Chapter 6

COKING COAL MARKET CHARACTERISTICS

The rapid expansion of the Japanese steel industry (JSI), which took place in the fifties, sixties and early seventies was described in Chapter 3. The resulting impact on blast furnace size and mode of operations in Japan was then discussed in Chapter 5. The importance of these events as far as Queensland was concerned, was the initiation of a number of large scale export coking coal mines in the Bowen Basin, involving long term supply agreements between foreign controlled mine development joint ventures and the JSI.

This chapter focuses on these developments and the characteristics of the principal market which is served by Queensland's coking coal producers. Regression modelling is used to relate actual coking coal prices to the coal properties already described in Chapter 5, which are deemed to be important for coke and ironmaking. Evidence of the use of market power by the JSI is also investigated.

6.1) International Coking Coal Market Literature

The patterns of development of the world coking coal trade, and the major exporting nations were outlined in Chapter 1. In 1989, some 184 million tonnes of coking coal was traded internationally, with North Asian regional trade (Japan, South Korea, and Taiwan) accounting for 49% of this total. The JSI was the largest single importer with demands of 67 million tonnes. Australian and Queensland's fortunes in the coking coal trade have been closely linked to the evolution of North Asia's steel industry, which has been dominated by the JSI, so this discussion focuses on an examination of Japanese coking coal markets.

6.1.1) Canadian Studies of Pacific Coking Coal Markets

Several studies have already examined aspects of JSI resource procurement, the most notable being those of the Canadian researchers Anderson[6.1] and D'Cruz[6.2]. Surprisingly, considering the importance of coking coal exports to Australia's balance of trade, little published research by Australian authors specific to this topic can be found.

6.1) Anderson, D.L. "An Analysis of Japanese Coking Coal

Procurement Policies:The Canadian and Australian Experience" Centre for Resource Studies, Queen's University Ontario (1987).

6.2) D'Cruz, J.R. "Quasi Integration in Raw Material Markets: The Overseas Procurement of Coking Coal by the Japanese Steel Industry" Ph.D. Dissertation Harvard Univ.(1979).

The more general works of Smith and others[6.3] associated with economic research into trade and market behaviour, address broader issues of bilateral monopoly in resource trade, without specifically focussing on coal market characteristics and behaviour.

D'Cruz examined the impact of quasi integration resulting from the JSI's establishment of long term purchasing agreements for coking coal supplies on the price and offtake quantity experience of producers over the years 1970 to 1977. His research hypothesis was that quasi integration would attenuate the use of market power during cyclical phases of supply and demand imbalance. It was expected that Canadian and Australian coking coal producers linked with the JSI through long term contracts would experience higher export shipments and prices during periods of steel production decline, thereby benefiting from quasi integration. A finding of the D'Cruz research was that the beneficial effects of quasi integration on price, for producers having long term contracts, were minor relative to the detrimental effects of price discrimination practiced by the JSI in Pacific markets over the period of study.

Anderson examined the impact of the JSI coking coal

6.3) Smith, B."Bilateral Monopoly and Export Price Bargaining in the Resource Goods Trade" Economic Record, Vol 53 (1977) p.30-50.

Harris, S. and T. Ikuta eds. "Australia, Japan and the Energy Coal Trade" Australia-Japan Research Centre (1982) p.9-12.

procurement system on Canadian and Australian suppliers, including those not linked through long term contractual arrangements. His study discussed both the historic and possible future policy responses available for Australian and Canadian interests to combat an oligopsonistic procurement system. In his view also, there is evidence that the market power created as a result of JSI purchasing arrangements has resulted in price discrimination amongst the major suppliers, to the detriment of some Canadian and all Australian producers.

Anderson cites regression modelling studies of Japanese coking coal markets by Kittredge and Sivertson[6.4], which concluded that no statistically significant evidence of price discrimination existed in 1977, in contradiction to the findings of D'Cruz which were also based on regression modelling of price and limited quality specification data over eight years from 1970 to 1978.

Anderson's study offered no statistical analysis confirming that JSI purchasing policies were resulting in price discrimination. Furthermore, he identified shortcomings[6.5] in the analysis used by D'Cruz in support of that study's finding in the matter.

6.4) Kittredge, P. and L. Sivertson "Competition and Canadian Coal Prices in the Japanese Coking Coal Market" Canadian Institute of Minerals Bulletin September 1980 p.100-109.

6.5) Anderson, D.L. "An Analysis of Japanese Coking Coal Procurement Policies:The Canadian and Australian Experience" Centre for Resource Studies, Queen's University Ontario (1987). p.165. 6.1.2) Australian Perceptions of Pacific Coal Markets

A submission of Utah Development (now BHP/Utah) to the Senate Standing Committee on Trade and Commerce enquiry into Australia's export coal industry of July 1982 disputes assertions of price discrimination. The company states the following with respect to prices obtained in Japanese markets: "Utah's prices have at times been compared unfavorably with other producers' prices by uninformed commentators. Such comparisons either ignore the facts or fail to comprehend the significance of major quality differences between coals from different sources. Utah's coking coal prices have been in line with market values."

A recent paper by Porter and Gooday[6.6] examined the relationship of average coking coal prices paid by the JSI in the years from 1985 to 1988, with a number of coal quality parameters thought to be important in the economics of coke making and blast furnace operation. A finding of this analysis is that the new Canadian mines of north east British Columbia command substantially higher average prices in the Japanese market than would be expected on the basis of coal quality characteristics, compared with coking coals from other sources.

6.6) Porter, D. and P. Gooday "The Effects of Coal Quality on Japanese Coking Coal Contract Prices" presented at Conference of Economists (1990), University of New South Wales Sydney, 24th to 27th September.

In its study of Australia's minerals and mineral processing industries, the Industry Commission examined the issue of international market distortions due to coordinated purchasing arrangements, such as that ascribed by Anderson and D'Cruz to the JSI. The conclusion of the Commission[6.7] in this matter is as follows: "In the Commission's view, distorted purchasing arrangements do not exist or are insufficient to justify use of export controls".

From these citations, it is apparent that differences of opinion exist regarding the presence and/or significance of price discrimination in Japanese coking coal markets. Clearly the question requires resolution before policy and strategy implications can be addressed. A possible methodology for investigating the issue involves the development of a theoretical model relating price to coal properties in the Japanese coking coal market. Cross-sectional testing of the model can then be performed at such times when sufficient price and quality data are available to allow statistical analysis.

6.2) Modelling of Coking Coal Value in Japanese Markets

It is clear from the discussions of blast furnace ironmaking, coking coal composition and cokemaking of Chapter 5, that the

6.7) Industry Commission Report - "Mining and Minerals Processing in Australia" AGPS Canberra (September 1990) Volume 1:Report p.8-5.

value of individual coking coals may vary depending on a number of factors. For example, during the period of rapidly increasing levels of pig iron production, which took place in Japan in the fifties, sixties and early seventies, coke strength was a prime consideration when selecting coals for the coke blend. It might be expected that a price premium would be paid for "hard" coking coals at such times. Hard coals, having the maceral characteristics described in Chapter 5, are defined as those which individually exhibit high coke strength as measured by a value of 90 or greater in the JSI standard drum test. Later, as discussed in Chapter 3, pig iron production declined with declining demands for steel in Japan and most industrially developed countries. High levels of blast furnace productivity were no longer required and coke strength became of less concern. In such circumstances, lower quality coals could be used in the coke blend, premium priced hard coal imports were reduced, and quality related price differentials might be expected to decline due to increased supplier competition.

6.2.1) Japanese Pig Iron Production History

Pig iron production in Japan from 1960 to 1989 is charted in Figure 6.1. The highest recorded annual level of pig iron produced by the JSI was 90.9 million tonnes in Japanese fiscal year 1973. The year chosen for investigation by Kittredge and Silvertson was 1977, which was the second of three years of declining pig iron production which occurred from 1976 to 1978. That study provided all the cost and coal

FIGURE 6.1 JPIG1.GRA

quality data necessary for detailed cross-sectional regression modelling, so the 1977 year data will be reanalysed. Sufficient data are available to analyse 1983, a recessional year for pig iron manufacture in Japan and elsewhere within the OECD. More current data are available for 1988, which is the third year of a recent recovery in pig iron production in Japan. A model of the price quality relationship for 1988 when compared with a model for 1973, for which coal quality and price data are also available, might provide some indication of the changes in coking coal quality valuations which could be associated with the changes of cokemaking and blast furnace technologies over the intervening period, and perhaps indicate any changes of market power over that duration.

6.2.2) JSI Coking Coal Acquisition Cost History

Economic theory suggests that the general levels of coking coal price at any time in international markets are related to the economics of production of the major world suppliers and the short term supply/demand balance in world trade. The behaviour of coking coal prices in US markets was discussed in Chapter 2 and shown in Figure 2.3 series "D". A similar pattern of price behaviour occurred for hard coking coals imported by the JSI as is evidenced in Figure 6.2 on the following page.

FIGURE 6.2 JCIF.GRA

The data presented in Figure 6.2 merit comment and further analysis. The landed costs of hard coals from all three sources have exhibited a significant increase followed by equally significant decrease in real $US terms over the period from 1969 to 1989. Costs first increased sharply for imported US coals in 1974. Landed costs for Canadian and Australian coals also increased in real terms, but more gradually. US coal costs in 1989 are once again below the real levels of 1969. Average Canadian hard coal landed costs in 1989 remain significantly higher than Australian costs, and above the levels of 1973. Australian landed costs in 1989 were below the real levels of 1973.

The data presented in Figure 6.2 demonstrate a fluctuating pattern of hard coking coal acquisition costs over the twenty six year duration. It is also obvious that significant real differences have existed between the landed costs for US, Australian, and Canadian sourced hard coking coals. Such patterns suggest the existence of a multiple tiered market. The exercise of market power by the JSI in the bilateral bargaining process could explain persistently lower acquisition costs for Australian sourced coals, unless it can be shown that coal quality differences which influence the value of individual coals in the coke blend can justify the higher cif costs generally incurred by the JSI for American sourced hard coking coals, and for Canadian coking coals in recent years.

The other major category of coking coal referenced in Japanese trade literature is soft coking coal, which exhibits lower coke strength but provides fluidity in the coke blend. In the fifties and sixties, according to Matsuoka[6.8], Japanese domestic production was the major source of soft coking coal (and fluidity) for the JSI. As Japan has never possessed significant economic reserves of hard coking coals, practically all the hard coking coals used by the JSI have been imported.

During the seventies increased quantities of soft coking coal were imported from Australia (New South Wales), South Africa and the US, as domestic production steadily declined. Early in the eighties, a decision was made to phase out Japanese coking coal production completely, due to its excessive cif cost relative to imported coals. By 1988 domestic production had fallen to less than 800,000 tonnes from a level of ten million tonnes produced and consumed in the early seventies.

Differential cif cost behaviour can be noted between Japanese soft coking coals and Australian imported coking coals in Figure 6.3. Comparative data are available only from 1960. Australian coking coal shipments to Japan were less than 500,000 tonnes per year prior to that time, and only commenced in 1956, so the historic duration shown in the figure is representative. Throughout the entire period Japanese domestic coal maintained a higher real cif cost than

6.8) Matsuoka, H. "Requirements for Coals in Japanese Coking Blends" Symposium Paper 20 (1975) Australian Institute of Mining and Metallurgy Illawarra Branch.

Figure 6.3 SFTCC1.GRA

either soft or hard coals from Australia. The magnitude of the differential widened considerably in 1977, but is significant throughout the twenty nine years charted. This fact, together with its high subsidy cost (see Table 4.3), was no doubt a factor in the MITI decision to phase out domestic coking coal production.

In the early eighties there also appeared a new category of imported coking coal termed "briquetting or semi-soft" coal. Such coals have lower swelling characteristics (as measured by the free swelling index), and frequently have higher ash contents than premium coking coals. The coals are generally produced as a lower quality byproduct from coal washing processes, and command considerably lower prices than premium hard or soft coking varieties. The Queensland mines producing such coals are frequently joint venture operations having minority Japanese trading company equity interests. There is the potential for these trading companies to cause knowledge asymmetry in the bilateral bargaining process, for byproducts such as semi-soft coking coal, by providing marginal production cost information to the JSI oligopsony involved in purchasing this product.

During periods of low pig iron demand, when high blast furnace productivity and coke strength is not required, the JSI has used as much as 30% of such coals in the coke blend to replace more costly premium hard or soft coking coals. Semi-soft coals are also frequently used for pulverized coal injection, further reducing the demands for furnace coke. Unless coal quality differences provide a satisfactory explanation, the trends of

Figures 6.2 and 6.3 suggest a pattern of differential costs which may be the result of the use of market power by Japan, as the largest buyer of coking coal in the Pacific region, in a situation of bilateral monopoly. To pursue this question from the Queensland perspective, it is necessary to focus on the hard coking coal statistics provided in annual Japanese coal manuals.

All low volatile coals and most mid volatile coals imported from the US are considered hard coking coals. All Australian low volatile coals from the Bowen Basin and the Illawarra (South Coast) producing region of New South Wales are also considered hard coking coals. Low volatile Canadian coking coals from Alberta and British Columbia also fit into this category. The analysis will consider these sources of coal.

It is clear from the discussion so far that coking coal valuation in the Japanese steel market is a complex issue. Blending requirements are dynamic both from the aspects of technological evolution and business cycle demands for pig iron. These have become of greater significance since overall levels of JSI crude steel production reached a plateau at about the 100 million tonne annual level since the early seventies.

A hypothesis that price discrimination according to coal source has been exercised by the JSI can be tested by developing cross-sectional regression models which relate coking coal cif cost and quality characteristics for the Japanese market by country source. These models can be tested for structural consistency using the Chow test6.9. If significant differences do occur according to country source, the models can be respecified by including dummy variables related to country source in the regression analysis[6.10]. Such cross-sectional regression models will be developed for the major brands of US, Australian and Canadian hard coals imported by the JSI for Japanese fiscal years 1973, 1977, 1983, and 1988, to investigate this issue. However, before proceeding it is necessary to develop a theoretical model to identify the quality characteristics most likely to influence prices from a technical viewpoint, and review published literature on the topic.

6.3) Price/Quality Relationships for Hard Coking Coal

In the descriptions of byproduct cokemaking and blast furnace operation of Chapter 5, it was suggested that fixed carbon (or mean maximum reflectance of vitrinite as a measure of coal rank) would be an important factor in determining a hard coal's economic worth. High Gieseler fluidity and free swelling index (FSI) characteristics are beneficial for coke manufacture, and might be significant in a regression

6.9) Chow, G.C."Tests of Equality between Sets of Coefficients in Two Linear Regressions" Econometrica (1960) 28(3) p.591-605.

6.10) Gujarati, D. "Use of Dummy Variables in Testing for

Equality between sets of Coefficients in Two Linear Regressions" The American Statistician (Feb.1970) p.50.

equation. However Gieseler fluidity and FSI are both physical testing techniques to determine the caking characteristics of a particular coal. Inclusion of both variables in the regression equation is unnecessary, particularly for hard coking coals whose principal contribution to the coke blend is carbon. Increased ash and sulphur content would be expected to result in lower acquisition costs, as these impurities contaminate the coke and add costs in the blast furnace operation. Such parameters should have negative regression coefficients.

Moisture content adds to the costs of transportation and must be considered when modelling fob price/quality relationships. However, as this modelling exercise examines landed costs (cif) rather than fob prices, and as moisture is a minor impurity removed in preheating the coke blend before the coking process, it is not a quality parameter which needs be considered in this modelling study. For the same reasons ocean transportation costs should not be included. Variables associated with mine productivity should not be considered if Japanese markets are assumed to be competitive, as is the conventional wisdom, which will be further investigated in this study.

For the above technical reasons, the expected parameters, and influence of changes in such coal quality parameters on cif value to the ironmaker relative to other hard coking coals, can be summarized in Table 6.1 as follows:

TABLE 6.1

HARD COKING COAL CHARACTERISTIC'S INFLUENCE ON CIF COST

Property	Value	Regression Sign
Higher Fixed Carbon Content	Increase	+ Higher
Fluidity (or FSI)	Increase	+ Higher Ash
Decrease	- Higher Sulphur	Decrease
-		

It seems unlikely for the same technical reasons that coking coal quality related valuations at the point of end use would differ significantly depending on the source of coal. That would imply that Australian ash or sulphur impurities were somehow different to US or Canadian ash or sulphur in their economic impact on coking and blast furnace operations.

6.3.1) <u>Price/Quality</u> <u>Modelling</u> <u>Literature</u>

Prior to the recent modelling work of Porter and Gooday, four regression modelling studies of the Japanese coking coal market had been performed attempting to relate fob prices to coal quality characteristics.

Callcott, Kittredge and Sivertson, Pearson, and Miyazu, Takekawa and Fukuyama, developed fob pricing models using cross-sectional regression analysis techniques involving detailed coal quality characteristics for a number of individual coal brands, as is indicated in Table 6.2

TABLE 6.2

REGRESSION MODELLING OF COKING COAL PRICES IN JAPAN

Author	Callcott[6.11]	Kittredge Pearson[6.12] Sivertson	Miyazu[6.13]	et al
Year of Data	1966	1977	1978	1979
Coal Sources	Australia USA	USA Australia	USA Australia Canada	All coals except domestic
Number of Coals	57	27	33	51
Statistically Significant Parameters (at at least 10% level of significance)	FC	FC (or $\bar{R}_0$)	$\bar{R}_0$ max	$\bar{R}_0$ max
	ash%	FSI	FSI	Reactives%
	volatile matter%	FLDTY	ash%	Organic
	sulphur%	ash%	Inerts%	
	moisture%	Log(FLDTY)		
		ash%		
		transport		sulphur%
		labour productivity		contract term

where: FC is fixed carbon.

$\bar{R}_0$ max is the mean maximum reflectance of vitrinite.

FLDTY is Gieseler fluidity.

FSI is free swelling index.

All models developed in the studies listed, related fob prices and coal quality for both hard and soft imported coking coal brands. Japanese domestic soft coking coals were

6.11) Callcott, T.G. "Conjoint Papers on Coal, Coke, and Size Reduction" Dissertation for doctorate in Applied Science, University of Melbourne (1970) papers 52 & 53.

6.12) Pearson, D.E."The Quality of Western Canadian Coking Coal" Canadian Institute of Minerals Bulletin (January 1980) p.70-84.

6.13) Miyazu T., T. Takekawa and Y. Funabiki, "The Selection of Coal and Additives for the Reduction of Coke Cost" Proceedings of McMaster Symposium #8 "Blast Furnace Coke Quality, Cause and Effect" May 1980. McMaster University, Hamilton Ontario Canada p.6-1 to 6-12.

not considered in the regression relationships. This omission is a serious shortcoming if modelling seeks to examine evidence of price discrimination practices in the coking coal purchasing policies of the JSI, which is the principal objective of this study.

It was pointed out in Chapter 4 that support of the domestic coal industry was a specific element of Japanese industrial policy during the reconstruction era from 1945 to 1960, and average cif prices for Japanese soft coking coals have exceeded the average price of all imported coals in all but two years since 1960. These facts alone lend support to a view that price discrimination has favoured domestic suppliers over foreign sourced coals throughout the period. Indeed, the stated reason for the decision to phase out Japanese coking coal production was its high acquisition cost relative to imported coals.

All Queensland premium coking coals are <u>hard</u>, and the focus of this study is the examination of the Japanese market for these coals. Problems associated with the inclusion of imported soft coals without considering Japanese sourced soft coals, which occurs in all the studies cited, can be avoided by eliminating soft coals from the US and Australian brands of coal considered when modelling, and using only hard coking cif cost and quality data. The approach differs from that of all other authors in developing their respective regression models, and deliberately excludes consideration of price discrimination for soft coking coals in Japanese markets. That topic is worthy of study in its own right, but is not pursued here because Queensland does not export soft coking coals.

The work of the Kittredge and Sivertson is a major contribution in the research on the characteristics of the Japanese coking coal market, which concluded that assertions price discrimination are not justified. It is worthwhile to review the methodology used in that study, and reexamine the Japanese coking coal market for 1977 using the coal prices and quality data only for hard coking coals, for the reasons explained above.

6.3.2) <u>Remodelling of Japanese Fiscal Year 1977 Data</u>

A listing of the coal quality and cost data used by Kittredge and Sivertson in their investigation of competition in Pacific markets in 1977, appears in Table 4 of that paper. The methodology used by these authors in the regression analysis, was to pool coking coal price and quality data for thirty six brands of hard and soft coking coal imported by the JSI to generate the following relationship:

$$P = 56.398 + \underset{(4.40)^*}{.488FC} + \underset{(3.00)^*}{1.839FSI} + \underset{(2.57)^*}{.00034FLDY} - \underset{(-2.45)^*}{1.255A}$$
$$- \underset{(-2.16)^*}{13.729S} - \underset{(-2.56)^*}{1.38TM} - \underset{(-1.84)^*}{.278T} - \underset{(-1.47)}{1.214TRANS} - \underset{(-1.71)^*}{.372PR}$$

$$F_{(9,26)} = 27.0^*,\ \text{R-square} = .90,\ \bar{\text{R}}\text{-square} = .87$$

where: P is fob price paid by the JSI in $US per long ton

The figures in parenthesis are "t" values, * indicates significant at at least the 5% level of significance.

FC is fixed carbon content

FSI is free swelling index

FLDY is fluidity

A is % ash

S is % sulphur

TM is % total moisture (as shipped)

T is the contractural term in years

TRANS is the ocean shipping cost

PR is the mine labour productivity

A similar regression model using only the brand data for US and Australian coals was then used by the authors to predict fob prices for Canadian coals purchased by the JSI in 1977. These predicted prices were close to the actual prices paid for the three brands of Canadian coal making up the bulk of exports. The authors therefore concluded that a competitive market situation existed, and quality differences could account for price differentials between US, Australian, and Canadian coking coals sold into Japanese markets in 1977.

There are several difficulties with this analytical approach and the findings. The authors included both hard and soft coking coal brands from the US and Australia when developing the regression equations. Inclusion of soft coal data does not recognize the different roles paid by hard and soft coking coals in coke manufacture. It also ignores the fact that high priced Japanese domestic coking coals (see Figure 6.3) made up some 35% of the soft coking coal used by the JSI in 1977, compared with 37.5% of much lower priced soft coal from Australia, which was the largest foreign supplier in that year. The inclusion of Australian and US soft coking coals in the price model should then also have required the consideration of Japanese domestic soft coals when developing a comprehensive price regression model designed to cover the full spectrum of coal quality.

The difficulty of Japanese domestic coals exclusion (perhaps because of a lack of cif cost information by brand) can be overcome if a respecified cif model considers only the principal sources of hard coking coals which are in fact fully imported. For such a respecified model, landed cost and coal quality data for the twenty one hard coking coals brands imported from the US, Australia, and Canada in 1977 are available.

A modelling relationship with cif cost as dependent variable should not include all the independent variables considered in the Kittredge and Sivertson study which analysed fob prices. For cif cost modelling, coal moisture and ocean transport cost parameters are not required. The mine productivity term is of no relevance to the landed value of coal to the ironmaker in a competitive market environment. As free swelling index (FSI) and Geiseler plasticity are different physical measurements of the caking characteristic, inclusion of both parameters is not warranted, particularly in an analysis of the hard coking coal market. Miyazu et al. indicate that log Geiseler plasticity is the caking related parameter used in brand evaluations by the JSI, so this caking related parameter shall be used in this study. D'Cruz determined that quasi integration is a statistically significant factor in determining fob coal price, so a contractual term "T" should also be included as an independent variable in the regression equation. From a priori reasoning then, a model relating cif cost to quality should be of the form of cif cost as a function of fixed carbon, ash, sulphur, log fluidity, and contractual term. Also, from a priori reasoning, regression coefficients should have the signs indicated in Table 6.1 in the regression relationship.

The definite cif cost tiers appearing in Figure 6.2 suggest the possibility that differences might exist between the regression models for Australian and Canadian coals vis-a-vis the US coals imported by the JSI in 1977. This possibility can be investigated by performing Chow[6.14] tests to determine if pooling of the Australian and Canadian coal data can be justified. The test results, which are given in Appendix C, suggest that all nine Australian coal brands can be pooled with four of the five Canadian hard coals, but the Smoky River Canadian brand should be treated separately. Chow tests also suggest that the eight US coal brands should be treated separately from the pool of nine Australian and four Canadian brands. Finally, a Chow test also demonstrates that the Smoky River brand is not significantly different to the US brands in these regression relationships.

6.14) Chow, G.C."Tests of Equality between Sets of Coefficients in Two Linear Regressions" Econometrica (1960) 28(3) p.591-605.

The regression model result obtained when Australian coals are pooled with four Canadian coals and is as follows:

$$C = 47.21 - \underset{(-.199)}{.0454\,FC} + \underset{(1.427)}{1.367\,A} - \underset{(-1.158)}{7.02\,S} + \underset{(.411)}{.143\,FY} + \underset{(1.390)}{.300\,T}$$

$$F_{(5,12)} = 2.133,\ \text{R-square} = .6038,\ \bar{R}\text{-square} = .3207$$

where: C is the cif value of each coal in $US per long ton

FC is % fixed carbon on a dry, ash free, basis

A is % ash

S is % sulphur

FY is log Geiseler plasticity

T is contractual term in years

Figures in parenthesis are "t" values, and none are significant at at least the 5% level of significance.

The model is notable for the lack of statistical significance of the overall regression equation (as evidenced by the "F" statistic), considering that the independent variables used for modelling were selected on a priori technical grounds.

The regression model obtained for the US coals and the Smoky River brand from Canada, which Chow tests also suggest can be pooled is as follows:

$$C = -7.691 + \underset{(1.710)}{.827\,FC} + \underset{(.497)}{.394\,A} + \underset{(1.339)}{16.217\,S} + \underset{(.909)}{.768\,FY} + \underset{(1.492)}{.514\,T}$$

$$F_{(5,8)} = 1.415,\ \text{R-square} = .7022,\ \bar{R}\text{-square} = .2058$$

A similar comment can be made regarding the absence of statistical significance, as was the case for the pooled Australian and Canadian brands, considering that independent variables used in regression modelling were selected on a priori technical grounds.

Chow tests can be used to determine whether differences between linear regression equations are due to differing independent variable (or slope) coefficients, or different intercept values. Such tests allow the determination of the source of difference between regression equations. The results, given in Appendix C, show that the cause of the model difference between the pooled Australian and four lower tier Canadian brands, and the US brands with Smoky River, is the result of different intercept values in each regression equation. A regression equation for cif cost "C", in which a dummy variable is introduced to permit intercept shift to take place, is as follows:

$$C=62.084 + .214\ FC + .028\ A - 3.95\ S - .108\ FY + .078\ T - 19.703\ C1$$
$$\quad (1.714) \quad (.067) \quad (-.667) \quad (-.379) \quad (.532) \quad (-9.249)^{*}$$

$$F_{(6,15)} = 55.47^{*},\ \text{R-square} = .9569,\ \bar{R}\text{-square} = .9396$$

where: C1 an intercept shift dummy variable is zero for the US and Smoky River coal brands, and one for the nine Australian and four lower tier Canadian brands.

FC is % fixed carbon on a dry ash free basis

A is % ash

S is % sulphur

FY is log Geiseler plasticity

T is contractual term in years

* denotes significant at at least the 5% level of significance.

The error sum of squares (E.S.S.) for the model is 78.3, and the standard error of the estimate is 3.576. However, the significance of the coefficients of quality parameters raises a question as to the significance, at at least the 5% level of significance, of any the independent variables apart from the intercept shift dummy variable C1 in this model. "F" testing of the combined impact of the quality variables removed shows that these variables have not made a significant contribution to the regression at at least the 5% level of significance. Compared with the other results this suggests that the low "t" values for the quality variable coefficients are not due to multicollinearity.

The coefficient of the dummy variable C1 ($19.70 per long ton), provides a measure of the magnitude of producer surplus sacrificed by Australian and Canadian producers in their bilateral negotiations with the JSI vis-a-vis the acquisition cost of US hard coking coals. The fact that Smoky River, a Canadian underground mine, achieved a price in 1977 comparable with US coals, provides an example of the use of differential pricing as a buyer strategy to encourage additional production capacity, which has been an effective element of JSI acquisition strategy.

These results are consistent with the findings of Kittredge and Sivertson only in that Australian and most Canadian hard coals are shown to have consistent fob prices and cif costs (as ocean freight to Japan is practically identical from each source). The finding that Canadian coals were receiving fob prices consistent with a competitive market is not supported by the analysis because of the tiered nature of the Japanese market. All Australian, and four of the Canadian hard coal brands were in fact $19.70 per long ton lower in acquisition cost than would be expected relative to US brands, and quality related characteristics are not significant as explanatory factors, at at least the 5% level of significance.

However, it is possible that 1977 was an unusual year. Analysis of coal quality and cif cost data for other years might better support a position that the persistent cif cost differentials illustrated in Figure 6.2, can be satisfactorily explained by differing quality related valuations of individual coal brands, as has been the position of Utah Development Company and other Australian coking coal exporters. Cross-sectional analysis of coal quality and cif cost data for other years might in fact demonstrate that the persistent cif price differentials, illustrated in Figure 6.2, can be satisfactorily explained by quality related differences between the individual coal brands.

Pearson examined fob price and quality relationships for 1978. But, as was the case in the Kittredge and Sivertson study, both hard and soft coals were pooled in Pearson's regression model. The modelling studies of the Japanese authors Miyazu et. al. again only considered both the hard and soft coking coals imported in 1979. Although the use of domestic soft coking coals was declining in 1979, the volume used (6.8 million tonnes) was very nearly as great as that of Australian soft coking coal (7.6 million tonnes). For reasons relating to differential pricing for Japanese soft coking coals outlined when reviewing the Kittredge and Sivertson study, the Miyazu study could not address issues of market distortion. Unlike the Canadian papers, no details of prices or the coal brands which were used to create the regression model is provided by these

Japanese authors. This makes reanalysis of their data difficult. Also, as the years of the Pearson study (1978) and the Miyazu study (1979) are so close to the year already reexamined (1977), there seems little point in attempting to repeat the analysis of hard coking coal markets for 1978 and 1979.

Cost and quality data for nineteen hard coking coals imported by the JSI are available for fiscal year 1973 from Tex coal manuals of 1974 and 1975. In 1973, the JSI's highest level of pig iron production was recorded. It is also the last year of reasonable world energy price stability prior to the first oil shock, and a year when demand for hard coking coal exceeded supply. Well defined cif price differentials were already established between US hard coals and Australian and Canadian hard coals by that time (see Figure 6.2), so 1973 is a worthy year for an analysis of hard coking coal cif cost/ quality relationships.

6.3.3) Regression Modelling for Japanese Fiscal Year 1973

The individual brand data available for 1973 consists of seven US hard coals, eight Australian, and four Canadian hard coal brands. The Australian and Canadian brand information encompasses all the hard coals shipped at that time, and the available data are listed in Appendix B. In 1973, JSI domestic soft coking coal purchases of 9.6 million tonnes was 61% of all soft coking coal purchased in that year. NSW soft coking coal producers were by far the largest foreign suppliers of the remaining soft coking coal purchased in 1973. As Figure 6.3 shows, both hard and soft coking coals from Australia were acquired at a substantially lower average cif costs than were Japanese domestic coking coals in 1973.

No detailed information on cif acquisition costs for Japanese domestic coals, by brand, is available for that year.

The regression analysis methodology used is the same as has been described in detail for 1977. Chow tests support the pooling of eight Australian with four Canadian hard coal brands. Again, Chow and "F" tests suggest that US coals are structurally different due only to intercept shift. Based on priori expectations, the regression equation for cif cost "C" is:

$$\underset{}{C=29.798}+\underset{(.682)}{.064\,FC}+\underset{(1.549)}{.641\,A}\underset{(-1.717)}{-8.199\,S}\underset{(-.951)}{-.234\,FY}+\underset{(1.761)}{.221\,T}\underset{(-8.164)^{*}}{-15.063\,C1}$$

$$F_{(6,12)} = 35.27^{*},\ \text{R-square} = .9463,\ \text{R-}\overline{\text{square}} = .9195$$

where: C1, an intercept shift dummy variable, is zero for US coals, and one for Australian and Canadian coals.

Other symbols as previously defined

* denotes significant at at least the 5% level of significance.

The standard error for the model is 5.842, and E.S.S. = 30.4. As for 1977, the "t" values suggest that at the 5% level, intercept shift (C1) is the only significant variable. This finding was also confirmed by an additional "F" test on the combined effects of all quality related variables.

Again, the result suggests significant influence of buyer power in establishing the cif cost of imported coking coals. Australian and Canadian exporters appear to have given up $15.06 per tonne in producer surplus relative to US coking coals in the various bilateral bargaining processes which established actual cif costs in 1973.

Steel manufacturing is a basic industry, which by necessity had to be internationally competitive in order for Japan to achieve its industrial policy objectives relating to export growth of high value added manufactures. Therefore, if a premium is paid for a substantial volume of a key input from one country source, this must be offset by lower cost inputs from other suppliers for the industry to remain competitive. It is not surprising then that quality factors do not appear to account for cif cost differences for hard coking coals from the US vis-a-vis Australia and Canada in 1973.

A review of publications of the Joint Coal Board (JCB) of the time supports this statistical confirmation of two tier pricing for imports into Japan which cannot be explained by quality differences. In 1971 the JCB stated "The Board has been and continues to be critical of the unduely low prices at which our export coals continue to be sold"[6.15]. In the

6.15) JCB Annual Report 1970/71, paragraph 2.23, p.18.

marketing section of the JCB annual report of the following year it was stated categorically " --the differences in price (cif prices in Japan for low ash hard coking coals from the US, Australia and Canada) do not correspond with the quality variations. Indeed the major variations in cif prices are between countries and not between coal qualities"[6.16].

In 1973 the JCB compared the fob prices for two US hard coals with two North Bowen Basin hard coals and two South Coast New South Wales (NSW) coals as of 1st September of that year. All six were low volatile hard coking coals reasonably comparable in quality, supplied under long term contractual terms. The price of both NSW coals was $21.07, the Queensland coals were priced at $16.86 and $16.89 respectively, and the US coals at $23.88 and $25.03 per long ton[6.17]. Ocean freight from the US to Japan had risen to $15 per long ton versus $5 from Australia at that time. The cif costs of US coals were then $38.88 and $40.03 compared with $26.07 for the NSW coals and $21.86 and $21.89 for the Queensland coals. Quality differences alone cannot explain such variations, as the regression modelling exercise has shown.

Investigation of more current data is also necessary.

Examination of cif cost and coal quality data for 1983 affords the opportunity to examine quality and cif cost behaviour during the recessional cycle of 1982/83 when

6.16) JCB Annual Report 1971/72, paragraph 5.150 p.140.
6.17) JCB Annual Report 1972/73, paragraph 3.115 p.110.

Japanese pig iron production fell to 74.5 and 75.2 million tonnes, the lowest annual levels between 1971 and that time.

6.3.4) Regression Modelling for Japanese Fiscal Year 1983

Quality and cif cost data are available from the Tex coal manuals of 1984 and 1985 for thirty different brands of hard coking coal imported by the JSI from the US, Australia and Canada in 1983. Data for seven US brands, fifteen Australian brands, and nine Canadian brands were obtained from these sources and are listed in Appendix B. The regression analysis methodology used is the same as has been described in detail for 1977 and 1973. Chow tests support the pooling of the fifteen Australian with the four Canadian hard coal brands having the lowest cif costs. Again, Chow tests show that US coals are structurally different due to intercept shift from the nineteen low cif cost brands from Australia and Canada. Chow testing also shows that the remaining five higher cif cost brands from Canada are structurally different from lower cif cost Canadian and Australian brands, but not different from the seven US brands.

Based on a priori expectations, and the results of Chow tests, the regression equation for cif cost "C" is:

$$C = 93.118 \underset{(-1.817)}{-.294FC} \underset{(1.251)}{+.710\,A} \underset{(0.760)}{+3.764\,S} \underset{(-1.694)}{-.688\,FY} \underset{(1.255)}{+.133\,T} \underset{(-9.238)^{*}}{-14.821\,C1}$$

$F_{(6,24)} = 23.95^{*}$, R-square = .8569, $\bar{R}$-square = .8211

* denotes significant at at least the 5% level of significance.

where: C1, an intercept shift dummy variable, is zero for US coal brands and the five higher cif cost Canadian brands, and one for Australian and the four lower cif cost Canadian coal brands.

Other symbols as previously defined

The standard error for the model is 4.603, and E.S.S. = 236.14. Again, "F" testing on the combined effects of the quality variables shows the only independent variable of significance to be C1. The result suggests the significant influence of buyer power in establishing the cif cost of imported coking coals in 1983. Australian and Canadian exporters appear to have given up $14.82 per tonne in producer surplus relative to US exporters in the various bilateral bargaining processes which established actual cif costs in 1983.

Japanese crude steel production rebounded quickly in 1984, and by 1988 had again reached levels not seen since 1980. Pig iron production also rebounded to 80.9 and 79.3 million tonne levels in fiscal years 1984 and 1985, only to decline for two years and then return to 79.3 million tonnes in 1988. Recent coal quality and cif cost data is available from Tex coal manual sources for Japanese fiscal year 1988, and cif cost modelling for that year can be performed.

6.3.5) Regression Modelling for Japanese Fiscal Year 1988

Data by individual brand for twenty nine hard coking coals from US, Australian and Canadian sources were obtained from the Tex coal manuals of 1989 and 1990. Data for six US brands, fourteen Australian brands, and nine Canadian brands from these sources are listed in Appendix B. The regression analysis methodology used is the same as has been described in detail in the reanalysis of price quality relationships for 1977.

Chow tests support the pooling of the fourteen Australian with the five Canadian hard coal brands having the lowest cif costs. It is notable that in 1988, coals from Smoky River and Greenhills were being acquired by the JSI at the same low cif cost as the Australian and lower tier Canadian coals such as Balmer, Luscar and Fording River. In earlier years (1977 and 1983), these coals obtained a price premium from the JSI, and their acquisition costs were not significantly different from US coals on a quality adjusted basis.

Again, Chow tests show that US coals are structurally different due to intercept shift from the nineteen low cif cost brands from Australia and Canada. Chow testing also shows that the remaining four higher cif cost brands from Canada are structurally different from lower cif cost Canadian and Australian brands. Chow tests suggest that the Canadian brands of Line Creek and Gregg River are not different from the six US brands, but the Bullmoose and Quintette brands are structurally different. Based on a priori expectations, the regression equation for cif cost "C" for 1988 is then:

$$C = 55.36 \underset{(1.190)}{+.154\ FC} \underset{(-.183)}{-.076\ A} \underset{(-2.83)^*}{-7.399\ S} \underset{(1.253)}{+.109\ T} \underset{(2.352)^*}{+.576\ FY}$$

$$\underset{(-9.981)^*}{-10.738\ C1} \underset{(15.341)^*}{+27.391\ C2}$$

$$F_{(7,21)} = 111.3^*,\ \text{R-square} = .9738,\ \bar{R}\text{-square} = .965$$

* denotes significant at at least the 5% level of significance.

where: C1 is zero for US brands and upper tier Canadian brands, and one for Australian brands and lower tier Canadian brands.

C2 is one for Quintette and Bullmoose, and zero for all other brands.

All other symbols are as previously defined.

The standard error for the model is 3.236, and the E.S.S.= 79.1. It is only in 1988 that there appears to be some support for the position that some quality related independent variables (S and FY) are statistically significant in influencing cif values in the Japanese coking coal market.

The fact that the coefficient of the fluidity variable has become significant in 1988, is probably a result of the phasing out of Japanese domestic production. Japanese domestic soft coking coals have particularly good fluidity properties, and their absence from the coke blend is now being reflected by increased recognition of the value of fluidity in hard coking coals. However, even in 1988, it is clear that quality effects are small compared with the intercept shift terms which are the outcome of the price discrimination practices implicit in the JSI's resource acquisition policies.

6.4) Evidence Supporting The Hypothesis of Market Distortion

The above results support a hypothesis that quality differences have been relatively insignificant in determining cif values of hard coking coals to Japanese ironmakers in the past, and that market power in the bilateral bargaining process is the principal determining factor. It seems likely that for a span of twenty six years (1963 to 1989), Australia's hard coking coals have had lower cif costs relative to US hard coals and some Canadian hard coals than would be expected, due to JSI acquisition policies which have biased the outcome of the bilateral bargaining process. These findings support the positions of Anderson and D'Cruz, and the many public comments of the Joint Coal Board (JCB).

6.4.1) JCB Comments Regarding Exports to JSI

The reason for the prevailing pattern of lower Australian cif costs, shown in Figure 6.2, stems from early hard coking coal contracts signed with New South Wales producers in the late fifties. Certainly a differential trend was well established by then. The problem was noted as early as 1968 in the Joint Coal Board's Annual Report of 1967/68 which stated[6.18] "-- prices at which Australian coals were being sold to Japan were unduely low compared with prices paid to United States, Canada and other suppliers, even when quality allowances were made."

6.18) JCB Annual Report 1967/68 paragraph 2.20 p.14. Such concerns were voiced with increasing urgency by the Board in subsequent years, but as the JCB lacked authority to influence the coal marketing activities of Queensland's hard coal producers, no coordinated marketing effort ensued. The JSI, acting as an oligopsony contracting for all Australian coking coals, was able to maintain an environment of destructive competition between competing suppliers within New South Wales and Queensland, and between the export industries of each state.

A similar acquisition strategy was adopted for Canada, where interfirm competition and interstate competition between Alberta and British Columbia assured the same outcome in the sixties and seventies. It surely is no coincidence that the research of Kittredge and Sivertson was performed for the British Columbian Ministry of Industry to investigate state government concerns over the apparent discrepancy in cif cost between Canadian and American coals sold into the Japanese market. It is unfortunate, in hindsight, that these authors apparently were not familiar with, or chose to ignore, concerns expressed by the JCB in the late sixties and early seventies. Had there been greater recognition of that viewpoint, it is doubtful whether an assumption that prices received by Australian coking coal exporters were determined in a competitive market environment, would have been made in the Kittredge and Sivertson study of Canadian prices in 1977.

Success in eliciting low cost hard coal supplies from both Australia and Canada, enabled the JSI to achieve another key element of Japanese industrial policy with respect to steel production. That objective was to diversify supplies of steel commodity inputs, and reduce reliance on the US for coking coal supplies.

6.5) JSI Supply Diversification Strategies

The degree of success in achieving an objective of supply diversification as far as hard coking coal supplies are concerned is well illustrated in Figure 6.4 (following page).

The import trends of Figure 6.4 are worthy of further analysis and discussion. When viewed in conjunction with Japanese pig iron production trends of Figure 6.1, and Figures 6.2 and 6.3 showing imported coking coal cif costs, the trends in import volume from the three major world suppliers of coking coals reveal the success of JSI's supplier diversification policy[6.19], and further market distortion resulting from that policy.

In the decade from 1963 to 1973, annual pig iron production grew from 20.7 million tonnes to 90.9 million tonnes at an average growth rate of nearly 16% per annum. As realization of future high growth rates became accepted by the JSI in the

6.19) JSI policies with respect to supply diversification are spelled out in Horie, H. (ed.) Coal Manual (1969), The Tex Report Ltd. pp.1-4. As is further stated on p.41 of the 1969 Coal Manual, it was anticipated that imports from the US, Australia, and Canada would eventually rise to levels of approximately 20 million tonnes annually from each of these key suppliers.

Figure 6.4 JIMP1.GRA

sixties, a strenuous effort was made to reduce reliance on the US as its sole supplier of hard coking coals. Prior to 1960, only small quantities (< 100,000 tonnes per year) of NSW south coast hard coals had been imported, beginning in the mid fifties. Rapid growth of Australian imports between 1963 and 1965 then came from an expansion of NSW supplies from existing mines, which increased from 535,000 long tons in 1959/60 (Australian financial year) to 2,874,000 long tons in 1964/65. But also, and more importantly, the commissioning of the Moura mine in central Queensland took place.

6.5.1) <u>The JSI's Supply Strategy in Queensland</u>

Moura was a large development (approximately 3 million tonnes annual capacity) whose total output was committed to the Japanese market. The original contract was signed in 1961 for 2.9 million tonnes, and that Moura contract was instrumental in establishing the low price regime for Australian hard coking coals in the Japanese market which exists to this day.

This view is supported by comments contained in the Tex coal manual[6.20] for 1969, which states "-- high appreciation of the following merits of the coal (from Moura) that contributed greatly to the Japanese steel industry's coking coal supply at least until 1967.

6.20) Horie, H. (ed.) Coal Manual (1969), The Tex Report Ltd. Tokyo, p.63.

1) The initially contracted low price of the coal served as a restraining factor to the price hike tendency of other imported coals.

2) Having the highest fluidity of all the imported coals, Moura coal was used as a basic component of coal mix.

3) Its annual volume of import was larger than that of any other overseas coal at that time."

The fob price precedent established by the Moura contract has haunted the Australian coking coal industry ever since.

Rapid growth in Australian hard coal imports by the JSI, which then occurred from 1967 to 1976, was due to the commissioning of five new mines in Central Queensland. Like Moura, these new mines were committed on the basis of long term supply contracts, and with prices based on the Moura precedent. Apart from the South Blackwater mine, which was owned and operated by a Queensland company (Thiess), all the mines were large scale open cut operations owned and operated by Utah International, a US multinational company. A list of these capacity additions, and the management groups having operational control, is provided in Table 6.3.

TABLE 6.3

EXPORT COKING COAL MINE COMMISSIONINGS - QUEENSLAND

Year	Project	Management	Capacity Million Tonnes

1961 Moura Peabody (US) 3.0 1968 Blackwater Utah (US) 3.0 1971 South Blackwater Thiess (Qld.) 1.0 1972 Goonyella Utah (US) 4.0 1973 Peak Downs Utah (US) 4.5 1975 Saraji Utah (US) 4.5

Source: Queensland Coal Board Annual Reports 1960 to 1976.

Total annual capacity additions, in the period from 1968 to 1975 of 17 million tonnes, far exceeded the JSI's increased imports of Queensland's hard coking coals. That increase amounted to only 11 million tonnes annually over the same period to create an excess of supply capacity relative to JSI demands. Failure of the JSI to expand pig iron production and demand for hard coking coals, was not the reason that Australian capacity expansions exceeded Japanese imports. That was due to the JSI's initiation of a large expansion in western Canadian hard coking coal export capacity in the same time frame as the Queensland expansions.

6.5.2) <u>The JSI's Supply Strategy in Canada</u>

In 1968, a Canadian contract for fifteen years of supply of hard coking coal at an annual rate of 5 million long tons per year was signed. This contract resulted in the expansion of the Balmer mine to a large scale open pit operation of 5 million tonne annual capacity in 1970. Two more contracts were concluded soon after, which resulted in the opening of the Fording River and Luscar mines. All three Canadian mines were large scale open cut operations producing hard coking coals having quality characteristics very similar to Queensland's coking coals.

As was the case for the Moura mine in Queensland, the Balmer mine was controlled by a foreign company (Kaiser Steel of the US). Also, as was the case with Moura for Australian hard coals, that price settlement established the precedent of low average cif costs for Canadian hard coking coals, which was to continue until the early eighties. The sequence of contractual arrangements leading to new mine developments in Queensland in the late sixties and Canada in the early seventies explains to a great extent the similarity of cif cost trends for coals from these sources. Regression modelling studies have confirmed the close relationship between Queensland's hard coal producers and the lower tier Canadian mines of Balmer, Luscar and Fording River. Some of the mines which commenced production in Canada in the early eighties obtain higher prices in Japanese markets for coals of very similar characteristics to those commencing operations in the seventies. However, do the import trends of Figure 6.4 provide an indication of further market distortion due to the purchasing power of the JSI, or reflect a legitimate need for supply diversity? 6.5.3) The Need for Supply Diversity

Supply diversity is certainly an important issue for an industry having significant economies of scale, situated in a country like Japan which lacks most of the resource commodity inputs required to support an internationally competitive steel industry. Reliability of supply is also an important issue for importers of a commodity like coking coal, because of the effect of oxidation on caking characteristics. Unlike thermal coals, which can be stockpiled for long periods as a security against supply disruption, coking coals must be converted into coke within about six months after mine production. This limits the buyers ability to employ long term stockpiling as a strategy against supply disruption in coking coal production. For this reason the monopoly power of labour unions in Australia's coking coal mines, and in state railway operations, has long been of concern to the JSI.

These issues were certainly of concern to MITI when formulating the Japanese industrial policies relating to the steel industry. In Chapter 4, the role of Japanese industrial policy relating to shipbuilding and ocean transportation was discussed. A shipping industry capable of efficiently transporting the large quantities of iron ore and coal imports over great distances was fundamental to attaining internationally competitive resource input costs for Japan's steel industry. An important outcome of the ocean shipping element of Japanese industrial policy was the ability of the JSI to control the ocean transportation component of delivered cost. By contracting on an fob basis rather than cif, as was the case for both Australian and Canadian coking coal purchases, the JSI was able to influence the distribution of locational rents associated with shorter ocean haul distances from Australian and Western Canadian coal export terminals to Japan (4,400 nautical miles), versus the much longer distance from Norfolk Virginia in the US (9,400 nautical miles).

6.5.4) Departures from Competitive Market Behaviour

Up until 1978, the displacement of the US as principal supplier by Australia and Canada as lower cost suppliers, as is illustrated in the trends of Figure 6.4, is consistent with competitive market behaviour. From 1978 on the pattern of imports does not correspond with expectations, recognizing that quality differences are not a significant factor, were the JSI acting as an input cost minimizing industry. US imports rose above 10 million tonnes annually from 1979 to 1984, despite much lower costs for Australian hard coals. This was not a consequence of supply scarcity from Australia with rising levels of pig iron production. Additional export capacity of 5 million tonnes was added in 1981 in Queensland, as a result of the commissioning of the Gregory and Norich Park mines, and annual rates of Japanese pig iron production had continued the declining trend which commenced in 1973.

Since 1983, imports from Canada have risen while both US and Australian imports have declined. These patterns have evolved despite the fact that Australia has continued as the low cost supplier throughout the period, and Canada has now displaced the US as the highest cost supplier. As it has already been demonstrated that quality differences are unimportant in explaining the persistent trend of lower cif costs for Australian hard coals, so this behaviour is not indicative of a functioning competitive market situation in the Japanese hard coking coal trade. A conclusion which could be drawn from these import trends is that the JSI have adopted a policy of limiting their reliance on Australian coking coal imports to some ceiling quota or share, irrespective of the cost competitiveness of Australian sourced coals. The patterns provide further evidence of market failure in the Japanese coking coal trade. This can be demonstrated by longitudinal modelling of changes of market share with cif costs for Australian, US and Canadian hard coking coal producers over the period from 1973 to 1989.

6.6) Modelling of Japanese Market Response

Data are available by Japanese fiscal years from 1963 to 1989, for hard coking coal cif costs in constant 1987 $US (Figure

6.2), and hard coking coal import quantities from Australia, Canada, and the US (Figure 6.4). From the import volume data of Figure 6.4, each country's market share in Japan for each year can be calculated as the volume of imports from that major supplier (Australia, Canada or the US), divided by the sum of imports from all three of these major suppliers. In a similar fashion, the cif cost data of Figure 6.2 can be used to calculate the percentage change in real cif cost by year, by dividing the annual change in real 1987 US dollar cif costs from one year to the next by the cif cost in the initial year, for hard coals from Australia, the US, and Canada.

Pig iron manufacture is the principal end use for coke. Figure 6.1 shows quite clearly the declining overall trend in pig iron production in Japan which has taken place since 1973. Although integrated steel manufacturing capacity increases in South Korea and Taiwan have compensated to some extent for declining Japanese demands for coking coal in the Pacific Rim, a similar pattern of decline of pig iron production in Europe, the other major importing region, has resulted in an excess of supply over demand in the seaborne coking coal trade since 1973. In such a situation, if the Japanese market was acting in accord with economic theory, buyers would seek to minimize their cost of coking coal inputs, and one would expect a relationship to exist between changes of market share for each of the three major suppliers of hard coking coal, with changes of cif cost from each of these sources.

Evidence has already been presented that normal competitive market behaviour was not permitted. Horie's quotation relating to the JSI's supply diversification policy (footnoted on page 245) states the intent to increase imports from the US, Australia, and Canada, to approximately equal levels. However, it is the conventional wisdom that competitive market behaviour does exist in Japan's coking coal trade, so an attempt will be made to confirm such behaviour by market modelling.

6.6.1) Theoretical Market Share/Acquisition Cost Models

Economic theory suggests that the level of a buyer's demands for a commodity from a particular seller should be a function of its acquisition costs, on a quality adjusted basis, relative to other sellers. It has already been demonstrated that coal quality is not significant in explaining the acquisition costs of hard coking coals imported by the JSI. It should follow then, from the cif trends of Figure 6.2, that lower cost Australian hard coking coals should gain market share at the expense of higher cif cost suppliers if Japanese markets were competitive. A model can be hypothesized for annual changes in market share Australian hard coking coal imports by the JSI as follows:

$$MSCH = fn(PEA, PEUS, PEC,)$$

where: MSCH, the dependent variable, is the annual change of market share for Australian coking coal for Japanese fiscal years from 1973 to 1989, expressed as a percentage. Australia's market share is calculated as the proportion of hard coking coal imports from Australia, as a percentage of the total imports from Australia, Canada and the US.

PEA is the annual real percentage cif cost change by year from 1973 to 1989 for Australian imports.

PEUS is the annual real percentage cif cost change by year from 1973 to 1989, for US imports.

PEC is the annual real percentage cif cost change by year from 1973 to 1989, for Canadian imports.

Market response models for US and Canadian hard coal imports can also be hypothesized in a conceptually similar fashion, with each model having the same set of independent variables[6.21].

6.6.2) Australian Market Response Model

The market response model relating Australia's market share changes to own price change, and cross price changes is as follows:

$$MSCH = .0126 - \underset{(-2.13)}{.0025\,PEUS} + \underset{(1.44)}{.006\,PEA} - \underset{(-1.03)}{.003\,PEC}$$

$F_{(3,12)}$ =1.663, R-square =.2937, $\bar{R}$-square =.1171, D-W =2.319

"t" values are not significant at 5% (two tailed test)

6.21) As the sum of coal market shares in this market sum to one, this is an example of Zellner's "Seemingly Unrelated Regressions(SUR)" problem. However as the independent variables are identical, the OLS estimates used are equivalent to the SUR generalized least squares estimates. On this see Kmenta, J."Elements of Econometrics" McMillan Publishing Co. New York,(1990) pp. 635-648.

Chow tests for structural change, due to the second oil shock of 1979, do not indicate significant change.

This model is notable both for its low R-square value, negligible "F" value, and the lack of statistical significance for all coefficients of cost related independent variables thought to be important in competitive markets. In short, these results fail to demonstrate statistically significant model relationships, at at least the 5% level of significance. Also, as the previous cross-sectional analyses supported the presence of a two tier market situation which could not be explained by quality differences, this result could further indicate that too great a cif cost advantage has historically been given up by Australian exporters in their bilateral bargaining with the JSI vis-a-vis US and Canadian sellers.

Having examined the Japanese market share response model for Australian hard coal imports, it is informative to generate and compare similar models for US and Canadian hard coals.

6.6.3) US Hard Coking Coal Market Response Model

The market response model relating annual percentage demand changes for US hard coking coal imports by the JSI with cif costs is the following:

$$\underset{}{MSCH = -.0373 + \underset{(1.95)}{.0044\ PEUS} - \underset{(-.81)}{.0064\ PEA} + \underset{(.336)}{.002\ PEC}}$$

$F_{(3,12)}$ =1.512, R-square =.2744, $\bar{R}$-square =.0929, D-W =1.121

"t" values are not significant at 5% (two tailed test)

As was the case for the Australian market model, regression coefficients of independent variables are of negligible significance in this model. Chow tests for structural change due to the second oil shock of 1979 again support the view that the relationship is stable throughout the period.

6.6.4) Canadian Hard Coking Coal Market Response Model

The market response model relating annual percentage change of market share for Canadian hard coking coals with percentage real cif cost changes from the three major suppliers is as follows:

$$\underset{}{MSCH} = .0330 - \underset{(-1.21)}{.0026\ PEUS} - \underset{(-.50)}{.0038\ PEA} + \underset{(1.18)}{.0066\ PEC}$$

$F_{(3,12)}$ =1.493, R-square =.2718, $\bar{R}$-square =.0897, D-W =2.008

"t" values are not significant at 5% (two tailed test)

Chow tests for structural change due to the second oil shock of 1979, and at the commencement of production of Bullmoose and Quintette do not indicate significant change. Again, the model is notable both for the negligible "F" value, and the lack of statistical significance for all coefficients of cost related independent variables thought to be important in competitive markets.

All three major suppliers appear to have experienced distortions in the normal relationships between demand with acquisition cost competitiveness in Japanese hard coking coal markets. However Australia's situation is unique in being the only supplier whose cif costs have consistently been lower than other major suppliers. What motives might have caused the JSI to abandon cost minimizing behaviour for hard coking coal acquisitions, by maintaining higher cost imports from the US and increasing imports from Canada, rather than increasing lower cif cost shipments from Australia? A number of possible reasons can be suggested:

1) Concern over concentrations of supply side monopoly power

within Australia's coal export industry.

2) The need for supply diversification to reduce the risk of supply disruption.

3) Ownership issues, such as the substantial Japanese equity position in the North East British Columbian coal projects.

4) Bilateral balance of trade pressures, particularly the trade surplus with the US relative to the deficit with Australia.

Any one or all of these motives could explain the JSI's reluctance to permit coking coal imports from any one country source to exceed an apparent maximum purchasing ratio ceiling of about 40% as is illustrated in Figure 6.5 (on the following page).

The trends of Figure 6.5 provide strong evidence of the reluctance of the JSI to permit excessive exposure to any one

Figure 6.5 purat1.gra

country source. Only once, in 1970, were US coking coal purchases over 40% of the total annual purchase (at 44.1% in 1970). Australian coking coal imports have never exceeded 42.5% of the total in any one year, although exceeding 40% in nine of the last eleven years. This has occurred in spite of the cif cost competitiveness of Australia's hard and soft coals over the period as evidenced in Figures 6.2 and 6.3, and an excess of productive capacity both in Queensland and NSW. Canadian imports (Figure 6.5 series "B") have recently made up about 24% of annual purchases. Other purchases (series "C"), have also increased as a percentage of the total in recent years (17.4% in 1987), due to increases from South Africa (soft coking coal) and the USSR (hard coking coals).

Comparisons between the three country market response models can now be performed.

6.7) Japanese Hard Coking Coal Market Response Comparisons

The regression model results for the three major suppliers are summarized in Table 6.4

TABLE 6.4

REGRESSION MODELLING OF HARD COKING COAL MARKET RESPONSE

SUMMARY OF FINDINGS

Country Source	Australia	US	Canada
Statistically Significant Independent Variables (at at least 5% level of significance)	none	none	none
Structural Changes	none	none	none
R-square Value	.294	.274	.272
Adjusted R-square	.117	.093	.090

"F" value	1.66	1.51	1.49

This comparison is notable for the similarities of each individual country's regression modelling outcome. No statistically significant independent variable is found for all three country models. In each case the "F" values of the models fail to indicate significant relationships between percentage changes of market share with cif cost at at least the 5% level of significance.

The failure of any cif cost related coefficient to be significant in these regression equations implies that cif costs of Australian coals relative to those from Canada and the US is not important in establishing year to year changes in market share. This result suggests the possibility that over the full twenty six years of this study the price elasticity of demand for Australian hard coals has been inelastic in the Japanese market. The modelling results are not surprising considering the cif cost segmentation of the Japanese hard coking coal market, which were confirmed in the findings of the cost/quality cross-sectional modelling studies performed for individual years.

Findings that Australian hard coking coal own and cross price elasticities of demand are zero or insignificant in Japanese markets are supported by Ball and Loncar[6.22]. Their study of Japanese coking coal markets was based on quarterly import value and volume data for all imported coals from the first quarter of 1978 to the third quarter of 1989. Ball and Loncar concluded that own and cross price elasticities of demand for coking coal are not significantly different from zero at the 10% level of significance.

6.8) Conclusions Regarding Pacific Market Structure

Based on the research and analysis described here it is difficult to endorse the preliminary findings of the Industry Commission that "-- distorted purchasing arrangements do not exist or are insufficient to justify use of export controls", as far as Australia's coking coal exports to Japan are concerned. Also it is difficult to agree with Utah's statement that: "Australian coal export prices in general,

6.22) Ball, K. and T. Loncar "European and Japanese Demand for Australian Coal: A Systems approach to Import Demand" Proceedings of the Conference of Economists University of NSW, Sydney (1990) 24-27 September.

and Utah's in particular, have at times been compared unfavorably with other producers' prices by uninformed commentators. Such comparisons either ignore the facts or fail to comprehend the significance of major quality differences between coals from different sources. Utah's coking coal prices have been in line with market values."

A respecification of the data used in the Kittredge and Sivertson study, to include only hard coking coals, supports the research hypothesis of price discrimination in Pacific markets in 1977, which cannot be explained by coal quality difference. Similar evidence was present for all other years examined. Market response models for Australia, the US and Canada, also show no statistically significant relationships between changes in market share with changes in cif cost.

Considerable debate regarding the solution to Australia's current account problems has revolved around abstract concepts of competitive markets and free trade. To relate such market and trade theories to the practical realities for Queensland's coal exports it is first necessary to provide the definition of a competitive market.

6.8.1) Competitive Market Definition

A purely competitive market[6.23] is defined as one in which the following conditions apply:

6.23) Tisdell, C.A. "Microeconomics of Markets" John Wiley & Sons (1986). p.42.

1) No individual buyer or seller is able to influence the conditions of exchange.

2) No traders are in collusion.

3) In the opinion of the buyers the commodities are homogeneous.

4) Buyers and sellers act in their anticipated (individual) self interest, free of any artificial restriction.

5) Commodities are perfectly mobile, which occurs if transport costs are negligible.

The attitudes of the Industry Commission and many firms in Australia's export coal industry reflect a view that competitive markets exist in the Pacific coking coal trade. In reality, few if any of the above conditions necessary for ideal competitive markets apply in the Japanese coking coal market.

The first two conditions relating to market power are violated by the coordinated purchasing strategies of the JSI.

The contractual and purchasing strategies used to initiate new mining developments in Queensland and Western Canada were designed to stimulate destructive competition between firms state governments and the two nations, as has been described by Anderson[6.24].

The discussion of the technical aspects of coke making and the function of coke in blast furnace smelting has shown that coking coal is not a homogeneous commodity as far as coke and ironmaking is concerned. The presence of Japanese trading companies as minor equity participants in many Australian and Canadian joint venture operations provides access to detailed cost information regarding mine production operations. No such detailed information regarding the values of individual coals in the coke blend is available to Australian or Canadian negotiators. This situation creates the condition of knowledge asymmetry which, in a bilateral bargaining process, is likely to distort the outcome in favour of those parties having superior economic and technical information. The JSI's purchasing strategy, which is designed to prevent excessive reliance on purchases from any one country, is a trade restriction in conflict with the cost minimization interests of individual firms, and prevents the formation of competitive markets on the demand side.

Finally, it will be shown in the following chapter that transportation costs are a substantial proportion (more than 50% of the cash costs) of the cost of supplying coking coal to Japanese buyers.

6.24) Anderson, D.L."An Analysis of Japanese Coking Coal Procurement Policies : The Canadian and Australian Experience" Centre for Resource Studies, Queen's University Ontario (1987) pp.54-57.

6.9) Summary of Findings

Contrary to the conventional wisdom, the findings of this chapter suggest that the persistent differentials in cif cost between Australian, US and Canadian hard coking coals cannot be adequately explained by the quality differences which, from a priori technical expectations, should impact each coal's value in coke blending and ironmaking. Quality differences do not seem to be significant relative to price discrimination, which is the major contributing factor.

Regression modelling of changes of market share with cif acquisition costs fails to demonstrate significant relationships, further indicating market failure in the Japanese hard coking coal trade.

Ample evidence has been provided to show that the Japanese hard coking market has failed to behave as an ideal competitive market over the years. Other major buyers in the region, such as South Korea and Taiwan, also tend to base their prices on precedents set in the annual price negotiations with the JSI. In this fashion the market distortions caused by the purchasing policies of the largest buyer of the region flow into the entire Pacific coking coal trade.

The existence of large subsidy payments made to German and other EEC coal producers (Tables 4.2 and 4.3) prevents the formation of competitive coking coal markets in Europe, the other major importing centre for internationally traded coal.

Attention is now devoted to examining the structure of production and delivery costs from the world's three principal suppliers, and the response of the major input factor cost elements in Australia and America to the commodity price cycle which the international coking coal trade has experienced from 1973 to 1989.

The behaviour of Pacific metallurgical coal markets

The impact of Japan's acquisition strategy on market price

Richard J. Koerner

This paper examines whether some elements of Japan's resource acquisition strategies might have caused price and other distortions of market behaviour in the Pacific metallurgical coal trade. The industry chosen for investigation is that of steel manufacture, and the traded resources commodity examined is coking coal, which is the primary energy input for blast furnace iron making. Regression modelling studies to determine historic acquisition value and quality relationships for US, Australian and Canadian coals sold into the Japanese coking coal market are described. Departures from normal demand response behaviour to price competitiveness are also investigated.

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In any exchange economy, the gains from exchange depend on the initial endowment of the participants. In international trade, such gains are greatly influenced by the industrial structure and resource endowment of the trading nations, which determine which goods are exported and which goods are imported. If a particular nation's industrial structure is such that international demand for its exports is strong, and foreign countries can supply inputs which support that nation's exports cheaply, the economic welfare of the nation will be differentially advanced through trade relative to those nations not able to export such sought after goods. Furthermore, if the nation is able to stimulate competing input resource development projects among foreign suppliers, without also providing the capital investment, to further reduce the price of essential imports which are resource inputs to its exports, gains from trade are further enhanced.

Steel manufacture was selected as a preferred industry in the reconstruction of the Japanese economy after the Second World War as it is a critical material factor cost for many of the elaborately transformed manufactured goods referred to above. It is an industry where specific microeconomic policies might have resulted in a differential advantage for the Japanese steel industry (JSI), whose products in turn have underpinned Japan's export driven rise to economic prominence. Table 1 shows that by the mid-1970s Japanese steel makers had overcome their comparative disadvantage relative to the USA arising from a lack of indigenous low cost coking coal resources, by achieving higher process energy efficiencies, and by obtaining access to inexpensive foreign coals. This outcome, together with the maintenance of a labour factor cost advantage, and the depletion of low cost iron ore for US steel producers, enabled the JSI to directly penetrate US domestic steel markets in the 1960s and 1970s.

In 1989 183.5 million tonnes of coking coal were traded internationally,[1] with Asian regional trade (Japan, South Korea and Taiwan) accounting for 49% of that total. Japan was the world's largest single importer with a demand of 68.7 million tonnes. Australia, Canada and the USA supplied 57.9 million tonnes or 84% of these imports. The fortunes of Australia and Canada in the coking coal trade have been closely linked to the evolution of Pacific Rim steel industries, and particularly that of Japan.

Studies of Japanese coking coal markets

Several studies have already examined aspects of JSI coal procurement, the most notable being those of the Canadian researchers Anderson and D'Cruz.[2] Anderson examined the impact

1 **International Energy Agency (IEA),** *Coal Information,* **1990, OECD, Paris.**

of the JSI's coking coal procurement system on Canadian and Australian suppliers, including those not linked through long-term contractual arrangements. His study discussed both the historic and possible future policy responses available for Australian and Canadian interests to combat an oligopsonistic procurement system. In his view, evidence exists that the market power created as a result of JSI purchasing arrangements have resulted in price discrimination, to the detriment of some Canadian and most Australian coking coal producers. However, Anderson also cites a regression modelling study of Japanese coking coal markets by Kittredge and Sivertson, which concluded that no significant evidence of price discrimination existed in 1977.3

D'Cruz examined the impact of quasi-integration resulting from the JSI's establishment of long-term purchasing agreements for coking coal supplies on the price and offtake quantity experience of producers over the years 1970 to 1977. His research hypothesis was that quasi integration would attenuate the use of market power during cyclical phases of supply and demand imbalance. It was expected that Canadian and Australian coking coal producers linked with the JSI through long-term contracts would experience higher export shipments and prices during periods of steel production decline, thereby benefiting from quasi-integration. His findings were that any beneficial effects of quasi-integration on price were minor compared with the detrimental effects of price discrimination practised by the JSI in Pacific markets over the duration of the study.

The Industry Commission of the Australian federal government examined the issue of international market distortions due to coordination purchasing arrangements in its recent study of Australia's minerals and mineral processing industries. The conclusion of the study was that 'in the Commission's view, distorted purchasing arrangements do not exist or are insufficient to justify use of export controls.',

It is apparent from these citations that differences of opinion remain among Australian and Canadian experts regarding the presence and/or significance of market distortion in the Japanese coking coal trade. A resolution of the question is needed before policy implications can be addressed. One methodology for investigating the issue involves *a priori* development of a model relating price to coal properties in the Japanese coking coal market, and cross-sectional testing of the model at times when sufficient price and quality data are available to provide statistically significant findings.

It is clear from descriptions of the technologies of blast furnace iron making, coking coal composition and coke making, that the value of individual coking coals could vary depending on a number of factors.5 For example, during the period of rapidly increasing levels of pig iron production which took place in Japan in the 1950s, 1960s and early 1970s, coke strength would be a prime consideration when selecting coals for the coke blend. It might be expected that a premium would be paid for low volatile (or hard) coking coals at such times.

As big iron production levels have declined in most industrially developed countries since the 1974 recession, lower levels of blast furnace productivity have been required and coke strength has

2D.L.Anderson, *An Analysis of Japan Coking Coal Procurement Policies:*

*Canadian and Australian Experience, Cen*tre for Resource Studies, Queens I *University,* Ontario, 1987;J.R *D'Cruz Quasi Integration in Raw Material Markets:*

Overseas Procurement of Coking Coal the Japanese Steel Industry, PhD Dissertation, *Harvard University,* 1979.

3P. *Kittredge and L. Sivertson, 'Competition and* Canadian coal prices in

Japanese coking coal *market', Canat Institute of Minerals Bulletin, September* 1980,pp100-109.

become of less concern. In such circumstances lower quality coals could be used in the coke blend. Premium priced hard coal imports could be reduced, and price differentials between hard and other coking coals might decline due to increased supply competition.

4 Industry Commission Report, *Mining an Minerals Processing in Australia,* Vol 1 AGPS, Canberra, September 1990, p 8-' 5Discussion of the technical characteristic of coking coal and the various properties of importance in coke making and blast furnance operation can be found in D.E. Pea son, 'The quality of western Canadian coking coal', *Canadian Institute of Minera Bulletin,* January 1980, pp 70-84, and Matsuoka, 'Requirements for coals Japanese coking blends', Australian Ins tute of Mining and Metallurgy- Illawar Branch, Sydney, 1975, pp 251-261.

6B. Smith, 'Bilateral monopoly and export price bargaining in the resource goo' trade', *Economic Record, Vol* 53, 1977, I 30-50; S. Harris and T Ikuta, eds, *Australia, Japan and the Energy Coal Trade* Australia-Japan **Research Centre,** Canberra, 1982, pp 9-12.

JSI coking coal acquisition history

The general level of coking coal price in international markets at any time are related to the economics of production of major world suppliers, and the short-term supply/demand balance in world trade. 1 The history of landed (cif) costs for hard coking coals imported by the JSI is shown in Figure 1. In Figure 1 the data presented for Australia, the USA and Canada represent more than 80% of hard coking coals f imported by the JSI over the period considered, with the cif costs being expressed in constant 1987 US dollars per tonne. These acquisition cost patterns suggest the existence of a multitiered market. Exercise of buyer s power by the JSI in the bilateral bargaining process could explain the l. persistently lower acquisition costs for Australian sourced coal; throughout the period,6 and for Canadian coals in the earlier years unless it can be shown that superior coal qualities justify the higher costs generally incurred for US coals, and some of the Canadian sourced hard s coking coals in later years.

The other major category of coking coal referenced in Japanese trade literature is soft coking coal, which exhibits lower coke strength but provides the necessary caking or plasticity properties in the coke blend. In the 1950s and 1960s Japanese domestic production was the major source of such coals for the JSI. During the 1970s increased quantities of soft coking coal were imported from Australia, South Africa and the USA, and domestic production steadily declined. Differential cif cost behaviour can also be noted between Japanese soft coking coals and Australian imported coking coals in Figure 2.

Figure 1. Hard coking coal acqisition costs

Figure 2. Japanese-Australian coking coal acquisition costs

Throughout the entire period Japanese domestic coals have maintained a higher real cif cost than either hard or soft coking coals from Australia. The magnitude of this differential widened considerably in 1977. Again, unless coal quality differences provide a satisfactory explanation, the trends of Figure 2 suggest patterns of differential acquisition cost which could be an outcome of buyer power being exercised by the JSI in the conduct of bilateral bargaining with Australian coal producers.

The highest recorded annual level of pig iron produced by the JSI was 90.9 million tonnes in Japanese fiscal year (JFY) 1973. The coal price and quality data are available for that year. The year chosen for investigation in the Kittredge and Sivertson study was 1977. Price and quality data are also available for 1988, which is the third year of a recovery in Japanese pig iron production. Cross-sectional modelling studies of the acquisition cost and quality relationship for the years 1973, 1977 and 1988 may provide some indication of coking coal quality valuations associated with coke making and blast furnace operations in Japan at varying levels of pig iron production, and the changes in such

Table 2. Coal quality characteristics.

valuation caused by technology improvements in coking and iron making processes.

In order to test a hypothesis that market distortion has resulted from acquisition strategies of the JSI, it is first necessary to develop a model relating cif cost with those coking coal quality characteristics likely to be significant for blast furnace iron making.

Price/quality relationships for hard coking coal

From technical descriptions of by product coke making and blast furnace operations it is expected that available (or fixed) carbon would be the most important factor in determining a hard coal s economic worth. Caking properties, measured by plasticity and/or free swelling index (FSI) characteristics, are related to the volatile content of the coal and are also beneficial for coke manufacture. As hard coking coals are low or medium volatile coals, the necessary caking property of the coke blend is generally obtained by mixing soft (or high volatile) coals with hard coals. If statistically significant in the valuation of hard coals, a caking parameter coefficient should be positively signed in the regression equation.

Increased ash and sulphur content reduces available carbon, and i~ deleterious in blast furnace operations. Higher levels of such impuritie' should result in lower acquisition costs. Ash and sulphur qualit' parameters, if statistically significant, should have negative regression coefficients.

Although moisture content adds to the cost of transport, a mocte relating cif cost with quality need not consider either moisture o differential transportation costs, as such factors influence fob prices pai~ at the port of export rather than cif value, which is the dependen variable in this analysis. Influence on cif value of the coal qualit characteristics most commonly reported for different coking coal brand can then be summarized as shown in Table 2.

Price/quality modelling literature

Four cross-sectional regression modelling studies of the Japanese cokin coal market have been performed in attempts to relate fob prices to co; quality characteristics. Callcott, Kittredge and Sivertson, Pearson, an Miyazu, Takekawa and Fukuyama,7 developed fob pricing models usir cross-sectional regression analysis techniques involving detailed co quality characteristics for a number of individual coal brands, as indicated in Table 3.

Only imported coking coal brands were considered in developing tl models listed in Table 3. Japanese soft coking coals were not includeed This omission is a serious shortcoming if modelling seeks to examine evidence of market distortion. The problem of including imported sc coals, without also including Japanese domestic soft coking coals, can I avoided by eliminating all soft coals from the US and Australian bran of coal considered, and using only cif cost and quality data for ha coals, which have made up the bulk of the Pacific coking coal trade ov the years.

7T.G. Callcott, *Conjoint Papers on Coal, Coke, and Size Reduction,* **Dissertation for senior doctorate in applied science, University of Melbourne, 1970, papers 52 & 53, T. Miyazu, T. Takekawa and Y. Funabiki, 'The selection of coal and additives for the reduction of coke cost',** *Proceedings of McMaster Symposium No 8, Blast Furnance Coke Ouality, Cause* *and* ***Effect, May*** **1980, McMaster University, Hamilton, Ontario, Canada, pp ~1 to - 12.**

Table 3. Regression modelling of coking coal prices in Japan.

The work of the Canadian authors constitutes a considerable body published research on the characteristics of the Japanese coking c~ market. It is worthwhile reviewing the methodology used in such studies, and reexamining the Japanese coking coal market of 1977 using the coal prices and quality data only for hard coking coals.

Remodelling of Japanese fiscal year 1977 data

A listing of the coal quality and cost data used by Kittredge and Sivertson in their investigation of competition in Pacific markets in 1977 appears in Table 4 of their paper. The authors pooled coking coal price and quality data for all 36 brands of hard and soft coking coal imported bv the JSI in 1977 to generate the following' relationship:

56.398 + 0.488FC + 1.839FSI + 0.00034FLDY– 1.255A
(4.40)* (3.00) (2.57) (2.45)
- 13.729S – 1.38TM – 0.278T – 1.2147TRANS – 0.372PR
(2.16) (2.56) (1.84) (1.47) (1.71)*

**t* - values for H_0 (*t.05 = 1.69)*

where

P is fob price paid by the JSI in $US per long ton
FC is fixed carbon content
FSI is free swelling index
FLDY is Geiseler plasticity
A is % ash
S is % sulphur
TM is % total moisture (as shipped)
T is the contractual term in years
TRANS is the ocean shipping cost
PR is the mine labour productivity

All regression coefficients in this model are significant at at least the 10% level. The ability of the model equation to fit actual data as indicated by the coefficient of determination (R2 value) is 0.90, and the adjusted R2 value is 0.87. The F value for this model is F(g *26)* = 27.0, and the standard error of estimate is 3.32.

Asimilar regression model using only the brand data for US and Australian coals was then developed to predict fob prices for Canadian coals purchased by the JSI in 1977. It was found that predicted prices generated by this second model were close to the actual prices paid for the three brands of Canadian coal making up the bulk of imports. It was concluded that a competitive market situation existed, and that quality differences could account for the fob price differences between US, Australian and Canadian coking coals sold into Japanese markets in 1977.

There are difficulties with this analytical approach if the presence of price discrimination is an issue of interest. First, the authors included both hard and soft coking coal imported brands when developing the regression equations. Inclusion of only the imported soft coal data ignores the fact that high priced Japanese domestic coking coals (see Figure 2) made up some 35% of the soft coking coal used by the JSI in 1977, compared with the 38% of much lower priced soft coal from Australia, the largest foreign supplier of soft coking coal in that year. Inclusion of soft coking coals in a price model would then also require consideration of Japanese domestic soft coals, if we are attempting to develop a comprehensive price-quality model designed to cover the full spectrum of coal quality. However, information relating cif cost and coal quality for the seven individual brands of Japanese soft coking coal purchased is not available within the public domain.

This lack of data problem can be overcome if we consider only hard coking coals, which are also fully imported in the analysis. In such a respecified model for 1977, landed cost and coal quality data for 22 hard coking coals are available. The data consist of eight brands imported from the US, nine brands from Australia and five brands from Canada, which can be used from the study to examine cif cost and quality relationships for 1977.

Amodelling relationship with cif costs as dependent variable should not include all the independent variables used in the original Kittredge and Sivertson study. Coal moisture and ocean transport cost parameters are not required. The mine productivity term is of no relevance to the landed value of coal to the iron maker in a competitive market environment. As *ee swelling index (FSI) and Geiseler plasticity are different physical measurements of the caking characteristic, inclusion of both parameters is not warranted, particularly in the analysis of a hard coking coal market. Miyazu *et a/* indicate that log Geiseler plasticity is the caking related parameter used in brand evaluations by the JSI, so this caking related parameter will be used in the model.8 D'Cruz determined that quasi-integration is a statistically significant factor in determining fob coal price, so the contractual term T should also be included as an independent variable in the regression equation.9

The definite cif cost tiers appearing in Figure 1 suggest the possibility that differences might exist between the regression models for Australian and Canadian costs *vis-a-vis* the US coals imported by the JSI in 1977. This possibility can be investigated by performing Chow tests to determine whether pooling the Australian and Canadian coal data can be justified.'° The test results suggest that the nine Australian coal brands can be pooled with four of the five Canadian hard coals, but that the Smoky River Canadian brand should be treated separately. Chow tests also suggest that the eight US coal brands should be treated separately from the pool of nine Australian and four Canadian brands. Finally, a Chow test also demonstrates that the Smoky River brand is not significantly different from the US brands in these regression relationships.

Chow tests will also determine whether differences between linear egression equations are due to differing independent variable (or slope) coefficients, or different intercept values. The dummy variable approach of Gujarati together with Chow and F testing of the error sum of squares as constraints are removed, allows the determination of the source of difference between regression equations." Such tests show that the cause of the model difference between the pooled Australian and four lower-tier Canadian brands, and the US brands with Smoky River, is a result of different intercept values in each regression equation, or intercept shift. A regression equation for cif cost C, in which a dummy variable is

8 *Ibid,* **Miyazu** *et al.*

9 *0p cit,* **Ref 2, D'Cruz.**

10 **G.C. Chow, 'Tests of equalil sets of coefficients in two fin' signs', *Econometrica,* 1960, Vc pp 591-605.**

introduced to permit intercept shift to take place, is as follows:

C= 62.084 + 0.214FC + 0.028A-3.95S-0.108FY + 0.078T-19.703C1
(1.714)* (0.067) (0.667) (0.379) (0.532) (9.249)*

*t-value for Ho

where

C1, an intercept dummy variable, is 0 for the US and Smoky River coal brands, and l for the nine Australian and four lower-tier Canadian brands
FC is % fixed carbon on a dry ash free basis A is % ash
S is % sulphur
FY is log Geiseler plasticity
T is contractual term in years

This model has an R2 value of 0.9569, and an adjusted R2 value of 0.9396. The F value is F(6 ls) = 55.47, and the error sum of squares (ESS) is 78.3. The standard error of the estimate is 3.576. However, the significance of the coefficients of quality parameters raises a question as to the significance, at at least the 5% level, of any of the independent variables apart from the intercept shift dummy variable C1 in this model. F testing of the residual sum of squares as constraints are removed shows that, at at least the 5% level, C1 is the only significant independent variable. Therefore, the regression equation can be expressed as:

C= 74.45 - 17.87CI
(16.976)*

*t-value for HO

This model has an R2 value of 0.9351 and an adjusted R2 value of 0.9319. The F value for the model is F(l 20) = 288.2. The error sum of squares (ESS) is 117.8. The standard error of the model is 3.799 and of the C1 coefficient 1.053.
The coefficient of the dummy variable C1 (US$17.87 per long ton), provides a measure of the magnitude of producer surplus sacrificed by Australian and Canadian producers in their bilateral negotiations with the JSI *vis-d-vis* the acquisition cost of US hard coking coals. The fact that Smoky River, a Canadian underground mine, achieved a price in 1977 comparable with US coals, provides an example of the use of differential pricing as a buyer strategy to encourage additional production capacity; this has been an effective element of JSI acquisition strategy.
These results are consistent with the findings of Kittredge and Sivertson only in that Australian and most Canadian hard coals are shown to have consistent fob prices and cif costs (as ocean freight to
Japan is virtually identical from each source). A finding that Canadian oafs were receiving fob prices consistent with a competitive market is ~ot supported by the analysis, because of the tiered nature of the apanese market. All Australian and four of the Canadian hard coal ~rands are in fact US$17.87 per long ton lower

11 **D. Gujarati, 'Use of dummy variables testing for equality between sets of coefl cients in two linear regressions', TA** *American Statistician,* **February 1970, p** *50.*

in acquisition cost than vould be expected relative to US brands, and quality related characterstics are not significant as explanatory factors at least at the 5% level ~f significance. However, it is possible that 1977 was an unusual year. Analysis of coal quality and cif cost data for other years might better support a position that the persistent cif cost differentials illustrated in Figure 1 can be satisfactorily explained by differing quality related valuations of individual coal brands, as has been the position of Utah Development Company and other Australian coal exporters.~2

Cost and quality data for 19 hard coking coals imported by the JSI are available for fiscal year 1973 from Tex Coal Manuals of 1974 and 1975 *13* Eight Australian, four Canadian and seven US brands made up over 90% of hard coking coal imports in that year. This was also the final year of reasonable world energy price stability prior to the first oil shock, and the last year when demand for hard coking coals exceeded supply. Well defined cif cost differentials were already established between US and hard coals and Australian and Canadian hard coals by that time, so 1973 is a suitable year for reexamining the effects of JSI acquisition strategy on Pacific coking coal markets.

The regression analysis methodology used is the same as has been described in detail for 1977. Chow tests support the pooling of eight Australian with four Canadian hard coal brands. Again F tests show that US coals are structurally different due to intercept shift. From a *priori* expectations, the regression equation for cif cost C is:

$$C=29.798+\underset{(0.682)^*}{0.064FC}+\underset{(1.549)}{0.641A}-\underset{(1.717)}{8.199S}-\underset{(0.951)}{0.234FY}+\underset{(1.761)}{0.221T}-\underset{(8.164)^*}{15.063C1}$$

* t-values for Ho

where C_1, an intercept shift dummy variable, is 0 for US coals, and 1 for Australian and Canadian coals. Other symbols are as previously defined.

In a rising price environment, as was the case in 1973, we should anticipate the sign of the coefficient of T to be negative rather than positive, as quasi-integration would be expected to restrain cif cost increases. Likewise, the signs of coefficients for ash and fluidity do not accord with a *priori* directional expectations. This model has an F value of $F(6\ 12) = 35.27$, an $R2$ value of 0.9463, and an adjusted $R2$ value of 0.9195. The standard error is 5.842 and ESS = 30.4. Again, F testing at at least the 5% level of significance shows the only independent variable of significance to be C1. The model is then:

$$C= 33.933 - \underset{(11.105)^*}{10.61CI}$$

* *t*-value for Ho

This model has an R2 value of 0.8789 and an adjusted R2 value of 0.8717. The F value for the model is $F(l\ 17) = 123.3$, and ESS = 68.5. The standard error of the model is 7.373, and of the C1 coefficient, 0.955. As in 1977, a dummy variable permitting

12Utah Development Company's submission to Senate Standing Committee on Trade and Commerce (July 1982), *Enquiry into Australia's Export Coal*

*Industry, Sec*tion 5, 'Coking coal pricing policies', p 85. '3H. Horie, ed, *Coal Manual*, The Tex Publishing Company, Tokyo, 1969-91.

intercept shift is the only significant independent variable at at least the 5% level of significance. Again, the result indicates significant influence of buyer power in establishing the cif cost of imported coking coals. Australian and Canadian exporters appear to have given up US$10.61 per tonne in producer surplus relative to US coking coals in the various bilateral bargaining processes which established actual cif costs in 1973.

In 1988 Japanese pig iron production again rose to levels close to these of 1977. Hard coal quality and cif cost data for 6 US brands, 14 Australian brands and 9 Canadian brands are available from the Tex Coal Manuals of 1989 and 1990 for Japanese fiscal year 1988. Crosssectional cif cost modelling for this year can also be performed.

Again, the regression analysis methodology used is that already described in detail for 1977. Chow testing supports the pooling of 14 Australian with 5 of the lower priced Canadian hard coal brands. Interestingly, a Chow test for the situation of limited degrees of freedom now shows that Smoky River coal, which was not significantly different from US brands in 1977, is now not significantly different from Balmer, Luscar and Fording River, the lower-tier Canadian brands, and the Australian brands. Chow and F tests suggest that US coals are significantly different from Australian and lower-tier Canadian coals in the intercept value, and that Gregg River and Line Creck, two newer Canadian mines, should be pooled with the US brands. Chow and F tests also suggest that Quintette and Bullmoose, the two high cost, open cut mines in north-eastern British Columbia, are significantly different from the other Canadian mines and US mines, due to intercept shift. From a *priori* expectations, and the results of these Chow and F tests just described, the regression equation for cif cost C can be derived as follows:

C = 55.36 + 0.154FC-0.076A - 7.399S + 0.109T + 0.576FY
(1.190)* (0.183) (2.83) (1.253) (2.352)
- 10.738C1 + 27.391C2
(9.981) (15.341)*

* t-values for Ho

where C1 is 0 for US brands and upper tier Canadian brands, and 1 for Australian brands and lower-tier Canadian brands; C2 is 1 for Quintette and Bullmoose and O for all other brands. All other symbols are as previously defined.

This model has an R2 value of 0.9738 and an adjusted R2 value of 0.965. The F value for the model is F(79*21)* = 111.3, and the ESS = 79.1. The standard error for the model is 3.236. As has been the case for other years, F testing at at least the 5% level of significance shows the independent variables of significance to be C1 and C2. The model is then:

C = 64.24 - 9.58C1 + 28.97C2
(10.506)* (16.932)*

*t-values for Ho

This model has an R2 value of 0.9596 and an adjusted R2 value of 0.9565. The F value for the model is F(2 26' = 308.7, and the ESS = 121.8. The standard error of the regression is 3.609, of the C1 coefficient 0.912 and of the C2 coefficient 1.711. The result again supports the

Figure 3. Major suppliers of hard coking coal to Japan (million tonnes per fiscal year).

visual evidence of Figure 1, with intercept shift account for cif cost differences at at least the 5% level of significance.

Quality differences have not been statistically significant in determining the value of these coals to Japanese iron makers at at least the 5% level of significance for the three years examined here. Analysis of cost and quality data for the years 1978 and 1983 yields similar findings. It seems possible that for the span of 26 years (1963 to 1989), Australia's hard coking coals have had lower cif costs to the JSI relative to US hard coals and some Canadian hard coals than would be expected, as a consequence of JSI acquisition policies which have biased the outcome of the bilateral bargaining process.

Steel manufacturing is a basic industry, which of necessity had to be internationally competitive in order for Japan to achieve its policy objectives relating to the export growth of high value-added manufactures. Therefore, if a premium is paid for a substantial volume of a key input from one country source, this must be offset by lower cost inputs from some other major suppliers for the JSI to remain internationally competitive. Australia appears to have played this necessary role as the low cost supplier of hard coking coals.

Supply diversification strategies

Success in eliciting low cost hard coal supplies from both Australia and Canada enabled the JSI to achieve other key elements of Japanese acquisition policy with respect to steel manufacture. These objectives were to diversify supplies of steel commodity inputs, and reduce reliance on the USA for coking coal supplies. The degree of success in achieving such supply diversification as far as hard coking coal is concerned is well illustrated in Figure 3. When viewed in conjunction with Figures 1 and 2 showing imported coking coal cif costs, the trends of import volume from the three major world suppliers of coking coals reveal the success of JSI's supplier diversification policy.

In the decade from 1963 to 1973, Japan's pig iron production grew at an average annual growth rate of 15.95%. As the reality of continuing high growth rates became accepted by the JSI in the late 1950s, a strenuous effort was made to reduce reliance on the USA as sole supplier of hard coking coals. Prior to 1960 only small quantities of New South Wales (NSW) south coast hard coals had been imported, beginning in the mid-19SOs. Rapid growth of Australian imports between 1963 and 1965 came from an expansion of NSW supplies from existing mines, which increased from 535 000 long tons in 1959-60 (Australian financial year) to ~ 874 0()() long tons in 1964-65. But also, and more importantly, in 19(31 the Moura mine in Queensland was commissioned.

The JSI's acquisition strategy in Queensland

Moura was a large development whose total output was committed to the Japanese market. The original long-term contract was signed for 2.88 million tons annually, and this contract was instrumental in consolidating the low price regime which exists to this day for Australian hard coking coals in the Japanese market.

The rapid growth which then occurred in Australian hard coal exports was due to the commissioning of five new Utah operated mines in Central Queensland from 1967 to 1976. These new mines were committed to long-term supply contracts with the JSI, and prices were based on the Moura precedent. These capacity additions, amounting to some 17 million tonnes annually, far exceeded Japan's increased imports of Queensland's hard coking coals, which amounted to only 11 million tonnes annually over that same period. Lack of expansion of pig iron production and growth in demand for hard coking coals were not the reasons why the Queensland capacity additions exceeded Japanese imports. This outcome was a result of the initiation of a large expansion in western Canadian hard coking coal export capacity in the same time frame as Queensland's expansions.

The JSI's acquisition strategy in Canada

In 1968, a Canadian contract was signed for 15 years' supply of hard coking coal at an annual rate of 5 million long tons per year. This contract resulted in the expansion of the small underground Balmer mine to a large-scale open pit operation of 5 million tonnes annual capacity in 1970. Additional contracts were concluded soon after, resulting in the opening of the Fording River and Luscar mines. All three Canadian mines were large-scale, open cut operations producing hard coking coals of a quality very similar to Queensland's coking coals.

As was the case with Moura for Australian hard coals, the Balmer contract established the precedent of low average cif costs for all Canadian hard coking coals with the exception of Smoky River. This sequence of contractual arrangements leading to new mine developments in Queensland in the late 1960s, and Canada in the early 1970s, explains to a great extent the similarity of cif cost trends for coals *om these sources. The Chow tests for 1973, 1977 and 1988 have confirmed the close relationship for these early projects.

Afurther expansion of Canadian capacity occurred from 1982 to 1984 with the opening of open cut mines the Line Creek, Greenhills and Gregg River, and finally the north-east British Columbian projects of Quintette and Bullmoose. However, do the import trends of Figure 3, which show the significant growth of Canadian supplies, provide evidence of market distortion due to the purchasing power of the JSI, or rather reflect the legitimate need for supply diversity?

Japan's need for supply diversity

Supply diversity is certainly an important issue for an industry having significant economies of scale situated in a country like Japan, which lacks most of the resource commodity inputs required to support an internationally competitive steel industry. A shipping industry capable of efficiently transporting the large quantities of iron ore and coal imports over great distances was fundamental to attaining internationally competitive resource input costs for Japan's steel industry. An important outcome of the ocean shipping element of Japanese industrial policy was the ability of the JSI to control the ocean transport component of delivered cost. By contracting on an fob basis rather than cif, as was the case for both Australian and Canadian coking coal purchases, Japanese interests were able to influence the distribution of locational rents associated with shorter ocean haul distances from Australian and western Canadian coal export terminals to Japan (4400 nautical miles) versus the much longer distance from Norfolk Virginia in the USA (9400 nautical miles).

Demand distortion in Japanese coking coal markets

Until 1978 the displacement of the USA as a high cost supplier by both Australia and Canada as lower cost suppliers, as illustrated in the trends of Figure 3, is consistent with competitive market behaviour. From 1978 on, the pattern of imports does not correspond with such behaviour, were the JSI acting as an input cost minimizing industry. US imports rose above 10 million tonnes annually from 1979 to 1984, despite the availability of much lower cost Australian hard coals. Additional export capacity of 5 million tonnes annually was added in 1981 in Queensland as a result of the commissioning of the Gregory and Norich Park mines, and annual rates of Japanese and EC pig iron production continued the declining trend which had commenced in 1973.

Since 1983 Canadian imports have risen, while both US and Australian imports have declined. These patterns have evolved despite the fact that Australia has been the lowest cost supplier throughout the period, and Canada has now displaced the USA as the highest average cost supplier. Such behaviour is not in accord with that of a competitive market situation.

An implication which could be drawn from examining these import trends is that the JSI has had a policy of limiting reliance on Australian coking coal imports to some ceiling quota or market share, irrespective of the cost competitiveness of Australian sourced coals. Factors which might cause the JSI to increase or maintain higher cost imports from Canada and the USA rather than increase lower cost shipments from Australia could be:

· concern over concentrations of supply-side monopoly power within Australia's coal export industry;

· the need for supply diversification to reduce the risk of supply disruption;

ownership issues (oligopoly power of suppl~ers); bilateral balance of trade pressures, particularly with the USA; and

contractual obligations, particularly when Japanese financial interests have high stakes in the projects.

Any one or all of these reasons could explain the JSI's reluctance to permit coking coal imports from Australia to exceed an apparent ceiling irrespective of cif cost.

Conclusions

The public positions *of* mine operators within Australia's export coal industry reflect the view that market forces function adequately in the Pacific coking coal trade. In reality, few of the conditions necessary for ideal competitive markets exist. The JSI's purchasing strategy, which is designed to prevent excessive reliance on purchases from any one country, is a trade restriction which conflicts with the cost minimization interests of individual firms, and prevents the formation of competitive markets on the demand side. The contractual and purchasing strategies which were used to initiate mining developments in Queensland and western Canada appear to have resulted in destructive competition between firms, state governments and the two supplier nations. Coking coal is not a homogeneous commodity and different brands should exhibit price and quality relationships which modelling fails to demonstrate. The substantial transport component of delivered cost creates a situation of bilateral monopoly bargaining over the distribution of locational rents. A situation of knowledge asymmetry has also existed, where Japanese trading companies with minority interests in coal projects have been able to provide marginal production cost information to JSI negotiators for use in contract bargaining. Negotiators for the coal producers have lacked such detailed knowledge of the worth of their coals to the JSI. Finally, the collective influence of these elements of acquisition strategy has resulted in the tiered nature of the cif cost in Japanese coking coal markets, so evident in Figure 1.

Over the 27 year duration of this study some 318 million tonnes of US, 365 million tonnes of Australian, and 213 million tonnes of Canadian hard coking coals have been imported by the JSI. The average acquisition cost of these coals has been US$76.98 (in constant 1987 dollars). The average cif cost of US coal was US$89.42 per tonne. Australian and Canadian hard coals were acquired for US$67.03 and US$75.93 per tonne respectively. The finding that coal quality differences have not been significant in explaining such low Australian cif costs permits an estimate of the producer surplus lost in bilateral bargaining with the JSI as a consequence of the distortionary effects of acquisition strategies over the years. This amount can be roughly estimated at US$3.6 billion (calculated as US$76.98-67.03 (in 1987 dollars) times 365 million tonnes), or approximately A$5.5 billion in current A$ terms. Such a total represents a substantial diversion of producer surplus from the Australian economy, and particularly from Queensland, which has been the major Australian exporter of hard coking coals. Preliminary cif cost and import quantity data for

JFY1990 indicate the diversion of an additional $A200 million of Australia's coking coal producer surplus as a result of JSI acquisition strategies that year.

Japan's successful use of a coordinated resource acquisition policy for its steel industry, and its large and growing surpluses from elaborately transformed manufactures, are increasing the pressure on world trade, and the likelihood of formation of restrictive regional blocs. This outcome is partially due to a failure by policy makers in resource exporting countries to recognize the limitations of simplistic competitive market theory in real situations of international trade. Departures from ideal first best economic situations require the adoption of second best policies to restore a measure of Paretian efficiency between producers and consumers. This study indicates that Pacific metallurgical coal markets have suffered significant distortion as a result of the resource procurement strategies of the Japanese steel industry establishment.