal to 3 (21% VM), and the CSN for Australian LV coals can be as low as 1.5 (19.5% VM) (Coal Manual 1989). Except for a few LV American coals, most LV brands need to be blended with MV or HV coals. In practice in the US, only one out of about 40 coke conversion facilities produces coke from a single coal. For the foregoing reasons, two, three, or more widely different coals are purchased and mixed at the coke plant to yield a highly synthesized coal for charge to the coke ovens (J. Leonard, 1988). As Japan lacks its own resource, it blends coals from more diverse sources to provide flexibility of qualified substitution and to ensure price and timely delivery concessions.

The impacts of this coal blending on the Japanese coking coal import market are to shift coal purchasing to more abundant and less expensive coals by relaxing the quality requirements on supplies. This has reduced price differences among coals of various qualities and between coals from various sources. For example, the negative relation between price and VM is no longer as strong as it once was, and most importantly, some qualities become less important through blending. All of these offsets increase coal substitution and have had negative impacts on US coal exports and price.

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3.1.3 Coal Classifications

Reflecting the inherent complexity of coal quality, coal classifications vary and may overlap on each other. Each classification appears to have been initially developed for a special use. To use data sources properly, understanding these classifications is helpful.

(1) Steam and Coking Coal Classified by End Use

The classification most commonly used in economic statistics are steam and coking coals, reflecting the final uses of coal. *Steam Coal*, also called thermal coal, is used as fuel primarily in the utility, cement, transportation and commercial sectors. The heat unit, BTU/lb or Kcal/lb, is the primary index of quality. Besides heat content, other quality characteristics for consideration are sulfur, ash, and moisture content.

As environmental concerns increase, demand for lower-sulfur and lower-ash clean coals increase. This trend has stimulated the building of coal preparation plants with the more sophisticated circuits commonly reserved for metallurgical coal and has caused utility companies increasingly to purchase coal from traditionally coking coal producers and mines. In this process, coals of coking quality or that could be blended and used for coking instead are dedicated to utility plants as steam coal. As this occurs, the difference between coking coal and steam coal prices decreases.

Coking coal, also called metallurgical coal, is used primarily by the steel, gas and mineral industries. High carbon content is a basic requirement. The absolute

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quality requirements for coking coal are always higher than those for steam coal, and the price of coking coal reflects those substantially higher standards.

(2) Classification According To Rank (ASTM)

Classification according to rank is based on the degree of metamorphism and the properties of coal, by which coal is ranked as lignite, subbituminous, bituminous, and anthracite; from low to high quality(I.A. Williamson, 1967). The American Society for Testing and Materials (ASTM) ranks coals according to their fixed-carbon content on a dry basis, and the lower rank coals according to Btu content on a moisture basis (ASTM Specification D388), see Table 3.3. These coal ranks overlap other classifications.

(3) Hard and Brown Coal Classification

The International Coal Classification of the Economic Commission for Europe (UN-ECE) recognizes two broad of categories coal: hard coal and brown coal by their calorific values. Hard coal is defined on a moisture and ash-free basis as having a calorific value above 5700 kcal/kg (gross calorific value). Typed according to total moisture content and low temperature yield, brown coals are defined as having a calorific value below 5700 kcal/kg.

Further sub-classes of hard coal, coking coal and steam coal, are used for market analyses and in statistics related to coal production, consumption and trade. Here coking coal is defined as "hard coal with a quality that allows the production of

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Table 3.3 Classification of Coals By Rank (American Society for Testing & Material)

Classification Of Coals By Rank
(American Society For Testing & Material)

Class/Group	Fixed Carbon[a]		Volatile[b]		Calorific[c]	
	Low	High	Low	High	Low	High
I. Anthracitic						
1. Meta-anthracite	98			2		
2. Anthracite	92	98	2	8		
3. Semianthracite	86	92	8	14		
II. Bituminous						
1. Low Volatile	78	86	14	22		
2. Medium Volatile	69	78	22	31		
3. High Volatile A		69	31		14000	
4. High Volatile B					13000	14000
5. High Volatile C					11500	13000
III. Subbituminous						
1. Subbituminous A					10500	11500
2. Subbituminous B					9500	10500
3. Subbituminous C					8300	9500
IV. Lignitic						
1. Lignite A					6300	8300
2. Lignite B						6300

Note:
a) Fixed Carbon in percentage on Dry, Mineral-Matter-Free Basis.
b) Volatile Matter in percentage on Dry, Mineral-Matter-Free Basis.
c) Calorific Value Btu per pound on Moist Mineral-Matter-Free Basis.

coke suitable for blast furnace use". By this definition, coking coal is defined by its quality instead of its final use, which could cause some confusion, as some coals with coking quality are used in electric generators as steam coal or the other way around.

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Therefore, statistics from exporters tend to place more coals in the coking coal category, while statistics from importers tend to place more coals in the steam coal category.

For comparison with other classifications, such as with rank, IEA indicates that hard coal includes anthracite and bituminous coal, and Brown coal includes subbituminous and lignite. Exceptions include the United States, Australia and New Zealand. These countries classify subbituminous as hard coal because of its high calorific value of such coals in these countries and because of the availability of data in national statistics. (Coal Information, 1988. pp. II.6)

(4) International Classification of Hard Coal by Type

This classification is commonly used in Europe and is also used in statistics on international trade. It includes those coals with a heating value of more than 23.8 MJ/kg (about 9520 Btu/lb).

In this classification, coals are divided into classes, groups and sub-groups, and assigned a 3-digit number on the basis of these subdivisions. The first digit refers to Class, numbered from 0 to 9, based upon volatile matter yield on a dry, ash-free basis. The second digit refers to the Group, numbered from 0 to 3, based upon FSI (CSN). The third digit refers to the Sub-Group, numbered from 0 to 5, based on maximum dilatometer value or Gray-King coke assay. For example, if a 3-digit index, 423, is used in statistics on international coal trade, it indicates a coal with volatile matter in a range of 20-28%, FSI in a range of 2½ - 4, and dilatometer in a range of

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0 - 50. This index includes very good information about coking quality, but ignores impurity content, such as ash, sulfur and moisture content. (D. Pearson, 1985)

(5) Nippon Steel Corporation's Classification of Coking Coals

This classification has not been formally described by the company, but a version of it was described by Pearson (D. Pearson, 1980). The main elements of this lexicographical classification are shown in Pearson (1980), which includes rank, inert content, maximum dilatation, maximum fluidity, FSI (CSN), volatile matter, and coke strength. Six groups, represented by six typical coal trading brands, are given in this classification. In this way numerical properties are replaced by six distinct coal groups related to the Japanese steel market. (D. Pearson, 1985)

(6) Contract Information -- *Coal Manual*, Japanese Agency

In most parts of this study, I use the data from *Coal Manual*. *Coal Manual* contains various historical and current information about the supply and demand of coking and steam coal, such as steel production, coke consumption per ton of steel, major coking and steam coal consumers, quality and production of the on going coal mines and projects, inland shipping companies. The most useful data *Coal Manual* provided are detailed contract information by each trading brand from each country. No aggregated classification is recommended in this manual, since the quality specification data, such as impurity contents and coking property, are given for each brand, which provides the most objective information of coking coal supplies. The

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actual shipping tonnage, quality, and price may be different from those of the contract, thus there may be some gap between these contract data and other statistical data based on actual transactions.

For detailed information about classifications see International Classification of Hard Coals, American Society for the Testing of Materials (ASTM), and related articles.

3.1.4 Illustration of Quality Characteristics

There are five quality variables available for each trade brand. Four of them are impurity contents, which generally have a negative impact on price; the last is a measure of coking quality, which in general is positively related to price. Plotting the FOBT price against each of variables shows the patterns of the relations between each of those qualities and price (Figure 3.2 to Figure 3.6). Here, the plots describe 76 brands. Four outlier Canadian brands are excluded, as they are quoted in Canadian dollars and three of them are for an escalated price.

As all coking coals have to be low sulfur and ash, the differences of sulfur and ash content among producers are small; these small differences may not play a very big role in price. The need for blending and the value of by-products from coke furnace blurs the role of volatile matter. CSN is the only one variable having a strong positive relation with the price. This pattern is strong within a single country or across countries. Average qualities of the coals purchased by all eight Japanese steel mills are very similar, which indicates that they all use similar technology. Thus we will

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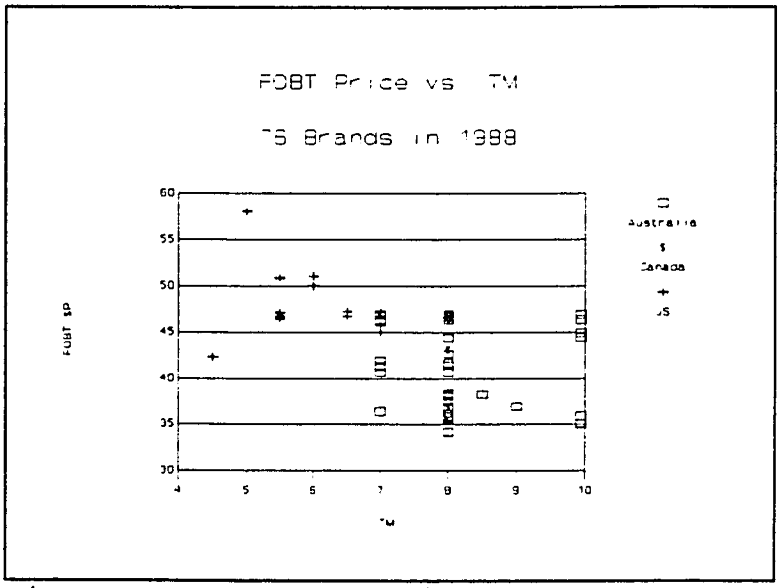

Figure 3.2 FOBT prices verse total moisture (TM)

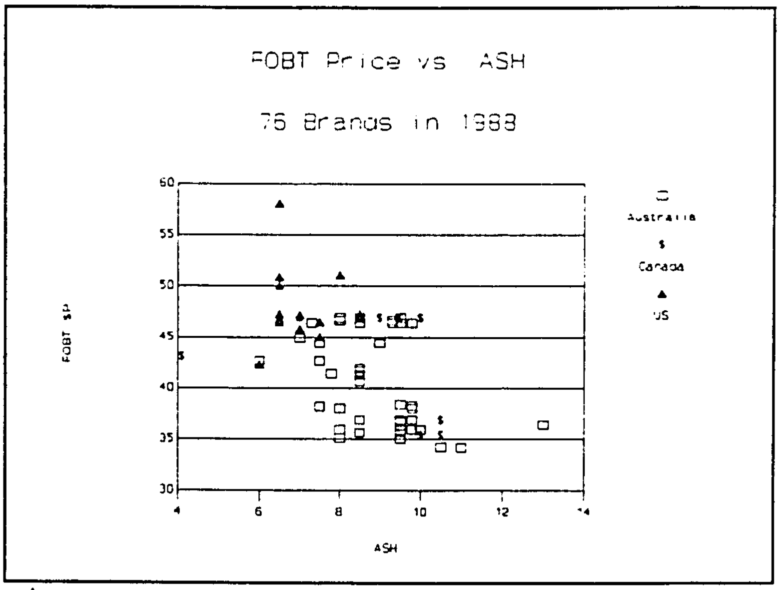

Figure 3.3 FOBT verse Ash

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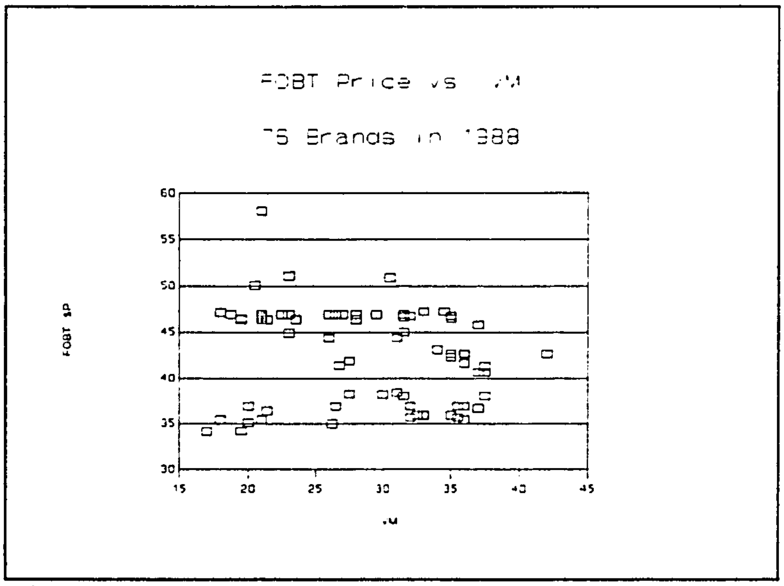

Figure 4.4 FOBT Prices vèrse Volatile Matter (VM)

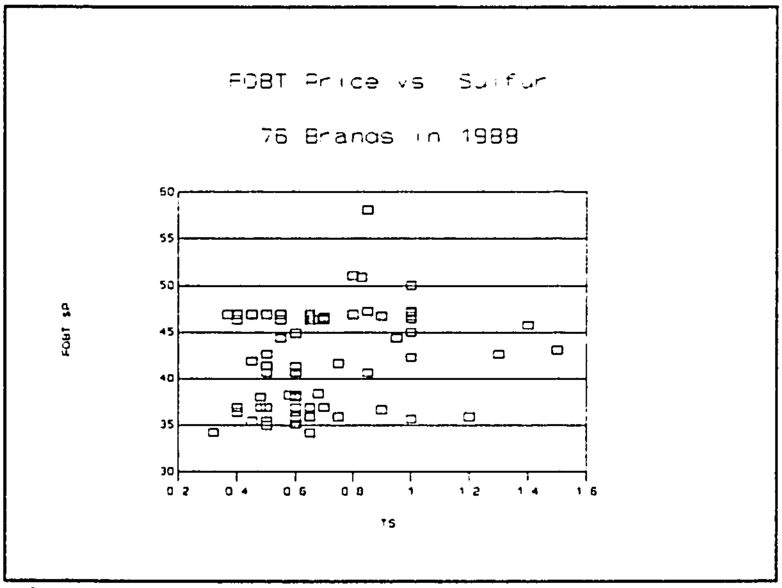

Figure 3.5 FOBT prices verse total sulfur (TS)

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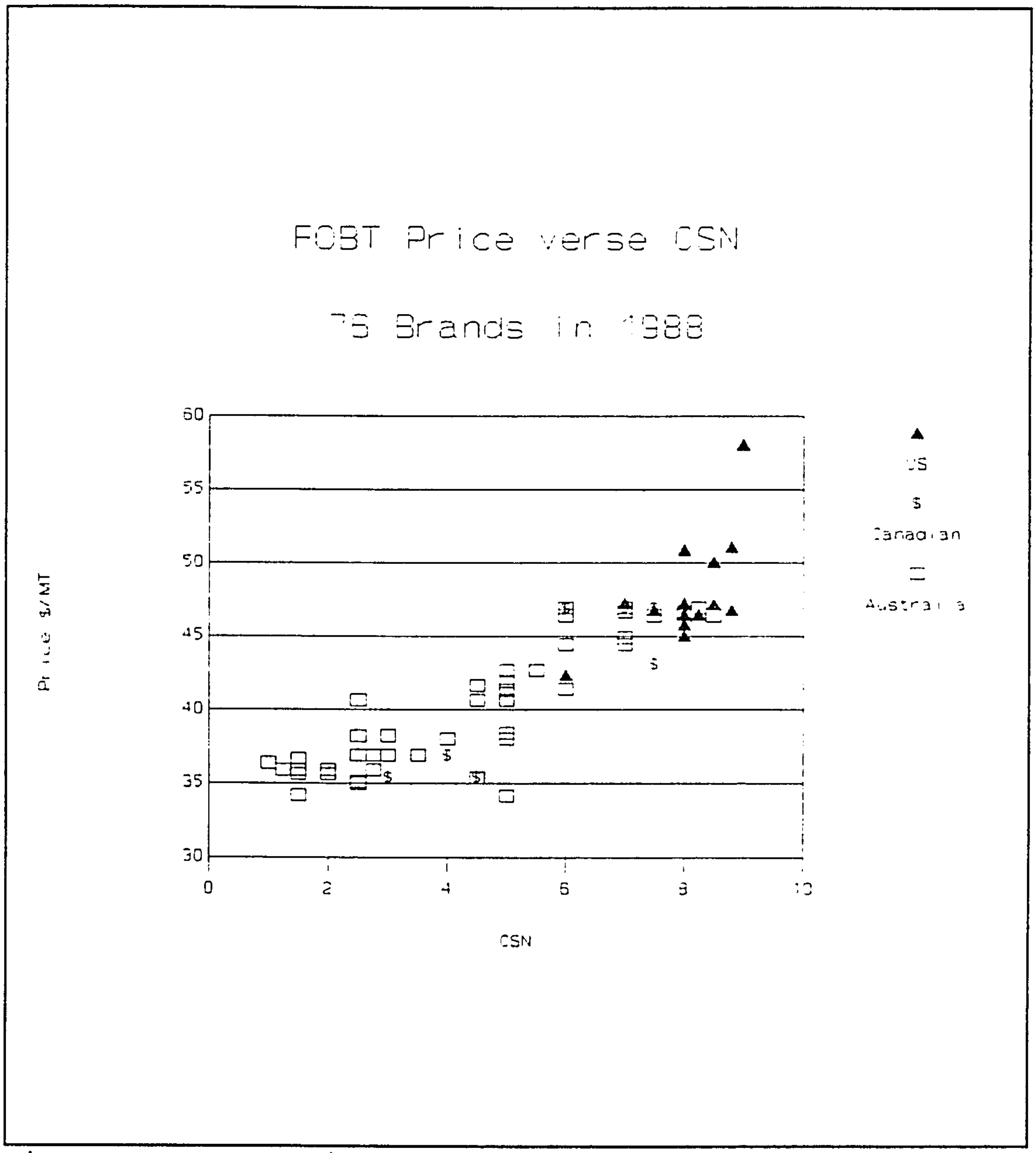

Figure 3.6 FOBT prices verse crucible swollen number (CSN)

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not distinguish individual consumers. Instead, we will examine aggregate demand for coking coal by all Japanese steel mills.

The qualities of coal from individual supply region, however, are more complicated. The Table 3.4 shows the weighted average and range of qualities from each supply region and in general.

The US coals are low moisture and low ash, but high sulfur. The real advantage of US coals is their superior coking quality, indicated by the highest swelling number. Since CSN has a strong positive impact on price, these high CSN values seem to support the argument that the higher US prices is primarily caused by higher quality. Below we will examine how effective CSN really is in earning a price premium; is it important enough to offset other quality and price differences? Canadian coals are good, having the lowest sulfur and lowest volatile matter and good coking quality. The 15 year-long term contracts of four high price Canadian brands were signed in 1981 (started from 1983, Greeg River, Quintette, Bullmoose and Line Creek). Three of the prices were set by using escalated price clauses, in Canadian dollars, in order to recover the initial investment. The last one is a fixed price 1988 contract, but it is in Canadian dollars. These four brands are excluded from this study of quality, because their price is obviously affected by conditions other than quality. Qualities of Australian coals vary from the best to the worst.

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Table 3.4 Average and Range of the Quality By Countries

Average and Range of the Quality By Countries

(1) Average Qualities Weighted by Tonnage

	TM	ASH	VM	TS	CSN
US	5.86	7.03	28.46	0.88	8.15
Canada-17	7.82	9.11	23.23	0.48	6.19
Canada-13	7.68	8.74	23.10	0.48	6.40
Australia	8.21	8.77	27.95	0.62	5.43
Sub T-17[b]	7.68	8.66	26.50	0.62	6.15
Sub T-13[a]	7.62	8.50	27.14	0.65	6.18
S.Africa	7.67	8.08	31.17	0.70	1.42
USSR	7.00	9.00	19.50	0.30	8.00
China	10.00	10.50	28.94	0.68	6.00

(2) The Ranges of Quality Specifications

	TM (L, H)	ASH (L, H)	VM (L, H)	TS (L, H)	CSN (L, H)
US	(4.5, 8)	(6, 8.5)	(18, 37)	(0.7, 1.4)	(6, 9)
Can.	(5.0, 9)	(4, 10.5)	(17, 34)	(.37, 1.5)	(3, 8)
Aust.	(7,10.5)	(6, 13)	(17, 42)	(.32, 1.3)	(1, 8.5)
total	(4.5,10.5)	(4,10.5)	(17, 42)	(.32, 1.5)	(1, 9)

Sources: Coal Manual 1989.

Note:
(a) are derived from 14 US, 13 Canadian and 49 Australian brands. It takes about 97% export tonnage from these three countries, and 87% to Japanese Coking Coal Market from these countries.
(b) 4 Canadian, with escalated prices or price in Canadian currency, brands are included.

3.2 Estimation of Quality Component--Previous Work & Penalty Clauses

3.2.1 Previous work -- BSC Model

The work done by the Coke and Ironmaking Working Party in the General Steels Division of the British Steel Corporation (BSC) was discussed by R.Bennett

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(1975). To simplify communication, this work is referred to as the BSC model.

Bennett introduced a price formula developed by BSC by which the delivered price of a specific coal can be estimated using the market price for a standard coal minus the cost of impurities of a specific coal. These estimated prices were then compared with actual prices for the purpose of economic feasibility studies.

As Bennett pointed out, no standard set of coking quality is widely used. Thus, the cost estimation is not only dependent on the method utilized but also upon the parameters chosen for this estimation.

> "It is impossible to set absolute values on coke quality parameters, but feasible, if difficult, to estimate the values of variations from a given mean. Similarly there is no common worldwide basis for calculating coal prices and no absolute scale of value for the principle chemical components of coal, but the costing of variations in impurity levels can be applied to an arbitrarily chosen 'standard' quality to calculate the relative value-in-use of the other coals." (R. Bennett, 1975)

While, there is no unique method for quality evaluation in use, the BSC model primarily used the proximate approach to coal analyses, and coal property indexes included moisture, ash, sulfur content, and volatile matter. Similar qualities plus CSN, as a measure of coking properties, will be used in the present study.

In the BSC model the delivered price of coal is defined as a combination of the absolute price and the relative price. The absolute price is the price of the "coal" with an homogeneous quality and is determined by market conditions, ie. the market price of a "standard coal". Quality differentiations result in relative prices around the market price level of the standard coal. Bennett also called this relative price a cost of impurity, which is supposed to be the per unit costs of removing these impurities;

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thus costs are obtained by external technical evaluations.

In the formula used to evaluate the delivered price, the delivered price of coal is equal to the market price of carbon and by-products minus the processing costs for removal of impurities and the transportation cost for moving waste:

$$P = K\,(FC + Rv \times V)$$
$$- (Cm \times M + Ca \times A' + Cv \times V + Cs \times S')$$
$$- \text{Transport Rate} \times [M + A + V\,(1 - Rv)]/100 \qquad (1)$$

Where,

K = parameter reflects market price for standard coal.

FC = % fixed carbon as received.

M, A, V = % moisture, ash, volatile matter, respectively as received.

A', S' = % ash and sulfur as received above the standard level, respectively.

Rv = percentage value of by-product, ie. (Average value per ton of by-products)/(Value per ton of blast furnace coke).

Cm, Ca, Cv, Cs = cash cost of *processing* each 1% of moisture, ash and volatile matter, and 0.1% of sulfur above the standard level, respectively.

The first term of the formula is the pure economic benefit from carbon and the useful by-products created from the volatile matter. The second term is the cost of removing impurities and the third is the extra cost of transporting waste.

The general procedure for estimation is:

(1) Select a "standard" coal or "reference" coal. As an example, the standard coal chosen by BSC was arbitrary:

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Moisture	0%
Ash	6%
Volatile Matter	0%
Sulfur	1%
Rv	.856 (end of 1974)

The idea of the "reference coal" has also been used by Japanese importers, except that the "reference coal" in the Japanese import market consists of actual coal trading brands which are not only the reference for the quality standards but are also the reference for the current market price. The coals used as reference in the Japanese coking coal import market are the following (Coal Manual, 1987):

(a) Export prices of both Pittston MV Blending coal and Mettiki LV coals to Japan.

(b) Export price of U.S. metallurgical coal to markets other than Japan.

(c) Prices of thermal coal, produced from underground mines in the U.S.

(d) Export prices of three brands of coking coal (Muran (MV), South Blackwater (MV), German Creek (LV)) from Queensland, Australia, to Japan (Coal Manual 1987). The qualities and prices of the five reference brands listed above are given in Table 3.5. Because we do not know how these four parts are weighted in calculating the base price, or if the fixed weights even exist, these references are of little use.

(2) A gross value for each coal is then adjusted by deducting the costs of impurities to give a net value-in-use. Here the cost coefficients are estimates of the costs for

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Table 3.5 Five Reference Brands With Their Price & Qualities

Five Reference Brands With Their Price & Qualities

Brand	FOBT1988 ($/MT)	TM%	ASH%	VM%	TS%	CSN
Pittston MV	50.88	5.50	6.50	30.50	0.83	8.00
Mettiki	50.04	6.00	6.50	20.50	1.00	8.50
Moura	44.40	8.00	7.50	30.50	0.55	7.00
South Blackwater	46.40	10.00	7.30	28.00	0.55	6.00
German Creek	46.40	10.00	8.50	21.00	0.66	8.50

removing a unit of impurities, which reflects current technology. In 1975, the costs of processing impurities estimated by BSC in terms of British pounds were:

Cm	£ 0.0966
Ca	£ 0.081
Cv	£ 0.004
Cs	£ 0.158

If the value of parameter K and the unit cost of transportation are known, then the delivered price of any coal with given specifications can be estimated and compared with the existing market price of that coal brand to decide if the market price is acceptable. As this was done more than 15 years ago and by the British Steel Company, the numbers can not be applied directly to Japanese steel mills in 1988.

Comment on Bennett's paper:

Bennett's paper describes an interesting approach for relating quality to monetary values in terms of cost of removing impurities and gives a decomposed price

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formula to explicitly express the quality component. The weak points of this model are: (1) it more or less is a technical model. A specific value of market parameter K represents only a single equilibrium point of supply and demand. (2) The model's cost coefficients are defined as the cost of removing impurities, which are obtained from some external technical assessment. As no further detailed information or procedures were given, the actual numbers have little value 13 years later, for the technology has changed over time. Not only are actual costs hard to get, they change with time and by consumer. The price that a consumer would be willing to pay for a coal is dependent upon a number of factors, such as blending capability. It is, therefore, necessary to estimate the economic value of quality from market data.

3.2.2 Estimation From Quality Penalty Clauses in The Current Contracts

One way of determining the costs of impurities is from the penalty clauses in coal contracts. In 1988, about 30 contracts gave penalty rates (Table A.3). They are effective only when the received ash or sulfur content exceeds the level guaranteed by the producer. The penalty rates appear to be independent of the initially guaranteed level and independent of country.

Although the range of these penalties is fairly large, considering when the contracts were signed, the variation in penalty rates in each year is small to nil (see Table A.3). While these data reflect impurity removal technology, they also reflect such market conditions as expected supply shortage or surplus at the time the contract was negotiated. It seems reasonable to consider the minimum levels of the latest

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penalty rates as the upper bounds of the costs per ton of removing an impurity:

Cost of 1% ash $\leq$ \$1.10

Cost of 0.1% sulfur $\leq$ \$0.55

If we had some idea of the importance of the market factor, we could estimate the costs of impurities with reasonable accuracy. As we do not known it, these upper bounds should be used with caution, as they may overestimate these costs.

3.3 Estimating the Quality Component by Regression

A feasible way to distinguish the quality impact on price is to estimate it by statistical analysis, such as regression, based on observable market data. We start by setting up a basic model according to the economic theory of an homogeneous commodity. The quality adjustment is then added to modify the basic model to be utilized for an heterogeneous commodity. This modified model is then used to estimate the cost component by regression analysis.

3.3.1 Economic Theory

In the coal market, the homogeneous commodity can be defined as a standard coal with an assigned quality. According to general economic theory the market equilibrium price of the standard coal is determined by market conditions, such as supply and demand. If supply (S) and demand (D) are represented by functions f and g, the equilibrium price P^0 can be solved from the following system of supply and demand equations:

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$$\begin{cases} S = f(P;V) \\ D = g(P;W) \end{cases} \qquad (2)$$

$$D = S$$

where,

P = market price for standard coal;

V = other supply variables;

W = other demand variables;

S, D = supply and demand of standard coal.

Considering the demand side first, demand for coking coal is derived from the demand for steel and other industrial production. It is highly dependent on the demand for final goods and not very elastic with respect to coal price changes in the short run. This is particularly true in the contract market. Therefore, it is reasonable to assume that total demand for coking coal to Japan is almost fixed at D_T in a given year. Because we are more interested in the relative price differentiation among coals rather than the absolute value of the market price, this strong assumption will not undermine our results. Under this assumption, the demand equation becomes:

$$D = D_T = \text{constant}$$

Set,

$$D = D_T = S$$

substitute it into the supply equation:

$$S = f(P;V) = D_T$$

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or,

$$P^0 = f^1 (D_T; V)$$

This equation is a reduced form of the supply and demand equations. Vector, V, represents all supply side variables except price.

To meet the given market demand the amounts of coal traded from two suppliers are decided by market price P^0 and the supply curves. Graphically, optimum supply distribution of the two suppliers is indicated by t^0_i and t^0_j, if transportation cost differences are ignored:

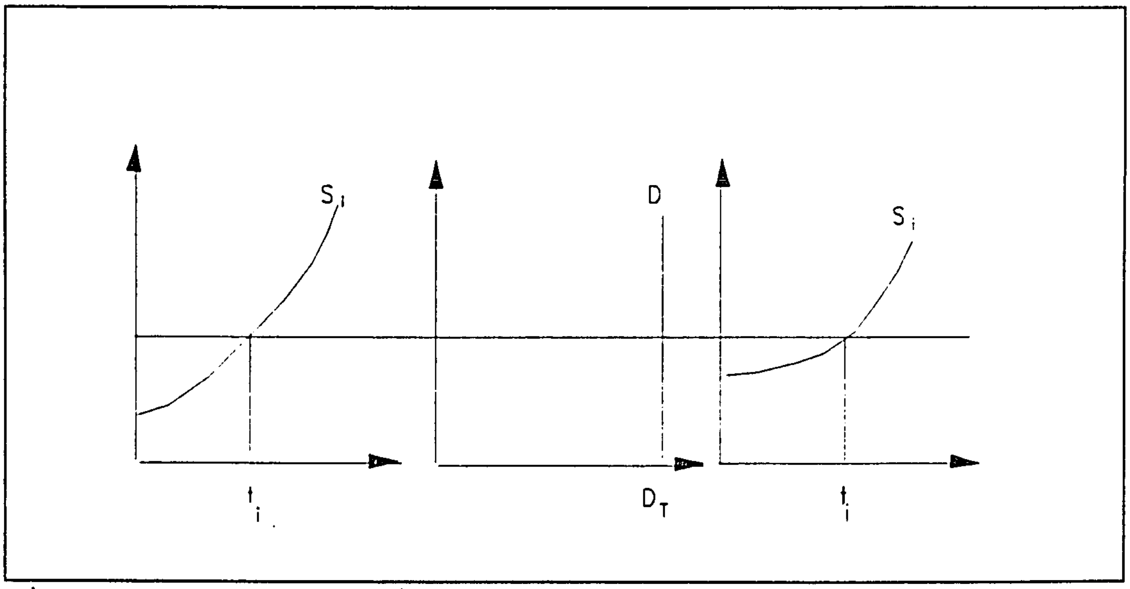

Figure 3.7 Illustration of trade model

As each of the supply curves are assumed locally linear, the optimum solutions are solved mathematically by the system:

$$P^0 = \alpha_{i1} + \alpha_{i2}\, t_i$$

$$P^0 = \alpha_{j1} + \alpha_{j2}\, t_j$$

subject to

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$$t_i + t_j = D_T$$

Since all the coefficients of these supply curves are unknown, if we have n coal supply brands there will be 2n unknown parameters (α_{1i},α_{2i}, i,j = 1,..., n) and n+2 variables (p^0, D_T, t_i, i=1,...,n) in n+1 equations. It is impossible to estimate the parameters without employing some constraints. Consequently, the following two assumptions on the slopes and intercepts are adopted in the adjacent areas:

(1) Suppose that the slopes of all brands are the same within a small range, ie.:

$a_{2i} = a_2$;

where,

$i = 1, 2, \ldots , N_T$; N_T is total number of brands from three countries;

This is a very strong assumption in any market analysis. In the contract market, however, price tends toward the Long Run Marginal Cost (LRMC) of supply. According to the previous discussion, the supply of coal is close to competitive. Therefore, the long run supply curve. The LRMC curve, tends to be horizontal within a range which is bounded by minimum economic scale and capacity. It is reasonable to expect that the slopes of supply curves are all close to zero. In fact, in many contracts, for the given price the shipping tonnage is allowed to change by ±10% at the buyer's option. Obviously, these 10% derivations are falling between the minimum economic scale and the maximum capacity.

(2) Suppose that the intercepts of all coal brands from a given country, in the form of standard coal, are equal within in a small range. Therefore the supply equations of standard coal are simplified to three equations for three countries:

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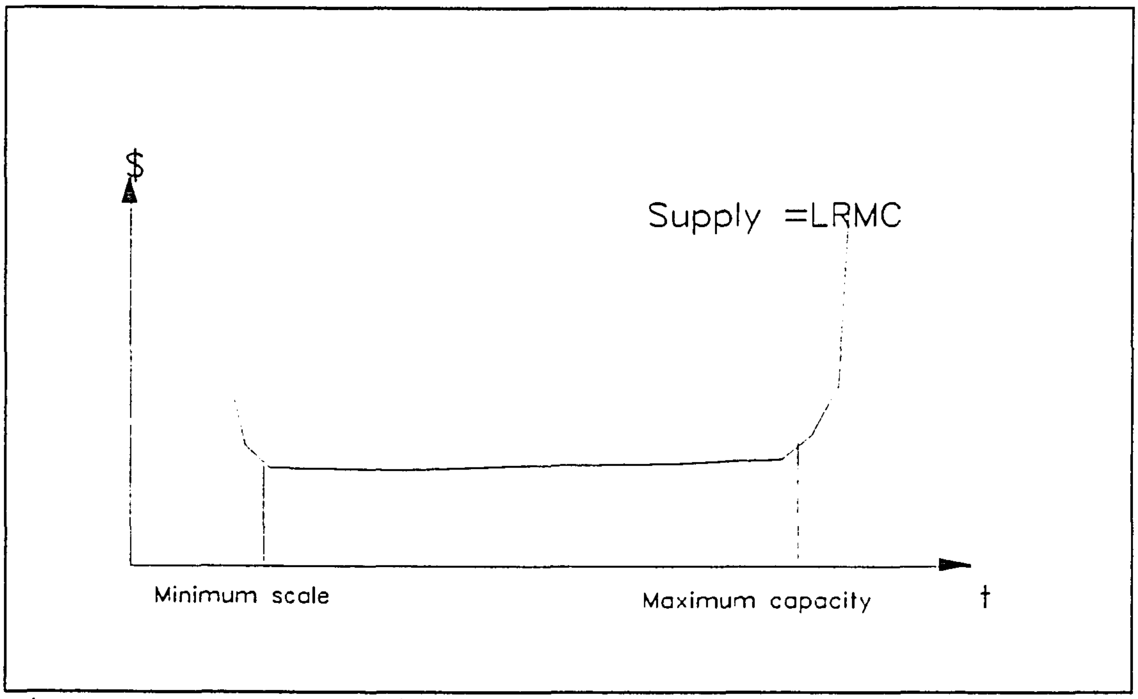

Figure 3.8 Illustration of long run supply model

$$P^0=\alpha_{C1}+\alpha_2*t_i \tag{3}$$

where,

C = *1, 2, 3* = *US, Canada, Australia*, representing the three supply regions;

i = *1,..., Nc; Nc* is the number of brands from country C.

Alternatively, these three equations could be replaced by a single equation by using dummy variables:

$$P^0=\alpha_1+\alpha_{21}^{(US)}I_{us}+\alpha_{22}^{(CA)}I_{ca}+\alpha_3*t_i \tag{4}$$

where, dummy variables:

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$$I_{us}=\begin{cases}1 & i^{th} \text{ brand is from US;} \\ 0 & \text{otherwise}\end{cases} \tag{5}$$

$$I_{ca}=\begin{cases}1 & i^{th} \text{ brand is from Canada;} \\ 0 & \text{otherwise}\end{cases}$$

These equations can only be used for the standard coal. When the quality component is being considered, the actual intercepts of each of the brands will be different, reflecting either cost or premium for the quality of that brand. Also, the supply curve of each brand will shift to reflect the quality difference.

3.3.2 Quality Adjustment

The market price for standard coal (P^0) cannot be used to determine the amounts of coals with different qualities being purchased. Quality differences have to be taken into account by adjusting the market price for a standard coal to the actual price for an heterogeneous coal.

From the previous discussion on the cost of impurities (Bennett, 1975), the actual price of the i^{th} coal brand is a combination of market price and adjustment for quality.

$$P_i=P^0+C_i \tag{6}$$

The quality component (C_i) is a penalty or premium depending upon the sign and

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value of the following adjustment formula:

$$\begin{aligned} C_i = & \beta_1 (TM_i - TM^0) + \beta_2 (ASH_i - ASH^0) + \beta_3 (VM_i - VM^0) \\ & + \beta_4 (TS_i - TS^0) + \beta_5 (CSN_i - CSN^0) \\ & = \sum_{k=1}^{k=5} \beta_k (q_{ik} - q_k^0) \end{aligned} \tag{7}$$

where,

$Q^0 = (q_1^0, q_2^0, q_3^0, q_4^0, q_5^0) = (TM^0, ASH^0, VM^0, TS^0, CSN^0)$

= quality of standard coal.

$Q_i = (q_{i1}, q_{i2}, q_{i3}, q_{i4}, q_{i5}) = (TM_i, ASH_i, VM_i, TS_i, CSN_i)$

= quality specifications for the i^{th} brand.

Since CSN is a positive index of coking quality, β_5 is a premium coefficient, so the quality component can be positive or negative. A large value of it represents the premium for better quality of coal while small or negative values represent penalties for lower than standard quality.

The cost of impurity in the BSC model reflects the cost to remove the impurity. Here the coefficients are no longer the estimated cost of treatment. Besides removal cost, they reflect the importance of the quality component for coal blending or other technical requirements.

Substituting of equations (3) and (6) into equation (4) and adding an error term to represent all unexpressed factors, the regression model is given as follows:

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$$P_i = P^0 + C_i$$
$$= \alpha_1 + \alpha_{21}^{(US)} I_{us} + \alpha_{22}^{(CA)} I_{ca} + \alpha_3 * t_{i_c} + \sum_{k=1}^{k=5} \beta_{cik} (q_{i_c k} - q_k^0) + e_i \tag{8}$$

Choosing the level of standard coal is quite arbitrary, but this choice only shifts the constant term α_1, and the shift remains unchanged for all brands. For simplicity, we set up the standard coal as a coal with zero percent of impurities and zero Crucible Swelling Number, ie:

$$Q^0 = (0, 0, 0, 0, 0) \tag{9}$$

To be consistent with this setting, t_i should stand for the coal with zero percent of impurities too. If other trace elements, such as phosphorus content, are ignored, t_i approaches the pure carbon content and can be expressed as:

$$t_i = (1 - \sum_{k=1}^{k=4} q_{ik}/100) * Ton_i \tag{10}$$

Substituting (8) and (9) into (7) and adopting simple notation, we obtain our final equation for the regression analysis:

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$$P_i = \alpha_1 + \alpha_{21}^{(US)} I_{us} + \alpha_{22}^{(CA)} I_{ca} + \alpha_3 (1 - \sum_{k=1}^{k=4} q_{ik}/100) Ton_i + \sum_{k=1}^{k=5} \beta_k q_{ik} + e_i$$

$$= \alpha_1 + \alpha_{21}^{(US)} I_{us} + \alpha_{22}^{(CA)} I_{ca} + \sum_{k=1}^{k=5} \beta_k q_{ik} + \alpha_3 (1 - \sum_{k=1}^{k=4} q_{ik}/100) Ton_i + e_i \quad (11)$$

$$= \sum_{k=0}^{k=6} \beta_k x_{ik} + e_i$$

$$= \boldsymbol{X_i} \beta' + e_i$$

Here, the vectors:

$X_i = [1, I_{us}, I_{CA}, q_{i1}, q_{i2}, q_{i3}, q_{i4}, q_{i5}, (1 - \Sigma q_{ik}/100)Ton_i]$

= independent variables.

$\beta = [\alpha_1, \mathrm{I_{US}}, \mathrm{I_{CA}}, \beta_1, \beta_2, \beta_{c3}, \beta_4, \beta_5, \alpha_2]$

= parameters that must be estimated.

e_i = error term; it is a random variable with a standard normal distribution.

Also, we can put all 76 brands from three countries together and describe them in terms of our model in matrix form:

$$\boldsymbol{P} = \boldsymbol{X} \beta' + \boldsymbol{e} \quad (12)$$

where,

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$$\mathbf{P} = \begin{bmatrix} P_1 \\ . \\ . \\ P_{14} \\ \cdots\cdots \\ P_1 \\ . \\ . \\ P_{13} \\ \cdots\cdots \\ P_1 \\ . \\ . \\ P_{49} \end{bmatrix} \tag{13}$$

$$\mathbf{X} = \begin{bmatrix} 1 & 1 & 0 & q_{11} & q_{12} & \cdots & q_{15} & (1-\sum q_{ik}/100)\,Ton_1 \\ & & . & . & . & . & & \\ & & . & . & . & . & & \\ 1 & 1 & 0 & q_{14,1} & q_{14,2} & \cdots & q_{14,5} & (1-\sum q_{14,k}/100)\,Ton_{15} \\ 1 & 0 & 1 & q_{15,1} & q_{15,2} & \cdots & q_{15,5} & (1-\sum q_{15,k}/100)\,Ton_{15} \\ & & . & . & . & . & & \\ & & . & . & . & . & & \\ 1 & 0 & 1 & q_{27,1} & q_{27,2} & \cdots & q_{27,5} & (1-\sum q_{27}k/100)\,Ton_{27} \\ 1 & 0 & 0 & q_{28,1} & q_{28,2} & \cdots & q28,5 & (1-\sum q_{28}k/100)\,Ton_{28} \\ & & . & . & . & . & & \\ & & . & . & . & . & & \\ 1 & 0 & 0 & q_{76,1} & q_{76,2} & \cdots & q_{76,5} & (1-\sum q_{76}k/100)\,Ton_{76} \end{bmatrix} \tag{14}$$

3.3.3 The Data

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Data for 76 coal brands contracted in 1988 are used in the regression. They include 14 US brands, 17 Canadian brands and 49 Australian brands (Table A.2). Four Canadian brands are excluded as three of them have escalated prices in Canadian dollars; another is priced in Canadian dollars. They are obviously affected by escalation clauses and exchange rates which are irrelevant to quality. But these four brands are considered in other analyses, because their total tonnage to Japan is 9.7 million tons, which amounts to about 13% of total Japanese imports. Data from South Africa, former USSR, and China are excluded because they do not simply determine their prices by quality and market conditions.

In this estimation, prices in use are FOBT contract prices. As Japan may compromise on FOBT prices for Australian coals due to their cheaper ocean transportation cost, the natural question is should we use CIF prices? While this compromise may exist, it can not be documented, at least for this study. At this stage, as we want to estimate the cost of quality objectively, transport cost differentials should be reduced as much as possible. If mine mouth FOB prices were available, they might be better data for purposes of quality estimation. Further statistical demonstration are discussed in the following section to support this intuitive illustration.

3.3.4 Estimating Prices With Quality Component -- Model (I)

The regression result for equation (11) is shown below.

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$$P = 39.0524 + 0.158 I_{US} - 0.111 I_{ca} - 0.744\,TM - 1.842\,TS \qquad (15)$$

$$t-\ (12)\quad (0.13)\quad (-0.14)\quad (-2.1)\quad (-1.4)$$

$$+1.8\,CSN + 0.001539\,(1-(TM+ASH+VM+TS)/100)\,Ton$$

$$(12)\quad (2.0)$$

$$R^2 = 0.8298$$

$$URSS\,(Unrestricted\ ResidualSum\ of\ Square) = 353.86221 \qquad (16)$$

$$d.f. = 69$$

The numbers in parentheses are t-statistic for the estimated parameters.

The signs and the values of this estimation are consistent with theory and our knowledge of the market. As expected, the coefficient for tonnage of pure carbon is a small positive number. The negative signs for Total Moisture and Total Sulfur indicate the penalties on these impurities, which do not exceed the upper bounds obtained from penalty clauses of the contracts. It is not surprising that the best result does not include all of the independent variables. Because those variables naturally are not all statistically independent and some of them do not show a strong impact on price. For example, low volatile matter is supposed to be important in the coking coal trade, but the relation between volatile matter and price is not clear because of the practice of coal blending.

Recall that our purpose is to identify the quality component in price formation and to use the adjusted prices to determine whether real price differentials exist across countries. The t-values of dummy variables in the equation (15) are very small, which

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indicates that individually each of those coefficients is not significantly different from zero. To confirm this indication, the F-test is used to test the null hypothesis that both of those coefficients are simultaneously equal to zero:

$$H_0 : \alpha_{21}^{(US)} = 0 \quad and \quad \alpha_{22}^{(CA)} = 0 \tag{17}$$

One way of testing this hypothesis is to test the incremental variance of P that is explained with α_{21} and α_{22} and without α_{21} and α_{22}. Accordingly we estimate the regression equation without α_{21} and α_{22} with pooled data, which are for 76 brands across countries:

$$\begin{aligned} P &= 39.220 - 0.776\,TM - 1.718\,TS + 1.8\,CSN \\ &\quad (14.6) \quad (-2.8) \quad (-1.5) \quad (13.6) \\ &\quad + 0.001538\,(1 - (TM + ASH + VM + TS)/100)\,Ton \\ &\quad (2.0) \end{aligned} \tag{18}$$

$$\begin{aligned} & R^2 = 0.8296 \\ & RRSS\,(Restricted\ Residual\ Sum\ of\ Squares) = 354.149 \\ & d.f. = 71 \end{aligned} \tag{19}$$

To test the null hypothesis, we use the statistic:

which has an F-distribution with degrees of freedom $(r, N_T - K)$, where r is the number

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$$F = \frac{(RRSS-URSS)/r}{URSS/(N_T-K)} = \frac{(354.1533-353.86221)/2}{353.86221/(76-7)} = 0.028 \tag{20}$$

of restrictions, N_T, as indicated earlier, is the total number of observations, and K is the number of independent variables including the constant term. From an F table, at the 5 percent level, $F(2,60) = 3.15$ and $F(2,120) = 3.07$. Thus, since $F < F_\alpha$, we can not reject the hypothesis that FOBT prices across countries are equal at the 5% significant level. This is an important conclusion for this study, for it implies that once prices are adjusted for quality, real price differences exist only at the CIF level, and that they come primarily from ocean transportation cost differences.

Another support for this conclusion is even more direct. Under the assumption that the domestic market is competitive, price differentials among suppliers from the same country truly can reflect only quality differences. As data from Australia cover a wide range of all independent variables, we can perform the same regression on the Australian data:

$$P = 38.36 - 0.73\,TM + 1.66\,CSN + 0.001753\left(1 - \frac{\sum_{i=1}^{i=4} q_i}{100}\right) Ton \tag{21}$$

t- (9.7) (-1.5) (9.7) (1.3)

$R^2 = 0.80$ $RSS = 184.59$ $Cases = 49$

Comparing this regression on Australian data with regression on pooled data (equation (18)), the coefficients of these two equations are so close that we can say that the

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quality coefficients are independent of non-market factors.

The fit of the equation is shown by plotting the actual contract prices versus the estimated prices (Figure 3.9). The residuals of this estimation do not indicate any significant bias for any country (figure 10).

3.3.5 Predicted Prices and Quality Premiums

Table 3.6 Average Observed Prices and Estimated Prices

Average Observed Prices and Estimated Prices

	Obs.FOBT Price ($/MT)	Estimated (overall)[a]	Estimated (Austrlia)[b]	Est.P-P (Australia)
US	49.71	49.84	49.90	0.19
Canada	45.41	45.03	44.53	-0.82
	(59.62)[c]	(45.56)	(45.31)	-14.31
Australia	42.31	42.38	42.23	-0.08
sub-average	44.44	44.44		
South Africa	34.78	37.56	38.92	4.14
Russia	46.90	51.70	52.10	5.20
China	41.51	39.82	40.60	-0.91

(a) Estimation equation based on dada from three countries.
(b) Estimation equation based on Australian data only.
(c) including 4 brands with escalated prices or in local currency.

Estimated prices using equation (21), which is estimated from Australian data only, show: (1) If only coal quality is considered in price formation, the observed weighted average FOBT prices of US, China, most of Canadian brands, and of

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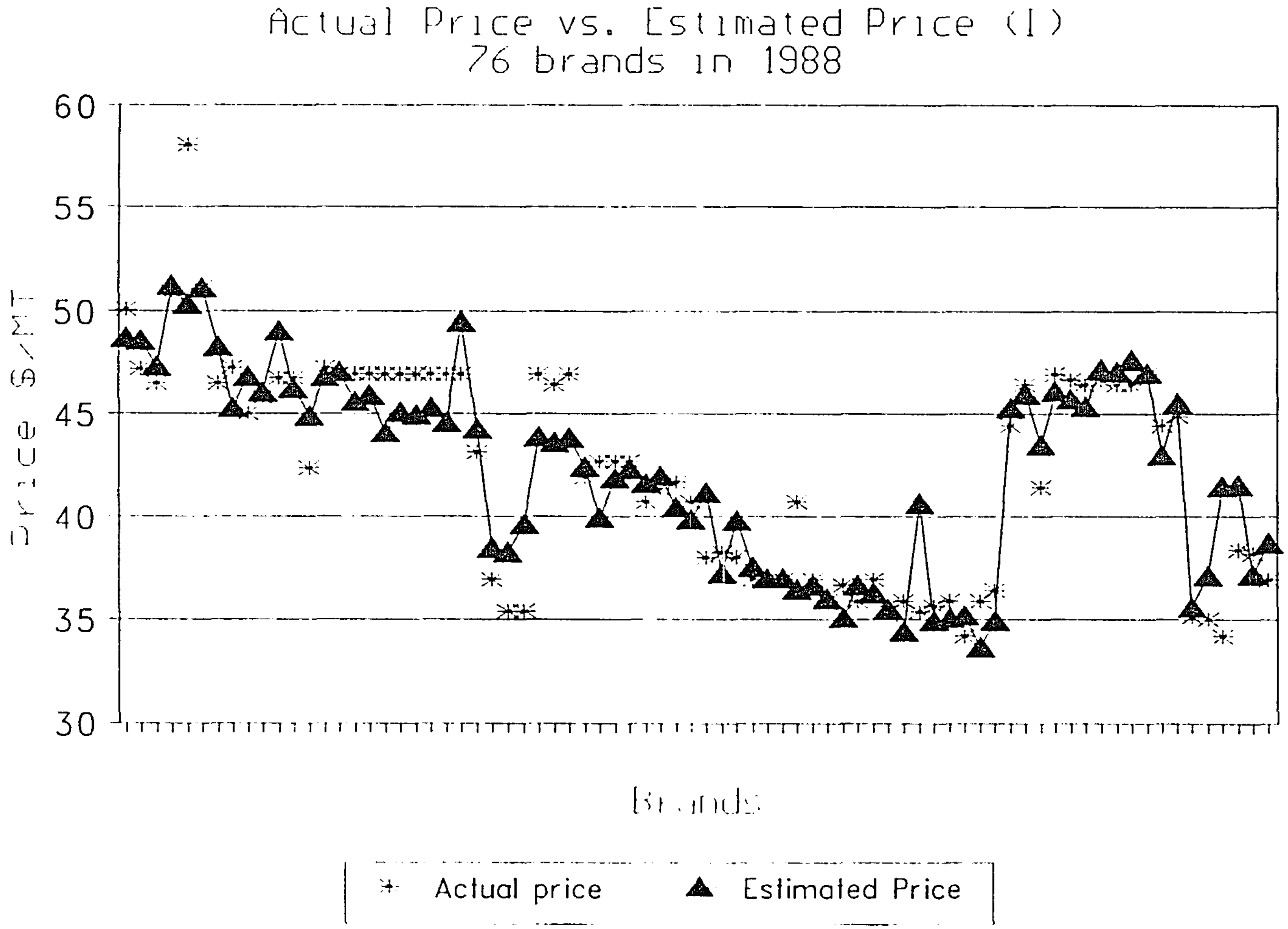

Figure 3.9 Estimating Prices By Model (I) -- Using Carbon Content

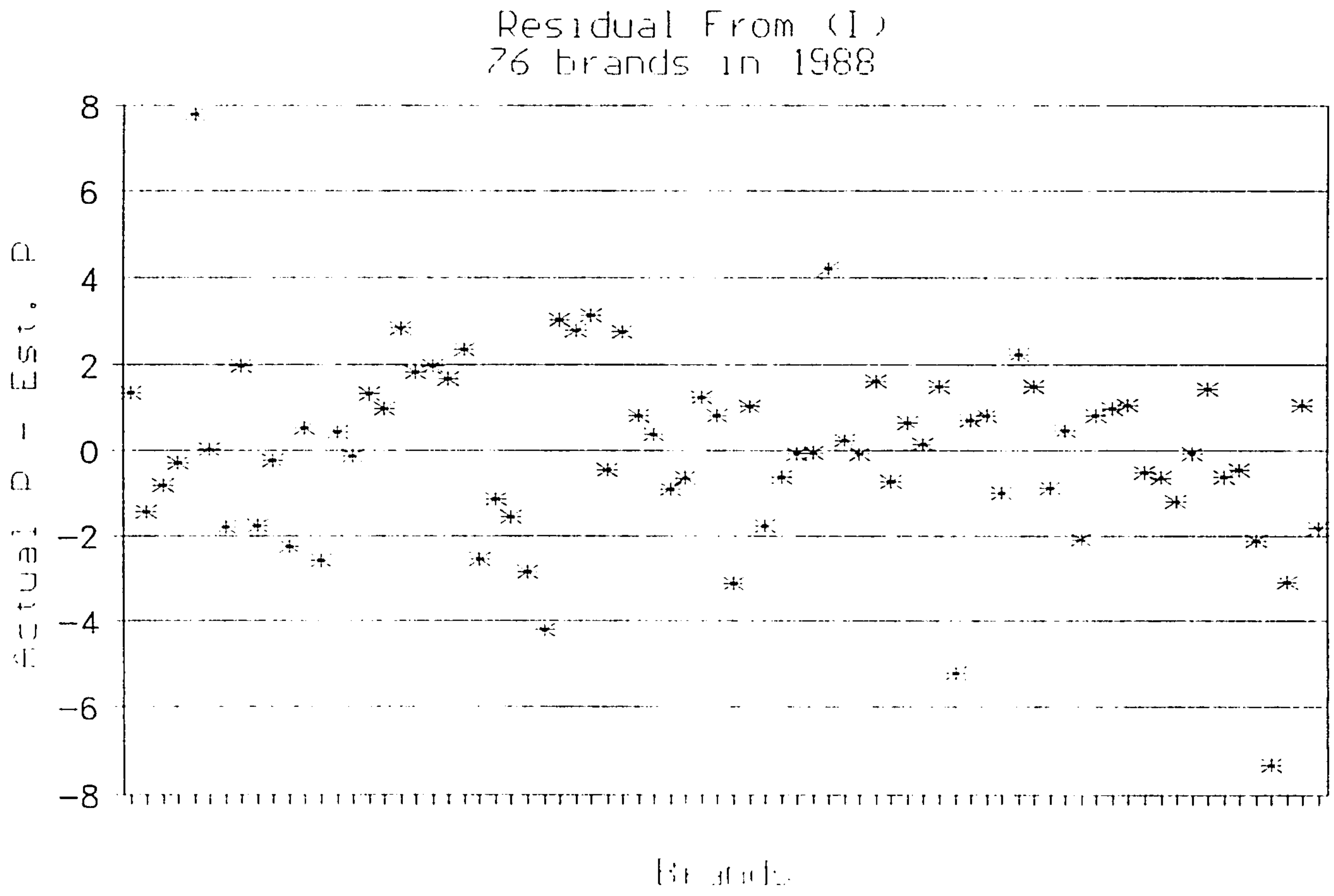

Figure 3.10 Residuals of Prices (I)

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course, Australian brands are consistent with their quality, while observed prices of South Africa and former USSR brands are lower than those paid to Australian coals with the same hypothetical quality. The prices of four Canadian brands are much higher than required for their quality, as they receive subsidies from the Japanese. (2) If the ocean transportation costs are considered, at CIF level, the US prices are obviously high, even after quality premiums are accounted for. From the Japanese buyers viewpoint, the rent collected from paying less to Australian brands or subsidies, such as paying more to the US brands, are implemented through the ocean transportation cost and CIF prices.

3.3.6 Taking the Contract Term In To Consideration -- Model (II)

There are two natural difficulties with making accurate estimate of quality components of coal price. First, in practice economic and commercial factors often are more powerful than are technical factors in the determination of price. The effects of some quality differences on price are frequently swamped by changing economic conditions, or more simply by commercial negotiations at the last stage. Second, the greater the quality variation of coals that are blended, the greater is the consumers' flexibility in purchasing. Especially in the contract market, the incremental purchase decision by a consumer is to seek that coal with the lowest quality required at the minimum cost level. Under this principle, coals of higher quality have less leverage than in the past to bargain a higher price. Coals of comparable quality in blending may be sold at different prices depending on when the contract is made and the

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additional qualities required by the consumer.

To take the contract terms into consideration another dummy variable is imposed to distinguish continuing contracts from yearly contracts. The dummy variable is

$$I_{us}=\begin{cases}1 & i^{th} \text{ brand contract continues from previous contract;}\\ 0 & \text{yearly contract.}\end{cases} \tag{22}$$

Although, prices are renegotiated every 6 or 12 months, for most contracts in a time of supply surplus, suppliers having long term contracts may be in a better position for the negotiation of price settlements than are those without any such contracts in hand. The regression is given by the following equation and the fitness plot is given in Figure 3.11:

$$\begin{aligned}P &= 39.802 - 0.812TM - 1.517TS + 1.73CSN + 2.011CTR\\ &\quad (15) \quad (-3) \quad (-1.3) \quad (13) \quad (3)\\ R^2 &= 0.84\\ RSS &= 330.76\end{aligned} \tag{23}$$

The result shows a good R-square and that the contract term dummy variable, CTR, replaces the carbon content tonnage variable. These two variables are positively correlated because the large tonnages are set by the long term contracts. See Table 3.7 -- Distribution of Tonnage By Their Contract Term. Taking the contract term into

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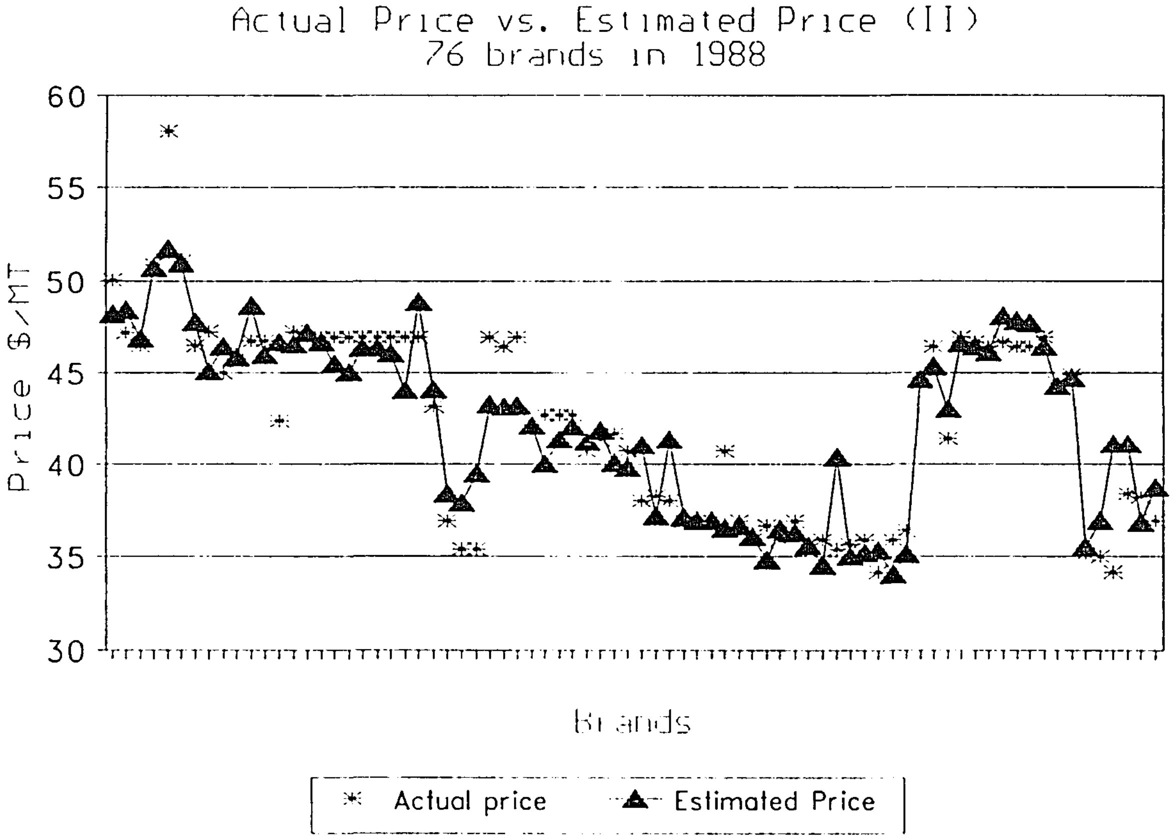

Figure 3.11 Estimating Prices By Model (II) -- Using Contract Term

account makes sense, since more commercial information is included. This equation can be considered as an alternative to equation (18).

Table 3.7 Distribution of Tonnage By Their Contract Term

Distribution of Tonnage By Their Contract Term

Tonnage Interval (1000 MT)	Yearly Contract (number of brands)	Continuous Contract
0 <Ton< 200	13	
200 <Ton< 400	15	4
400 <Ton< 600	11	2
600 <Ton< 800	10	
800 <Ton< 1000	6	2
1000 <Ton< 1500	2	6
1500 <Ton< 2000		2
2000 <Ton< 3000		3
3000 <Ton< 4000		1
4000 <Ton< 5000		1
Total	57	21

3.3.7 Apply Regression Equations To the Data of JFY 1986

In order to investigate the stability of the model in the short run, model (I) is applied to the data of JFY 1986. The nominal prices have to be deflated to real prices in 1988 US dollars. Choosing different deflators will lead to different base price levels. Since we are more interested in how the Japanese buyers make purchasing decisions among producers, we chose the Japanese Import Price Index as a deflator. Then the prices of 1986 contracts in real US dollar terms become:

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$$P_{86}^{(r)} = P_{86}^{(obs)} * r(86, \frac{Jap}{US}) * \frac{I_{imp}(88)}{I_{imp}(86)} / r(88, \frac{JAP}{US}) \quad (24)$$

$$P_{86}^{(r)} = P_{86}^{(obs)} * \frac{r(86, \frac{Jap}{US})}{r(88, \frac{JAP}{US})} * \frac{I_{imp}(88)}{I_{imp}(86)}$$

Where, r is a 15-month average exchange rate (January of previous year to March of the contract year), and I_{imp} is the Japanese Import Price Index of previous year. The lag is used because contracts are signed for the Japanese fiscal year which starts April 1 of each calendar year.

Estimating prices by both equation (18) and (23), and calculating the sum square of residual gives some idea about goodness of fit:

SRR for the data used to estimate the regression equation (1988 data, 76 cases):

SRR = 354.15 for equation (18) (Variable for pure carbon tonnage)

SRR = 330.76 for equation (23) (contract term replaces pure carbon)

SRR for estimates for 1986 price using the 1988 regression equation (62 cases):

SRR = 529.08 for equation (18)

SRR = 570.87 for equation (23)

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The estimates by the two models are given by Table 3.8. Here, the 1986 prices are in 1988 constant dollars. The results of this experiment show that estimates by the two models are very similar and that both models predict 1986 prices quite well, which lends strength to the conclusion that the main difference in FOBT prices across countries is due to quality difference.

Table 3.8 Estimated 1986 FOBT Prices By Two Models

Estimated 1986 Prices By Two Models

	Price(86) in 88 U$	Estimated Price (carbon content)	Estimated Price (contract term)
US	49.44	47.52	47.68
Canada	40.97	43.70	43.23
Australia	39.16	39.76	39.68
Total	42.05	42.31	42.16

This analysis is still static and partial. Further work is needed to build a more complete model in order to explain price variation more fully, i.e. the influence of exchange rates, the inflation and demand/supply changes over time.

3.3.8 Estimated Prices and Quality Premiums

The estimated prices of each brand by model (I) are given in Table 3.9, and fitness of the models is shown by Figures 9 and 10. Furthermore, we are interested in what the average estimated prices of each supply region are and how they match

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the average observed price. To avoid confusion, it is necessary to state the definition of the average estimated prices as a weighted average in which price is weighted by tonnage. Direct application of the models to the average quality of each country, setting the tonnage to 1, is not the correct way to estimate average prices because of the neglect of tonnage. In other word,

$$\overline{\hat{P}} = \overline{f(tm, ash, vm, ts, csn; ton)} \neq f(\overline{tm}, \overline{ash}, \overline{vm}, \overline{ts}, \overline{csn}, ;1) \tag{25}$$

Instead,

$$\overline{\hat{P}}_c = \frac{\sum_{i=1}^{i=N_c} \hat{P}_i \cdot Ton_i}{\sum_{i=1}^{i=N_c} Ton_i} \tag{26}$$

where $i=1, \ldots, N_c$;

and N_c *is the number of the brands in country c.*

The average estimated prices are given in Table 3.9.

The models also are applied to three minor supply regions; the estimates basically are good, except for the former USSR. In the case of former USSR, data actually are from one mine with 4,950,000 tons of supply, which is beyond the range of the independent variable in the data used to estimate the regression equation.

To estimate quality premiums, the theoretical model should be reviewed to

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Estimated 1988 FOBT Prices By Two Models

	Ton (1000MT)	Price (obs.)	Estimated (model I)	Estimated (Model II)
US	9929	49.70	49.84	49.15
Canada-13	8973	45.41	45.03	45.29
Canada-17	18678	59.62	45.60	-
Australia	28623	42.31	42.38	42.31
Sub T-13	47534	44.44	43.44	44.30
Sub T-17	57238	49.24	44.72	-
S.Africa	3648	34.78	36.69	-
USSR	5250	46.89	52.56	-
China	1550	41.51	40.68	-

Note:
* Average Price from top three counties, excluding 4 Canadian Brands.

be viewed as the sum of two components, a general economic model and a cost component of quality:

$$P^{(est)} = f^{-1}(Ton) + C \quad (27)$$

$$= (\alpha_0 + \alpha_2 Ton) + (\alpha_{21} TM + \alpha_{22} TS + \alpha_{23} CSN)$$

where,

C is the cost component of quality. By substituting average quality specifications in the cost component, the average cost component of quality can be obtained. The quality premiums are relative values, which are defined as the

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differences of cost components of each region minus the cost component calculated from the average quality of the top three countries[2]. The results are shown in Table 3.10, and the average quality specifications are given by Table 3.4. The US and former USSR have the highest quality premiums. Quality premium for Canadian coals is close to the market average, and for Australia, China and South Africa premiums are negative.

Table 3.10 Quality Premium And Quality Adjusted CIF Prices (JFY 1988)

	Cost Component	Quality Premiums
US	\$ 8.61	\$ 4.56
Canada-13	\$ 4.74	\$ 0.69
Canada-17	\$ 4.25	\$ 0.20
Australia	\$ 2.34	\$ -1.71
Sub T-13	\$ 4.09	-
Sub T-17	\$ 4.05	\$ 0.00
S.Africa	\$-4.60	\$ -8.65
USSR	\$ 8.45	\$ 4.40
China	\$ 1.87	\$ -2.18

The quality premiums can be used to adjust observed prices. For instance, subtracting quality premium from observed prices will give the quality adjusted prices that represent coals theoretically with the same quality. When CIF prices are being adjusted in this way, an assumption is made implicitly that the ocean transportation

[2] Because the rest of them are price riders. (see the discussion in Chapter 2)

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cost has not been adjusted by quality premium in order to form correct CIF prices. Indeed, the correct CIF price should reflect how many tons of effective carbon content are being transported to the import port, not how many tons of massive material are being shipped (see BSC model). The nominal CIF prices shown in Table 3.10, which are subtractions of nominal quality premiums from the observed CIF prices, are based upon this simplifying assumption.

3.4 Conclusion

1. Coal is a commodity of heterogenous quality, and this is a distinguishing characteristic of the coal trading market. Quality of coal plays an important role in price formation. Without taking quality into account, any further market analysis would be based upon an incorrect foundation.

There are two ways to estimate the quality component of price:

The first way is technical assessment of actual costs of removing impurities and using coal with low coking quality in the steel making processing. Theoretically, the quality component of price could be set equal to the sum of these costs. The cost estimation by BSC seems partly based on such technical assessment. The biggest advantage is that the estimation is independent of market conditions. Thus, the estimation is less distorted by factors other than quality. The difficulties of this approach are that these costs, actually, can not be explicitly separated from other costs in steel making processing and that they change with changes in technology used by different producers and across time. Therefore, any estimated formula is only

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applicable to a restricted circumstance.

The second way is statistical estimation using observed market data under some reasonable assumptions. It is obviously not as good as the first way, since observed market data include not just quality factor, but all other factors also. But, this is the only feasible way in most of cases, given the data that are available.

2. Applying statistical analysis, two regression models are obtained using the contract data in JFY 1988. Both of them fit the observed data pretty well. As a test, regression model (I) is applied to the data set of JFY 1986, which are inflated to 1988 constant dollars. The fit of estimates to 1986 prices is good, thus the model could be considered stable in the short run.

The average quality premiums of the countries are obtained by applying model (I) to the average quality of the three major supply regions. These quality premiums are relative, since they are the price differences between the estimated price of each region and the estimated average price of three regions.

3. A major issue to be examined by the estimation is whether there are any significant price differences among countries at the FOBT level. IF the price differences across regions, besides quality, are significant, the estimates from pooled data will be distorted. The statistics on country dummy variables indicate that these differences are statistically non-significant. Therefore, models obtained from pooled data are acceptable. Comparing the regression equation on pooled data to the regression

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equation on Australian data only shows consistency in the estimates of coefficients, which also support the conclusion that price (difference) across regions mainly reflect regional variations in coal quality.

This conclusion is not only useful to rationalize the regression result, but it is also a useful support of the following important conclusion:

(1) Price differences that exist at the CIF level are not caused by quality differences. In other words, the argument that the higher prices paid to US coals are due to their higher qualities is not accurate.

(2) Actual price discrimination, rent or subsidy, exerted by the Japanese buyers is completed at the stage of ocean transportation. This idea will be discussed further in Chapter 4.

4. By all standards, the models obtained in this chapter are simple, partial, and static.

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4. BUYERS' STRATEGY AND MARKET POWER

4.1 Discussion of Previous Work on Coal Market Conduct

The purpose of studying coal market conduct is to discover whether the market is competitive and what the major causes are if the market is non-competitive. Most market conduct studies are either on the world coal market or on the Japanese steam coal market. Here, we are going to review some important works on the coal market in general, then we will examine the Japanese coking coal market and its connection with the larger framework.

4.1.1 Market Conduct of the World Coal Trading Market

Some investigators (Baylis, 1984, etc.) reckon that the world coal market is competitive and will remain competitive; coal prices will reflect the long-run marginal cost of production and are likely to remain constant in real terms. It has been demonstrated that there are large and widespread reserves of coal throughout the world. The basic infrastructure for export has been established, so existing mines do not face a very high cost of entry to the export market, but potential coal mining development still faces barriers to entry, such as large capital costs. Sellers are numerous enough to preclude the formation of cartels. Buyers are dominant and generally larger. It is estimated that 75% of international coal trade is controlled by 40-50 buyers (Baylis, 1984).

Other researchers have different opinions of market conduct in world coal trade

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(Kolstad and Abbey 1984, Wolak and Kolstad 1991, etc.). They try to explain the world coal market as a non-competitive market model or by risk diversification behavior. However, most of these works are partial and suffer some deficiencies.

Kolstad and Abbey (1984) pointed out that simple competitive market models failed to explain most of the cases in the coal and grain markets. They also criticized those works which use institutional factors, such as an inability to increase export port capacity or non-economic buying preferences, to explain competitive market failures. These constraints on short-run capacity undoubtedly exist, but it is difficult to determine and justify such constraints on long-run capacity. The explanation of reducing risk by diversifying supply has lacked a quantitative analysis. Except for the Reddy's (1976) work[1], which estimated an elasticity of substitution between US and Australian coals in the Japanese market, this kind of work had not been done.

Using programming methods, Kolstad tested four different models representing different market conduct in world steam coal trade. Cournot-Nash behavior is assumed, because it is common in the economic analysis of market behavior and probably because it is the simplest of many oligopoly/oligopsony models. Cournot-Nash supposes that when producers/consumers set the export/import quantity, the shipment patterns from other competitors are taken as given. The four models used in that paper are: (1) competition; (2) Republic of South Africa acting as monopolist with all other producers acting competitively (the Republic of South Africa is assumed

[1] Mentioned by Kolstad, but no further citation was given.

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to have a cost advantage and institutional power in delivering steam coal); (3) non-cooperative duopoly involving the Republic of South Africa and Australia, with all others acting competitively. Australia is assumed to have a cost advantage but less institutional power; and (4) the Republic of South Africa and Australia acting as duopolists, with Japan acting as a monopsonist. In Japan there is a high degree of cooperation among the few coal importers. To determine which is the best of the four models, two measures, the Theil (1961) inequality coefficient and the Spearman rank correlation coefficient (Conover, 1980), are used. The analysis showed that the simple competitive model failed to yield the observed trade patterns.

Kolstad, however, also admitted that this analysis did not prove the converse of the hypothesis, that observed trading patterns are due to a particular type of market conduct. Thus this work rejected the simple model, but it did not lead to the identification of the correct one. Therefore, this work is limited to proving the simple model a failure and provided a new way of computing spatial equilibrium of a market operating in other than in perfect competition.

Wolak and Kolstad (1991) limited their work to the Japanese steam market. The Japanese buyers' behavior was studied in this specific market. The focus of the work concentrated mainly on quantitatively demonstrating how Japanese buyers make their decisions based upon a risk minimization strategy. In their study, the imperfection of the coal market is assumed as given or proven.

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4.1.2 The Japanese Coking Coal Market

Regardless of whether the world coal trade market is generally competitive or not, one should be careful in applying that conclusion to the Japanese coking coal market. First, the conclusion aggregates the steam coal and coking coal markets. Second, the connection between the separated markets is not a consideration. In the Japanese coking coal market there are still a large number of suppliers. Thus the present study is focused on how much market power Japanese buyers have in the Japanese coking coal market.

Compared to the steam coal market, the coking coal market is less likely to be as competitive. This is because steel mills purchase at a larger economic scale than do the utilities. For example, the top four Japanese coking coal buyers consume about 50 Mmt per year, while Nippon steel alone consumes 20 Mmt per year, and the top four utilities consume about 15 Mmt per year (Coal Manual, 1989). These two markets are separated in the sense of different quality requirements, but the markets overlap on that portion in which high quality steam coals can be used in coking coal blending and lower quality coking coals, with lower prices, can be used economically by steam consumers. Technically, all coking coals can be used as steam coal due to their higher quality. The inverse is not true (see chapter 3 for a more detailed technical discussion).

The second concern is more important. The conduct of the Japanese coking coal market is highly dependent on how much the Japanese market can be separated from the world market. If we isolate Japanese coking coal market, the consumer

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concentration is high. The top five steel mills take 88% of total imports (1988). Nippon Steel Company, as the largest single consumer, controls one third of the Japanese coking coal consumption. If the market is generalized to the larger regions, Nippon Steel accounts for 25.6% of the Pacific Rim and 12.9% of the world coking coal trade. If the shifting between two final uses is included, Nippon Steel accounts for only 6.1% of the total world coal trade. Thus Nippon Steel can not control world coking coal trade and has little influence in world coal trade.

Theoretically, the elasticity of substitution is a useful measure of these two considerations. The elasticity of substitution between steam and coking coal with respect to their CIF prices would reflect how easily the coal can flow between these two consuming sectors. Similarly, for producers the elasticity of substitution between two consumer regions with respect to their FOBT prices would reflect the flexibility with which coal can flow between regions. The less this elasticity is, the more isolated is the Japanese market. Unfortunately, the use of annual data to estimate those elasticities yields inconsistent results. For instance, in some years elasticities are very negative, in others they become positive. This could be caused by the complexity of market conditions. Simply fixing other conditions such as prices and demand/supply in order to calculate partial elasticity makes it impossible to explore the relationship between those substitutions. Another very important reason is that the Japanese coking coal import market is not a spot market, long term contracts create inertia for market reactions to price changes. The time lag is one of the important reasons for this inconsistency.

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Intuitively, due to the high ratio of weight to value of coal, transport distance in international coal trade creates geographic isolation among consuming markets. Therefore, by the nature of the coal and the separated locations of coal consumption markets, the Japanese consumers should be considered to have local monopsony or oligopsony power.

It should be emphasized that we must be very clear which coking coal market we are talking about. Although it has been demonstrated that Japanese buyers have local power, this does not imply that the Japanese have the same power in the world coking coal market. Because local monopsony or oligopsony power is mainly due to the geographic isolation of the market, there is counter evidence which rejects the hypothesis that the Japanese have monopsony power in the world coking coal market. To obtain this evidence we look at the FOBT prices received by producers in the world coking coal market.

First of all, a technical assumption is made that the quality requirements for coals for the Japanese steel mills and European[2] steel mills are similar in the long run. It is easy to accept that, at least, the quality requirement of the Japanese, who rely almost completely on foreign supply, can not be higher than that of the Europeans, who have some natural resources. Then, one finds that the FOBT prices paid by the Japanese and Europeans to the *same* producer regions, the United States and Australia, respectively, are consistently different (see Table 4.1 and Figure 4.1).

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[2] Here, European refers to ECC in general.

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Table 4.1 Comparison of FOBT prices received by producers

Comparison of FOBT Prices Received By Producers
(FOB US$/MT)

(1) The prices received by the United States

	Buyers: Europe	Japan	Difference (Japan-Euro)
1980	56.71	63.32	6.61
1981	62.13	64.44	2.31
1982	66.67	66.58	-0.09
1983	59.58	62.89	3.31
1984	56.81	59.01	2.20
1985	55.24	56.52	1.28
1986	51.68	54.59	2.91
1987	48.35	51.31	2.96
1988	48.59	47.76	-0.83
1989	50.01	48.31	-1.70

(2) The prices received by Australia

	Buyers: Europe	Japan	Difference (Japan-Euro)
1980	44.92	48.82	3.89
1981	52.65	54.48	1.83
1982	54.86	57.15	2.29
1983	46.53	55.81	9.27
1984	43.80	50.34	6.54
1985	41.80	45.99	4.19
1986	40.73	44.78	4.05
1987	37.94	40.15	2.21
1988	37.83	39.98	2.15
1989	43.72	44.10	0.38

Source: Derived from Coal Information 1990/IEA, Table 2.10, pp.20

Although, the higher prices paid to US producers by both European and Japanese buyers can be mainly explained by the higher quality of US coal, the higher

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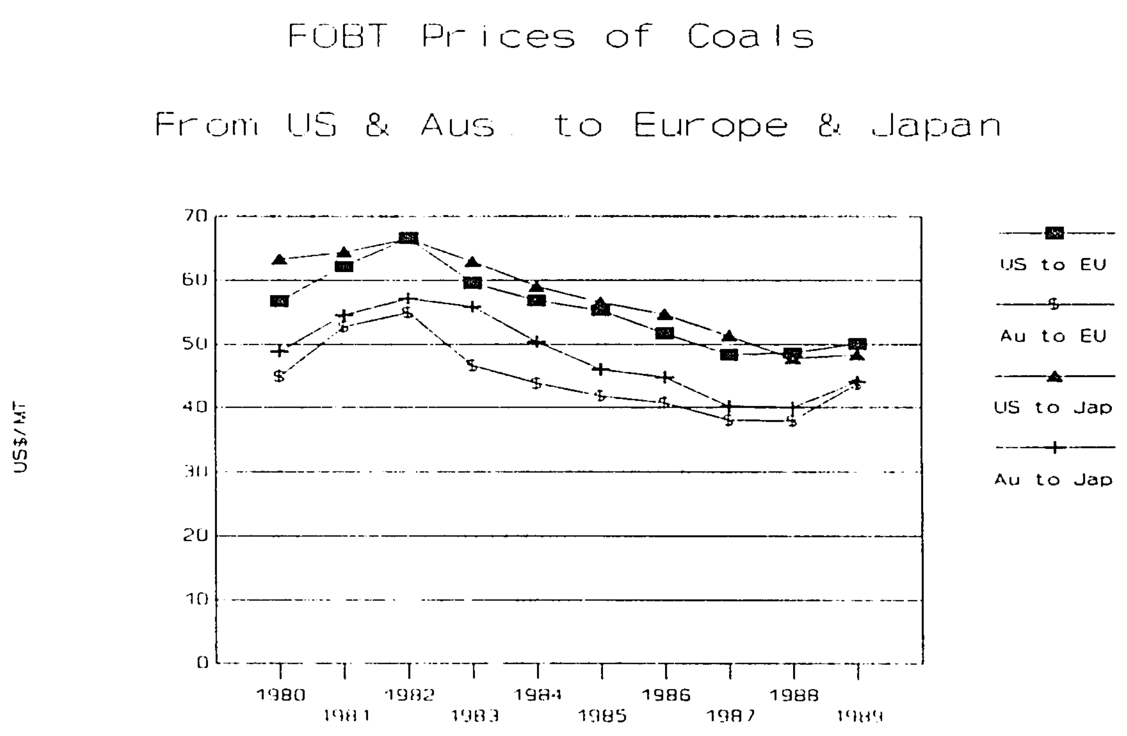

Figure 4.1 FOBT prices from US and Aust. to Europe and Japan

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prices received by both US and Australia from European buyers can not be explained by the quality factor. The FOBT prices paid by the Japanese were consistently higher than those paid by the Europeans. The range is from $1.28 to $9.27 dollars in nominal terms. The exceptions are two very small negative numbers which indicate that the Japanese twice paid slightly more to US producers in last decade. If the Japanese have monopsony power in the world coking coal market, why did they not cut the prices to the level at which other major consumer group paid. There is no reason for a powerful buyer to let producers or other buyers collect economic rents at the FOBT level. If the Japanese truly have more power than European consumers, they can even further cut the prices. Therefore, the conclusion is that the Japanese coking coal market is a local monopsony. Evidence for the hypothesis that the Japanese have monopsonistic power in the world coking coal market, is very weak.

In the current market, the Japanese buyers are highly concentrated and powerful and have been facing continuing overcapacity of supply since early 1982. No one denies the existence of Japanese buyers' power in this market. But how do the Japanese gain their power, and how do they exercise that power to minimize their long run costs? To answer these questions, conclusions by researchers can be divided into two major groups: (1) Japanese consumers gain their power by exerting institutional factors, and (2) the Japanese gain their power by the nature of the market, such as isolation from other major consumption areas, high concentration of the steel industry, and a vertically integrated market structure. I agree that there are more institutional factors and government interventions in the Japanese coal market than in

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other major consuming sectors, which helped to generate the buyers' power but, fundamentally, the nature of this market made it possible for the Japanese buyer to have power, and vertical integration actually allowed the Japanese to develop this power and exercise it.

4.2 Institutional Factors

Many people complain that the Japanese play an unfair game by forming a buyers' cartel and by acting as one buyer with government assistance in the coking coal import market. The Japanese government, primarily through the activities of MITI (Ministry of International Trade and Industry), has long promulgated the collective purchasing of raw materials (C.Johnson, 1983; and D. Rodrik , 1982).

The Japanese coking coal procurement system (JCCPS) is an example of this collusion (D. Anderson, 1987). Initially this policy was promoted to ensure that economic rents were not dissipated through unnecessary competition between Japanese firms. In 1964, with MITI's blessing, the JSM formed a formal joint-purchasing scheme. Each major steel producer is represented on the coordinating committee, henceforth denoted as the JSM. With the government assisting, they select the projects to be awarded long-term contracts, soft loans and equity financing. The JSM makes an initial tonnage allocation among countries and individual coking coal producers and also determines the bargaining sequence expected to yield maximum benefits. Furthermore, the group decides when, where and which new coking coal projects to support.

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An important component of the collective decision-making mechanism is the "lead negotiator" system. Under this scheme, each major coking coal exporting nation is placed under the jurisdiction of two JSM members: one acts as the coordinator, the other as the former's assistant. For example, Australia and the US are assigned to the dominant steel producer, Nippon, while South Africa and Canada are assigned to the second largest firm, NKK (D'Cruz 1985, and O'Grady 1985). In practice, this means that an Australian group wishing to develop a mine to serve the JSM, must conduct all negotiations through Nippon Steel. It is impossible for such a developer to by-pass Nippon to deal with other JSM members to discuss the projects. Similarly, annual price and tonnage negotiations are also conducted through the coordinator. Thus, the consumer acts as a monopsonist in practice, given the inter-firm negotiations which undoubtedly take place within the JSM (Anderson, 1987).

Another example is the Japanese coal import "allocation system". By this system the Japanese government can monitor and direct the allocation quantity within each category of quality of coal among domestic and foreign suppliers (Coal Mining Research Center, Japan). Low grade coals are, particularly, affected by this allocation system. This is an example of government interference.

4.3 Market Structure -- Vertical Integration of the Japanese Companies

Through gradual long-term planning and investment, the Japanese fundamentally changed market structure. Step by step, the Japanese companies became vertically integrated. Thus they gained some control of the sellers' market. I believe

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that this structural change is the intrinsic basis of buyers' power. Additionally, the high concentration of buyers in this market and institutional factors helped the Japanese exercise their power.

Building up partially-owned-mines was a carefully planned strategic long term decision rather than a spontaneous short term business decision of the Japanese coking coal consuming companies. More than that, it was supported by the Japanese Government and financial institutions. MITI and other government agencies have encouraged Japanese raw material buyers to set up partially-owned-captive mines. These developments tied producers and consumers together by long term contracts and by other financial arrangements - particularly the provision of soft loans and direct investment. This approach is known as the "Develop and Import" (D&I) policy (Anderson, 1987; D'Cruz 1985, etc.). This policy helped expand production capacity and extended Japanese control to production in order to secure coal supply and cut down the costs of adverse events.

There are two ways for buyers to penetrate the supply market: (1) Through the Japanese Export/Import Bank, bank groups, and some government-controlled institutions to finance projects by soft-loans, and indirect subsidies (in the coking coal market, this type of finance is widely used to finance Chinese, Russian, US, and some Australian and Canadian projects), and (2) Equity - direct foreign investment: during 1960-1980, the "Japanese consistently avoided acquiring substantial equity holding in coking coal projects. This was certainly a politically superior strategy." (Anderson 1987). From 1980, the Japanese trading houses encouraged JSM to take more equity

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share, as such a participation gives the investor representation on the management board, thus access to more complete information and a better position for bargaining. By promoting a project, trading houses would get a commission from the sale of coal. Banks would much rather see the Japanese steel mills directly participating in those projects that the banks finance in order to obtain the maximum degree of security during the worst events. Financial institutions are more confident with respect to those projects in which JSM is directly involved and which would receive preferential treatment in difficult times. The Quintette project (north-eastern B.C.) is an example of this agreement. The operating and capital recovery cost of the Quintette mine is much higher than the current market price. Since abundant over capacity exists, Quintette would ordinarily be closed except that the Japanese steel mills had a significant equity share in this high cost mine over the years of supply surplus. That would have left the Japanese banks and financial institutions with a large unpaid debt. Indeed, the steel companies are indirectly subsidizing those projects and partly absorbing mining company losses, though they may have to do this unwillingly.

All these efforts were initially made to secure the natural resource supply of Japan. Later market conditions proved that some of these financings were not profitable, since they were made on the basis of an overestimation of steel production and coal consumption. Therefore, over investment was made in this market, which not only created abundant supply, but also raised the cost of keeping some of these mines operating. Although Japanese steel mills went a little too far in stimulating development of supply capacity, their initial goal of insuring supply was achieved. At

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the same time, a vertically integrated industry had been developed.

4.3.1 Vertically Integrated Firms -- Theory and Application

Vertical integration is characterized by the transfer of intermediate products in neighboring stages of productions between firms which are wholly or partially owned by the same company. Grossman and Hart (1986) simply argue that vertical integration is the ownership and thus complete control over "assets". Vertical "partially-owned-integration" is a term used by Blois (1972) to define financial relationships between firms in neighboring stages. This relationship may be set up by equity investments, loans, or loan guarantees. A lot of international investments and transactions involve some degree of partially-owned-integration. In the Japanese coking coal market, the existence of vertical integration is mainly represented in the form of partially-owned-mines.

Three broad determinants of vertical integration are given by Perry (1989) : (1) technological economies, (2) market imperfections, and (3) transactional economies.

Vertical integration may arise from technological requirements in some industries to use resources more efficiently. It is especially applicable in the industries in which technological or operational coordination is highly needed. Obviously, the Japanese coking coal market is not one of this type of industries.

Imperfection in a market can cause vertical integration. For example, if the imperfection is caused by imperfect or asymmetric information, firms will tend to get

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inside information by penetrating into the neighboring stages. Also, it is more possible for firms in an imperfect market to build up vertically, it would be hard to do so in a competitive market. Imperfect competition raises several incentives for firms to integrate into the neighboring competitive stages: to be able to internalize the efficiency losses from the imperfectly competitive behavior, to be able to extract the rent from the neighboring competitive stage, and to be able to price discriminate among firms in the neighboring competitive stage.

Vertical integration usually arises from transaction economies. Transaction cost is different from production cost as it is only associated with the exchange process. When the cost of internal transactions is lower than the cost of external exchange, it creates a motivation for firms to vertically integrate.

In particular, vertical integration can be caused by uncertainty in the market. Price and supply fluctuations can result in substantial transactional cost increases. Vertical integration will reduce these fluctuations through transferring part or all output within the control of the firm. In imperfect markets, partial internal transactions may also put some pressure on external suppliers/buyers to smooth price and secure supply.

In financial and commodity futures markets, a liquidity premium is given to individuals or firms for holding the right to acquire the resource at the time it is needed. A futures contract is used to facilitate this transaction and to cut down the cost of unexpected market changes. In the Japanese coking coal market a similar idea is used for a long term view. The individuals or firms having a right to access coal

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resources are given an implicit premium. To capture this premium, direct and indirect investments and long term contracts are utilized. Meanwhile a vertically integrated market is built. Like other tools for reducing risk, the decisions are made based on a forecast of which direction the market would go. Incorrect forecasting will cause some damage, but overall, the purpose of reducing risk is achieved by the consequences in the Japanese coking coal market.

In the Japanese coking coal market vertical integration is due to transaction costs and imperfect competition. The Japanese consumers' objectives are: to cut down the transaction costs caused mainly by uncertainty; to price discriminate among suppliers; and to appropriate economic rent, where possible.

Measurements of vertical integration are classified into three categories (quantity, employment and equity): Since vertical integration can be characterized in terms of quantity transferred internally within a firm, quantity is thus a feasible measurement. The example given by Perry (1989) is the self-sufficiency ratio used to measure backward integration into crude oil production in a refinery. For the Japanese steel mills, the difficulty in getting this ratio is how to define the control of partially-owned-mines, eg. how one converts this partial ownership into control over quantity. Gort (1962) measures vertical integration in terms of employment rather than assets. He defines the "major" activity of a firm as the one with the most employment. "Auxiliary" activities are the other activities in neighboring stages. The measure of integration is the ratio of employment in auxiliary activities to total employment. The problem with this measurement is that it does not reflect the internal transfer of

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quantity. And if the labor intensities are different in neighboring stages, this measurement will be biased and meaningless. If the labor intensities are similar in the neighboring states, this measurement is only useful to determine which stage is the major stage of production for a firm. It is useless to determine how much this firm controls in a neighboring stage. The amount of equity holding or financial aid can reflect the partial control of the investing companies on partially-owned-mines. Whether the investing companies have control of distribution by contract is varied. They may have control over production and distribution through voting rights or they may have influence on these planning through contracts. A combination of the first and third measurements will be applied in this study.

4.3.2 Japanese Investment in Coal Mines

To obtain an accurate measure of equity holdings of Japanese investors in foreign mines is a continuing effort as the shares can be moved or sold between investors, and sometimes the holding companies can be very complex. In this section, the survey of direct investment of the Japanese steel mills is based on the explicitly listed equity data from *Coal Manual* 1987, 1990. Therefore, the results of this survey mainly reflect circumstances in the second half of the 1980s. The results of the survey are given in Table 4.2.

From this survey we find: (1) The total tonnage supplied by partially-owned-mines is about 32 million tons, 49 percent of the total contract tonnage. This is the upper boundary of the self-sufficiency ratio. In most of the cases, the Japanese equity

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holdings are much less than 50%, which limits their control of distribution and production. Unfortunately, no proper way has been developed to measure this partial control. For instance, if the Japanese steel mills have a 20% equity holding in a mine, they may have more or less than 20% voting rights. And it is more difficult to predict how this limited voting right can control the quantity of production and its distribution. Therefore, it is impossible to convert equity holdings to a quantity measurement. Although an accurate ratio is unknown, the upper limit of the self-sufficiency ratio still can give us some information about market conduct. Direct investment not only gives the Japanese buyers the right to participate in production and export decisions if they are big equity holders, but also allows them to acquire internal information even if they are small equity holders.

(2) The Japanese companies heavily invested in the coal mines of Canada and Queensland, Australia. The Japanese companies have influence or control on 64% of the Canadian coals and 49% of the Australian coals exported to the Japanese coking coal market. Japan has no direct investment in the US, but they finance some coal mine projects and operations which, at least, indicates that there is a strong tie between these producers and consumers.

(3) About 17 mines (or coal brands) ship at least one million tons of metallurgical coal to Japan per year. Japanese investors have direct investments in 11 of them and finance one other. Once again, it indicates that the Japanese buyers try to secure their supply by controlling or influencing large suppliers as much as possible, leaving small producers as swing suppliers.

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Table 4.2 Japanese equity and financing situations

Japanese Equity and Financing Situations in Major Supply Regions

Mine or Brand	Equity Holding (%)	Financing	Shipment (>1 Mmt)
United States			
Lancashire		Yes	No
Blue Creek		Yes	Yes
Total Tonnage			2,863,000
(percentage)(*)			(29%)
Canada			
Balmer	33.4%		Yes
Westar	33.4%		No
Greenhills	27%-47%		No
Greeg River	40%		Yes
Quintette	38%		Yes
Bullmoose	10%		Yes
Total Tonnage			12,039,000
(percentage)			(64%)
Australia			
New South Wales			
South Bulli	4%		No
Hunter Valley	9%		No
Warworth	25%		No
Liddell	9%		No
C&A	9%		No
Sub-Total			(2,930,000)
Queensland			
Moura	20%		No
Blackwater(+Semi)	12%		Yes
Goonyella	12%		Yes
Peak Down	12%		Yes
Saraji	12%		Yes
German Creek	12%		Yes
Riverside	25%		Yes
Curragh	10%		Yes
"K" Coal	20%		No
Sub-Total			
(11,175,000)			
Total Tonnage			14,105,000
(percentage)			(49%)

Note: (*) percentage of total contract tonnages.

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4.3.3 Japanese Companies in Inland Transportation

In chapter 2, the discussion of inland transportation in each producing region shows: In Australia, inland transportation is controlled by the state government. Therefore, the Japanese companies can not control movement plans through the partnership at all. Nevertheless, inland transportation distance in Australia is short and costs are relatively low. Therefore, it is not the major part of the market that the Japanese companies need to control. In Canada, the three railway companies operating in western Canada are owned by the federal government, the state government and a private company, respectively. The Japanese have no control over government owned railways. It appears that the Japanese companies do not have too much control of the privately owned Canadian Pacific Rail, because Canadian Pacific Rail is owned by Canadian Pacific Limited, in which 73% of the voting rights is in Canada, and the major foreign holder is in the US[3]. In the United States, inland freight transportation is privately owned. US railways were highly regulated until 1981. It is apparent that the Japanese companies do not have significant equity holdings in those transportation companies.

Overall, the Japanese have no control over inland transportation. This is the most vulnerable stage in their vertical integration practice.

[3] Moody's International 1990, and the Annual Report of Canadian Pacific Limited.

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4.3.4 The Japanese Companies in Ocean Transportation

Based on an interview with Mr. Takebe (Mitsui Co., USA, Inc. - a Japanese trading company), ocean transportation of coal is completely controlled by the Japanese buyers. An interview with Ms. Karen Kiefer (BHP-Utah mineral (USA)) confirms Mr. Takebe's statement. For instance, BHP-Utah, as the largest coal company in Australia, sometimes use its own ships to transport coals to the European market, but there is no such shipping of coals to Japan. The Japanese companies have full control of ocean transportation.

The total control of ocean transportation by the Japanese companies has been a major source for the Japanese buyers of cost transferral and rent collection. In the next section, a numerical example will be given to demonstrate the cost transfer within the Japanese companies.

4.3.5 How Rent Is Transferred Within Japanese Companies - A Demonstration

With ocean transportation, the coals from the different supply regions arrive at the Japanese import ports. We have shown that prices at the export ports (FOBT) of all supply regions basically reflect their qualities. No other significant price differences among regions were found (chapter 3). Therefore, price discrimination among producers is shown by CIF prices and the cost differences may be transferred through the ocean transportation charges.

Using observed market prices, we use "shadow cost" to estimated the internal price between the two vertically integrated stages. The shadow price is defined as the

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difference between the CIF and FOBT price:

Shadow Price = CIF - FOBT

Table 4.3 Shadow Price of ocean transportation to Japan

Shadow Price of Ocean Transportation to Japan

(Shadow Price = CIF-FOB : US$/MT)

From	US	Australia
1980	17.95	10.77
1981	18.65	11.08
1982	17.38	11.07
1983	15.91	7.54
1984	11.93	8.69
1985	12.14	8.36
1986	10.11	8.03
1987	12.74	8.12
1988	12.58	8.32
1989	15.03	8.48

The estimated shadow prices are shown in Table 4.3.

Although the ocean transportation cost from Australia to Japan is much lower than that from the United States to Japan, Australian producers do not capture the economic rent created by being close to the market. If the ocean coal shipping market were open, Australian producers would obtain at least part of the ocean transportation rent from shipping companies. The cost transferral is carried on within the Japanese companies. The rent collected by the Japanese companies can be used to compensate the high cost producers. Hence, the Japanese buyers spread their suppliers and cut down overall cost.

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Table 4.4 Comparison of estimated ocean transportation costs

Comparison of Estimated Ocean Transportation Costs
(1989 US$/MT)

	IEA Estimation	Shadow Cost
Queensland	7.8	
New South Wales	9.3	
Australia	8.45*	8.48
United States	17.3	15.03

Source: Coal Information, 1990/IEA, pp.26.

Note:
* weighted average by contract tonnage:
(57%) X $7.8 + (43%) X $9.3 = $8.45

Anderson (1987) pointed out that "In the 1960's JSM arbitrarily switched from CIF price to FOBT price. Thus, the Japanese captured all ocean-transportation rent. Given subsequent events, this has been an important source of cost saving for the JSM." Anderson didn't give further numerical examples to prove his statement. From time to time, whether the Japanese companies can actually save money is dependent upon the market condition of the international bulk cargo market at that time. For instance, it seems that the Japanese did not obtain real cost saving in 1989. The real ocean transportation cost is private information. An estimation of representative export costs for coking coal (1989) is given by the International Energy Agency Coal Research (1990). Though their estimates are close to the shadow costs derived from observed market prices, the comparison shows that the shadow cost is over $2 per ton less than the estimated cost from US to Japan (Table 4.4).

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4.4 Practice of Buyers' Power -- A Case Study of Long Term Contracts

Contracts are used in this market because buyers need to secure their coal supply and producers need to make producing and development plans. Although a contract is desired by both parties, the Japanese buyers showed that they have increased control over the contract components in order to maximize their interests. From 1980 to 1990, the Japanese coking coal market experienced fundamental changes -- from fear of a supply shortage to world wide over capacity of coal production. Thus the price of coal has declined substantially since 1984. Consequently, the Japanese changed their strategy in response to basic changes in the market condition. The top priority of the Japanese consumers has changed from securing supply to a combination of securing supply and cutting cost given the foreseeable supply surplus. Japanese buyers exercised their power through controlling tonnage, price formation, and term of contract to cut cost and secure supply.

4.4.1 Changes in Contract Components

The evidence of buyers' power is that during the time of over supply Japanese buyers can cut extra tonnage by such "unfair tactics" as shifting contracts from an escalated price to a fixed price, and reduce the length of the contract term. Weaker evidence is that the Japanese buyers paid widely varying prices for similar quality coals. The suppliers seem to have had no other choice except to accept these changes that are obviously in favor of the buyers.

Consider Canadian coal supply as an example of tonnage cutting. Since the

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tonnage level is important for open-cut producers the Japanese use the "first-batter" principle to promote the "new world price" by allowing greater tonnage to the first group of producers. Then, later groups of producers usually get less tonnage for the same new prices (Anderson, 1987). The tonnage cut then is dependent on the type of contract: generally long term contracts with price escalation clauses, which were commonly used by most new joint projects, were revised and volumes cutback 10-20%; long term contracts with fixed prices were cutback 30%; and short term contracts either were not renewed or were cut down 50% (R. Goodman, 1983).

Escalated prices based on production cost components used to be widely used to insure the cash flow to producers. Although escalated price was also used by the Japanese to encourage the development of new capacity, it favored producers. When the market price dropped sharply in 1984, the escalated prices became a cost burden to the Japanese consumers. Old contracts with escalated prices were replaced by contracts with lower fixed prices either at the time the old contracts expired or through renegotiation. The number of contracts using escalated price has declined. In JFY 1981, all eight major US export brands used escalated prices. In JFY 1985, ten Australian brands, four Canadian brands and no US brands used escalated prices. In JFY 1990, only three Canadian coal brands had escalated prices (*Coal Manual, 1982, 1987, 1991)*. These three mines all had 15 year contracts signed in 1981, and are partially owned by the Japanese steel mills (Greeg River, Quintette and Bullmoose). The evidence, suggested by Mr. Anderson, was that the Japanese paid varied prices for coals with similar quality, which indeed is a weak evidence. The

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JSM pay new mines higher prices and purchase larger tonnages. The existing mines in south-eastern British Columbia, developed prior 1980, received less than C$70 /tonne (FOBT) and 55% of the initial contract tonnage. The new mines in the same area received C$80/tonne and 80-90% tonnage. The new mines in the north-east of B.C. received C$94/tonne and almost 100% tonnage (such as Bullmoose and Quintette, which are partially Japanese owned) (Anderson, 1987). Anderson called this a cost/plus reimbursement model, which provides a minimum cash-flow payment to each producer. It seems that, "at one extreme, no one goes out of business, and at the other extreme, that no one acquires substantial economic rents". In this way, the excess supply capacity and low market price can be kept for a longer time. It benefits the Japanese buyers in long run by securing supply and lowering cost. Actually, without the JSM's willingness to engage in differential pricing and output policies, it is unlikely that the western Canadian coking coal industry would exist.

The reason we think this is weak evidence is that one can argue with Mr. Anderson that these high prices paid to new Canadian coal mines with large tonnage volumes are not only because the Japanese are willing to do so, but also because they have to do so, as they are equity holders in most of these mines and are locked into the long term contracts.

The changes of contract terms have been favorable to the buyers. The observations and conclusions related to these changes are:

(1) The length of the contract term has decreased. The longer terms, as long as 15 years, were used before oversupply occurred. At that time, the top priority of the

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Japanese steel mills was to secure supply. Long term contracts, for the Japanese, were used to ensure coal delivery and to stimulate the build up of new supply capacity. For the export oriented coal suppliers, especially the newly developed large open pit mines, long term contracts are needed to ensure the cash flow for paying back debt and to make production schedules. Those concerns of both buyers and producers led to the longer contract term. When steel production started to slow down and demand for coking coal stagnated, Japanese consumers suffered because they were locked into long term contracts. For them the long term contract means higher prices, as spot prices were lower than contract prices, and less flexibility on tonnage. Particularly since the risk of supply shortage has been reduced, the large amount of cash lost was no longer considered worth as much as before. Thus, shorter term and yearly contracts were introduced to this market (interview with the Japanese trading company, Mitsui & Co.(U.S.A.), Inc, New York). For example, the contract with South Blackwater, Australia, shifted immediately to a yearly contract after the old 15 year contract terminated on March 31, 1985. A little less than three quarters of the brands (56 out of 80 brands traded) and 43% of the tonnage is traded by yearly contract (*Coal Manual, 1989)*. (Table 2.5). Currently, in the U.S. only two suppliers still hold long term contracts, Pittston and Jim Walter (Blue Creek). Most Australian coals are on short term or yearly contracts. Canadian mines have more long term contracts, but all of them were signed around 1981 and most of them are newly developed mines under Japanese participation by investment.

(2) Small producers are more likely to lose their long term contracts. If we look not

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only at the number of brands, but also at the volume of each contract, we find that coals with large volumes are more likely to be purchased under long term contract, eg. the yearly contracts are spread mainly over a lot of small suppliers (Table 2.5). For buyers, a long term settlement with major producers is facilitated to insure the basic supply, while short term purchasing from smaller suppliers reduces costs and allows more flexibility on tonnage.

4.4.2 Limitations To the Trend of Changes

Regardless of the current market condition, secure supply is not going to be completely ignored in Japanese long term strategic plans. The decision will be made based on both long and short term strategies, which puts some constraints on how far these trends can develop.

Current business practice also puts constraints on how the Japanese react to market condition changes. Indeed, in order to secure their long term natural resource supply, some investment decisions made in the later 70's and early 80's have proven very costly to the Japanese investors. Today, they are still locked into some high cost contracts, and they find it is very difficult to break them, because the Japanese companies are partners in those mines.

The three-year law suit between the Japanese steel mills and Quintette is a good example. The Japanese accused the Quintette of over charging them, and the final court settlement includes a price cutting plan and reimbursement to the Japanese companies (see Chapter Two).

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4.4.3 Different Impacts on Different Producers and Possible Solutions

The impacts on large and small producers are different. Small producers experienced more price and tonnage cutting. Long term contracts provide market inertia. During over supply, they can provide some protection to suppliers who hold long term contracts. The length of contract has been proven to have a strong positive impact on the price level, eg. prices of contracts with longer terms are higher than prices of contracts with shorter terms. In Chapter Three, Equation (23) shows that average prices received from yearly contracts are significantly lower than from longer contracts. Therefore, smaller producers, who usually have shorter or yearly, contracts experienced more price reductions and tonnage cutting. Some of them eventually dropped out of the market. For instance, the number of US coal brands traded has dropped from 104 in the peak year 1982 (JFY 1982) to 22 in 1989 (JFY 1989).

The impacts on each country may be different. (Table 2.5) Australia seems to be the least favored in terms of contract length, especially if over supply continues. It is unlikely, however, that many Australian brands are going to be out of the market because they are low cost, but the loss of protection by longer term contracts can be used by Japanese negotiators to further cut prices of Australian coals. Canadian suppliers seem to be in a much better position, as they are in "safe" long term contracts. But they have experienced tough negotiations with Japanese buyers. These buyers complained about the high contract price and went to court to gain price reductions and reimbursement (see Chapter 2.5, Japanese law suit against Quintette, 1990). When those long term contracts are terminated, western Canadian coal mines

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will have a tough time maintaining sales of large volumes of coal at high prices. For US producers, the situation is that small US producers with yearly contracts could face more losses of tonnages if demand continues slack and prices of U.S. coals remain high.

One natural result from over capacity is the closure of inefficient mines. It is particularly true for the small mines, since most small mines are less efficient than large open pits. Therefore, interesting questions regarding the producers are: can this closure trend lead to higher producer concentration? Should producers accelerate mergers to become stronger against vertically integrated buyers? How does the higher concentration help the remaining producers in this troubled time. Especially, what are US producers facing now? (see chapter 6)

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5. ESTIMATING RISK PREMIUM AND COST OF DIVERSIFICATION BY USING PARTIAL ELASTICITY FACTOR SUBSTITUTION (PEFS)

5.1 Risk Assessment

The major aspects of risk assessment are: risk acceptability, risk evaluation and decision making. Risk acceptability includes risk measurement, attitudes toward this risk and perceptions of risk. Defining risk measurement and the personal reaction to this risk is always difficult. The well known method uses a utility function to combine risk and the personal risk attitude and makes the decision based on the values of the utility function. For instance, the Arrow (1971)-Pratt (1964) coefficient $r(x)$ is defined as $r(x)=-u(x)''/u(x)'$, which is a local measure of the strength of preference of an individual for a given level of x conditioned by the chance that the level may change. Subsequently, many different utility functions and measurements were developed for decisions under risk. Risk evaluation estimates the magnitude, or level of outcome, and the probability for that outcome: for example, the cost of failure in a procedure and the probability that this failure will occur. Decision making requires the identification of that strategy which optimize some utility or risk adjusted measure. In this study, the relevant risk arises from failure to deliver the qualified coal to the Japanese market.

5.1.1 Conceptual Framework

Defining $\Re$ as a set of possible combinations of coal purchase that meet the

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technical requirement of coking coal for the Japanese steel mills at the time, the cost $c(x)$ of any combination x is defined as:

$$
\begin{aligned}
&C(X) = R'X \qquad X \in \Re \\
&X' = [x_1, x_2, \ldots\ldots x_n] \\
&R' = [r_1(x_1), r_2(x_2), \ldots\ldots r_n(x_n)]
\end{aligned}
\tag{1}
$$

x_i, $r_i(x_i)$ are coal tonnage and delivered cost per ton, respectively for coal from the i^{th} region. Here we assume the prices may not be constant.

Let $\mathbf{X}^*$ be the combination of coal purchase that minimizes the cost of meeting coking coal requirements, and let C^* be that minimum cost:

$$
\begin{aligned}
&C(X^*) = R'X^* \\
&X^{*\prime} = [x_1^*, x_2^*, \ldots\ldots x_n^*] \\
&R' = [r_1(x_1^*), r_2(x_2^*), \ldots\ldots r_n(x_n^*)]
\end{aligned}
\tag{2}
$$

Here, X^* is determined strictly by coal quality characteristics and by production plus delivery costs. Clearly, everything else being equal, X^* is the optimal, preferred purchase.

Define

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$$Y=[y_1, y_2, \ldots y_n] \quad (3)$$

as a combination of shortfalls:

$$Y=X^{*}-X^{(D)} \quad (4)$$

where,

$$\boldsymbol{X}^{(D)\prime}=[x_1^{(D)}, x_2^{(D)}, \ldots\ldots, X_n^{(D)}] = \mathit{actual\ deliveries}. \quad (5)$$

Let $c(Y) = c(X^{*} - X^{(D)})$ be the minimum cost of compensating for this shortfall, given that the shortfall has occurred, and let $\phi(X^{(D)};X^{*})$ be the conditional probability distribution for $X^{(D)}$, which actually represents the probability of failure to deliver X^{*}. Then $S(X^{*})$, the expected cost of purchasing with optimum strategy X^{*}, is the following:

$$S(\boldsymbol{X}^{*}) = \int_{\Re} [C(\boldsymbol{X}^{(D)} + c(\boldsymbol{X}^{*} - \boldsymbol{X}^{(D)}] \, \phi(\boldsymbol{X}^{(D)}; \boldsymbol{X}^{*}) \, dX^{(D)}$$

or,

$$S(\boldsymbol{X}^{*}) = \int_{\Re} [\boldsymbol{R}' X^{(D)} + c(\boldsymbol{X}^{*} - \boldsymbol{X}^{(D)})] \, \phi(\boldsymbol{X}^{(D)}; \boldsymbol{X}^{*}) \, d\boldsymbol{X}^{(D)} \quad (6)$$

Then, the total risk premium will be bounded by 0 and $S(X^{*})-R'X^{*}$:

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$$0 \leq RP^{max} \leq S(X^{*}) - R'X^{*} \tag{7}$$

Clearly, while this inequality gives the bounds of total risk premium, the magnitude of RP_i reflects the resolution of buyer and seller power of the i^{th} coal, subject to the following constraint over all purchased coals:

$$0 \leq \sum_{i=1}^{n} RP_i \leq RP^{(max)} \tag{8}$$

specifically

RP_1 = *risk premium for US*

RP_2 = *risk premium for Australia*

RP_3 = *risk premium for Canada*

Thus, actual risk premiums paid by Japan to major supply regions are expected to be various mixes of risk premiums, monopoly and monopsony power, inefficiencies, and stochastic influence. These mixes will vary from region to region as supply reliability, coal quality, and sellers power vary. In concept, it is possible that all of the risk premium $RP^{(max)}$ is paid to coal producers from only one region, provided that they have strong monopoly power, high coal quality and high supply reliability and provided that producers from the other regions have no monopoly power and behave as price takers.

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5.1.2 Overall Approach

With the data available here, it is impossible to estimate or describe probability for failure in numerical form. Instead, a subjective description -- high risk expectation versus low risk expectation -- is used. The study procedure is to describe how the magnitude of the relative risk premium *(RP)* paid by Japan in the last decade, in an "efficient market" has changed with changes in the probability for failure or in the cost of failure as a result of basic market condition changes. The term "efficient", as used here, refers to a market in which price and shipment can quickly response to changes in basic market conditions. It will be demonstrated in the case of an "efficient market" that the expectation for failure has sharply decreased as a result of supply surplus and technical change. In contrast to this type of market conduct, in the "inefficient market" there is a lag in the response of price and market share to basic market conditions. Due to this delay, the Japanese continue to pay a large risk premium based upon decisions made years ago.

The foregoing simplified discussion of utility theory and risk is a useful way to identify the major concepts involved in the purchasing strategies of Japanese buyers of coking coal. But beyond the highlighting of major concepts, the simplified case is of little use, because, as noted in previous chapters, coal qualities vary considerably across the major suppliers, and risk includes not just failure to supply but also the failure to supply the coal with anticipated qualities. Accordingly, a full theoretical exposition of the purchasing strategies using utility theory would require a multi-dimensional utility function, allowing for the premiums and penalties of the various

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coal characteristics. As the data necessary for such analyses are not available, a much less comprehensive analysis of risk is presented in this section.

Coal trade between Japan and the US will be viewed as "efficient" conduct. Contracts with US producers consist of prices which are fixed for only 6 months to 1 year. Thus, these prices are actually adjusted frequently enough to reflect the changes in basic market conditions and risk expectations. Using US empirical data to estimate risk premiums discloses changes across time in the expected possibility of failure or the cost failure.

Coal trade with Canadian producers is different. It is referred to as "inefficient conduct". Large amounts of Canadian coals are sold to the Japanese under long term contracts with clauses for the escalation of prices. After the escalated clauses are set up, the prices are adjusted only by price indexes, and the clauses themselves are very difficult to renegotiate. Accordingly, there is a long lag between a change of basic market conditions and changes in actual shares or prices. In 1980-1981, when securing supply was of top priority to Japanese steel mills, the Japanese signed some long term contracts with escalated prices to support their diversification strategy. The higher escalated prices were accepted by the Japanese as a trade-off for secure coal delivery. Later, changes in market conditions sharply reduced the risk of coal shortages. This study shows that these early decisions have proven very costly to the Japanese.

Australia is chosen as a base for estimating relative risk premiums. Australian producers have abundant resources and large export capacity. Although they are low cash cost suppliers for the Japanese, they have a bad reputation for delayed delivery

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because of strikes. Thus, for the Japanese, Australian coal is purchased because of its low delivered cost, not for reliability of delivery. Therefore, it is reasonable to assume that the risk premium paid to Australia is zero. i.e.. RP_{au} is set to 0.

5.2 Deriving Risk Premium by the Partial Elasticity of Factor Substitution

5.2.1 Production Theory Foundations

Suppose the production function for Japanese steel making is

$$y=f(x_1,x_2,x_3;X)\ ; \qquad (9)$$

Here, x_1, x_2, x_3 are factor inputs -- coals from US, Australia, and Canada, respectively. Vector X represents the rest of the inputs, such as iron ore, labor etc.

The partial elasticity of factor substitution is defined as the percentage change of the ratio of coal purchased from two regions with respect to the percentage change of the ratio of marginal physical products:

$$\epsilon_{12}=-\frac{d(\frac{x_1}{x_2})/(\frac{x_1}{x_2})}{d(\frac{f_1}{f_2})/(\frac{f_1}{f_2})}\ , \qquad (10)$$

where,

$$f_i=MPP_i=\frac{\partial Y}{\partial x_i}\ ; \qquad (11)$$

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As we have chosen Australia as base, its risk premium is set to zero. The measure σ_{12} represents the PEFS between US and Australia. Similarly, σ_{32} represents PEFS between Canada and Australia.

We assume that the Japanese are rational buyers, meaning that the Japanese purchasing decision is based upon cost minimization when risk is given explicit consideration. Alternatively, the Japanese are cost minimizers when shadow prices, rather than cash prices, are used in decision making. Consequently, they produce along the expansion path, meaning that the ratio of marginal physical products is equal to the ratio of shadow prices of these coals:

$$\frac{f_1}{f_2} = \frac{P_1^s}{P_2^s} \quad \text{-- expansion path.}$$
$$\frac{f_3}{f_2} = \frac{P_3^s}{P_2^s} \quad \text{-- expansion path.} \tag{12}$$

The term "shadow price" is used in this study to distinguish it from "observed cash price". Observed price is how much cash the buyer paid to the producer. Shadow price is what the coal is worth to production in the absence of risk considerations, i.e. a non-risk, strictly production sense. Shadow prices can be defined as a combination of cash cost and the risk premium:

$$P^{shadow} = P^{observed} - risk\ Premium$$
$$Thus, \quad P_i^s = P_i^{obs} - r_i \tag{13}$$

The risk premium can be explained in a broader sense. It can be used to

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represent all the extra cost. For instance, the high price paid by the Japanese to newly developed Canadian mines is a kind of subsidy, as a part of their diversification strategy. The extra paid above market price is here considered as a risk premium.

For Japanese steel makers, the coals from different regions are technically substitutable, thus PEFS is in the elastic range. The absolute value of elasticity of substitution should be in the range between 1 and infinity ($1 \leq \sigma \leq \infty$). Actually, prices will be adjusted by their quality premium (Chapter 3). The quality adjusted prices are supposed to represent a coal of a standard quality from each region. Technically, the elasticity of substitution between coals with the same quality approaches infinity. So, the absolute value of PEFS can be very large. Using the result from Chapter 3, the quality adjusted prices (P^{adj}) are obtained by subtracting the quality premium (*QP*) from the observed price (P^{obs}):

$$P = P^{adj} = P^{obs} - QP$$

Where, the quality premiums in 1988 *are*: **(14)**

$$QP_{au} = -\$1.71$$

$$QP_{ca} = \$0.20$$

$$QP_{us} = \$4.56$$

The nominal quality premiums deflated by US GNP deflators are given in Table 5.1.

Quality adjusted prices are used hereafter instead of observed prices in the

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Table 5.1 Nominal quality premiums and quality adjusted prices (1982 dollar)

Nominal Quality Premiums and Nominal Quality Adjusted Prices (1981-1989)

Quality Premiums

(Nominal U$/mt, inflated by US GNP index)

	Australia	Canada	USA	S Africa	USSR	China
1988=	-1.71	0.2	4.56	-8.65	4.4	-2.18
1981	-1.33	0.15	3.53	-6.70	3.41	-1.69
1982	-1.41	0.16	3.76	-7.13	3.63	-1.80
1983	-1.46	0.17	3.91	-7.41	3.77	-1.87
1984	-1.52	0.18	4.05	-7.68	3.91	-1.94
1985	-1.57	0.18	4.18	-7.93	4.03	-2.00
1986	-1.61	0.19	4.29	-8.14	4.14	-2.05
1987	-1.66	0.19	4.41	-8.37	4.26	-2.11
1988	-1.71	0.20	4.56	-8.65	4.40	-2.18
1989	-1.78	0.21	4.75	-9.01	4.58	-2.27

Quality Adjusted Nominal CIF Prices

	Australia	Canada	USA	S.Africa	USSR	China
1981	66.89	64.46	79.56	70.42	60.94	66.66
1982	69.63	70.62	80.20	74.31	67.40	70.45
1983	64.81	69.98	74.89	65.28	56.19	57.96
1984	60.55	69.34	66.89	58.65	48.33	54.09
1985	55.92	67.33	64.48	57.55	50.66	53.17
1986	54.42	66.45	60.41	55.12	48.58	49.26
1987	49.93	65.24	59.64	51.72	44.37	45.42
1988	50.01	67.17	55.78	51.20	45.74	48.23
1989	54.36	69.52	58.59	56.69	50.07	54.35

Quality adjusted prices are used hereafter instead of observed prices in the following study. Hence,

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$$P^s = P^{obs} - Quality\ Premium - Risk\ Premium$$

$$eg. \quad P^s = P^{obs} - QP - RP \tag{15}$$

$$= P^{adj} - RP$$

$$P^s = P - r$$

5.2.2 Deriving Risk Premium In General

The definition of the elasticity of substitution becomes:

$$\epsilon_{12} = -\frac{d(\frac{X_1}{X_2})/(\frac{X_1}{X_2})}{d(\frac{P_1^s}{P_2^s})/(\frac{P_1^s}{P_2^s})} \tag{16}$$

Substituting equation (15) into (16) and recalling that the risk premium for Australia is 0 (r_2=0), we have the following expression of σ_{12} :

$$\epsilon_{12} = -\frac{d(\frac{X_1}{X_2})/(\frac{X_1}{X_2})}{d(\frac{P_1 - r_1}{P_2})/(\frac{P_1 - r_1}{P_2})} \tag{17}$$

MultiplyING both sides by the denominator :

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$$-\epsilon_{12}\ \frac{d(\frac{P_1-r_1}{P_2})}{\frac{P_1-r_1}{P_2}} = \frac{d(\frac{X_1}{X_2})}{\frac{X_1}{X_2}} \tag{18}$$

Integrating both sides:

$$\int -\frac{\epsilon}{(\frac{P_1-R_1}{P_2})}\, d(\frac{P_1-r_1}{P_2}) = \int \frac{1}{(\frac{X_1}{X_2})}\, d(\frac{X_1}{X_2}) \tag{19}$$

$$-\epsilon \ln(\frac{P_1-r_1}{P_2}) = \ln(\frac{X_1}{X_2}) + \ln C$$

Exponentiating both sides:

$$(\frac{P_1-r_1}{P_2})^{(-\epsilon)} = C(\frac{X_1}{X_2}) \tag{20}$$

$$\frac{P_1}{P_2} - \frac{r_1}{P_2} = (C\frac{X_1}{X_2})^{(-1/\epsilon)}$$

Thus, the expression for relative risk premium per ton is the following:

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$$\frac{r_1}{P_2} = \frac{P_1}{P_2} - (C\frac{X_1}{X_2})^{(-\frac{1}{\epsilon})} \qquad (21)$$

$$r_1 = P_2 (\frac{P_1}{P_2} - (C\frac{X_1}{X_2})^{(-\frac{1}{\epsilon})})$$

Since,

$$\frac{Share_i}{Share_j} = \frac{Ton_i/Total\ Ton}{Ton_j/Total\ Ton} = \frac{Ton_i}{Ton_j} \qquad (22)$$

the ratio of X_i to X_j can be either ratio of tonnages or ratio of shares.

Discussion of the constant C of the indefinite integral:

(1) Since risk premiums are relative, C could be any number greater than 0, as is required for the logarithm in equation (19).

(2) In order to determine a value for C, consider the special case of equation (14): for any given elasticity, purchases from two regions are the same ($X_1 = X_2$). For this circumstance, shadow prices between the two regions should be equal ($P^s_1 = P^s_2$). Otherwise, if coals from the two regions are perfectly substitutable, the small price difference will cause all purchases to quickly shift to the cheaper region. Therefore, from equation (19):

$$\epsilon \ln(1) = \ln(1) + \ln C \qquad (23)$$

$$\epsilon \cdot 0 = 0 + \ln C$$

$$\therefore\ C = 1$$

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5.3 Estimation of Relative Risk Premium

As indicated by equation (21), estimation of risk premium *r* requires estimation of price ratio and quantity ratio. Making these estimates requires the smoothing of stochastic effects in the annual data.

5.3.1 Estimating the US Risk Premium

The time series for the price ratio of US and Australian coals between 1981 to 1989, shown in Figure 5.1 is almost constant:

$$\frac{P_{1t}}{P_{2t}}=\frac{P_{us,t}}{P_{au,t}}=1.1195 \qquad (t=1,2,\ldots,9) \tag{24}$$

The quantity ratio, shown in Figure 5.2 is described as an inverse function of time:

$$\frac{X_{1t}}{X_{2t}}=\frac{X_{us,t}}{X_{au,t}}=0.34+0.54/t; \qquad R^2=0.56 \tag{25}$$

By equation (21), the risk premium across time is :

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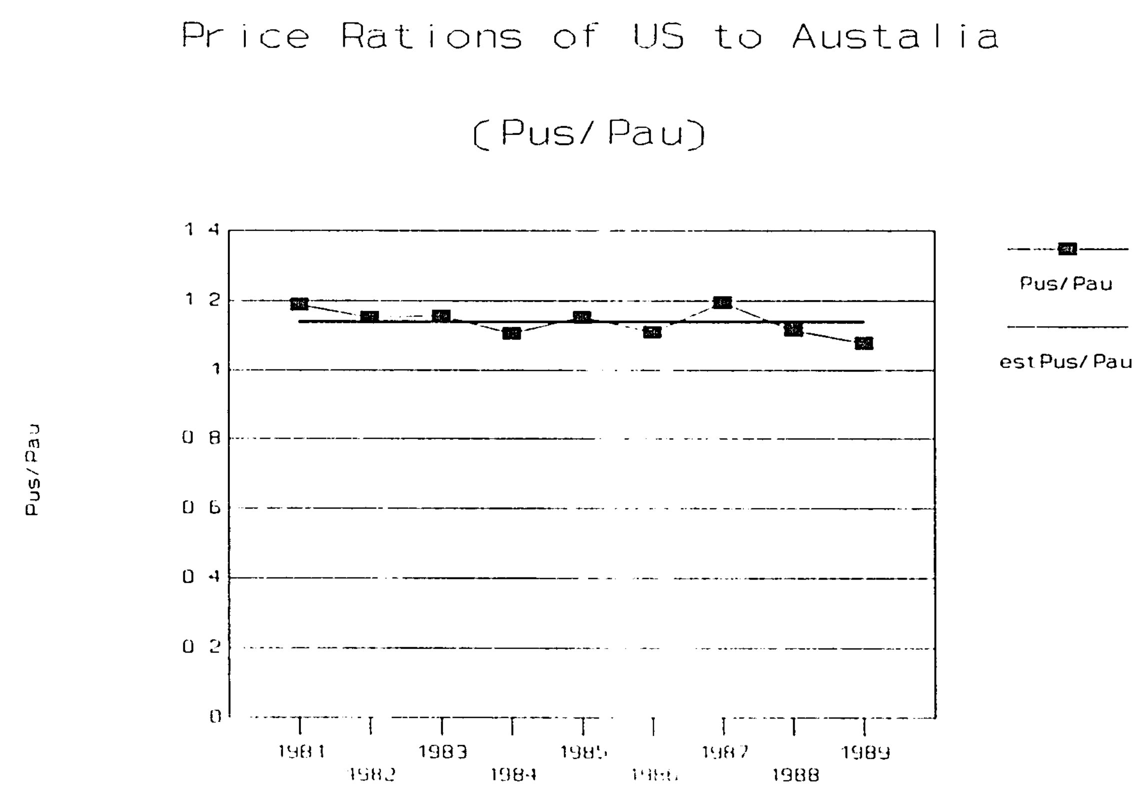

Figure 5.1 Price Ratios of US to Australia

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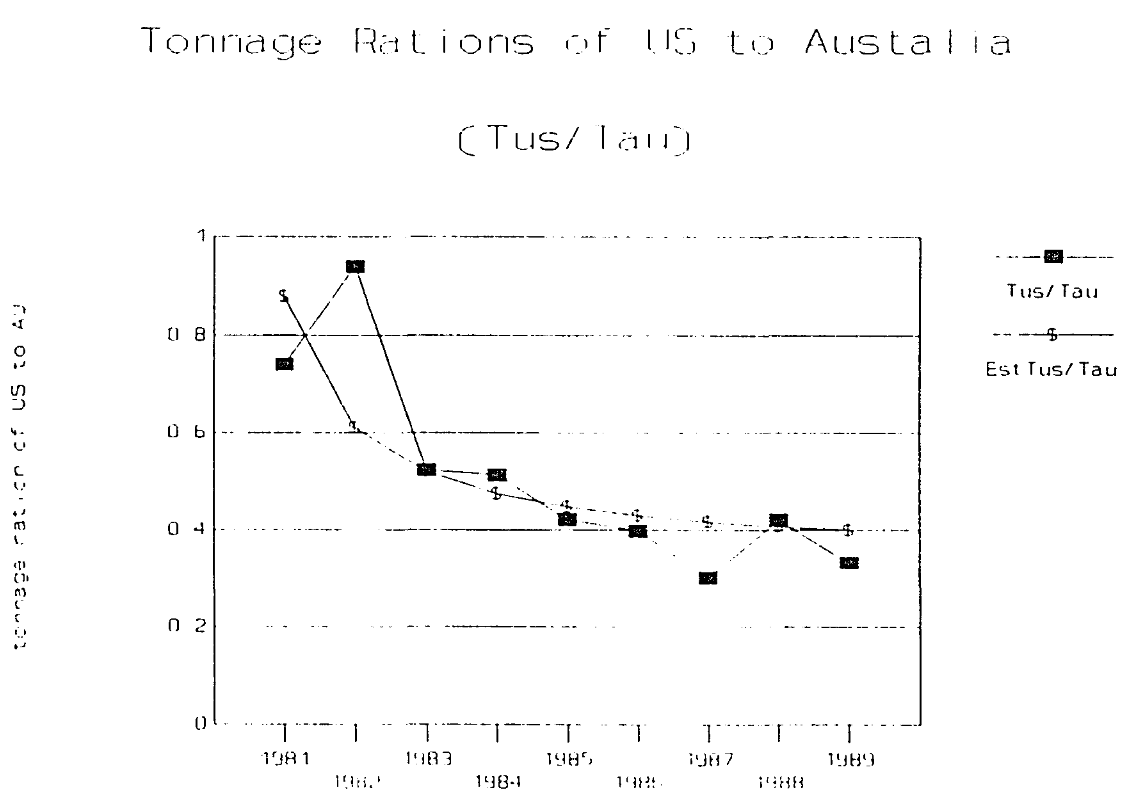

Figure 5.2 Tonnage Ratio of US Coal to Australian Coal

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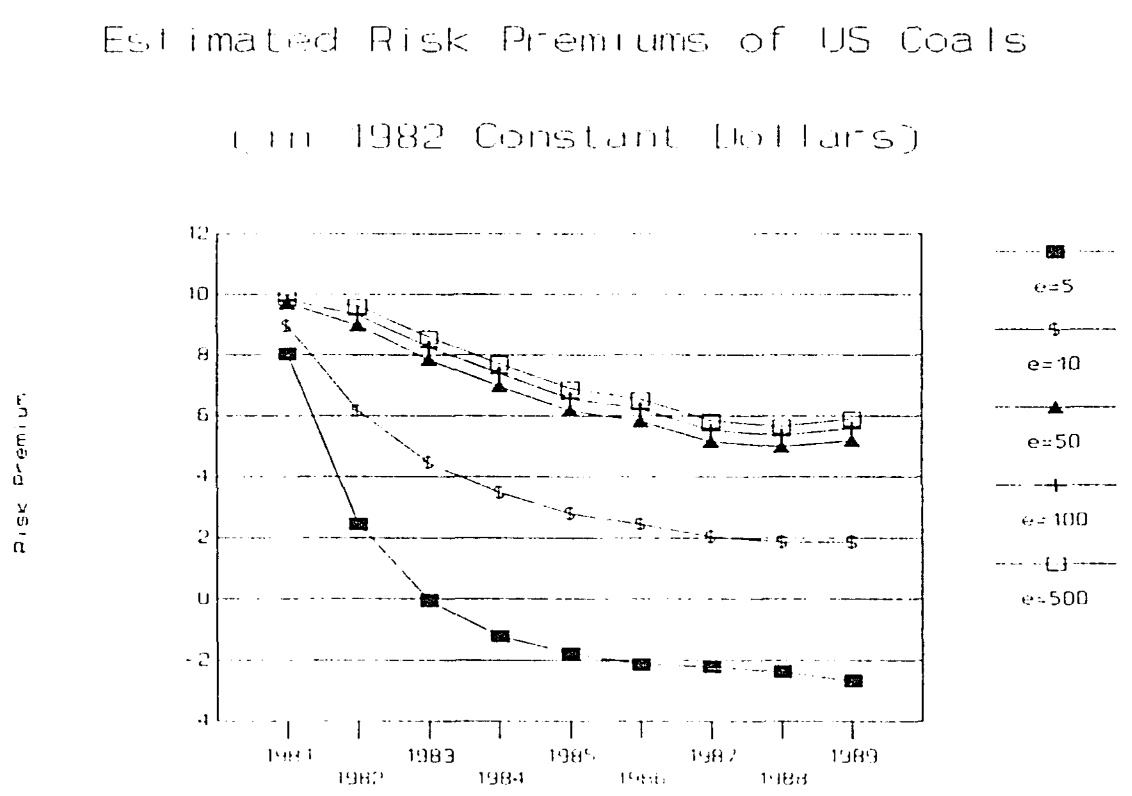

Figure 5.3 Estimated Risk Premium Per Ton of US Coal

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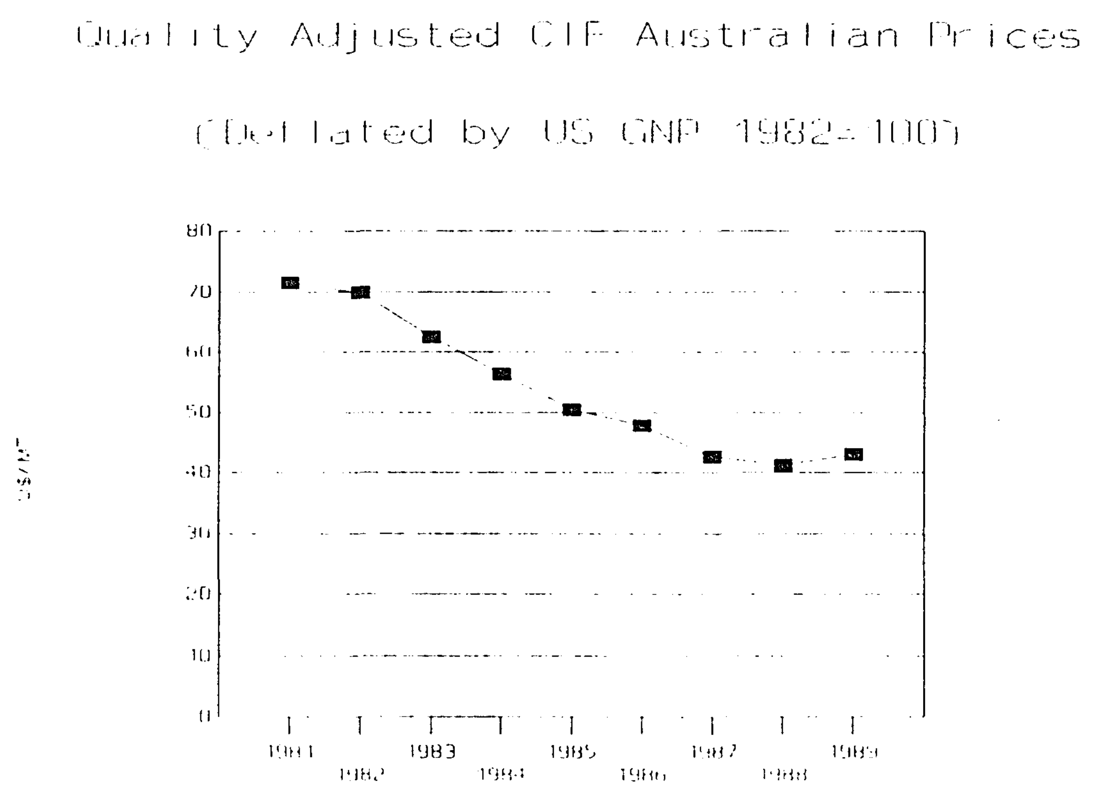

Figure 5.4 Real CIF Prices of Australian Coal

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$$r_t = f(t;\epsilon) = P_{au,t}(1.1195-(C(0.34+0.54/t))^{-1/\epsilon}) \quad (26)$$

The value and trend of Australia prices are given in Figure 5.4.

For any given σ, risk premium for US coals, as described by the model, declines with respect to time, regardless of the value for C. This trend can be verified by taking the partial derivative of risk premium with respect to time:

$$\frac{\partial r}{\partial t} = -P_{au}\left(-\frac{1}{\epsilon}\right)(C(0.34+0.54/t))^{\left(-\frac{1}{\epsilon}-1\right)}\left(\frac{-0.54}{t^2}\right)$$
$$= -P_{au}\left(\frac{0.54}{\epsilon t^2}\right)(C(0.34+0.54/t))^{\left(-\frac{1}{\epsilon}-1\right)} \leq 0 \quad (27)$$
$$\text{for } t=1,2,\ldots$$

Drawing upon the discussion about constant C, let us set C to 1.0. Quality adjusted prices are used here, Relevant values of elasticity of substitution are large. Thus, risk premiums for elasticities of 10, 50, 100 and 500 are evaluated according to equation (26); these are shown in Table 5.2 and Figures 5.3. From the trends of risk premiums the following conclusions are obtained:

(1) The greater the value of elasticity σ, the more substitutable are the coals between US and Australia and the higher the risk premium paid to US suppliers by Japanese buyers. The upper bound of risk premium, as σ

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approach infinity, is P_{us} - P_{au} :

$$\lim_{\epsilon \to \infty} r_t = P_{au}(1.1195-1) = P_{au}\left(\frac{P_{us}}{P_{au}} - \frac{P_{au}}{P_{Au}}\right) = P_{us} - P_{au} \qquad (28)$$

Therefore, if US coal can be perfectly substituted by Australian coal, the difference between the US price and Australia price is the risk premium.

(2) For a given elasticity, the relative risk premiums for US coal paid by the Japanese declined during the last decade. (These risk premiums are relative to the risk premium paid to Australian coals which, for simplicity, is considered to be zero). This decreasing trend reflects market condition and risk perception in the 1980's: after the energy crisis, secure supply was the top priority for Japanese buyers at the beginning of the 1980's. With the emergence of oversupply in 1982, the fear of supply shortage weakened, which led to changes in buyers' strategy. The Japanese became less willing to pay a high price on large volume.

(3) By using the estimated risk premium per ton of coal, the total cost of a diversification strategy can be obtained by multiplying the estimated risk premium per ton by shipping tonnage for a given year:

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$$TC_t = r_t \cdot Ton_t \qquad (29)$$

Table 5.2 Estimated risk premium per ton (1982 U$/MT)

Estimated Risk Premiums Per Ton
($/MT in 1982 dollar)

United States

Elasticity	5	10	50	100	500
1981	8.05	8.98	9.71	9.80	9.87
1982	2.44	6.15	8.99	9.33	9.61
1983	-0.05	4.46	7.85	8.26	8.59
1984	-1.21	3.47	6.97	7.39	7.73
1985	-1.77	2.79	6.18	6.58	6.91
1986	-2.14	2.43	5.82	6.23	6.55
1987	-2.21	2.03	5.16	5.54	5.84
1988	-2.38	1.86	4.98	5.36	5.66
1989	-2.67	1.85	5.19	5.59	5.90

Canada

Elasticity	5	10	50	100	500
1981	-17.20	-8.61	-2.36	-1.61	-1.02
1982	-13.60	-5.20	0.92	1.65	2.23
1983	-9.30	-1.77	3.71	4.37	4.88
1984	-0.02	3.66	6.45	6.78	7.05
1985	2.31	5.60	8.09	8.40	8.64
1986	4.40	7.52	9.88	10.17	10.40
1987	5.89	8.67	10.78	11.04	11.24
1988	7.62	10.32	12.36	12.61	12.81
1989	9.95	12.76	14.90	15.16	15.36

For $\sigma=10$, the Japanese, by this estimation, could have paid up to an extra 194 million dollars ($8.98 X 21.56 Mmt) in 1981 and $20.2 million ($1.85 X 10.9 Mmt) in 1989 by purchasing US coal instead of Australian coal for diversification purposes. Here we assume that the risk premium does not change as share changes, which

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implies that risk premiums are constant regardless of the magnitude of the US market share. Table 5.3 gives the estimated amount of payment by year for selected elasticity values.

5.3.2 Estimating Risk Premium for Canadian Coals

The average price ratios of Canadian to Australian coals steadily increased in the 1980's. A straight line is used to estimate this trend (Figure 5.5).

The quantity of Canadian coal relative to that of Australian coal can be divided into two separate periods: Before 1984 and after. Before 1984, Canadian coal shipments were about one third those of Australia. From 1983 to 1984, 4 newly developed Canadian mines sequentially started to export (about 7.9 Mmt since 1984)[1]. They were supported by Japanese investors at prices above market price in order to cover their cost. Therefore, the quantity ratio is represented by average values for two separated periods. (See Figure 5.6)

$$\frac{X_{ca,t}}{X_{au,t}} = \begin{cases} 0.356 & t \leq 1983 \\ 0.550 & t \geq 1984 \end{cases} \qquad (30)$$

The ratio of Canadian to Australian prices exhibits a linear trend (see Figure 5.5)

1 Quintette started in January 1984 at 3.5 Mmt; Bullmoose started in January 1984 at 1.7 Mmt; Gregg River started April 1983 exported 1.7 Mmt in 1984; and Line Creek started in April 1983 at 1 Mmt.

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$$\frac{P_{ca,t}}{P_{au,t}} = 0.934 + 0.045t\ ; \qquad (31)$$

$$R^2 = 0.92$$

Substituting these estimates into the risk estimation function yields :

$$r_t = \begin{cases} P_{au,t}[(0.934+0.045t) - (0.356C)^{(-1/\epsilon)}] & t \leq 1983; \\ P_{au,t}[(0.934+0.045t) - (0.55C)^{(-1/\epsilon)}] & t \geq 1984. \end{cases} \qquad (32)$$

It is easy to see that the risk premiums are increasing with respect to time. For any given σ, the C multiplied by a constant coefficient only shifts the value of risk premiums and does not affect the trend. Thus, once again, using the discussion about C in equation (19), we set C=1.0. For elasticities of 10, 50, 100, & 500, respectively, Table 5.2 and Figure 5.6 show increasing relative risk premiums for Canadian coal. This trend is not consistent with the changes in basic market conditions -- supply surplus, decreasing expectation of risk, and technical improvement in coal blending.

Beginning in the 1980's, the Japanese were willing to subsidize newly developed Canadian mines by paying them higher prices. This risk premium, which

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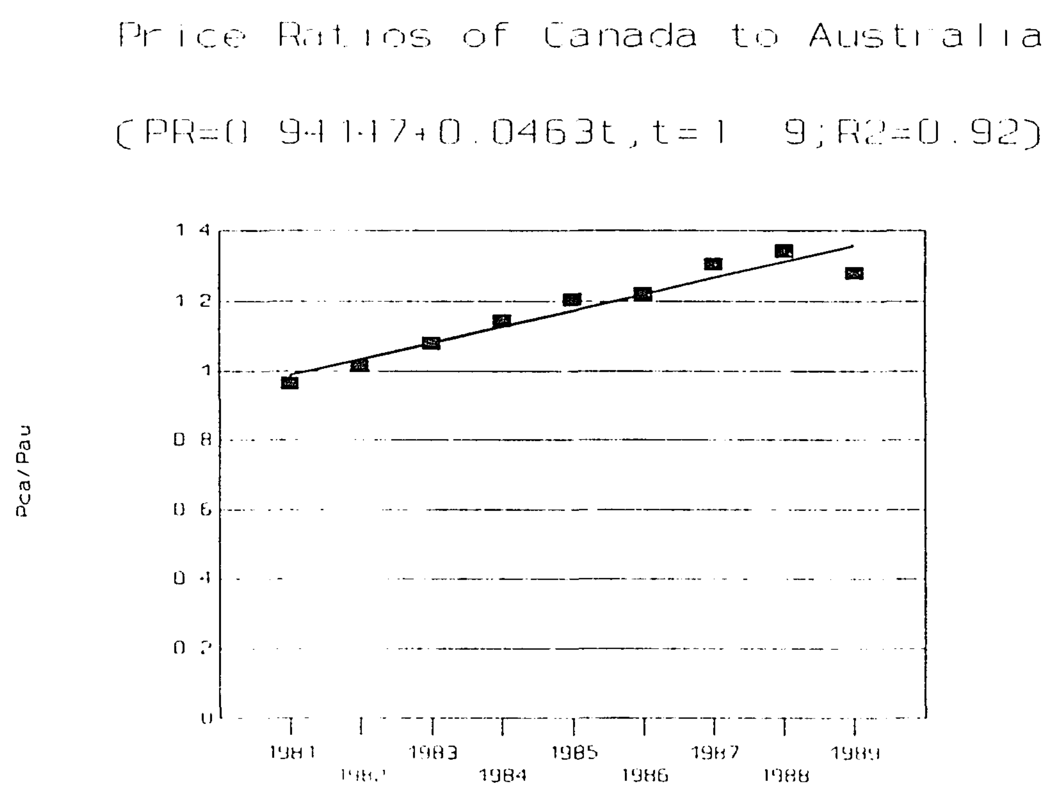

Figure 5.5 Price Ratio of Canadian Coal to Australian Coal

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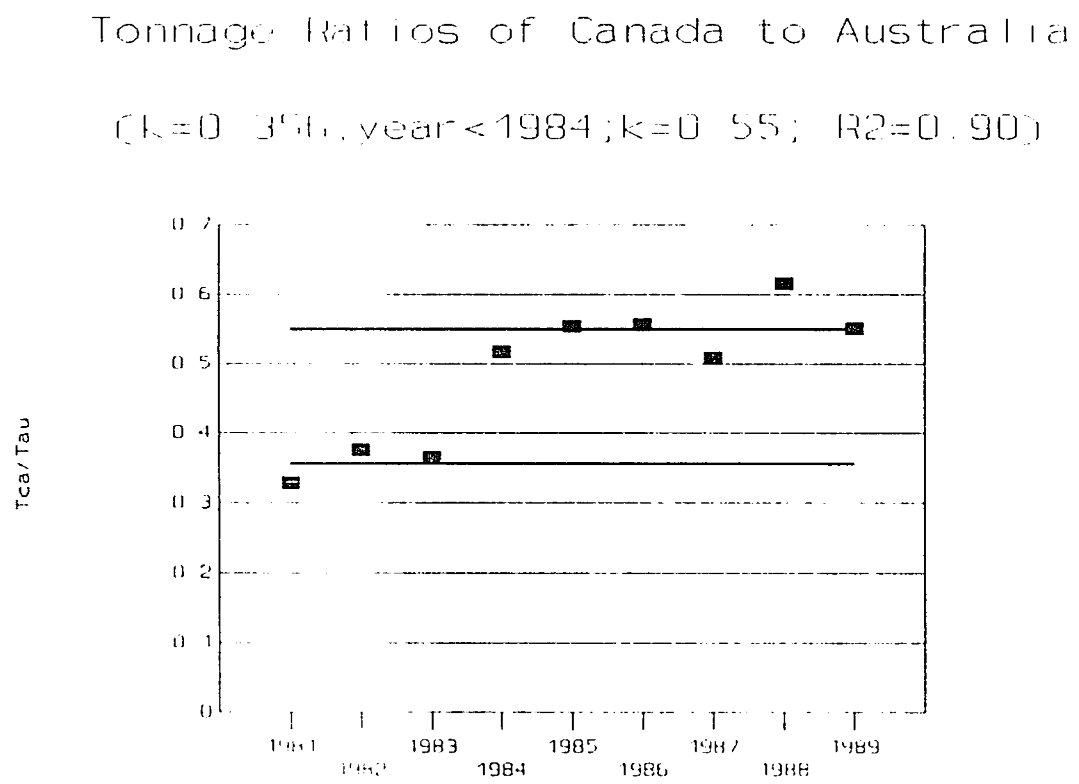

Figure 5.6 Tonnage ratio of Canadian coal to Australian coal

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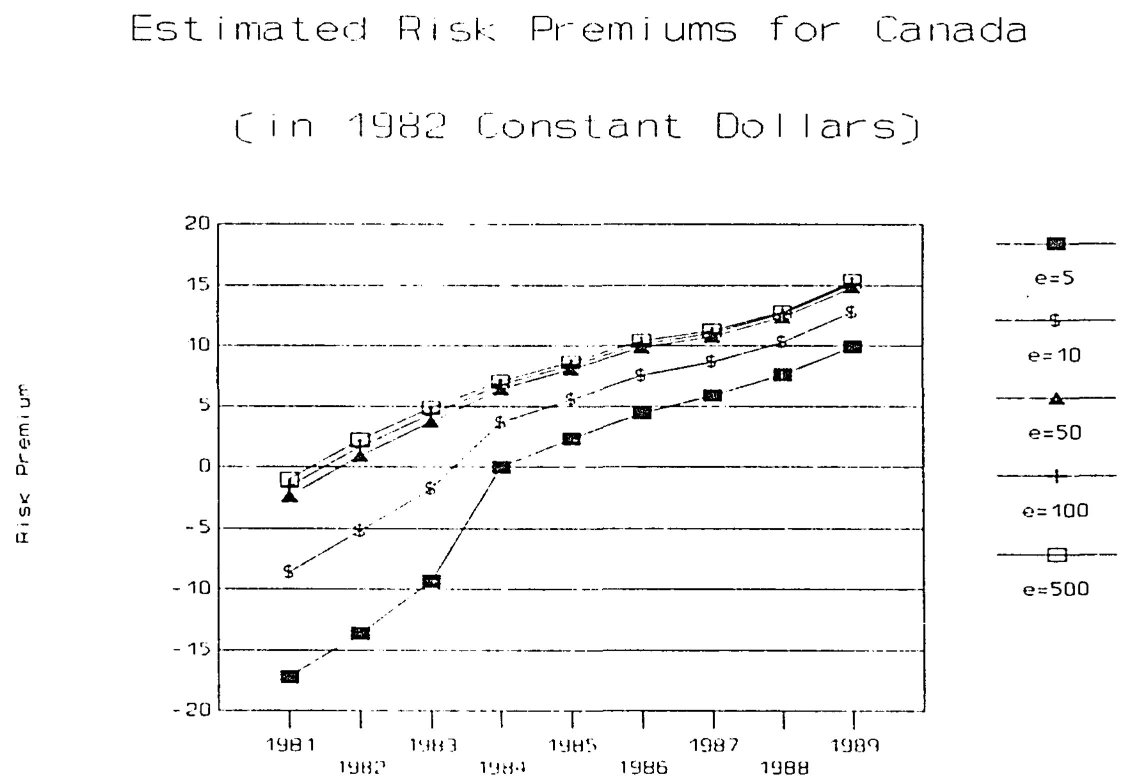

Figure 5.7 Estimated risk premium per ton of Canadian coal

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1980's due to price escalation clauses signed in 1980-1981. Considering the current over supply capacity in the coal market, the large amount of dollars (Table 5.2) paid to Canadian mines obviously has become very costly to the Japanese Steel mills. Thus, it is not surprising that Japanese Steel mills petitioned the British Columbia Court for a lower price and some compensation for over charges by Quintette. The court finally ruled in 1990 that Quintette will pay C$46 million compensation to Japanese Steel mills and that it will lower its coal price.

In contrast to what some think, US coal is not the most expensive coal. The risk premium paid for US coal is much less than that paid for Canadian coal in general. Those expensive Canadian mines would be out of the market without continuous support from Japan, since their costs are above market price.

5.4 Estimating the Total Cost of Risk Premiums (1981-1989)

The total cost of risk premiums is calculated by the equation:

$$TCRP_t(\sigma) = \sum_i RP_{it}(\sigma) * TON_{it}$$

$$PR_{it} = \text{risk premium per ton} \qquad (33)$$

$$t = 1981, \ldots, 1989; \quad i = US,\ Canada$$

$$\sigma = \text{related elasticity}$$

The parameter σ represents the different levels of elasticity. The higher the level of elasticity the more complete is the substitution between the two supply regions, thus the unit and total cost of the premium with respect to this higher

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elasticity level will be higher too. The results are shown in Table 5.3 and Figures 5.8, 5.9 and 5.10. At the $\sigma=10$ level, the total cost of risk premiums are from about $100 to $250 million dollars per year (1982 dollar) during the last decade, except for the $47 million in 1983. In 1983, the price of US coal dropped sharply by about $9, while the expensive, new Canadian mines did not start shipping until October 1983. Thus the average price for 1983 was low. The total cost of risk premiums have increased since 1983. This total cost is a combination of two trends: the decreasing trend of total risk premiums paid to the US and the increasing trend of total risk premiums paid to Canada. As discussed in the previous section, the US market is more likely to be an "immediate" market, while the Canadian market exhibits a long time lag for any market changes. Therefore, the decreasing trend of total risk premiums paid to US products actually reflects the current risk expectation in the market, which has been declining.

The percentages of the total purchasing costs constituted by total risk premium are also calculated (See Table 5.4). These range from 1.3 to 8.6 percent for $\sigma=10$ and 4.2 to 11.5 percent for $\sigma=100$. They are not very high.

To clarify the argument concerning the increasing trend of total risk premiums, the following points should be stressed:

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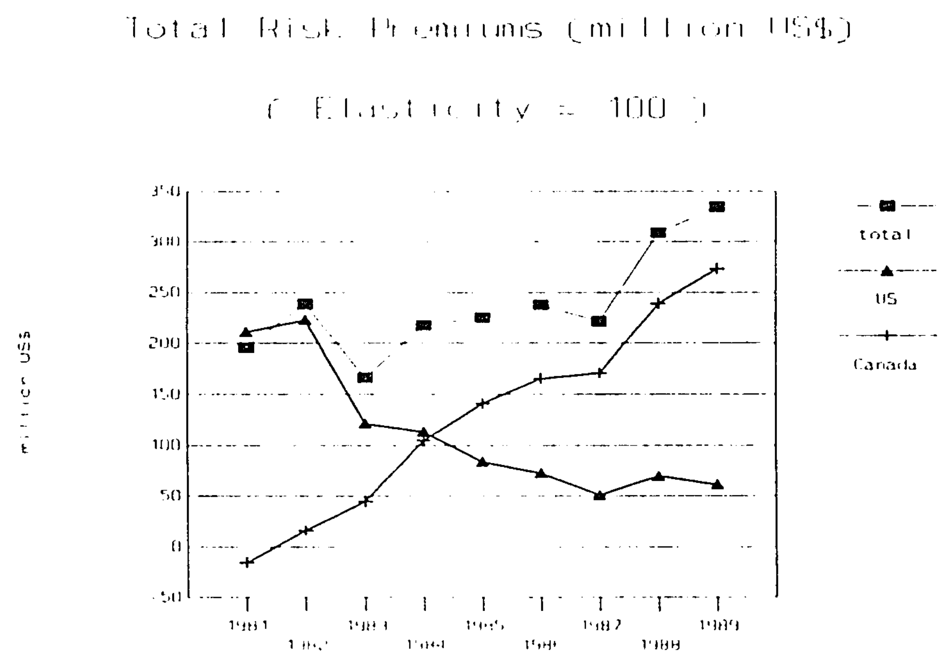

Figure 5.8 Total value of risk premium (ε=10)

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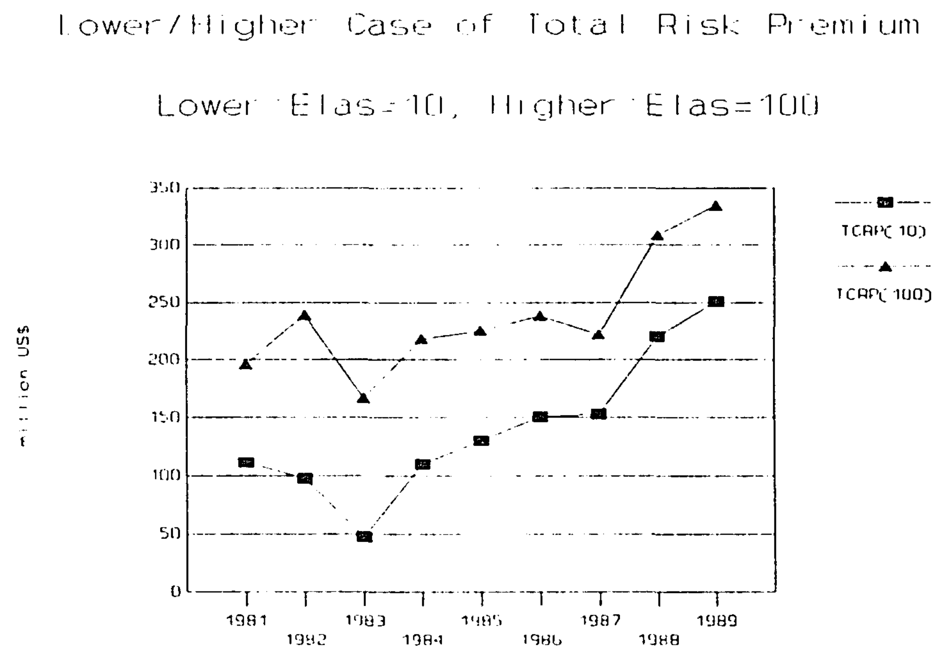

Figure 5.9 Low Case/Upper Case of Total Risk Premiums

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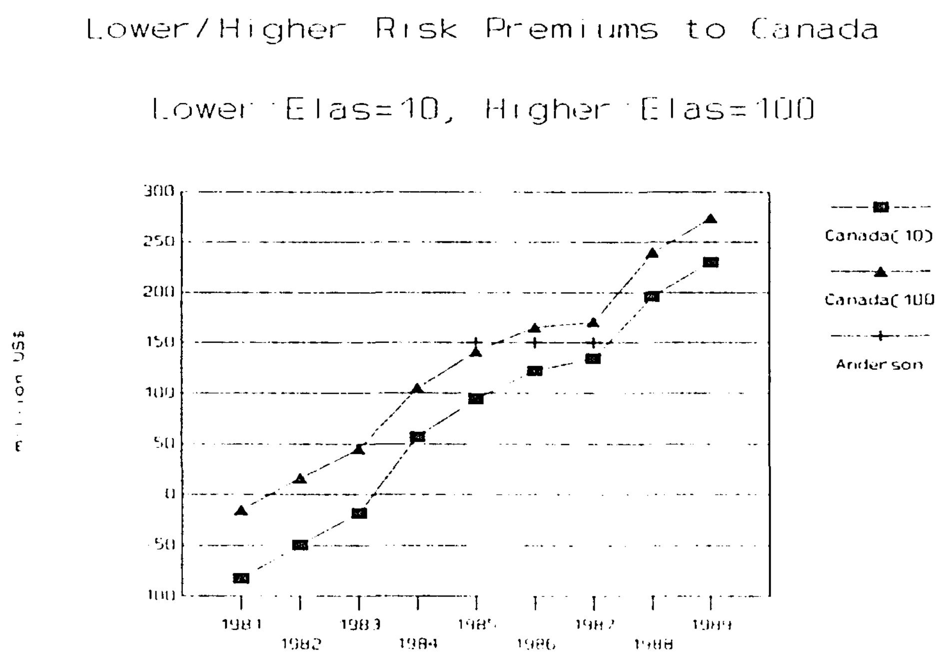

Figure 5.10 Low/Upper Case of Risk Premiums Paid to Canada

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Table 5.3 Total payment for risk premiums (millions 1982 U$)

Total Payment for Risk Premiums (million US$)
(1982 dollars)

	Elasticity = 10			Elasticity = 100		
	US	Canada	Total*	US	Canada	Total
1981	193.6	-82.3	111.3	211.4	-15.4	196.0
1982	147.1	-49.6	97.4	223.2	15.7	238.9
1983	65.6	-18.2	47.4	121.6	44.8	166.4
1984	53.1	56.4	109.6	113.3	104.6	217.9
1985	35.6	94.2	129.8	84.2	141.2	225.5
1986	28.3	122.4	150.7	72.6	165.5	238.1
1987	18.6	134.3	152.9	50.8	170.9	221.7
1988	24.1	195.9	220.1	69.6	239.5	309.1
1989	20.2	230.5	250.7	61.0	273.7	334.7

Note: * here, the total risk premiums are sum of the risk premiums paid to US and Canada.

Table 5.4 Ratio of total risk premiums to total purchasing

Ratio of Top Three Risk Premiums to Top Three Purchasers
(In 1982 dollar)

	Ave.CIF	Total Purchase (million)	Ratio of Risk Premium σ=10	σ=100
1981	$76.26	$4,594.9	2.42%	4.27%
1982	$75.03	$4,416.0	2.21%	5.41%
1983	$66.35	$3,527.1	1.34%	4.72%
1984	$60.09	$3,639.3	3.01%	5.99%
1985	$54.94	$3,294.6	3.94%	6.84%
1986	$51.86	$2,964.6	5.08%	8.03%
1987	$47.46	$2,616.0	5.84%	8.47%
1988	$46.62	$2,928.8	7.51%	10.55%
1989	$47.11	$2,909.4	8.62%	11.50%

Note: All data are for top three countries only.

(1) The total cost for risk management appears to be increasing. The term risk

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premium is used here to represent generally all costs that the Japanese are willing to pay for preventing unpredicted events and what they have to pay for their early risk management decisions, such as investments in mines as a part of an earlier risk management strategy. The fundamental differences between these two parts are that the first cost is an insurance premium and the second is a sunk cost. The total risk premium paid to Canadian mines is a combination of these two costs. The increasing trend of the Canadian risk premiums is mainly caused by the cost of subsidizing the partially-owned-mines.

(2) Since the total cost of risk premium has increased, it seems that the cost of purchasing coals has increased, which contradicts the current market condition of supply surplus. This conclusion is logically wrong. The risk premiums are relative figures with respect to the risk free base. In this study the prices of Australian coals are chosen to be the risk free base, thus the total risk premiums show how much the prices of the US and Canadian coals are relatively to the price of Australian coals. The Australian CIF price has declined steadily during the last decade; so has the average CIF prices of all producers (see average CIF prices in Appendix A). These over-all average prices reflect the supply surplus in the market.

Anderson (1987) provided a dollar figure for subsidizing the Canadian mines. He said that Japanese Steel Mills had to pay premium prices for some of the projects they supported. In northeastern British Columbia, the subsidy amounted to approximately $150 million per year. Although it is not clear whether he was talking about the combination of two types of costs or sunk cost only nor how he obtained

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this number, his figure is consistent with the estimates in this study. The \$150 million is equal to \$134.9 million in 1982 dollars which falls between the lower case, *TCRP*(σ=*10*), and the higher case, *TCRP*(σ=*100*), for the period 1985 to 1987 (see Table 5.3 and Figure 5.11). The results of this study are consistent with Anderson's result.

If the few Canadian mines that are heavily subsided by the Japanese steel mills were taken out of the analysis, the total risk premium to Canada would become an estimate of the insurance premium only; this would substantially improves the model, for it would exclude most of the sunk cost. Accordingly, the numerical value would be much a better estimates of the "pure risk premium". If ocean transportation data were available, such an estimate could be made using the FOBT contract prices by brand.

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6. CONCLUSIONS

This dissertation analyzes the efficiency of the Japanese coking coal market and the strategy of the Japanese coal buyers to manage risk. Throughout the study, efforts have been made to provide detailed industry and market data and to use economic theory to analyze these data in a practical way in order to reveal the mechanics which drive the market. Though there are many interesting topics on the supply side, this study focuses on the buyers side as the market has experienced almost a decade of over supply capacity. The Japanese buyers' purchasing scheme and their risk management strategies are the main objectives of this dissertation.

The objective of the Japanese buyers' strategy is a combination of securing qualified coal supply and cutting long run cost. These objectives are supported by both short run business practices and long run economic planning. Through long term investment, the Japanese steadily build up their partially owned vertically-integrated supply system which fundamentally changes market conditions in favor of the buyers.

The market is a buyers' market now. But, the impacts on different producers differ. The smaller producers without long term contracts are most at risk. A result of long term excess supply capacity is closure of small inefficient mines. An interesting topic for further study is whether this will lead to producer mergers and the formation of some supply power due to the increasing concentration of producers.

6.1 The Important Role of Coal Quality As An Economic Factor

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One characteristic which distinguishes the coal market from most of the other final or semi-final product mineral market is the complexity of coal quality combined with the specific requirements for coal quality by individual consumers. In most research papers coal quality has either been ignored or overly simplified. This is particularly true of research on energy markets in which only the single quality specification -- heating value -- is considered in economic analysis. Very few studies refer to the metallurgical coal market, part of the reason for this is that the quality of metallurgical coal is very complex and hard to transfer into economic measurement.

In this study, the importance of coal quality is highlighted, and the economic impact of coal quality was investigated prior to the examination of risk strategy and management. Technological improvements in the Japanese steel mills have provided consumers a wider range of selection among coal qualities. More low grade coals that were formerly used only as steam coals now are used as coking coal through coal blending. Therefore, the dependence on a few high quality coking coals has declined. In this study, coal quality is not only treated as a technical factor, but also as an economic factor. Quality has been proven to be a significant component of price formation.

A price equation with a quality component is estimated by statistical analysis using observed market data across three large supply countries. The data include FOBT contract prices and five quality specifications: total moisture, ash content, volatile matter, total sulfur and crucible swelling index. The estimated relation fits the observed FOBT prices across countries very well. During the estimation, country

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dummy variables are introduced into the equation to test whether price differentiation is significant at the FOBT level. All of the country dummy variables in the price equation were proven to be nonsignificant at the 95% level for FOBT prices. For comparison, a second regression was performed only on the Australian data. The estimated coefficients are consistent with those of the pooled data. Both equations can be used to estimate FOBT prices for all supply regions. These results indicate that if the quality component is considered there are no significant price differences among the supply regions at the FOBT level. Basically, the Japanese pay all producers prices which are consistent with respect to the quality they received. From this important result, we confirm that for the Japanese consumers the costs of coals from different supply regions are substantially different at the CIF level, since ocean transportation costs vary considerably by region. The argument that the higher prices paid for US coals is due to their higher quality has thus, been proven incorrect.

The average quality premiums of the United States, Canada and Australia are subsequently calculated by using the estimated equation. These quality premiums are used in later chapters to adjust observed prices in order to remove the quality factor in economic comparison.

Further work should be done in quality estimation to externally estimate the quality premium. The disadvantage of using observed market prices is that the data may be distorted by market factors. The objective way to eliminate this distortion is to estimate the costs of removing impurities by an engineering study. But this type of work requires proprietary information from steel mills and careful study of

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engineering costs.

6.2 Buyer's Power, Vertical Integration, and Cost Transfers

Generally speaking, coking coal consumers are much larger than producers. In the Japanese metallurgical market the consumers are highly concentrated compared with the producers. It can be demonstrated that the Japanese consumers have only local power in the Japanese market. Because of the long distance of ocean transportation and the large volume of coal cargos, individual consumption markets are quite isolated, thus arbitrage between the consumption markets can be excluded. The Japanese buyers do not have much control in the world coal market. Actually, in most years of the last decade, the US and Australian producers received higher prices from the Japanese than they did from European buyers. If the Japanese buyers have more control than do European buyers, they would not lose economic rents in this way. This is inconsistent with the hypothesis that the Japanese have power in the world coal market.

To determine how the Japanese build their market power, two alternatives are discussed in chapter 4. The first emphases institutional factors. The second focuses on changes in fundamental market structure. Each of these acknowledge the influence of the other.

According to the first opinion, Japanese buyers are assumed to have market power because they exercise institutional factors. With governmental blessing, Japanese consumers formed a joint-purchase group called the Japanese Steel Mills

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(JSM), which acts as a single buyer in the international coal market. JSM assigns a leading buyer to cooperate negotiations. The Japanese government also support the steel industry by providing information and financial and tax support. Some market observers condemn the Japanese for overestimating their steel production and coal demand in order to over-stimulate the expansion of coal supply. The erroneous forecasts provided by JSM around 1980 are the main reason for the long term supply surplus in last decade.

In this study the second opinion is considered to be more essential. Though institutional factors are important, they mainly function as a tool to help build a vertically integrated market. As long as the vertically integrated firms are set up, the Japanese can secure their supply and partially control or influence coal prices. This study investigated the current market structure situation and showed that the Japanese companies have penetrated mining and completely control their ocean transportation and trading companies, but they have almost no influence on inland transportation.

The initial Japanese motivations for forming a vertically integrated industry are: (1) to secure a qualified coal supply and (2) to reduce overall transaction costs, especially the cost paid for unexpected supply interruptions. Based on the sequence of events in the market, this vertical integration strategy has proven successful in reaching the first goal of insuring and controlling coal supply. Because world-wide coal capacity is over expanded and because the Japanese have some direct control over this capacity, their fear of supply shortage is greatly reduced. The effects of this strategy on reaching the second goal of reducing costs are mixed. On the one hand,

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market price has declined. On the other hand, some of the investments in mining are proving very costly. These costs are partially born by Japanese investors. The incorrect prediction of coal demand not only misled the suppliers who over developed their export capacities but also misled the consumers who over invested in these capacities. Therefore, the wrong prediction was caused by a common mistake in economic forecasting rather than by an unfair game. Although poor investments exist, over all, it is believed that vertical integration is a successful strategy for the Japanese as their costs are sharply reduced overall.

A case study of coal contracts discloses some interesting business practices that show how the Japanese exercise their market power. Although all producers are hurt during a period of over supply, losses are different for each producer. The small producers, the existing mines usually without long term contracts, are hurt much more than are these larger producers, which usually have long term contracts as well as, newly developed mines with Japanese participation.

6.3 Risk Assessment

Estimating risk premiums is always very difficult, subjective and partial. It is a question of how to transfer personal risk preference into a monetary measurement, which is obviously a difficult task. Like all previous work, this study is experimental, subjective and partial.

In chapter five, the time series of the relative risk premiums for each supply region are estimated by using partial elasticities of substitution. The general formula

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is derived first, then, the estimated formulas for the US and Canada are derived. If the other factors are unchanged, in particularly the elasticity of substitution is constant over the study period, then the estimated time series of the risk premiums mirrors the changes in risk expectation during the last decade. Since the changes in the risk expectation reflect the changes in basic market conditions, the time series of the risk premiums are the results of the changes in market conditions.

The risk premiums per ton paid to US and Canadian mines are estimated, respectively. Australia is selected as the reference base, ie., no risk premium is paid to Australian producers. Then the relative cost of risk premiums paid to the United States and Canada are calculated. For elasticity equal to 10, the results of the estimations are:

(1) Total risk premiums paid to US and Canada are between about \$100 to \$250 million dollars per year in the last decade, except for a substantially lower figure in 1983. On average, the cost of risk premiums as a percentage of the total cost of purchasing are 1.3 to 8.6 percent in the lower elasticity case ($\sigma=10$) and 2.4 to 11.5 percent in the higher elasticity case ($\sigma=100$),=; these are not very high percentage.

(2) The estimate provided by Anderson in 1987 of the cost to Japan of subsidizing Canadian coal mines is about \$150 million (\$134 million in 1982 dollars). Anderson's estimate falls between estimates made in this study for elasticity equal to 10 ($TCRP_t(\sigma=10)$) and elasticity equal to 100 ($TCRP_t(\sigma=100)$), $t=$ 1985,1986,1987. How Anderson got his number is unknown, but these two estimates are consistent.

(3) Total risk premiums paid to the US producers have decreased sharply from \$194

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million in 1981 to $20 million in 1989. In contrast, the risk premiums paid to Canada dramatically increased from negative, which means Canadian producers were underpaid, to $230 million over the ten years period, which is far more than previous payment to US producers. But a major part of the risk premiums paid to Canadian producers is actually a subsidy to a few partially Japanese owned mines. There is a long lag between these payments and changes in risk expectations. Thus the payments mainly reflect a subsidy rather than current risk expectation. According to this estimation, the total payments to Canada are above $100 million per year (1982 constant dollars) since 1986. Therefore, the $46 million compensation that would be paid under British Columbia court order to JSM by the dominant producer, Quintette, is just a portion of this high subsidy. That is why the court settlement is called a compromise between JSM as partial owner and the operating company.

Further work can be done to separate the subsidy and the real risk premium if these few partially-owned-mines can be separated from the aggregated data.

6.4 The Future for Producers

The conclusions related to producers may be summarized as:

(1) The importance of high quality coals has declined due to technology changes in the steel mills. More low grade coals are used as coking coal through coal blending. The quality premiums are getting smaller for higher quality coal.

(2) A supply shortage is not like for quite a long period. Therefore, the risk premium that the Japanese are willing to pay will be much less than in the past.

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(3) Business practices show that contract terms are getting shorter; the Japanese can get coals in a short time; small, old producers without long term contracts are most vulnerable in the current market.

Therefore, the future for each of the supply regions is:

<u>US:</u>

US producers gradually lose their advantages in this market. It is unlikely that the price of US coal will rise with respect to the prices of others because the risk and quality premiums will not increase in the foreseeable future. Only two US coal producers currently have long term contacts; the rest of the producers will face the possibility of losing their market shares. But, it is also unlikely that the US share in this market will fall sharply. The diversification of suppliers will remain one of the most important Japanese strategies in the long run.

<u>Canada:</u>

The average price of Canadian coals is now very expensive. This is mainly due to the substantially higher prices paid to a few partially-owned-mines. These mines would be closed without the subsidies of the Japanese Steel Mills. Therefore, the future of the western Canadian coals is highly dependent on what the JSM will do about these costly mines and how they can cut the costs. The prices paid to these mines will be reduced. If JSM decides not to support these mines, they will quickly withdraw from this market, since their costs are substantially above market price.

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Actually, at the beginning of 1990's, the British Columbia coal industry is in a very bad condition due to high costs plus a strong Canadian dollar. Quintette has been under court protection from bankruptcy proceedings since June, 1990, after the contract price was reduced to C$82.40. A restructuring of the company's debts changed the share structure: Teck's ownership dropped from 50% to 33%, JSM from 38% to 25%, Charbonnages de France from 12% to 8%, with the banks gaining share from zero to 33% (Kilburn, 1992). It is very unlikely that Quintette will continue operating after the current long term contract expires in 1998. There are a couple of mines, such as Bullmoose, which also face high cost problems. Even if Quintette alone quits the market, total metallurgical exports from Canada will drop 4 to 5 million tons per year; the suppliers from other regions will benefit.

Australia

As the cheapest suppliers, Australian producers will continue to export a large amount of coal to the Japanese market. There are no real threats to their position.

Others

Basically, the remaining supply regions are price takers. Collectively they will steadily take bigger shares if the top three producers cannot lower prices or fail to deliver coal. But these producers have no power to control the market and they are unlikely to further reduce prices.

A large supply increase from the former USSR and China is unlikely.

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Although China made major efforts to improve its mining efficiency and transportation system, it is facing a severe energy shortage in keeping pace with its economic growth; the extra coal produced is easily absorbed by domestic demand. The former USSR is facing domestic problems in industry and transportation; the current political situation causes some uncertainty about the export plan. As the their economy gets better and industry production gets in order, it is likely that they will be facing severe energy shortages as China is facing now.

South African producers are very low cost producers, thus there are no barriers to them taking a greater market share in terms of cost. But, the quality of South African coal is very low, which determines that they are very competitive in the steam coal market, but handicapped in the coking coal market. South Africa will benefit most from further technologic improvement in coke making and further structural changes in the steel industry.

Most governments in the supply regions are cutting taxes (Canada, Kilburn, 1992) or forming coordinate agencies and schemes (Australia and South Africa) to help their coal industry survive in adverse times. Besides this and more important, there are structural changes taking place on the supply side:

One result of long term over supply capacity is closure of small inefficient mines and some large costly mines. The closing trend leads to the merger of producers. Whether this merger actively can lead to higher supply concentration and, thereafter, create some supplier power to counter buyers' power is a very interesting topic for further study.

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6.5 Further Work

The major improvement to this study is expected to be made by employing a formal programming model. If detailed data on ocean transportation, production and port capacity, and costs can be assembled , a formal programming model could be used to estimate market equilibrium and risk premium and to predict optimal share distributions among suppliers.

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APPENDIX A

REFERENCE TABLES

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TABLE A.1 Exchange Rates

(Foreign Currency = US$1.00)

Year	Japan	Australia	Canada
1981	220.59	0.87	1.20
1982	249.08	0.99	1.23
1983	237.49	1.11	1.23
1984	237.55	1.14	1.30
1985	238.54	1.43	1.37
1986	168.52	1.49	1.39
1987	144.64	1.43	1.33
1988	128.15	1.28	1.23
1989	137.98	1.27	1.18

(Foreign currency = 100 Japanese Yen)

	Australia	Canada	US $
1981	0.39	0.54	0.45
1982	0.40	0.49	0.40
1983	0.47	0.52	0.42
1984	0.48	0.55	0.42
1985	0.60	0.57	0.42
1986	0.88	0.82	0.59
1987	0.99	0.92	0.69
1988	1.00	0.96	0.78
1989	0.92	0.86	0.72

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TABLE A.2

Contract Tonnage, Price and Quality JFY 1988

Index	Brand	TON	P1988	TM	ASH	VM	TS	CSN
101	Mettiki	521.23	50.04	6.00	6.50	20.50	1.00	8.50
102	Massey LV	50.80	47.14	5.50	7.00	18.00	1.00	8.50
103	Drummond LV	167.65	46.45	8.00	7.50	19.50	0.70	8.50
104	Pittston MV	3714.68	50.88	5.50	6.50	30.50	0.83	8.00
105	Lancashire	203.21	58.07	5.00	6.50	21.00	0.85	9.00
106	Blue Creek	2660.02	51.07	6.00	8.00	23.00	0.80	8.50
107	Sprague HV	751.88	46.45	5.50	6.50	35.00	1.00	8.00
108	ICC HV	264.17	47.24	6.50	8.50	33.00	1.00	7.00
109	Drummond HV	406.42	45.03	7.00	7.50	31.50	1.00	8.00
110	Pittsburgh 8(Bailay)	299.73	45.77	7.00	7.00	37.00	1.40	8.00
111	Massey HV	350.54	46.75	5.50	6.50	32.00	0.90	8.50
112	Royal Scot	335.30	46.75	6.50	6.50	35.00	1.00	7.50
113	Stinnes HV	101.60	42.32	4.50	6.00	35.00	1.00	6.00
114	Old Ben	101.60	47.24	7.00	6.50	34.50	0.85	8.00
201	Balmer(Westar LV)	2213.00	46.90	8.00	9.00	21.00	0.40	7.00
202	Westar LV	720.00	46.90	8.00	9.00	21.00	0.40	7.00
203	Greenhills	300.00	46.90	8.00	7.00	27.00	0.50	7.50
204	Fording River Stand	1100.00	46.90	8.00	9.50	23.00	0.45	6.00
205	Fording River HV	500.00	46.90	8.00	6.50	31.50	0.55	7.00
206	Fording River MV	215.00	46.90	8.00	8.50	27.00	0.50	7.00
207	Luscar Standard	1375.00	46.90	7.00	9.25	22.50	0.37	6.00
208	Luscar HV	550.00	46.90	8.00	10.00	26.50	0.37	6.50

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209 Greeg River	2106.00	60.62	8.00	9.50	24.00	0.40	6.00
210 Quintette	5000.00	80.01	8.00	9.50	23.00	0.50	6.00
211 Bullmoose	1700.00	77.54	8.00	9.25	23.50	0.50	6.00
212 Line Creek	900.00	51.92	7.50	9.50	23.50	0.50	6.00
213 Smoky River	550.00	46.90	5.00	7.00	18.75	0.50	8.00
214 Devco	400.00	43.10	8.00	4.00	34.00	1.50	7.50
215 Fording MV Weak	150.00	36.90	9.00	10.50	26.50	0.65	4.00
216 Coal Mountain	750.00	35.40	8.00	10.00	21.00	0.50	3.00
217 Smoky River Sem	150.00	35.40	8.00	10.50	18.00	0.45	4.00
301 Coal Cliff	800.00	46.90	7.00	9.50	21.00	0.40	6.00
302 South Bulli	520.00	46.40	7.00	9.50	21.40	0.40	6.00
303 Tahmoor	750.00	46.90	7.00	8.50	28.00	0.40	6.00
304 Wollondilly	400.00	41.90	7.00	8.50	27.50	0.45	5.00
305 Pelton-Ellalong	150.00	42.65	8.00	6.00	42.00	1.30	4.50
306 Hunter Valley	910.00	42.65	8.00	7.50	35.00	0.50	5.00
307 Warkworth	280.00	42.65	8.00	7.50	36.00	0.50	5.50
308 Lemington	540.00	40.65	8.00	8.50	37.50	0.50	5.00
309 Liddell	270.00	41.30	7.00	8.50	37.50	0.60	5.00
310 Daiyon	810.00	41.65	8.00	8.50	36.00	0.75	4.50
311 Rathluba	200.00	40.65	8.00	8.50	37.00	0.85	4.50
312 Big Ben	200.00	38.00	8.00	8.00	37.50	0.60	5.00
313 B.V. Blend	230.00	38.25	8.50	9.80	27.50	0.58	3.00
314 Warkworth Semi-	500.00	38.00	8.00	9.80	31.50	0.48	2.00
315 Hunter Valley S	950.00	36.90	9.00	9.50	32.00	0.50	3.00
316 C&A Semi-soft	250.00	36.90	9.00	9.80	32.00	0.48	3.00
317 C&A Blend	200.00	36.90	9.00	9.80	32.00	0.48	3.00
318 Newdell	150.00	40.65	7.00	8.50	37.50	0.60	5.00
319 Howick Semi-Sof	450.00	36.90	8.00	9.50	35.50	0.70	2.50

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320 Clarence	150.00	35.90	8.00	10.00	32.50	0.65	1.25
321 Peko Semi-cokin	1230.00	36.65	8.00	9.50	37.00	0.90	1.50
322 Hoskisson	640.00	35.90	10.00	8.00	35.00	0.75	2.75
323 Melvilles	80.00	36.90	9.00	8.50	36.00	0.60	5.50
324 Bayswater	300.00	35.65	8.00	8.50	35.50	1.00	1.75
325 Lighgow	300.00	35.90	8.00	10.00	32.50	0.65	1.25
326 Wambo	425.00	35.40	8.00	9.50	36.00	0.50	4.50
327 Charbon	300.00	35.65	8.00	9.50	32.00	0.60	1.50
328 Woodlands	272.00	35.90	8.00	9.50	33.00	0.60	1.50
329 Metropolian	50.00	34.20	8.00	10.50	19.50	0.32	1.50
330 Donaldson	10.00	35.90	8.00	9.80	35.00	1.20	1.50
331 Drewboy	10.00	36.40	7.00	13.00	21.40	0.40	1.00
332 Moura	700.00	44.40	8.00	7.50	31.00	0.55	7.00
333 South Blackwate	600.00	46.40	10.00	7.30	28.00	0.55	6.00
334 Blackwater	600.00	41.40	8.00	7.80	26.75	0.50	6.00
335 Goonyella	1800.00	46.90	8.00	8.00	26.00	0.65	7.00
336 Peak Downs	1350.00	46.65	8.00	9.30	21.00	0.65	7.00
337 Saraji	1050.00	46.40	8.00	9.30	19.50	0.70	8.00
338 Gregory	1200.00	46.65	8.00	8.00	31.50	0.70	8.00
339 German Creek	1000.00	46.40	10.00	8.50	21.00	0.66	8.50
340 Riverside	2475.00	46.40	8.00	9.80	23.50	0.65	7.50
341 Oaky Creek	600.00	46.90	10.00	8.00	29.50	0.80	8.25
342 Collinsville	800.00	44.40	10.00	9.00	26.00	0.95	6.00
343 Curragh	1000.00	44.90	10.00	7.00	23.00	0.60	7.00
344 Curragh Semi-S	250.00	35.10	10.00	8.00	20.00	0.60	2.50
345 Blackwater Weak	600.00	35.00	10.00	9.50	26.25	0.50	2.50
346 ULV(Nowich Park	580.00	34.15	8.00	11.00	17.00	0.65	8.00
347 UHV(Gregory Sem	800.00	38.40	8.00	9.50	31.00	0.68	5.00

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348 "K" Coal	800.00	38.20	8.00	7.50	30.00	0.60	2.50
349 Cook Semi-Soft	100.00	36.90	8.00	9.80	20.00	0.40	3.50

Source: Coal Manual 1989

Note:

(1) Index: the first digit number represents country, 1-US, 2-Canada, and 3-Australia.
Ton: in 1000 MT
Price in current US$.
Qualities are %.

(2) Three Canadian brands Greeg River, Quintette and Bullmoose use escalated price clauses in terms of Canadian dollar. Price of Line Creek is fixed in term of Canadian dollar.

(3) Includings are the sequence number by country, name of coal brand, contract tonnage (MT), 1988 contract FOBT prices, total moisture(%), ash content, volatile matter, total sulfur and Crucible Swelling Number(CSN). If a range of a quality index is given, the medium point is in use.

TABLE A.3

Penalty On Ash and Sulfur in Contract JFY 1988

Brand	Country	ASH	TS	PN-A	PN-S	Year	Other	
309	Australia	8.50	0.60	1.10	0.55	1988	1	
310	Australia	8.50	0.75	1.10	0.55	1988	1	
311	Australia	8.50	0.85	1.10	0.55	1988	1	
306	Australia	7.50	0.50	1.10	0.55	1988	1	
307	Australia	7.50	0.50	1.10	0.55	1988	10	
308	Australia	8.50	0.50	1.10	0.55	1988	1	
333	Australia	7.30	0.55	1.10	1.00	1988	1	
334	Australia	7.80	0.50	1.25	0.63	1988	1	
342	Australia	9.00	0.95	1.25	0.63	1988	1	
318	Australia	8.50	0.60	1.10	0.55	1988	1	
326	Australia	9.50	0.50	1.10	0.55	1988	1	
332	Australia	7.50	0.55	1.25	0.63	1988	1	
304	Australia	8.50	0.45	1.10	0.55	1988	1	
301	Australia	9.50	0.40	1.10	0.55	1988	1	
302	Australia	9.50	0.40	1.10	0.55	1988	1	
204	Canada	9.50	0.45	1.12	0.56	1987	3	
205	Canada	6.50	0.55	1.12	0.56	1987	3	
335	Australia	8.00	0.65	1.25	0.63	1987	2	
337	Australia	9.30	0.70	1.10	0.55	1987	2	
336	Australia	9.30	0.65	1.10	0.55	1987	2	
206	Canada	8.50	0.50	1.12	0.56	1987	3	
201	Canada	9.00	0.40	1.12	0.56	1985	10	
104	US	6.50	0.83	1.40	1.10	1985	15	
212	Canada	9.50	0.50	1.40	1.00	1983	15.5	Can$
210	Canada	9.50	0.50	1.40	1.00	1983	15	Can$
209	Canada	9.50	0.40	1.40	1.00	1983	15	Can$
211	Canada	9.25	0.50	1.40	1.00	1983	15	Can$
207	Canada	9.25	0.37	1.12	0.56	1981	10	
343	Australia	7.00	0.60	1.50	0.63	1980	15	
339	Australia	8.50	0.66	1.50	0.63	1980	10	
340	Australia	9.80	0.65	1.50	0.63	1980	14.5	

*Source: Coal Manual 1989.

Note:
Column 1: Coal brand index.

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Column 3,4: Guaranteed ash and sulfur content (%).
Column 5,6: Penalty on 1% ash, 0.1% sulfur excessed guaranteed level.
Column 7: Year contracted was signed.
Column 8: Other information includes the length of the contract and currency other than US dollar

TABLE A.4 Weighted Average Coking Coal Prices (FOB US$/MT)
(FOB US$/MT)

From US				From Australian		
To	Europe	Japan	Difference (Jap-Euro)	To Europe	Japan	Differenc (Jap-Euro
1980	56.71	63.32	6.61	44.93	48.82	3.89
1981	62.13	64.44	2.31	52.65	54.48	1.83
1982	66.67	66.58	-0.09	54.86	57.15	2.29
1983	59.58	62.89	3.31	46.54	55.81	9.27
1984	56.81	59.01	2.20	43.80	50.34	6.54
1985	55.24	56.52	1.28	41.80	45.99	4.19
1986	51.68	54.59	2.91	40.73	44.78	4.05
1987	48.35	51.31	2.96	37.94	40.15	2.21
1988	48.59	47.76	-0.83	37.83	39.98	2.15

Source: Compiled from:
Coal Information 1989/IEA, pp.II.68, pp.II.95.
Coal Information 1990/IEA, pp.246, pp.273.

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TABLE A.5 Average Coking Coal Prices (CIF US$/MT)

To Europe				To Japan		
	From US	AustraliDifference	(US-AU)	From US	AustraliDifferenc	(US-AU)
1980						
1981	77.31	73.83	3.48	83.09	65.56	17.53
1982	76.00	72.06	3.94	83.96	68.22	15.74
1983	67.12	60.70	6.42	78.80	63.35	15.45
1984	62.29	57.56	4.73	70.94	59.03	11.91
1985	62.64	58.83	3.81	68.66	54.35	14.31
1986	59.46	56.24	3.22	64.70	52.81	11.89
1987	56.85	52.90	3.95	64.05	48.27	15.78
1988	57.31	53.20	4.11	60.34	48.30	12.04
1989	58.52	54.29		63.34	52.58	
1990	62.95	67.13		66.52	54.96	

Source: Energy Prices and Taxes, 4th qrt. 1989/IEA. pp.19-20
1st qrt. 1991/IEA. pp.19-20. (89-90)

TABLE A.6 Implied Average Freight Rate (US$/MT)
(CIF-FOB)

From US			From Australia	
To	Europe	Japan	To Europe	Japan
1981	15.18	18.65	21.18	11.08
1982	9.33	17.38	17.20	11.07
1983	7.54	15.91	14.16	7.54
1984	5.48	11.93	13.76	8.69
1985	7.40	12.14	17.03	8.36
1986	7.78	10.11	15.51	8.03
1987	8.50	12.74	14.96	8.12
1988	8.72	12.58	15.37	8.32

Derived from above tables.

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TABLE A.7 Japan-Coking Coal Import Prices In US $/metric ton (AVE. CIF)

	total	Australia	Canada	USA	S. Africa	USSR	China
1981	71.08	65.56	64.61	83.09	63.72	64.35	64.97
1982	74.43	68.22	70.78	83.96	67.18	71.03	68.65
1983	67.75	63.35	70.15	78.80	57.87	59.96	56.09
1984	63.08	59.03	69.52	70.94	50.97	52.24	52.15
1985	59.76	54.35	67.51	68.66	49.62	54.69	51.17
1986	57.42	52.81	66.64	64.70	46.98	52.72	47.21
1987	53.97	48.27	65.43	64.05	43.35	48.63	43.31
1988	55.05	48.30	67.37	60.34	42.55	50.14	46.05
1989	58.39	52.58	69.73	63.34	47.68	54.65	52.08

Source:Energy Price & Taxes /IEA (qrl.)

TABLE A.8 Share In Japanese Coking Coal Imports Market (%)
(total is in 1000 wet MT)

	total	Australia	Canada	USA	S. Africa	USSR	China
1980	61816	41.71	17.12	31.15	4.66	3.04	1.58
1981	65757	44.30	14.53	32.80	4.50	1.72	1.77
1982	64870	39.17	11.70	36.86	5.10	1.71	2.11
1983	59834	47.09	17.15	24.60	4.99	2.47	3.16
1984	69339	43.02	22.24	22.09	6.59	2.40	2.89
1985	70144	43.27	23.98	18.24	6.38	4.17	2.95

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1986	69689	41.95	23.35	16.73	7.19	6.35	3.32
1987	67075	45.42	23.08	13.68	6.24	7.90	2.71
1988	74999	41.12	25.32	17.32	5.23	7.81	2.17
1989	73454	44.63	24.58	14.87	4.92	7.77	1.90

Source:Energy Price & Taxes /IEA (qrl.)
Note: 1981 data is derived from Coal Manual 1990.

TABLE A.9 Japanese Imported Coking Coal Tonnages

	Australia	Canada	USA	S.Africa	USSR	China
1981	29130	9554	21568	2959	1131	1164
1982	25410	9536	23911	3308	1109	1369
1983	28176	10262	14719	2986	1478	1891
1984	29830	15421	15317	4569	1664	2004
1985	30351	16820	12794	4475	2925	2069
1986	29235	16272	11659	5011	4425	2314
1987	30465	15481	9176	4185	5299	1818
1988	30839	18990	12990	3922	5857	1627
1989	32783	18055	10923	3614	5707	1396

TABLE A.10 GNP Deflators and Adjusted Prices of Australian Coal

	US GNP deflator	Quality Adjusted Australian Prices (1982=100)
1981	94	71.56
1982	100	69.93
1983	103.9	62.62
1984	107.7	56.40
1985	111.2	50.41
1986	114.1	47.78
1987	117.4	42.57
1988	121.3	41.23
1989	126.3	42.98

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