COMMODITY REPORT

Demand for coking coal: implications for suppliers to the Japanese market

By David L Anderson

The relative stagnation of the world steel industry has significantly changed the structure of a number of mineral industries supplying raw materials to the steel industry, notably iron ore and coking coal.
In this article David L Anderson looks at developments in the coking coal industry, with special reference to Japan, which is a major importer of coking coal and an important actor in the market.

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Introduction

The purpose of this paper is to outline changes in the demand for coking coal in the Japanese market. The resulting impact on prospective suppliers, particularly those based in Australia and Canada, is also discussed. The paper is divided into several sections. After a brief discussion of the historical development of the steel industry since World War II, the paper focusses on price and quantity trends in the coking coal industry. This is followed by a review of future demand estimates and an analysis of the influence of quality characteristics on individual suppliers. In Section five, the potential for technological change in the steel-making process is discussed with particular emphasis placed on the substitution of non-coking for coking coals. The following section explores, albeit briefly, the underlying cost structures of the major participants in the Japanese market. The paper concludes with a review of the major findings.

Coking coal is that coal which is suitable for use in the *blast furnaces* (BF) of the integrated steel industry. It is employed to produce coke which, in turn, is used to support the blast furnace charge and to generate the heat and gases necessary to produce pig iron. The demand for coking coal is therefore derived from the demand for steel products. Between 1946 and 1979, world-wide steel production rose from 112 to 747 Mt. The industry then entered a period of relative stagnation from which it displays few signs of recovery. This situation was undoubtedly caused, in part, by the macro-economic effects of the oil shocks of the 1970s; however, other factors, of a long-term nature,

Table 1

Coking coal imports 1963—1984 (in Mt)

	1963	1973	1979	1980	1981	1982	1983	1984[a]
Japan	9.3	55.9	56.1	61.8	65.3	64.1	59.7	69.3
EEC	38.1	32.7	30.8	32.9	31.0	29.6	23.9	32.5
Other West Europe	3.8	9.2	11.8	11.9	11.8	12.7	11.9	12.0
CPE[b]: Europe	10.7	7.8	9.0	9.6	9.2	9.3	10.9	11.3
Asia, excl Japan	0.6	0.6	5.9	6.0	8.8	10.4	10.3	10.9
Latin America	2.3	3.3	6.3	6.3	5.4	6.1	7.3	9.3
Canada	4.5	7.0	6.9	5.7	5.3	4.4	6.3	7.0
Africa/Mid East	0.6	0.6	1.3	1.9	1.9	2.1	1.8	na
CPE: Asia	0.0	0.0	1.5	1.4	1.4	1.3	1.2	na
Total	**69.9**	**117.1**	**129.6**	**137.5**	**140.1**	**140.0**	**133.3**	**155.8**

Notes:

[a]Total "other" imports total 3.5 Mt.

[b]Centrally Planned Economies.

Source:
Derived from Vincent Calarco, *World Coal Outlook: A Reassessment,* Chase Manhattan, April 1985, p 52; and Vincent Calarco, *The Coal Situation,* Chase Manhattan Bank, vol 5, no 2, March 1985.

were also at work.[1] For instance, as the economies of the industrialized nations approached advanced stages of maturity, the need for infrastructure investment, which is highly steel-intensive, declined in a slow but inexorable manner. Furthermore, the oil shocks led to the development of smaller scale products in order to increase energy efficiency — the so-called downsizing effect. Finally, the search for light-weight products also lead to the increasing use of substitutes such as plastics and aluminium.

Of particular relevance to this study is the phenomenal growth of the Japanese steel industry since the end of WWII.[2] In 1946, Japan produced a mere 0.6 Mt of crude steel; in 1973, its output reached 119.3 Mt[3] — a figure exceeded only by the USA and the USSR. Although Japan has never again matched her 1973 output, it has nevertheless improved her relative ranking and is now the world's second largest producer, trailing only the USSR. This is a remarkable feat for a nation which must import virtually all of its primary steel inputs, including approximately 90 per cent of her coking coal requirements. Not surprisingly, as shown in Table 1, Japan has become the world's largest importer of coking coal; in recent years, it accounts for approximately 45 per cent of total world seaborne trade.

From 1947 until 1972, the US was the leading supplier of coking coal to the *Japanese steel mills* (JSM).[4] Since then, as reported in Table 2, Australia has assumed first place, supplying between 40 and 45 per cent of the JSM's requirements. On the other hand, the proportion captured by US suppliers has declined from around 50 per cent to less than 25 per cent. Equally relevant to this study is the fact that Canada has also become an important supplier to Japan, its market share over the 1973—1983 period being in the order of 15—20 per cent. Furthermore, in 1984 Canadian coking coal exports to Japan nearly equalled the total for the USA.

Production, exports and prices

Although coal, of all types, is found throughout the world, approximately 80 per cent of the geological resources and 55 per cent of economically recoverable reserves are to be found in three nations: China, USA and USSR.[5] The reserves of Australia and Canada are relatively small, but they rank fourth and fifth in the former category and seventh and eight in the latter classification, respec-

Table 2

Market shares by major coking coal suppliers to the Japanese steel mills 1969—1984[a] (per cent)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984[b]
Australia	38	31	38	42	41	35	37	43	45	46	47	40	41	43	45	40
United States	49	53	39	32	33	42	37	30	24	20	25	33	37	33	26	24
Canada	2	9	15	18	18	15	19	17	19	22	17	17	14	15	19	22
South Africa	—	—	—	—	—	—	—	2	5	5	5	5	5	5	6	7
China	—	—	—	—	—	—	—	—	—	1	1	1	2	2	2	3
USSR	8	5	5	5	5	5	5	5	5	4	3	3	1	2	2	3
Poland	3	2	3	2	2	2	2	2	1	1	1	1	—	—	—	—
Other	—	—	—	—	—	—	1	1	1	1	1	—	—	—	—	1

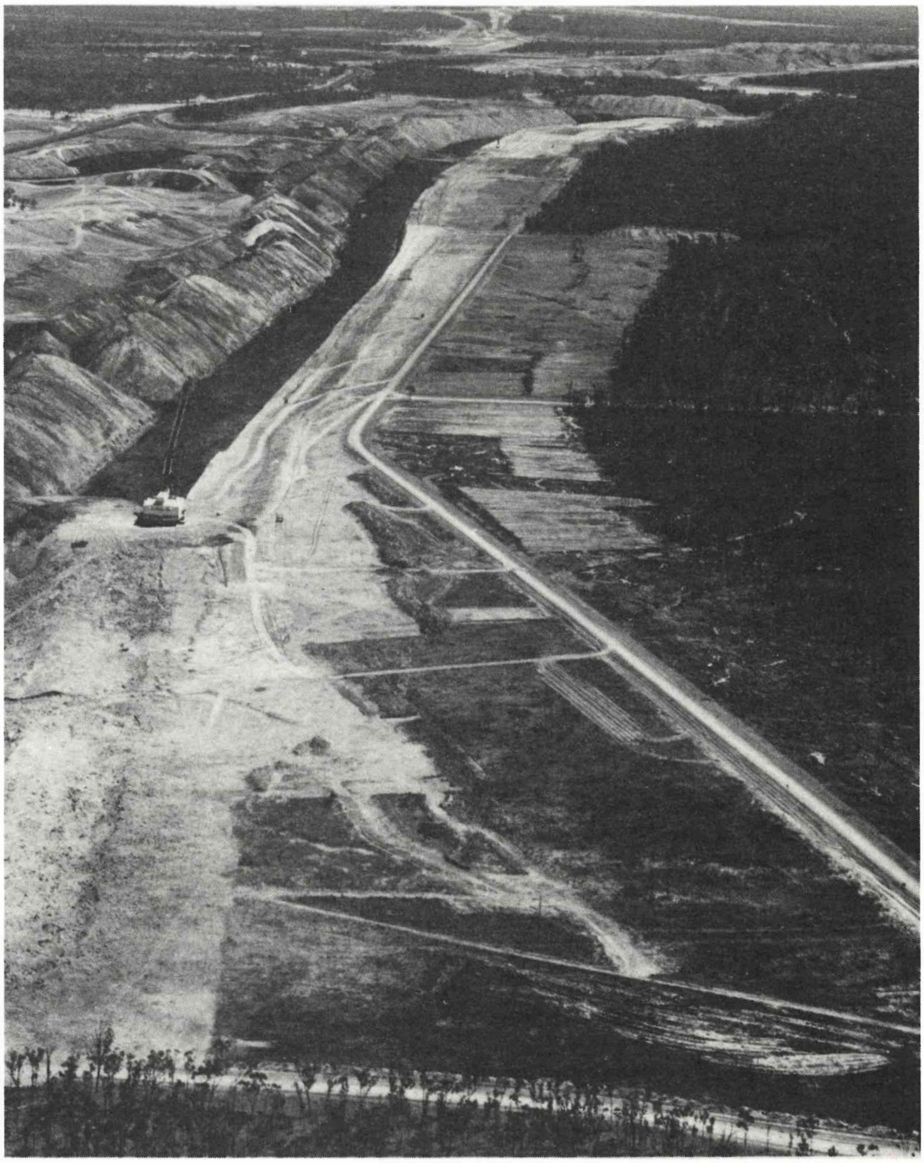
Notes:

[a] Totals may not add due to rounding.

[b] Based on six months acitivity, January—June 1984 (*Coal Manual* 1985, p 68).

Source:
Derived from *Coal Manual* (Tokyo: Tex Report, 1985), p 27.

In a relatively short time Australia has emerged as a major supplier of many minerals. In coking coal it is challenging the US as the world's leading exporter. Photo from open-cut mining in Peak Downs in central Queensland. The mine is controlled by BHP and production exported to Japan and Europe.



tively. However, because of their small populations Canada and Australia have surplus reserves and are important exporters.

Steaming and coking coal is also produced in many other nations, although much of it is used domestically for thermal purposes. The dominant producers are the USA, USSR, and China; they are followed, albeit at a considerable distance, by Poland, UK, India, South Africa and Australia. All of those nations produced in excess of 100 Mt in 1983. Canada ranked ninth in that year, producing 45 Mt.

The relative rankings associated with the export trade are quite different. Based on 1983 data, Canada is in sixth position behind the USA, Australia, Poland, South Africa, and the USSR. It should also be noted that the world export trade generally accounts for approximately 10 per cent of global production. The focal point of this study is the coking coal trade. From Table 3, it is apparent that this sub-set of the total market is highly concentrated with the two leading exporters, the USA and Australia, accounting for 65 per cent of total activity in 1983. Canada is the third largest exporter of coking coal and in 1983 supplied 10 per cent of coking coal exports.

Although the US is an important exporter, its sales have declined continuously since 1981. This is attributable to high production costs, exacerbated by the recent appreciation of the US dollar vis-à-vis its competitors, and long hauls to the Asian market.[6] On the other hand, US producers have guaranteed access to a large, albeit declining, domestic market, and their remaining sales are broadly dispersed throughout the non-socialist world. The latter point requires emphasis. In 1982, the US exported 58 per cent of its coking coal production; comparable figures for Australia and Canada are 78 and 92 per cent, respectively.[7] The corresponding estimates of the ratio of sales to Japan to total exports are 35, 69 and 72 per cent.

Table 3

Coking coal exports 1963—1984 (in Mt)

	1963	1973	1979	1980	1981	1982	1983	1984
United States	35.9	39.0	45.5	57.3	59.2	56.7	45.5	51.7
Australia	3.1	28.1	34.7	33.9	40.8	37.0	42.1	47.0
Canada	0.8	10.7	12.7	14.1	13.6	13.0	14.5	22.1
Poland	3.5	10.0	9.4	6.2	3.7	7.0	9.7	10.5
USSR	12.4	13.8	11.2	11.7	9.8	9.6	7.7	7.2
West Germany	13.9	10.5	8.6	6.9	7.8	6.5	6.7	6.8
South Africa	0.0	0.1	2.3	3.4	3.3	3.4	3.0	5.0
China (PR)	2.4	2.5	2.5	2.6	3.3	3.4	3.3	2.9
Others	0.0	3.0	0.8	2.5	2.8	2.8	2.6	2.6
Total	**72.3**	**117.7**	**127.8**	**138.7**	**144.9**	**139.6**	**135.3**	**155.8**

Source:
Derived from Vincent Calarco Jr, *World Coal Outlook: A Reassessment,* Chase Manhattan, April 1985, p 52; and Vincent Calarco, *The Coal Situation,* Chase Manhattan Bank, vol 5, no 2, March 1985.

The high dependency on the Japanese market is a distinguishing feature of the Australian and Canadian coking coal industry. In recent years, however, as shown in Tables 4 and 5, both countries have somewhat succeeded in capturing new markets. Nevertheless, in 1985, Canadian sales to the JSM are expected to once again exceed 80 per cent of total Canadian exports. This outcome is attributable to the opening of two new mines in northeast British Columbia which are dedicated to serving JSM.

As shown in Tables 6 and 7, coking coal prices rose rapidly after the 1973 energy crisis and, in real terms, remained relatively firm until the late 1970s.[8] Since then they have declined; in fact, they even fell in nominal terms from 1982 to 1985. Nevertheless, in real terms, present day prices are still

Table 4

Australia: Metallurgical coal exports 1970—1983[a]
(in Mt)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Japan	16.5	16.5	20.3	25.2	23.0	23.0	25.1	26.6	23.6	25.6	25.6	28.6	25.7	28.1
Europe	1.2	3.2	3.2	2.8	4.7	6.1	5.6	7.8	6.0	4.9	4.3	5.7	4.0	6.3
South Korea	—	—	—	0.4	0.6	0.6	1.0	1.1	1.2	2.1	2.3	3.5	3.8	3.4
Other	0.6	0.5	0.1	—	0.4	0.5	0.2	0.4	0.3	1.0	0.6	1.2	2.1	2.2
Taiwan	0.1	—	—	0.1	0.4	1.0	0.1	0.5	0.9	1.0	0.7	0.8	1.5	2.1
Total	**18.3**	**20.1**	**23.5**	**28.5**	**29.2**	**30.4**	**31.9**	**36.3**	**32.0**	**34.7**	**33.5**	**39.9**	**37.1**	**42.1**

Note:

[a] Statistics prior to 1978 include steaming coal exports. The total quantity of thermal coal exported over the interval 1970 to 1977 (in million metric tons) was as follows: 1.4; 2.7; 0.9; 0.1; 2.7; 3.4; 2.9; 3.7. (See *black coal in Australia 1982—83*, p 81).

Source:

Joint Coal Board, *Black Coal in Australia* (Sydney: Joint Coal Board, various years); and Australia, Department of Trade and Resources, *Inquiry into the Australian Export Coal Industry*, Submission to the Senate Standing Committee on Trade and Commerce, Canberra, September 1982, p 40.

Table 5

Canada: Metallurgical coal exports 1970—1983[a]
(in Mt)

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
Japan	3.75	6.73	7.56	10.65	9.97	10.76	10.60	10.64	10.87	10.58	10.80	9.40	9.42	10.15
South Korea	—	—	—	—	0.03	—	0.35	0.26	0.56	0.89	1.30	1.85	1.85	1.88
Latin America	—	—	0.10	0.10	0.02	—	0.05	0.21	0.64	0.53	0.84	1.47	1.47	1.14
Europe	0.12	0.20	0.07	0.01	0.39	0.82	0.74	1.21	1.48	1.24	0.70	0.58	0.58	0.74
Taiwan	—	—	—	—	—	—	—	—	0.03	0.06	0.21	0.31	0.31	0.52
Other	0.12	0.10	0.01	0.17	0.36	0.11	0.02	—	0.05	0.36	0.29	0.25	0.25	0.14
Total	**3.99**	**7.03**	**7.74**	**10.93**	**10.77**	**11.69**	**11.76**	**12.32**	**13.63**	**13.66**	**14.14**	**13.86**	**13.03**	**14.57**

Note:

[a] Statistics prior to 1980 include steaming coal exports. Although the exact figure are unavailable, discussions with industry officials suggest that it is unlikely that thermal coal exports accounted for more than 5 per cent of total coal exports prior to 1980.

Source:

Derived from Statistics Canada, *Coal Mines*, Cat No 26—206, various years.

substantially above their pre-1974 levels. Although the data presented are expressed in US dollars and incorporate ocean transport costs to Japan, they are nonetheless representative of *FOB port* (FOBT) domestic currency prices received by Australian and Canadian suppliers.

Demand forecasts

Despite the fact that estimates of future coking coal utilization abound, I have chosen to focus primarily on the work of Calarco. This decision is based on two important factors: his estimates appear to be generally consistent with those of many other forecasts;[9] and he has published estimates based on a consistent set of underlying assumptions for every stage of the steel-making process.

Let us start at the end of the process, the production of crude steel, and work back to the derived demand for metallurgical coal. It can be seen from Table 8, that Calarco expects raw steel production to increase only modestly over the 1985—2000 period; although regional variations exist, the global estimate is only 0.7 per cent per annum. Note that Japanese production is expected to decline, as is output in Europe and the USA. On the other hand, substantial growth is predicted for the newly industrialized countries (NICs), namely Korea, Taiwan, and several Latin American nations.

After adjusting for expected changes in the coke rate[10] and the mini-mills/BOF ratio, Calarco forecasts that the global demand for coking coal imports can also be expected to grow by 0.7 per cent per year over the next 15 years. Furthermore, his country and region-specific estimates closely parallel those for raw steel production. In particular, note that Japanese requirements are expected to decline marginally over the interval, while those in Korea, Taiwan and Latin America are anticipated to exhibit rapid growth.[11]

Table 6

Average prices paid by Japanese steel mills for coking coal imports 1969—1983
(CIF, current USD/t)

Fiscal year	USA	Australia	Canada	USSR	Poland	South Africa	China	Average
1969	19.51	13.60	15.72	14.48	15.88	—	—	16.69
1970	26.26	15.42	16.60	15.75	16.92	—	—	21.32
1971	27.47	16.07	20.04	18.37	22.09	—	11.76	21.36
1972	28.88	17.46	21.07	19.52	24.42	17.28	—	21.97
1973	33.42	21.48	22.88	21.29	25.94	19.31	—	25.64
1974	74.45	32.87	35.20	39.49	44.83	40.47	—	50.99
1975	70.22	44.02	54.03	53.87	60.41	44.89	—	56.16
1976	70.41	51.91	60.58	55.52	61.61	42.06	—	59.09
1977	72.37	54.06	58.80	54.94	61.19	42.73	—	59.06
1978	73.10	57.11	57.38	55.17	59.84	44.31	49.66	59.87
1979	76.51	56.53	58.69	53.92	58.69	48.00	51.25	61.51
1980	81.41	60.74	62.39	59.12	61.27	53.51	56.94	67.24
1981	83.85	67.03	65.83	67.48	63.76	66.66	67.68	72.93
1982	84.71	68.71	73.41	70.91	—	67.93	67.33	74.50
1983	76.24	60.84	69.07	56.12	—	54.61	53.28	65.40

Source:
Coal Manual 1985 (Tokyo: Tex Report, 1985), p 28.

Table 7

Average price paid by Japanese steel mills for coking coal imports 1969—1983
(CIF, constant 1983 USD/t)[a]

Fiscal year	USA	Australia	Canada	USSR	Poland	South Africa	China	Average
1969	52.87	36.86	42.60	39.24	43.03	—	—	45.23
1970	67.22	39.47	42.50	40.32	43.32	—	—	54.58
1971	67.30	39.37	49.10	45.01	54.12	—	28.81	52.33
1972	68.45	41.38	49.94	46.26	57.88	40.95	—	52.07
1973	74.52	47.90	51.02	47.48	57.85	43.06	—	57.18
1974	149.64	66.07	70.75	79.37	90.11	81.34	—	102.49
1975	129.20	80.99	99.41	99.12	111.15	82.50	—	103.33
1976	122.51	90.32	105.41	96.60	107.20	73.18	—	102.82
1977	118.69	88.66	96.43	90.10	100.35	70.07	—	96.85
1978	111.11	86.80	87.22	83.86	90.96	67.35	75.48	91.00
1979	104.81	77.45	80.41	73.87	80.40	65.76	70.21	84.27
1980	97.69	72.89	74.86	70.95	73.52	64.21	68.33	80.69
1981	91.40	73.06	71.75	73.55	69.50	72.66	73.77	79.49
1982	87.25	70.77	75.61	73.04	—	69.97	69.35	76.74
1983	76.24	60.84	69.07	56.12	—	54.61	53.28	65.40

Notes:
[a]Converted to constant dollars using the US CPI. See OECD, *Main Economic Indicators: Historical Statistics 1964—1983* (Paris: OECD, 1984).

Source:
Derived from Table 6.

Table 8

World raw steel production: 1983—2000
(in Mt)

	1983	Forecast 1985	1990	1995	2000	growth rate per year %[a]
CPE[b]: Europe	211.2	213.5	213.1	207.8	199.0	—0.5
Western Europe	143.6	151.0	146.2	141.6	135.2	—0.7
Japan	97.2	104.4	104.4	101.8	99.3	—0.3
CPE[b]: Asia	45.7	48.9	62.4	78.9	97.6	4.7
United States	76.8	81.9	79.9	77.8	76.0	—0.5
Latin America	28.9	33.6	43.2	52.0	61.6	4.1
Other Asia	29.8	33.6	42.7	50.9	59.0	3.8
Africa/Middle East	12.2	14.9	20.5	24.1	28.1	4.3
Canada	12.7	14.5	14.2	13.4	12.4	—1.0
Other Asia/New Zealand	5.8	6.8	7.4	7.5	7.5	0.3
World Total	**663.9**	**703.1**	**734.0**	**755.8**	**775.7**	**0.7**

Notes:

[a] Annual compound growth rate over the period 1985—2000.

[b] Centrally planned economies.

Sources:
Derived from Vincent Calarco Jr, *World Coal Outlook: A Reassessment,* Chase Manhattan, April 1985, p 94.

Table 9

World seaborne coking coal exports: 1983—2000
(in Mt)

	1983	1985	Forecast 1990	1995	2000	1985—2000 compound growth rates %/year
Australia	42.1	45.4	49.9	52.8	52.4	1.0
United States	39.0	40.8	43.6	46.7	46.3	0.8
Canada	14.5	22.0	24.8	25.0	25.9	1.1
Poland/USSR	7.6	11.4	12.3	10.9	12.3	0.5
PRC	1.9	2.4	3.6	4.2	5.0	5.0
South Africa	3.0	4.6	4.9	4.8	4.6	0.0
Others	3.9	2.3	1.8	1.6	1.6	—2.4
Colombia	0.0	0.3	0.5	0.7	1.0	8.4
Total	**112.0**	**129.2**	**141.5**	**146.9**	**149.1**	**1.0**

Source:
Derived from Vincent Calarco Jr, *World Coal Outlook: A Reassessment* Chase Manhattan, April 1985, p 115.

Country specific forecasts of sea-borne exports should be treated with caution; indeed, it is in this area that the available data shows the most variation.[12] In particular, the future performance of US and Australian exporters appears to generate widely differing estimates. Despite this note of caution, I shall continue to restrict the discussion to Calarco's forecast as reported in Table 9. Note that he expects sea-borne trade to increase at an average rate of 1 per cent per annum. Furthermore, he anticipates virtually no change in market shares among the major exporters. Indeed, Colombia is foreseen as the only new entrant, and its output is more than offset by a decline in off-shore sales by the existing fringe producers.

In summary, the estimate presented above are based on one source only — the work of Calarco. However, with the exception of country-specific export projections, his estimates are quite similar to these generated by a number of other respected forecasters. Nevertheless, it must be admitted that safety of numbers does not guarantee accuracy. Indeed, a world-wide economic recovery would render these consensus estimates too low; alternatively, possible implementation of new technologies would result in a radical reduction in future coking coal demand. It is towards an examination of the latter possibility that I now turn my attention; first, however, I must digress and briefly discuss selected coal quality issues.

Coal quality

The most commonly employed classification system "ranks" coal in descending order of desirability from anthracite to lignite. This scheme focusses on two characteristics: *fixed carbon content* (FC) and heat value. However, for purposes of steel-making the coal must also possess special characteristics called coking properties, that will allow the coal to be converted into a coke suitable

The world's largest coke oven battery was handed over by Krupp Koppers GmbH to Mannesmannröhrenwerken AG in October 1985. It will cover an important part of West Germany's consumption of coking coal.

for use in modern large blast furnaces. Only bituminous coal possesses sufficient carbon content and the other properties necessary to form coke. Among the latter properties are: *volatile matter* (VOL), *moisture* (MOIST), *sulphur* (SUL), *ash* (ASH), which is the inert material contained in the coal, and the coking properties (CK).[13]

The price of coking coal is said to be negatively related to the presence of moisture, sulphur and ash. Alternatively, it is positively related to a coal's fixed carbon content; this follows from the fact that the higher the proportion of FC in a unit of coal, the lower the quantity of coal required to produce a unit of coke, and to the *crucible swell number* (CSN) and to the fluidity, which are indicators of the coal's coking ability.[14] At this point, it should be noted that the steel industry normally broadly classifies coal on the basis of its volatile matter rather than its fixed carbon content. Although this may be confusing to those outside the industry, the terms can, with limited qualifications, be used interchangeably to reflect the carbon content of a coal; throughout this study, I shall follow this convention. Hence, a low volatile coal, denoted *lvb* (low volatile bituminous), is a "good" coal because it contains a high percentage of fixed carbon. Furthermore, *mvb* and *hvb* represent medium and high volatile bituminous coals, respectively.

A coal possessing "good" coking properties also yields a premium price, everything else being equal. The term coking properties, actually covers a number of desirable attributes. Among the more important are the two mentioned above, namely the coal's fluidity and swelling characteristics. The former is an important element in producing a "strong" coke since it facilitates the bonding of carbon particles. It should be noted that steel producers require a strong coke in order to support the blast furnace charge. The "swelling" attribute refers to the steel-makers desire to produce a coke which maintains its bulk density when heated at high temperatures. This follows from the fact that excessive expansion may damage the blast furnance walls; alternatively, excessive shrinkage results in reduction of the quality and quantity of output. It should be noted, for future reference, that important indices of fluidity and swelling are the *DDM* and *CSN* or *FSI* (free swell index) tests, respectively.[15]

In summary, it is apparent that an ideal coking coal is one that possesses: a low level of volatiles (lvb), *good coking properties* (hck), and limited quantities of moisture, sulphur and ash. As might be expected, the earth's crust is not heavily endowed with such coals; hence, where they do exist, primarily in the USA, they attract a premium price. Therefore, in order to minimize production costs, steel-makers resort to blending techniques and the Japanese are particularly skilled at this procedure. Thus coals of various qualities are combined to yield an acceptable coke. Although most steel-mills blend 4 to 8 coals, the Japanese reportedly combine 14 to 18 different products on a regular basis.

Indeed, it is by way of "blending" techniques that the JSM has reduced its dependence on high cost, low volatile/high quality coking coals from the US. It has done so by combining lvb/lck coals from Western Canada, Australia and the USSR, with hvb/hck coals, frequently denoted as soft-coking/high fluidity coals, from the USA, NSW, South Africa, China, and domestic sources. Although the primary purpose of blending is to reduce utilization of otherwise high cost coal, it also allows Japan to reduce its dependency on any single supplier to acceptable levels. Not only does this contribute towards its security of supply objective, but it may also reduce prices by increasing competition. Now, however, let us turn our attention to another important issue — technological change.

Technology

In this section, I shall first briefly describe recent changes in steelmaking technology and then shift to a cursory examination of those aspects of future technological change which could materially affect the utilization of coking coal. As previously noted, the primary method of making steel is the *basic oxygen furnace* (BOF) process. It utilizes coke to support the charge and to provide the heat and gases necessary for pig-iron production. Its major competitor is the *electric arc furnace* (EAF) which utilizes either scrap metal or pelletized iron ore as its basic feedstock and natural gas as its primary energy source.

For purposes of this study, the distinguishing feature of the EAF process is that it does not utilize coke; thus, it precludes the need for coking coal. In this regard, it is important to note that the proportion of steel production derived from the EAF process has increased significantly in recent years; it climbed from 17 to 23 per cent between 1975 and 1982.[16] In Japan, the corresponding figures are 16 and 17 per cent.[17] The EAF process possesses a number of attractive attributes: low capital costs per tonne of capacity; the availability of small scale, yet efficient designs; and the ability for many countries to utilize domestic energy sources — primarily natural gas.[18] These observations are supported by Goodman:

> "Lower capital costs and greater flexibility in scale-up options will continue to favour the development of scrap-based and direct reduction-based electric steelmaking in many developing countries. Current costs for emplacement of electric furnace — direct reduction plants are about 450—650 USD on annual tonne of crude steel production. Scrap-based, electric arc furnace plants are lower, with annual tonne crude steel costs of 200—300 USD. This contrasts dramatically with costs of integrated blast furnace-basic oxygen steelmaking complexes, where values are 1 200—1 500 USD on annual tonne of crude steel production. In addition, a minimum scale of about 3 million tonnes of annual steel plant capacity is normally required for project optimization." [19]

Hence, it is not surprising that most of the replacement and incremental steel capacity to be constructed over, say, the next twenty years, is expected to employ the EAF process.[20] Therefore, even if future steel demand were to substantially exceed current expectations, the long-term picture for coking coal will remain bleak.

On a more positive note, the BOF process is still anticipated to be the primary production process for at least the next two decades. It remains the most efficient method for producing large quantities of steel. Furthermore, significant excess capacity prevails throughout the industry and much of the current capital stock, at least in Asia, is of relatively recent vintage. This suggests that given current demand forecasts, major new investments in steel-making plants and equipment cannot be justified on the basis of traditional efficiency criteria, for at least the next decade. The situation obviously changes thereafter as current facilities deteriorate.

Unfortunately for coking coal producers, a number of technical innovations are being developed which suggest that even if the BOF process remains the dominant mode of steel-making, coking coal requirements may still decline over time. However, before exploring future developments, let us briefly examine other past innovations as they have affected the demand for coking coal.[21]

The major finding is that the coking coal market has been under attack for decades, the effects of which have been masked by an absolute increase in steel production. For instance, all important steel-making nations were able to substantially reduce their coke requirements per unit of crude steel over the 1963 to 1979 period. However, as a result of the 1979 oil shock, most steel-makers ceased using fuel oil as a supplemental heat source, and switched to all-coal furnaces. The result was a once and for all increase in the use of coking coal. An additional factor, although of lesser importance than that described above, has been the success of steel producers in reducing, over time, the amount of waste material produced in the process of transforming crude steel into products. This point has been made rather vigorously by Goodman:

> "Almost unnoticed over the past decade has been dramatic improvements in the yields of rolled steel per unit of crude steel. For example, in Japan the yield of rolled steel from a given unit of crude steel has improved by over 8 percentage points from 82.7 per cent in 1972 to an estimated 91 per cent in 1982. This has been accomplished largely by wide scale adoption of continuous casting and improvements in steel rolling techniques.[22]

Thus, less coking coal is required to produce a given quantity of finished steel. Although these historically important factors appear to be spent forces, new developments are starting to seriously threaten coking coal markets.

Recent activity has focused on ways of utilizing greater quantities of non-coking coal in the BOF process.[23] For example, the JSM continues to increase its reliance on *pulverized coal injection* (PCI) techniques. This approach, which utilizes non-coking coal, helps maintain stability in the furnace. It has been estimated that up to 10 to 15 per cent of total coal requirements could be utilized to produce pulverized coal.[24]

Another innovation, which has

reached the early stages of implementation, is that of "briquetting"; this process utilizes primarily non-coking coal to produce coke. According to a senior JSM official, this process could result in non-coking coals providing up to 20 per cent of total coal needs. Sumitomo Metal Industries Ltd has reportedly used this process since 1975 with some success.[25]

A third innovation utilizes "preheated" coal in coke oven. Its advocates claim that it could result in a non-coking/coking coal utilization ratio of approximately 30:70. However, the future of this process is unclear; for instance, Kinoshita states:

> "We shall have to consider whether this process can be implemented when the coke oven is to be replaced since the process requires drastic reconstruction of the coke oven in comparison with the normal process.[26]

The final development to be considered here is the use of "formed" coke. Once again, Kinoshita, the Senior Managing Director of Sumitomo Metal Industries Ltd reports:

> "By this carbonizing process coke is made with 100 per cent briquetted coal. In the system, use of non-coking coal amounting to over 70—80 per cent of the total coal feed is expected. At this stage, the government and steel industry are jointly proceeding with the study of the process and a pilot plant that has the capacity to make 200 tonnes of coke per day will start test operations in 1984."[27]

Although such developments have the potential to virtually destroy the coking coal industry, it must be stressed that the above discussion is based on technical, not economic, feasibility. That is, the cost savings generated by a greater reliance on lower cost, non-coking coal must be weighted against the incremental expenditure required to convert the coke ovens and blast furnaces to accept the new technology. As discussed previously, the JSM is currently characterized by both excess capacity and relatively new capital stock; hence, it is unlikely that the current coking/non-coking coal price ratio is sufficiently large to trigger a major round of investment. Nevertheless, the situation will change over the longer term as physical deterioration of present facilities necessitates major refurbishing activities; at this point, the incremental costs of incorporating the new technology into the BOF process should decline vis-à-vis the current situation. Therefore, assuming no radical change in the coking/non-coking coal price ratio, the movement towards the use of non-coking coal should be gradual but inexorable. The major impact of such initiatives should not be felt until after 1995.

In conclusion, it is apparent that it is not the price of coking coal per se, but its relationship to other types of coal, that is the critical factor in determining the rate at which non-coking coals are substituted for the former. These same facts can, however, be reinterpreted in the following manner: there may exist some room for coking coal prices to rise, at least over the short and medium term, before the necessary impetus is given to the wholesale introduction of "coking coal-saving" technologies. Nevertheless, as noted above, the critical price spread can be expected to diminish over time as normal reinvestment decisions are contemplated.

One further observation is warranted. Most forecasts suggest a strong demand for thermal coal over the next 15 to 20 years;[28] indeed, one might expect the price gap between coking and non-coking coals to narrow somewhat. If this were to occur, the financial incentives to the steel mills to substitute in favour of non-coking coals could be absent. On the other hand, thermal coal can be accessed from numerous supply points; thus, if the JSM were concerned about the possibility of cartelization of the coking coal market, they might attach a substantial "security of supply" premium to thermal coals — enough to warrant the capital outlays required to implement the "coking coal saving" new technologies.[24]

In conclusion, technological change in the steel-making industry is an ongoing process. Over the past thirty years, coking coal markets have been steadily eroded by the increasing use of mini-mills and improvements in the BOF steel-making process. A brief examination of the future suggests that an increasing share of world steel production will be derived from electric arc furnaces, and that PCI technology will become more widely employed within BOF operations. Although the commercial application of other technologies is somewhat problematical, especially if the coking/non-coking coal price ratio does not increase, the possibility obviously exists that new processes will be adopted which will seriously erode the coking coal market.

SUPPLY ISSUES

Cost comparison

Coking coal is extracted from both *underground* (UG) and *open-cut* (OC) mines. The former utilize long-wall and continuous mining machines and, to a more limited extent, hydraulic technology; the latter rely on truck/shovel and dragline extraction methods. In general, the underground operations are higher cost than the large-scale, open-cut projects. Furthermore, long-wall/UG and open-cut mines are significantly more capital intensive than the traditional underground mines.

Firm-specific cost data is extremely difficult to obtain. However, several researchers have developed hypothetical mine, country-specific models. Perhaps the best known is the work of Barnett.[30] He utilizes a disaggregated costing model, set within a discounted cashflow framework, to generate estimates of the international competitiveness of major thermal and coking coal producers.

According to Barnett, Australia is the world's lowest cost producer of hard coking coal, on a FOR and FOBT basis.[31] The Australian mines, especially those in Queensland, are large-scale, mine thick single seams, and are located between 100 and 300 kilometres from a major port. In contrast, Canadian mines, albeit also large-scale, face difficult climatic and geological conditions. Furthermore, the western Canadian mines face a 1 100 kilometre rail haul from mine site to port. The situation in the United States is somewhat different. The export-oriented coking coal mines are located in the Appalachian region at an average distance of 800 kilometres from port. The mines are generally small to medium scale, underground operations.

Comparative cost data on the Australian, Canadian and US operations are represented in Table 10. Note that operating costs are somewhat lower in Australia than in the US and Canada. The capital charge, which reflects a per ton levy necessary to yield a 10 per cent real rate of return on investment, varies primarily according to vintage of capital. In other words, the estimates are based on historical rather than replacement cost accounting concepts. The effect is that old operations, e g the Utah/BHP, Westar and Fording mines have a 8—11 USD/t advantage over new

Table 10

Cost of Australian, Canadian and United States coal delivered to Japan (1983 USD/t)

Region	Mine size Gt	Operating cost, USD/t FOR	Capital cost, USD/t	Rail USD/t	Port USD/t	Cost: FOB port	Freight to Japan	Cost: CIF Japan
Australia								
NSW, U/G, Old-Steam	1 000	21	3	12	4.1	40.1	6.5	46.6
NSW, O/C, New-Steam	3 000	18.8	8	7.9	4.2	38.9	6.5	45.4
QSLD, Old Opencut	4 500	21.9	3	6.5	1.8	33.2	6	39.2
QSLD, New Opencut	3 000	20.9	13	9.6	3.9	47.4	6	53.4
Canada								
South BC New O/C	5 500	29.8	3	15.2	2.2	50.2	5.5	55.7
South, BC new O/C	3 000	31.8	10.9	17	3.2	62.9	5.5	68.4
North East BC, O/C	4 000	35.8	14.3	17.7	3.1	70.9	5.5	76.4
USA—Appalachia								
Private O/C or U/G	200	25	2	17	1	45	13	58
Public Co Longwall	1 500	32.5	9.6	17	1	60.1	10	70.1
USA Western-Steam								
Utah Underground	1 500	20	7.2	22.2	6.6	56	7	63
Colorada Opencut	3 000	13.1	3	28.7	6.6	51.4	7	58.4
Powder River Basin	15 000	7.2	1.6	27	3.5	39.3	7	46.3

Note:

[a]U/G and O/C represent underground and open-cut mines, respectively.

Source:

D W Barnett, "Rail Freight and the Cost of Australian and North American Export Coal", *Journal of Business Administration*, vol 15, no 1—2, 1985.

entrants. Perhaps Australia's biggest advantage is in the area of freight rates; the older Queensland mines have a 10 USD/t advantage over their Canadian and American counterparts. The spread is slightly lower for new Queensland entrants, due not to locational factors, but to the perversities of the Queensland government's freight rate/rent extraction scheme. Australia's comparative cost advantage over its international competitors is really much larger than these data suggest, since it is widely acknowledged that a substantial proportion of current rail charges represent a disguised tax levy.[32] After adjusting for port loading charges, which are marginally higher in Australia then in the other nations under assessment, Barnett arrives at FOBT estimates which reinforce the earlier claim that Australia is the low-cost, coking coal exporter. Note however, that there is little difference between Canada and the USA. This statement no longer holds, at least for the Japanese market, once sea-freight charges are incorporated into the analysis. It is now apparent that Canadian producers gain a 5 to 7 USD/t advantage over their US competitors. In conclusion, the 1983 CIF cost for coking coal in Japan substantially favours Australian producers. Canadian operators, in turn, possess a small advantage over US based mines.

The above estimates are presented in terms of 1983 US dollars. Since that time, the US dollar has appreciated substantially against both the Australian and, to a lesser extent, the Canadian dollar. As reported in Table 11,[33] the 1985 cost structure has swung dramatically in favour of Australian producers and marginally in favour of Canadian operators vis-à-vis their American competitors. In fact, from a historical accounting perspective, the new Queensland open-cut operators possess a cost advantage over the old Canadian mines.

It should be stressed, once again, that Queensland and Canadian producers, in general, produce similar quality coal;[34] thus the Australian price advantage reported herein is "real". The situation with respect to US production is somewhat different. US coal is generally superior in quality to the lvb/mvb Australian/Canadian output. Nevertheless, a strict comparison of low volatile coals reveals that US coals are still uncompetitive in the Japanese market. In fact, Barnett estimates that at current prices, the old Queensland producers earn a profit of 23.5 USD/t on sales to the JSM; even the new Queensland producers earn a reasonable profit of 6.2 USD/t. In contrast, Canadian producers, as a group can be described as marginal: the old producers generate a small profit of approximately 5 USD/t, but the others face difficult times. Although Bullmoose and the new mines in southeast British Columbia are deemed to generate a small profit and a neglible loss respectively, the long-term picture is much more severe. This is due to the fact that the JSM is currently paying a hefty premium for coal from these mines which is equivalent to that produced by the old southeast BC producers. Hence, if the JSM continues to force the new producers to accept price cuts in order to bring their prices into line with world prices, then all Canadian coking-coal producers, save Balmer, Fording and Luscar, will face serious financial difficulty. The data also indicate that the situation with respect to US producers is equally depressing.

Other supply issues

In the preceeding analysis, I focused on the three leading coking coal exporters: Australia, Canada and the USA. This was done, in part, for the reason that

Table 11

Gross margin of coking coal exporters in 1985 (USD/t, FOB producer port)

Mine type	Price	Breakeven cost	Gross profit (loss)
Queensland			
Old opencut	52.0	28.5	23.5
New opencut	45.0	38.8	6.2
Canada			
Old southern	50.5	45.7	4.8
New southern	57.0	57.1	(0.1)
Bullmoose	64.7	62.6	2.1
Quintette	67.8	79.4	(11.6)
USA Appalachia			
Medium Volatile	55.6	63.0	(7.4)
Low Volatile	51.0	58.0	(7.0)

Donald W Barnett, "Export coal Costs in Australia, Canada, South Africa and the USA", *Materials and Society,* vol 9, no 4, 1985.

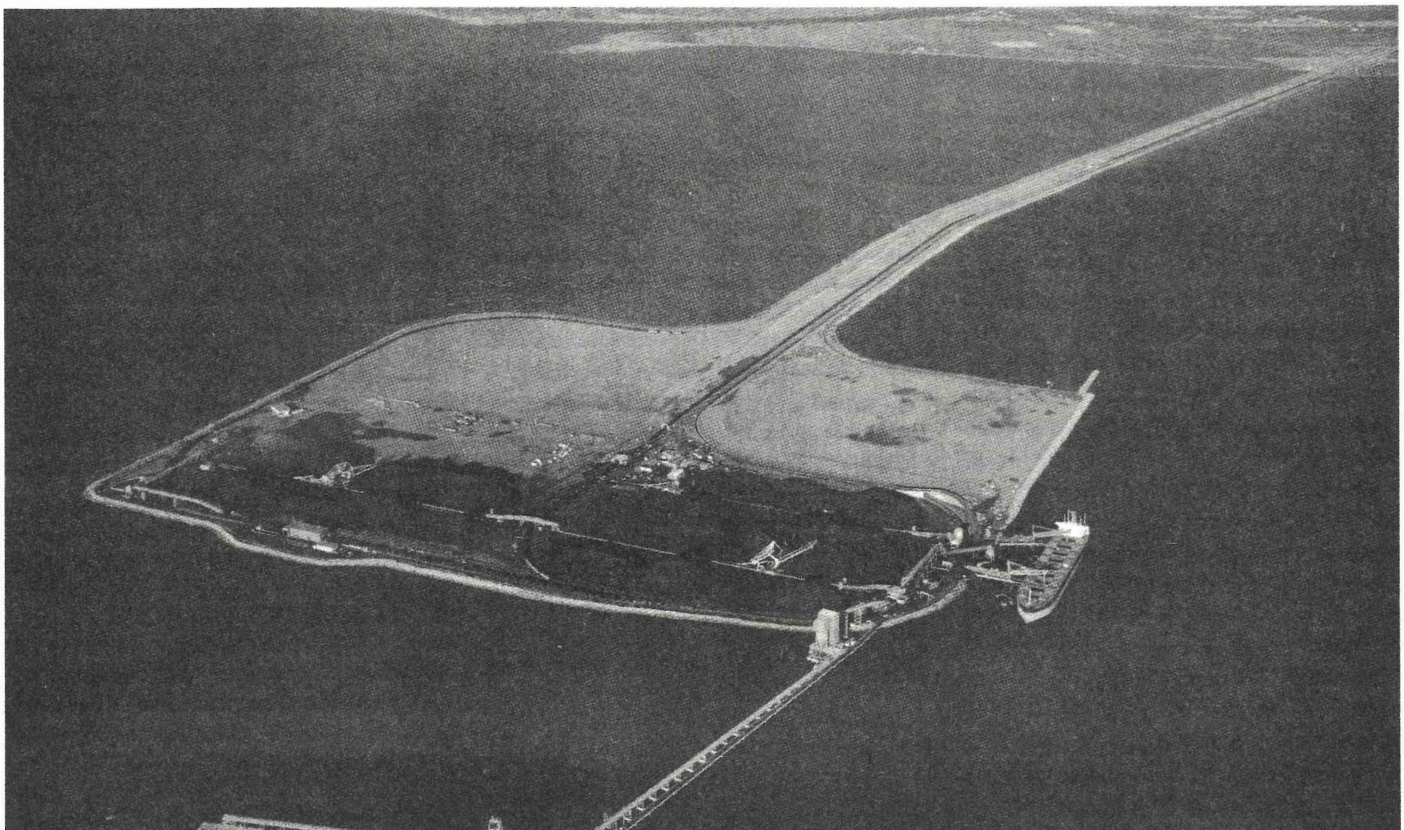
The high dependency of the Japanese market is a distinguishing feature of the Canadian coking coal industry. Photo shows coal port at Roberts Bank, BC, which handles 80 % of Canada's coal export. The port is owned by Westar Mining, a Canadian-Japanese joint venture.

they are the dominant suppliers. However, other reasons were also important, the primary one being that this study focuses on countries within which sales are made by individual producers. In all other nations, including South Africa, coking coal exports are handled through a collective selling agency. Furthermore, with the exception of South Africa, cost data is unavailable on the other important exporters into the Pacific Rim, namely the USSR, China, and Poland.

Future supplies of coking coal are unlikely to be constrained by resource limitations. First, substantial excess capacity existed throughout the industry in 1983; the situation in 1985 is probably one of even greater capacity overhang due to the opening in 1984 of major projects in Australia and Canada. The reader should note, for future reference, that most of the industry's excess capacity exists in Australia, Canada and the USA. Furthermore, both Canada and Australia are capable of adding substantial capacity at relatively low-cost within a 3- to 5-year horizon. The expression "relatively low cost" refers to the fact that the existing infrastructure is capable of handling significantly more tonnage. It should also be noted that operating and capital costs for new ventures should be roughly equivalent to those associated with recently constructed mines. Rephrased, Australia, on the basis of rational economic decision-making, should retain its position as the world's largest exporter under virtually all plausible demand scenarios. Canada, while higher cost, also has the potential to expand output in the Pacific Rim and Latin America, especially if purchases continue to place emphasis on supply diversification and political security.

The possibility of new entrants in the sea-borne export coking coal trade is obviously a concern to existing suppliers. However, as discussed previously, most market forecasts covering the 1985—2000 period, suggest otherwise. This is probably attributable to the fact that prices are expected to remain at current levels, in real terms, over the foreseeable future. Thus, unless extremely low cost reserves are discovered, it is unlikely that new projects could be justified, especially if projects must also bear some infrastructure costs.

Let us now consider the situation facing traditional suppliers. The USA has the potential, both in the short and long-term, to be a dominant supplier. Indeed, the US has, at times, exported approximately 60 Mt/year; this is in contrast to its current level of 45 Mt/year. Its problem in the short-term is one of high operating costs and relatively long distances to the Asian market. In



summary, the major role of the US is as a swing supplier.

The South African situation deserves a brief comment. Although it is undoubtedly the world's lowest cost thermal coal producer, and a major exporter of such coal, South Africa possesses limited quantities of coking coal. In fact, only soft coking coals are available for export with quantities limited to about 3 Mt/year. According to some observers, limited growth potential exists. However, if the steel industry increasingly moves towards the use of non-coking coals, then South Africa becomes a major threat to Canada and other high cost producers.

The USSR and China, from a resource perspective, are capable of dramatically expanding their exports of metallurgical coal. Although some expansion is currently underway in the USSR, industry officials do not envisage a dramatic increase in exports by either nation over the next decade.[35] Both countries require major infrastructure developments before being able to do so. Furthermore, domestic industrialization plans, especially in China, should preclude the release of vast quantities of coking coals on to the export market. Finally, for political reasons, it is unlikely that Japan and the market oriented NICs would tie themselves too closely to either the USSR or China. Nevertheless, so little is known about the long-run objective of these countries that it would be foolhardy to ignore them as potentially serious competitors.

In summary, Canada, Australia and the USA will remain the major suppliers in hard coking coal export market over the foreseeable future. If anything, one might expect the former two countries to improve their positions at the expense of the USA. However, given the importance of supply diversification and balance of payments objectives, it is possible that the US might achieve larger sales than that predicted by rational economic models.

Conclusion

In this paper I have attempted to provide the reader with a cursory knowledge of the institutional factors shaping the present and future environment of the coking coal export market. It was shown that the future prospects for the industry are not optimistic. For example, both steel and coking coal demands are expected to grow by less than 1 per cent per annum over the next 15 years. Furthermore, the Japanese market, the destination of approximately 65 to 70 per cent of Australian and Canadian coking coal exports, is expected to shrink, albeit modestly. Recent exchange rate movements have strengthened Australia's position as the low-cost supplier to the Pacific Rim. Although Canadian suppliers are only marginally profitable — if at all — they are reasonably well situated to maintain their position in this market. Nevertheless, if metallurgical coal markets were truly competitive, then Canada would clearly be vulnerable to predatory pricing by Australia. However, the Japanese procurement strategy clearly takes many factors, in addition to current selling price, into its decision-making claculus.[36]

Notes:

1 For a discussion of these structural issues, see Roger J Goodman, "Industrial Restructuring and Changing World metallurgical Coal Trade Patterns", *CIM Bulletin,* vol 78, no 873, January 1985, pp 56—61.

2 A thorough analysis of this phenomenon can be found in Joseph R D'Cruz, "Quasi Integration in Raw Material Markets: The Overseas Procurement of Coking Coal by the Japanese Steel Industry", unpublished DBA thesis, Harvard University, 1979.

3 *Ibid.*

4 *Ibid.*

5 The non-technical reader is warned that widely varying reserve and resource figures abound. The differences relate to different definitions underlying the analysis.

6 For elaboration, see David L Anderson, "An Analysis of Japanese Coking Coal Procurement Policies: The Canadian and Australian Experience", unpublished manuscript, Centre for Resource Studies, Queen's University, 1986.

7 Estimates derived from International Energy Agency, *Coal Information 1984* (Paris: OECD, 1984). It should be noted that 100 per cent of western Canadian coking coal production is exported; it is only Nova Scotia output which is consumed domestically, primarily in the Cape Breton steel works. Furthermore, the Australian figure is probably now in the order of 85 per cent due to increasing exports and stable domestic sales over the 1983—1985 period.

8 Although the data presented is satisfactory for purposes of detecting long-term trends, the reader is warned that the data are highly aggregative, and thus prone to generating errors of composition. That is, average price indices could show a decline attributable entirely to a shift towards the sale of lower quality and, hence lower priced coal. This result is obviously consistent with constant or even rising prices for each type of coal. Notwithstanding this qualification, the trends exhibited are considered to be a reasonable reflection of overall market performance.

9 Although some differences exist, especially with respect to country-specific export estimates, most available studies suggest a rather depressing picture of future coking coal demand over, say, the next twenty years. The interested reader is referred to: International Iron and Steel Institute (October 1984); Energy Information Agency, *Annual Prospects for World Coal Trade 1984: With Projections to 1995* (Washington: Department of Energy, 1984); Roger Goodman, "Western Canadian Export Metallurgical Coal Industry — Trends and Prospects", *CIM Reporter,* vol 10, no 4, 18/9/84; International Energy Agency, *Coal Information 1984* (Paris: OECD, 1984); Australian Coal Consultative Council, "A Toward Study of the New South Wales and Queensland Coal Industries to 1990", Report by Working Party, No 6, Canberra, February 1983; and National Coal Association, *Coal 2000* (Washington: National Coal Association, 1986). Additional information can be found in statements by various industry officials as presented to the Japan-Australia Coal Conference, 1984-10-29, Tokyo (see *Proceedings*); and the Canadian Coal Association Conference, September 1985, Van-

couver (*Proceedings,* forthcoming).

[10] For details, see David L Anderson, "An Analysis of Japanese Coking Coal Procurement Policies: The Canadian and Australian Experience".

[11] See Roger J Goodman, "The Western Canadian Export Metallurgical Coal Industry — Trends and Prospects", *op cit.*

[12] This is not unexpected, since it is much easier to estimate global requirements and even country-specific utilization, then it is to estimate country-specific export shares. This is, in part, due to unanticipated variations in exchange rates, tax and subsidy policies, political stability, transportation policies, and technological change which alters preferences of users between various types of coal.

[13] For information on coal properties, escpecially in relation to the needs of the Japanese steel industry, see David E Pearson, "The Quality of Western Canadian Coking Coal", *CIM Bulletin,* January 1980, pp 70—84; David E Pearson, "The Quality of Canadian Coal — a Petrographic Approach to its Characterization and classification", in TH Patching, ed, *Coal in Canada* (Montreal: Canadian Institute of Mining and Metallurgy, 1985), pp 21—30; Peter Kittredge and Lorne Sivertson, "Competition and Canadian Coal Prices in the Japanese Coking Coal Market", *CIM Bulletin,* September 1980, pp 100—109; and Peter Kittredge, "The Current Market Value of British Columbia's Coals", unpublished report prepared for the British Columbia Ministry of Industry and Small Business Development, Victoria, June 1982.

[14] For details on the price/quality relationship see Peter Kittredge and Lorne Sivertson, "Competition and Canadian Coal Prices in the Japanese Coking Coal Market", *op cit.*

[15] See David E Pearson, "The Quality of Western Canadian Coking Coal", *op cit,* pp 75—78.

[16] International Iron and Steel Institute, *Steel Statistical Yearbook 1984, op cit,* p 6.

[17] Derived from Roger J Goodman, "The Western Canadian Export Metallurgical Coal Industry — Trends and Prospects", *op cit.*

[18] See Roger J Goodman, "The Western Canadian Export Metallurgical Coal Industry — Trends and Prospects", *op cit;* and P K Pitler, "Steel Industry Process Technology Trends", *Materials and Society,* vol 9, no 2, 1985, pp 147—159.

[19] Roger J Goodman, "Industrial Restructuring and Changing World Metallurgical Coal Trade Pattern", *op cit,* pp 60—61.

[20] See Vincent Calarco Jr, *World Coal Outlook: A Reassessment,* Chase Manhattan, April 1985; and Roger J Goodman, "Industrial Restructuring and Changing World Metallurgical Coal Trade Pattern", *op cit.* In fact, Goodman cites a recent study which suggests that 69 per cent of all incremental capacity in the steel industry between 1983 and 1993 will be in the form of electric arc furnaces. It would seem reasonable based on the material presented in the text, to assume that the corresponding estimates for the following decade will be even larger.

[21] For details see *ibid,* and Roger J Goodman, "Industrial Restructuring and Changing World Metallurgical Coal Trade Pattern", *op cit.*

[22] Roger J Goodman, "The Western Canadian Export Metallurgical Coal Industry — Trends and Prospects", *op cit.*

[23] The following discussion of future trends in steel-making in Japan, relies heavily upon K Kinoshita, Senior Managing Director, Sumitomi Metal Industries Ltd, "Steel Making and its Implications for Coal", in *Coal — A Reappraisal: Proceedings of the 1984 Australian Coal Conference* (Sydney: Australian Coal Association, 1984), pp 50—61. Other useful references are R K Pitler, "Steel Industry Process Technology Trends", *op cit;* and Roger J Goodman, "The Western Canadian Export Metallurgical Coal Industry — Trends and Prospects", *op cit.*

[24] *See David Duval, "Coal Conference Addresses Realities of Marketplace", Northern Miner,* vol 71, no 28, 1985-09-23, p 1.

[25] K Kinoshita, "Steel Making and its Implications for Coal", *op cit,* p 51.

[26] *Ibid,* pp 51—52.

[27] *Ibid,* p 52.

[28] For example, Calarco expects that world sea-borne thermal coal exports will grow at an annual rate of 5.4 per cent over the 1985—2000 period (See Vincent Calarco, Jr, *World Coal Outlook: A Reassessment,* op cit, p 114.

[29] The possibility of Canada and Australia attempting to organize a supply management scheme in the respect to the coking coal markets in the *Pacific Lim,* is discussed briefly in David L Anderson, "Marketing Arrangements for Western Canadian Coking Coal", *Canadian Public Policy,* forthcoming.

[30] Recent examples of Barnett's work include: D W Barnett, "Export Coal Costs in Australia, Canada, South Africa and the USA", *Materials and Society,* vol 9, no 4, 1985; "Rail Freight and the Cost of Australian and North American Exports", *Journal of Business Administration,* vol 15, nos 1—2, 1985; and the Australian Export Coal Industry in the Mid-1980s — An Overview", *Materials and Society,* vol 9, no 4, 1985.

[31] See D W Barnett, "Export Coal Costs in Australia, Canada, South Africa and the USA", *op cit.*

[32] For details, see D W Barnett, "Rail Freight and the Cost of Australian and North American Exports", *op cit;* G Sturgees, "Queensland Puts the Squeeze on Coal Miners", *The Bulletin,* 1980-11-25; Roger Stuart, "Resource Development Policy: the Case of the Queensland Export Coal Industry", CRES Working Paper 1983/30, Australian National University, 1983; and J H Cassing and A L Hillman, "State-Federal Resource Tax Rivalry: The Queensland Railway and the Federal Export Tax", *Economic Record,* vol 58, no 3, September 1982, pp 235—241.

[33] Compare the column denoted "breakeven" in table 10 to that labelled "FOB Port" in table 11.

[34] David E Pearson, "The Quality of Western Canadian Coking Coal", *op cit,* pp 75—78.

[35] This view is promulgated in Andrew Gordon, *Guide to World Coal Markets* (Arlington, Virginia: Pasha Publications, 1984), pp 261—263.

[36] For a discussion of the Japanese procurement strategy, see David L Anderson, "An Analysis of Japanese Coking Coal Procurement Policies: The Canadian and Australian Experience", unpublished manuscript, Centre for Resource Studies, Queen's University, 1986; and Joseph R D'Cruz, "Quasi-Integration in Raw Material Markets: The Overseas Procurement of Coking Coal by the Japanese Steel Industry", unpublished Ph D dissertation, Harvard University, 1979. ■