Impact of Coal Price on Mine Development Investment

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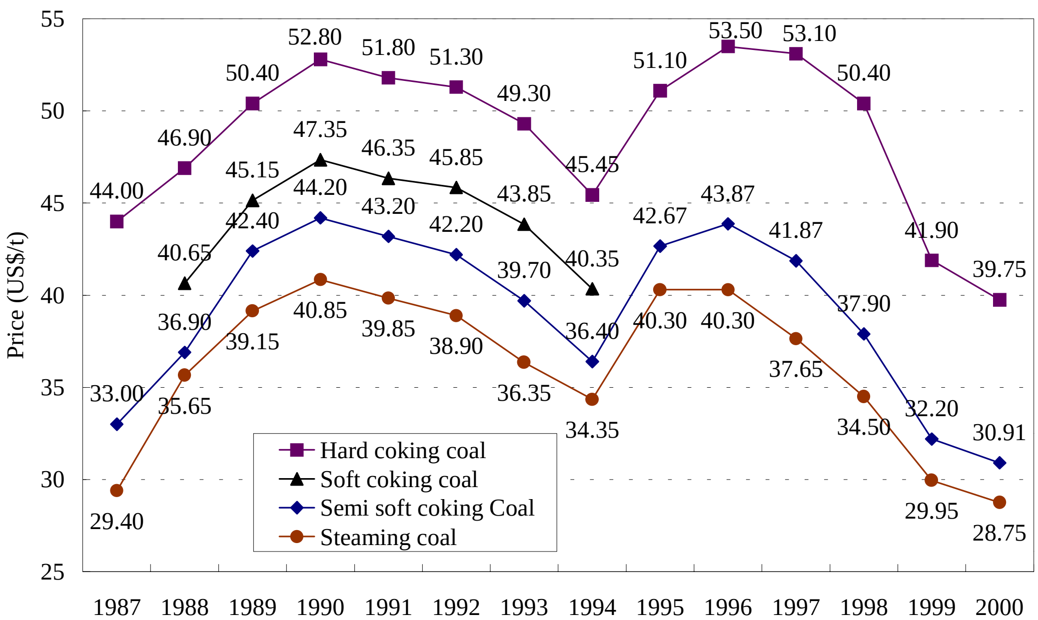
Introduction

The price of coal in recent years has remained low and stable. In supply and demand terms, coal is also esteemed for its superior supply stability among primary energies. The low price of coal, which is good for consumers, also provides producers with subjects for consideration in the operation and development of mines. This report looks at probable future Australian investment trends by analyzing the relation between coal prices and mine investments, primarily on the basis of Australian and U.S. data during the past 20 – 30 years.

1. Recent Trends of Coal Price and Mine Development Investment

1-1 Coal price trend

The world coal trade grew steadily from 386.90 million tons in 1990 to 468.20 million tons in 1995, and to an estimated 520.90 million tons in 1999. On the other hand, after reaching a peak in FY1996, the coal price (the benchmark price of Australian coals bound for Japan) continued to fall for four consecutive years up to FY2000 (Fig. 1-1).



Source: prepared from various reference materials

Fig. 1-1 Benchmark Prices of Australian Coals Bound for Japan

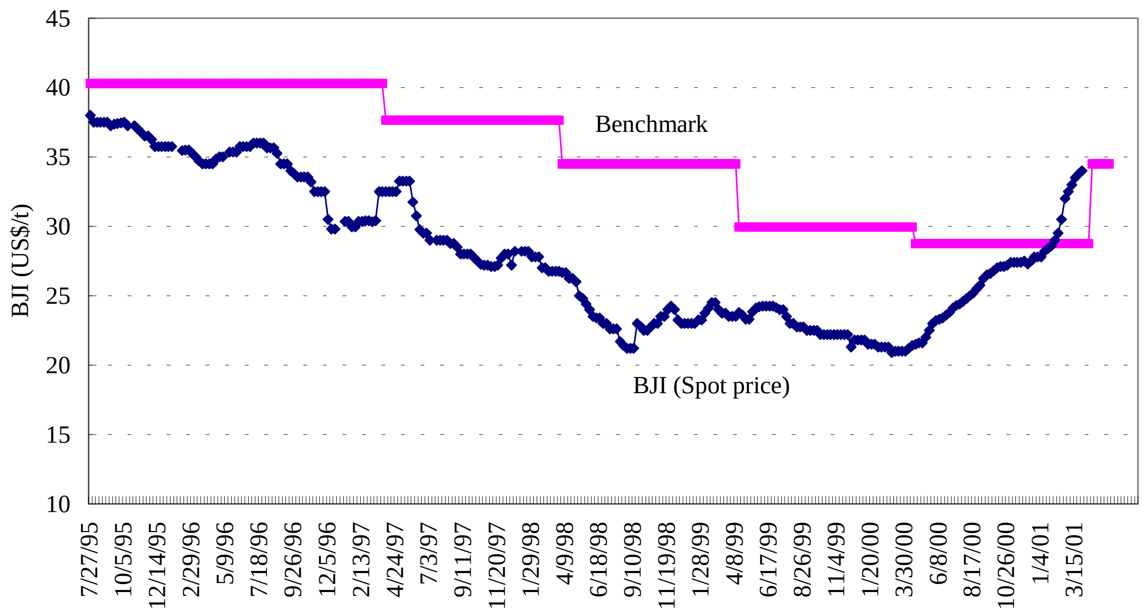
As shown in Fig. 1-1, the price trend from 1990 onward is characterized predominantly by periods of downturn.

Periods of downturn in coal price: 1990 – 1994 (4 years) 1996 – 2000 (4 years)
Period of upturn in coal price: 1994 – 1996 (2 years)

Because coal has few of the elements that characterize strategic and speculative commodities such as crude oil and gas, and because its price depends largely on direct deals between suppliers and consumers, the price of coal depends virtually on supply and demand in the market (i.e., conditions on both the supply and demand sides).

Its fall in price despite the growing demand for coal suggests oversupply, i.e., severer price competition on the supply side.

As from FY2000, however, supply and demand rapidly began to tighten. In addition to the sharply growing demand for coal imports, particularly in Japan, South Korea and Taiwan, this reflects new conditions on the supply side. A good indication of this is the Indonesian miners' strikes, an event that had never previously occurred. As a result, on the spot market, the prolonged stagnation showed clear signs of recovery and the coal price marked an upturn (Fig. 1-2).



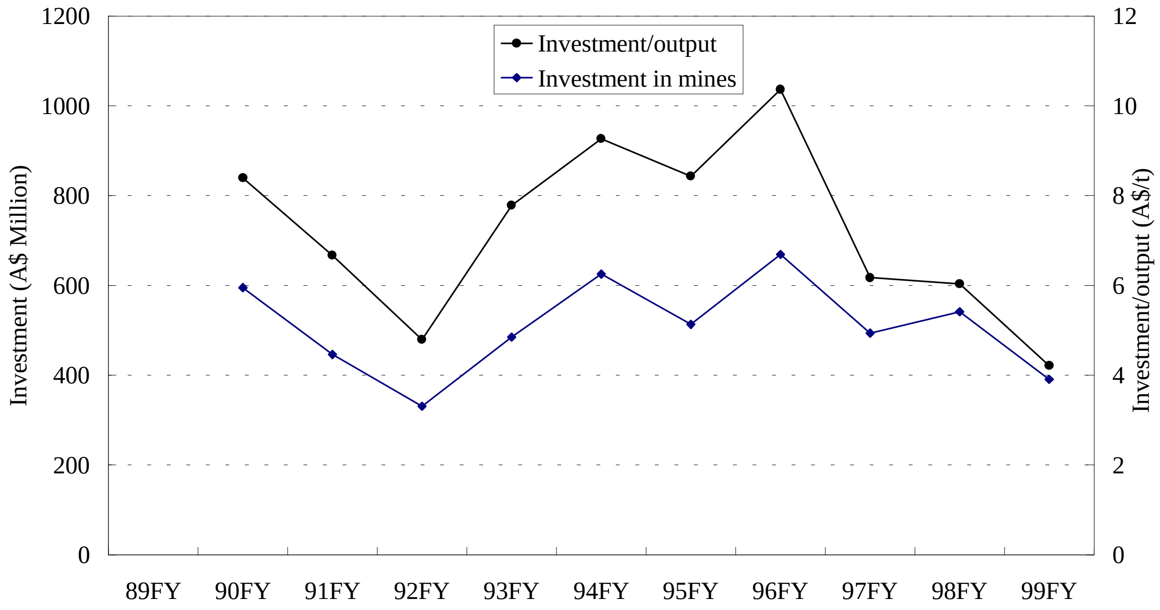
Source: Barlow Jonker, "Australian Coal Report."

Fig. 1-2 Coal Spot Prices

1-2 Development investment trend

1-2-1 Investment trend in New South Wales (NSW)

Fig. 1-3 shows total investment made in the period FY1990 – 1999 (the Australian fiscal year starts in July and ends in June of the following year) by major coal firms accounting for 88% (1999 records) of NSW's coal output. During this period, the average investment was A$509 million, or A$7.5/ton of output. The largest investment in this period was A$669 million spent in FY1996, and the smallest one was A$331 million in FY1992.

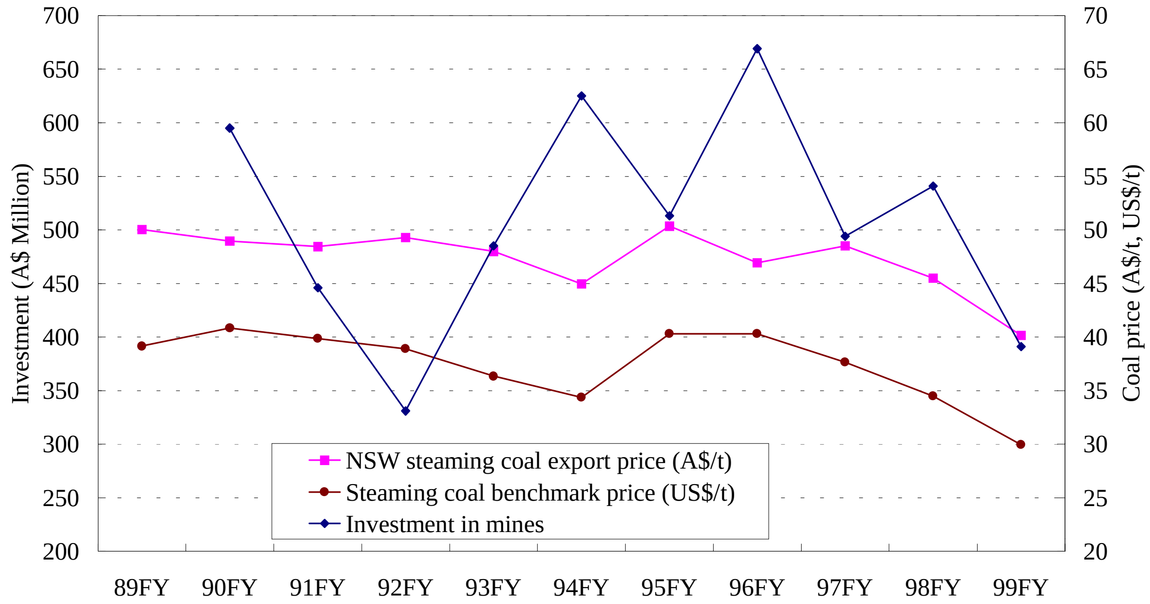


Source: materials of the NSW Mineral Council [1)]

Fig. 1-3 Investment by Major Coal Firms in NSW

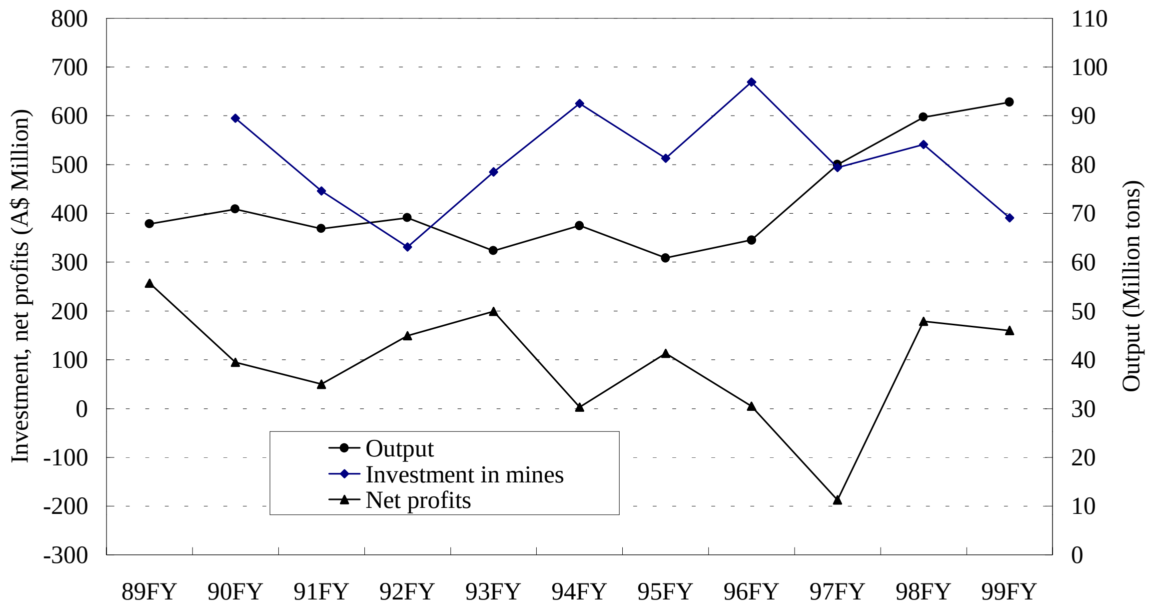
Changing total investments and coal prices are plotted in Fig. 1-4. While shrinking along with the price trend from FY1990 through FY1992, investment continued to rise from FY1992 to 1994 despite price falls. From FY1996 onward, investment dwindled along with the falling coal export price.

Fig. 1-5 illustrates how investment, coal output and the total net profits of coal investment firms have changed. Coal output and investment do not appear to be closely interrelated. Focusing on investment and net profits, the former appeared to follow in the footsteps of the latter a year later. Investment in FY1992 – 1994 is found to be not closely interrelated to the coal price, but is certainly linked to net profits a year earlier. However, despite a considerable plunge in net profits in FY1997, investment in FY1998 tended to increase in association with surging output and net profits. This sort of interrelationship can be attributed to decision-making for a big investment project, often made the previous year or earlier under favorable financial conditions.



Source: materials of the NSW Mineral Council.

Fig. 1-4 Investment by Major Coal Firms in NSW and Coal Prices

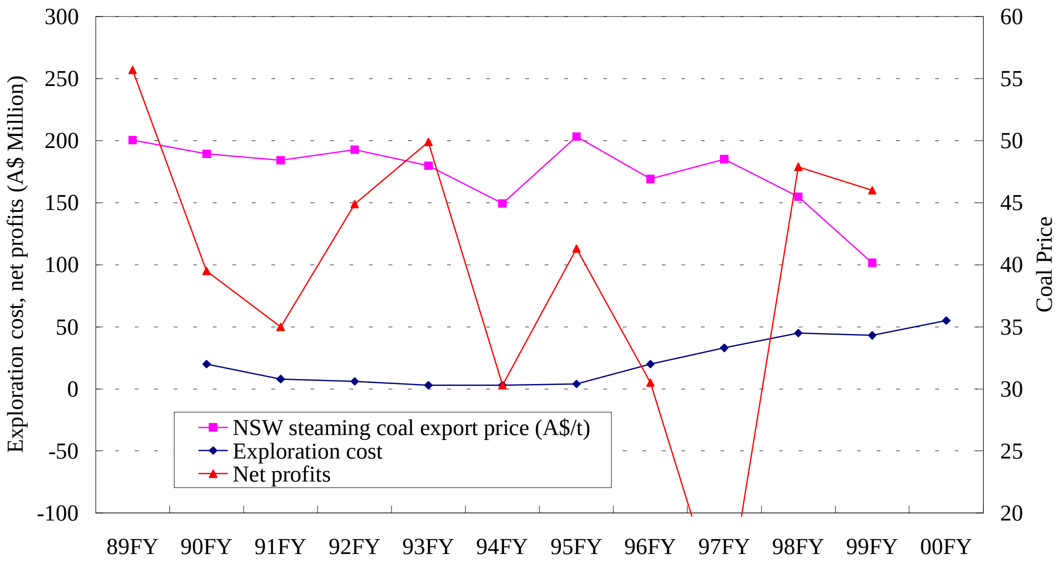


Source: materials of the NSW Mineral Council.

Fig. 1-5 Investments, Output and Net Profits of Major Coal Firms in NSW

For such reasons, not to mention the coal price in absolute terms, the profits of coal firms (= output X [coal price – cost]) are capable of having an impact on investment. In the next section, this hypothesis is analyzed in detail.

We also plotted past exploration costs incurred by major coal firms in NSW, the outcome of which is shown in Fig. 1-6. The exploration cost totaled A$20 million in FY1990, but dwindled steadily from FY1991 onward to less than A$10 million by FY1995. It then picked up in FY1996 and reached A$45 million in FY1998 and A$43 million in FY1999. The predicted cost for FY2000 is a record high of A$55 million for all years since FY1990. Partly because the exploration cost is limited in money amount, it is not closely interrelated either to coal prices or to profits. Comparing Figs. 1-5 and 1-6, it is noted that the exploration cost rose along with increasing coal output. Our interpretation is that growing coal production strengthened the need to get coal reserves proven, which resulted in the rise in the exploration cost.

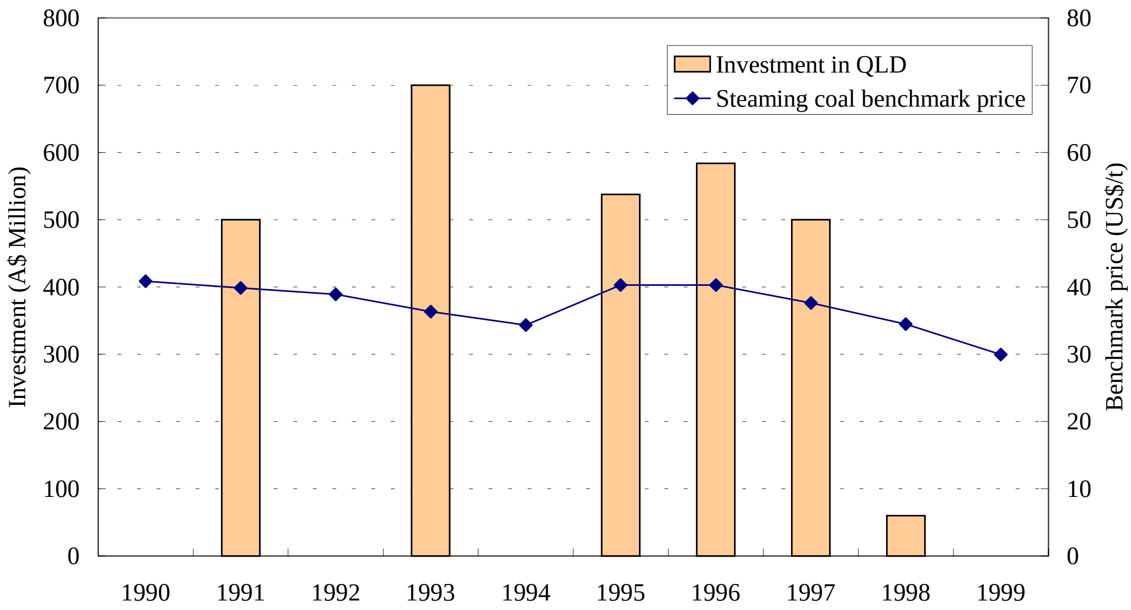


Source: materials of the NSW Mineral Council

Fig. 1-6 Exploration Cost, Net Profits and Coal Price of Major Coal Firms in NSW

1-2-2 Investment trend in Queensland (QLD)

Unlike NSW, few detailed data are published in QLD. For this reason, in Fig. 1-7 we plotted investments made by major new mines developed after 1990, which were shown in Table 1-1. Fig. 1-7 does not necessarily give an accurate picture of each investment trend, because these mines reckoned a lump sum of investments in the single year in which they started operation, and because the major new mines developed in the period 1990 – 1999 numbered only 13. Nevertheless, Fig. 1-7 suggests that investment was being stimulated in the periods 1991 – 1993 and 1995 – 1997 when the benchmark price remained at a high US$35 – 40/ton.



Source: data of Barlow Jonker Corp.

Fig. 1-7 Investment by Major Mines in QLD and Coal Prices

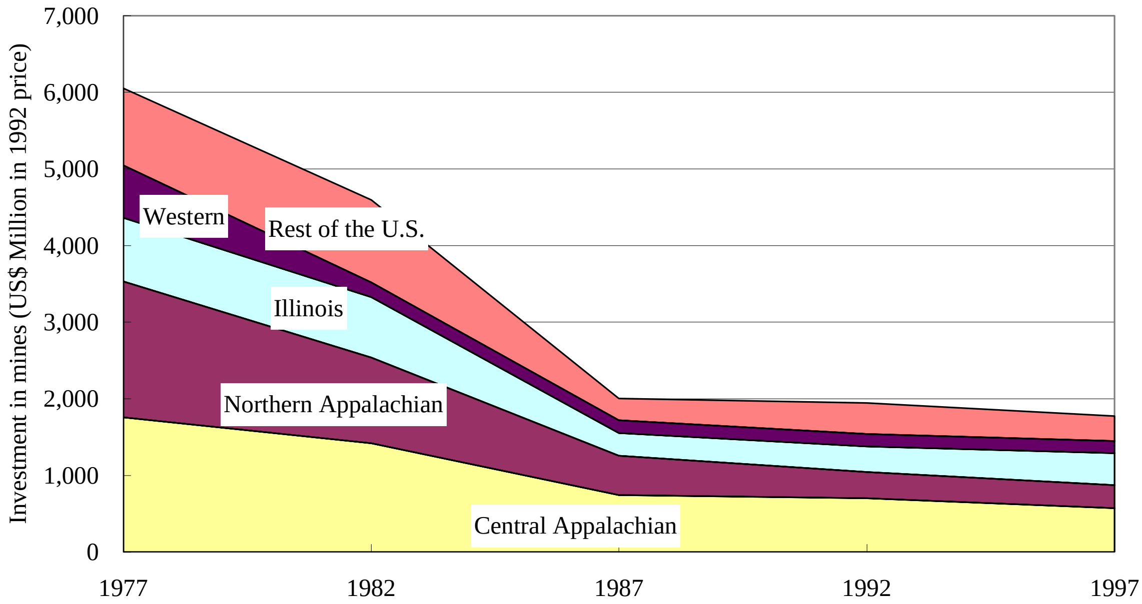
Table 1-1 Major Mines in QLD (1990-1999)

Name of mine	Type	Operation started in	Production capacity
Gordonstone/Kestrel	Underground	1991/5	4.80
Ensham	Surface mining	1993/7	5.00
North Goonyella	Underground	1993/7	3.50
Wilkie Creek	Surface mining	1995/3	1.10
Crinum	Underground	1995/4	3.25
Kenmare - South Blackwater	Underground	1995/9	2.00
Newlands	Underground	1996/1	3.00
Burton	Surface mining	1996/2	4.00
Oaky North - Oaky Creek mine	Underground	1996/7	3.40
South Walker Creek	Surface mining	1996/7	2.50
Alliance (Oaky Creek)	Underground	1997/7	0.80
Moranbah North	Underground	1997/7	6.00
Coppabella	Surface mining	1998/10	3.50

Source: data of the Department of Mines and Energy, QLD

1-2-3 Investment trend in the U.S.

Fig. 1-8 shows how the total cost of exploration, mine development and other equipment investment by the U.S. coal industry has changed. Despite a 56% increase in coal output in two decades from 697 million short tons in 1977 to 1,089 million short tons in 1997, the U.S. coal industry's investment shrank by as much as 71% during this period from US$6,053.60 million to US$1,774.50 million in 1992 price. In particular, investment plummeted from 1977 through 1987. As shown in Fig. 2-2 of the next chapter, the sharp plunge can be attributed to the downturns marked in 1978 in both the coal price and the number of mines.



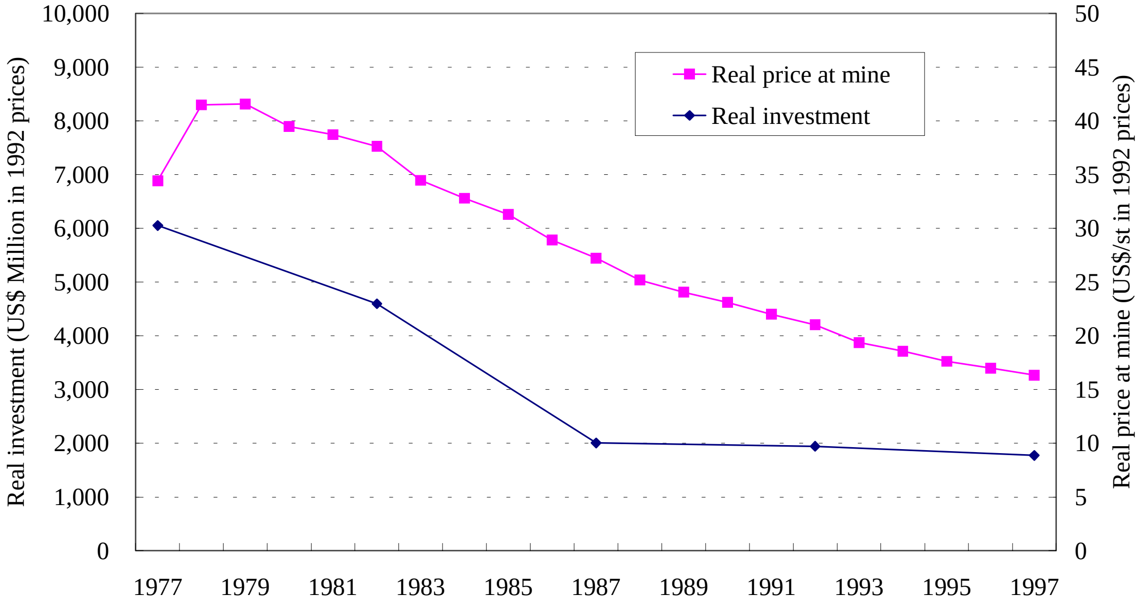
Source: U.S. Department of Commerce, "Mining Census [2)]," etc

Fig. 1-8 U.S. Investment by Coal Industry

Coal industry's investment declined in all regions—even including the Western region, where the booming Powder River Basin is located.

Between 1977 and 1997, the coal price at U.S. mines fell from US$19.82 to US$18.14/short ton. In real terms (1992 price), this represents a 53% drop from US$34.44 to US$16.34/short ton (Fig. 1-9).

The combination of declining investment and increased output may appear contradictory at first glance. However, this phenomenon can be explained by two factors: firstly, productivity gains boosted production; and secondly, investment cuts perhaps resulted from the reuse of idle capacities at closed mines that had lost price competitiveness as a result of the falling price. In the next chapter, productivity gains and the selection of mines will be examined in detail.



Source: U.S. Department of Commerce, "Mining Census," etc

Fig. 1-9 Investment by U.S. Coal Industry and Coal Prices

2. Coal Price and Corporate Behavior

2-1 Principles of consumer and supplier behavior in relation to coal price

When procuring coals, consumers' primary concerns are to secure as much coal of the required qualities as is needed (stable supply), and to keep the purchasing price as low as possible. The question as to which of these two concerns is more important, and to what extent, depends largely on consumers. Consumers who are able to choose alternative fuels can lower their coal requirements according to coal price levels. On the other hand, for those who have no such choice, securing as much as is needed always takes first priority, and how to keep the price down comes second.

Given the low coal prices in recent years, coal has an overwhelming economic advantage over oil and gas. Consumers who take account of this economic advantage are likely to maximize coal use in their choice of fuel. Environmental responses (particularly to global warming) are also an important factor. However, because the top priority in any corporate survival strategy is the strengthening of competitiveness by cutting costs, individual firms have to respect economics even when committing themselves to minimum environmental responses. Thus, when coal supply and demand is slack and the price of coal remains low, consumers tend to adopt the behavior principle of first securing their required quantities of coal, and then waiting for further price falls (that is, purchased amount of coals (constant) X price (variable) =

cost minimizing).

Conversely, when supply is limited, consumers tend to give first priority to securing absolute coal requirements (not replaceable by alternative fuels in case), and try to buy coal even if the price is very high. This is likely to result in a rising coal price. For these reasons, consumers will opt for a passive stance such as “waiting for a lower price” when the price is on a downward turn. When the price is moving upward, they adopt the more active stance of “quantitative security = price rises” which, in extreme terms, means it is consumers who cause the price to rise.

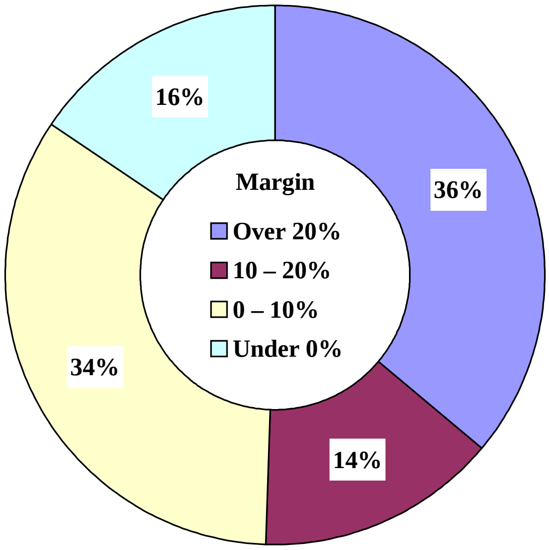
For suppliers, naturally, the higher the price, the better. However, because profits are more important than prices, it should be noted that a high price is not necessarily to be equated with maximum profits. Profits are expressed by the following equation.

Profits = Sales amount X (price – cost)

Naturally, a higher price yields greater profits, but even when the price remains low, it is possible to increase profits by cost cutting. The coal price depends on the market, in which large numbers of sellers and buyers participate. This means that individual coal firms on the supply side alone cannot raise the price, and the firms must try to increase their profits by selling more for a given price and by cutting costs. Some price-competitive firms may discount the coal price as a means of increasing their sales. This strategy encourages less price-competitive firms to follow suit by sacrificing profitability to some extent if they hope to maintain their sales level. With reference to Barlow Jonker’s data, this theory is verified as follows.

1998 Australian steaming coal average export price (FOB) = US$30.10/t
1998 Australian steaming coal exports = 83.02 million tons
Exports for FOB cash cost under the export price = Approx. 83 million tons
Exports for total FOB cost under the export price = Approx. 70 million tons
Exports for total FOB cost under 90% of the export price = Approx. 42 million tons
Exports for total FOB cost under 80% of the export price = Approx. 30 million tons

In 1998, the coal firms that succeeded in earning margins (= [price – total cost]/price) of over 10% of the steaming coal export price accounted for about half of total steaming coal exports. Those that earned margins of 0 – 10% held about 28 million tons, or 34% of the whole, and others earning no margins exported some 13 million tons, or 16% of total exports (Fig. 2-1).



Source: IEA, "Coal Information," and data of Barlow Jonker

Fig. 2-1 Breakdown of Steaming Coal Exports by Margin (1998)

These facts demonstrate that the coal firms responsible for about half of total exports were not able to earn satisfactory profits, but reluctantly accepted a given export price. On the other hand, firms having sufficient margins (of over 20%) shipped 36%, or a little more than one third of all exports. These coals left room for discount. In other words, cost- competitive firms that held these coals can be regarded as having led the price cut (a hypothesis at this stage). If this hypothesis is correct, the coal price was steered to a lower level by a small number of cost-competitive coal firms. The majority of coal firms would have preferred a higher price but had to agree on the price cut. To express this in extreme terms, it can be called a voluntary price cut by suppliers. In order to obtain a profit from the price thus lowered, suppliers then unavoidably become cost-cut-prone. Further confirmation of such behavior on the part of suppliers is provided in the subsequent section.

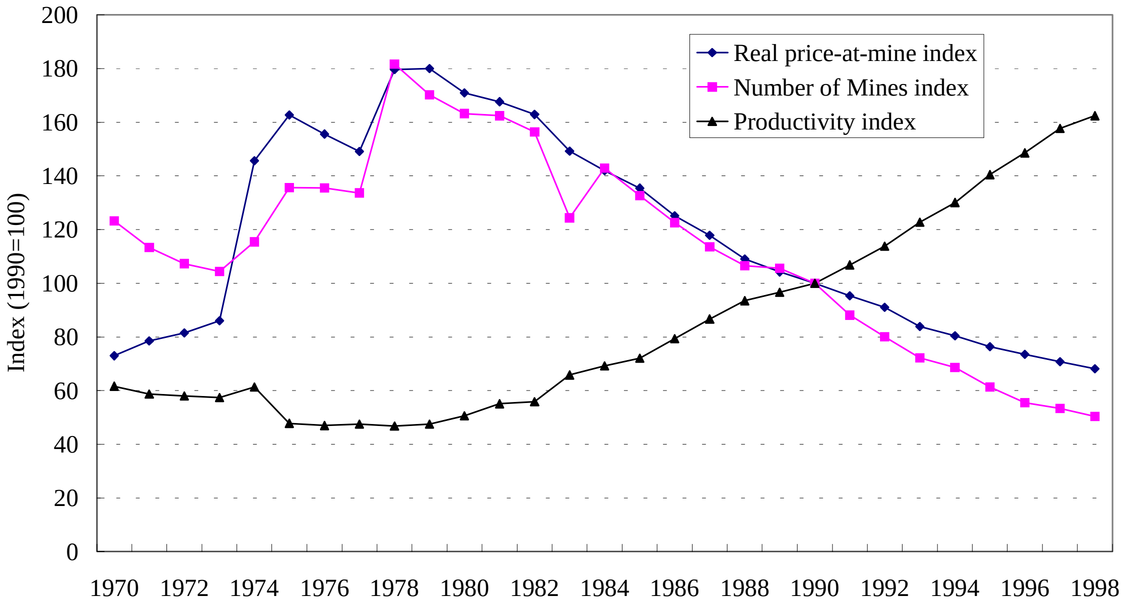
2-2 Interaction between price fall and supply cost cuts in the U.S.

The U.S. coal market is the world largest in size, dominated overwhelmingly by domestic marketing and free from exchange-rate impacts on price, since both export and domestic prices are settled in dollars. Because of these characteristics, the U.S. market can provide the best model for grasping the dynamics of coal supply cost and coal price. Corporate data on coal supply cost are confidential and almost impossible to obtain. Accordingly, our analysis made use of data on labor productivity (production efficiency) closely related to the cost. Because personnel cuts and output increases are both capable of lowering a unit cost, naturally the cost is closely tied to labor productivity. According to Edward J. Flynn[3)] as well as the Australian Industry Commission[4)], the labor cost accounts for 40 – 50% of the cost at mines in the U.S. and Australia alike. Accordingly, productivity gains lead directly to a significant reduction in the labor cost, which accounts for as much as 40 – 50% of the total cost. In addition, labor productivity, tightly tied to total productivity in which labor, capital, energy, etc. are all interwoven, is said to have a close link to the total cost. Meanwhile, in this report, productivity means labor productivity.

2-2-1 Coal price and productivity

Fig. 2-2 shows past changes in coal productivity and price in index terms. Plotted in the chart are indexes of real average price and productivity at all U.S. mines producing over 10,000 short tons/year each for 28 years from 1970 through 1998. The real price can be seen to have slipped along with constant productivity gains since 1980.

Compared with 1990 records, productivity was 62% higher in 1998, while the price fell by 32% in real terms (Table 2-1).



Source: internet-based data of the U.S. EIA

Fig. 2-2 U.S. Coal Prices, Productivity and Number of Mines

Table 2-1 U.S. Coal Prices, Productivity and Number of Mines

	Productivity		Average price at mine		Average real price at mine		Number of mines
	st/miner/hour	tce/miner/hour	US$/st	US$/tce	1990 US$/st	1990 US$/tce	
1990	3.83	3.01	21.76	27.70	21.76	27.70	3,430
1991	4.09	3.19	21.49	27.53	20.74	26.57	3,022
1992	4.36	3.40	21.03	26.94	19.81	25.38	2,746
1993	4.70	3.62	19.84	25.73	18.25	23.67	2,475
1994	4.98	3.84	19.41	25.20	17.49	22.71	2,354
1995	5.38	4.13	18.83	24.53	16.61	21.63	2,104
1996	5.69	4.37	18.50	24.10	16.00	20.85	1,903
1997	6.04	4.63	18.14	23.66	15.39	20.08	1,828
1998	6.22	4.75	17.67	23.13	14.81	19.38	1,726
1998/1990	62%	58%	-19%	-17%	-32%	-30%	-50%

Source: internet-based data of the U.S. EIA.

As mentioned later, the average calorific value of the U.S. coals is on the decline, reflecting the growing production of subbituminous coal in the Western region (Fig. 2-9). Corrected by calorific value, or in terms of coal equivalent (tce), productivity improved by 58% and the real price fell by 30%.

Fig. 2-2 shows that, with index = 100 as a symmetry axis, there is a clear symmetrical relation between the coal price and productivity, which represents production efficiency. When productivity y = f (x) +100, the price has a negative interrelation, which is expressed as follows: y’ = -a x f (x) + 100. Concurrently, it is noted that the number of mines changed in virtually the same pattern, as did the price. Hence, it can be expressed as y’’ = -b x f (x) + 100. Thus, the coal price, productivity and the number of mines are interrelated with each other. This can be expressed by the following equations with coefficients, a and b, in use.

Price index – 100 = -a x (productivity index – 100)
Mine number index – 100 = -b x (productivity index – 100)
Price index – 100 = (a/b) x (mine number index – 100)

From the 1998/1990 ratios shown in Table 2-1, we calculated the values for a and b. The outcomes were a = 0.5 and b = 0.8. In reflection of higher productivity, the price dropped by 50% of productivity gains. Of the productivity gains, 80% can be related to the falling number of mines.

As already stated, one behavior principle of coal suppliers is that they have to sell more and trim the cost in order to increase their profits from a given price established by the market. Because it is an axiom that improving productivity is the most effective way of increasing sales (= output) and lowering the cost, improving productivity is always a challenge of vital importance for the majority of coal firms. However, such improvement of productivity contributes to intensifying the already fierce competition among mines, accelerating the selection of mines, and sending the coal price down further.

As a causal relationship among the coal price, productivity and the selection of mines from what has been discussed above, it is possible to define a "coal productivity improvement cycle" as shown in Fig. 2-3. Individual routes contained in the chart can be explained as follows.

Main cycle route: R1

To increase profits, existing mines endeavor simultaneously to achieve cost reduction and sales increase (to improve productivity) >> Output increases >> Greater output slackens supply and demand (oversupply) >> Price falls >> Need for additional cost cuts (further productivity gains)

Selection-of-mines route: R2

Price falls >> Closures of less cost-competitive mines >> Resultant improvement in average productivity of mines as a whole.

New-mine-participation route: R3

Qualified new mines for participation: Excellent mines able to yield profits even at a low price (productivity gains) >> Output increases >> Greater output slackens supply and demand (oversupply) >> Price falls >> Need for additional cost cuts (Further productivity gains)

Production-increase route: R4

In this case, larger demand than supply causes supply and demand to tighten >> Price rises >> Development of new mines >> Expansion of production (a productivity improvement cycle is not formed in this case)

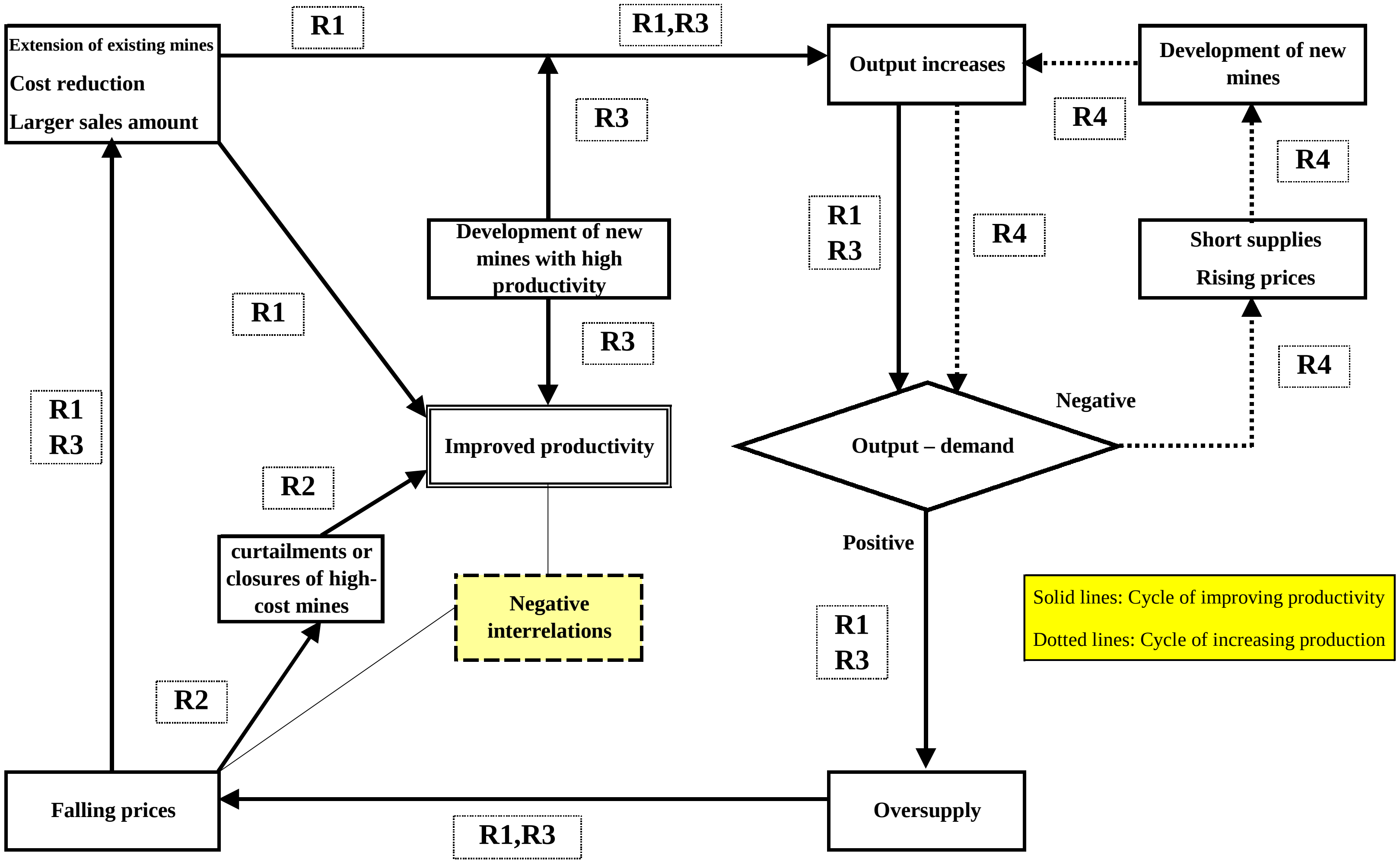
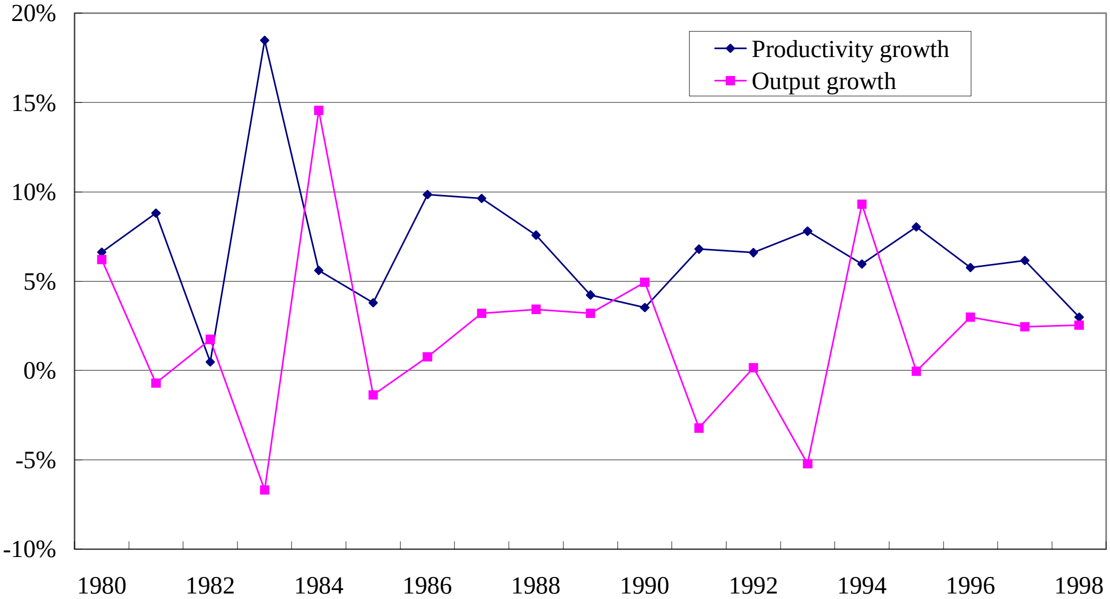


Fig. 2-3 Coal Productivity Improvement Cycle (Selection of Mines)

The diverging point of whether a productivity improvement cycle is completed or not in the first three routes depends on whether supply and demand leads to slackening or tightening. However, in 1980 – 1998, when productivity increased by as much as 222% in the U.S., output grew by a mere 35%.

Plotted in Fig. 2-4 are year-by-year growth rates of productivity and output in the U.S. During the 18 years from 1980 to 1998, output gains outgrew productivity gains only four times. In the remaining 14 years, the former remained below the latter. This caused oversupply because the output growth was unable to absorb productivity gains. As a result, the coal price began to fall, which caused closures of less cost-competitive mines (selection of mines).



Source: internet-based data of the U.S. EIA.

Fig. 2-4 Growth of U.S. Coal Productivity and Output

Theoretically, this productivity improvement cycle should last as long as supply and demand keeps slackening. This cycle appears to have continued for the last 20 years in the U.S.

The productivity improvement cycle stops when coal supply and demand leads to tightening as in Route 4, characterized by larger demand (= output) gains than productivity gains. The possibility of such a case is discussed later (in Section 2-3-2).

2-2-2 Actual state of the selection of mines

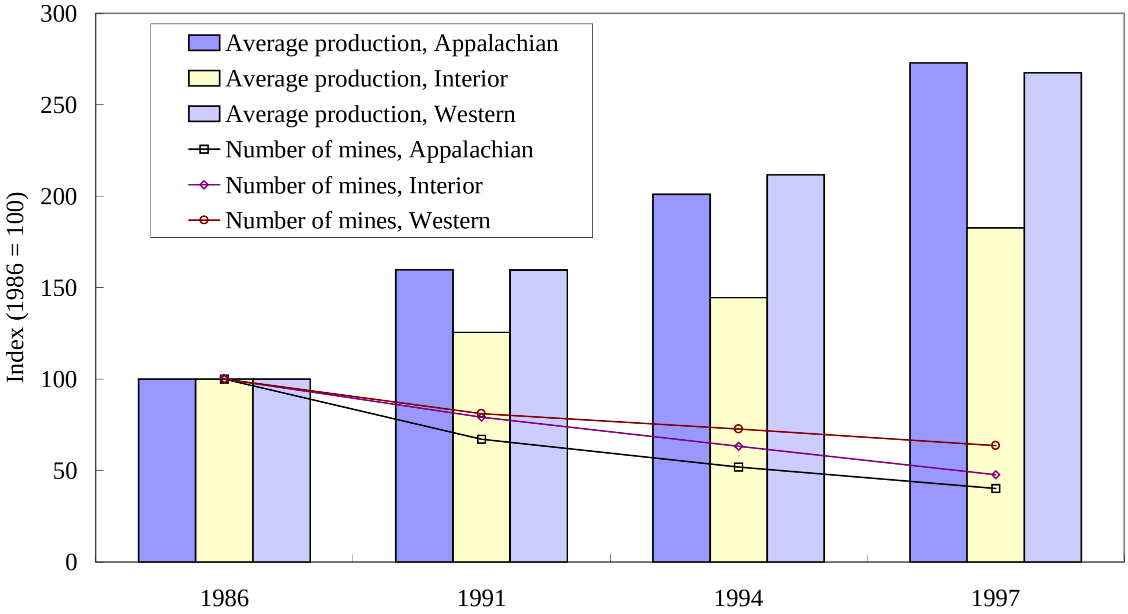
Since the 1980s up to the present, the U.S. has repeatedly experienced a productivity improvement cycle (selection of mines), and this section describes how the mines were actually selected. The combination of growing output and a falling number of mines naturally results in greater output per mine.

With all U.S. lands divided into three regions—the Appalachian, Interior and Western regions—Fig. 2-5 shows historical changes in the number of mines and average production per mine, both in index terms. According to the chart, the rate of fall in the number of mines (the rate of selection of mines) was sharpest in the Appalachian region. As a result, per mine production showed the highest increase in Appalachia. In the Western region, the rate of falling number of mines remained low, but production rose at a similar pace to the Appalachian level.

As shown in Table 2-2, among the three regions, the Appalachian region has a high output and numerous mines. Between 1986 and 1997, the Appalachian region registered the sharpest decline in the number of mines, down 59.8%, followed by the Interior region (down 52.4%) and the Western region (down 36.4%).

Regarding ups/downs in output, the Western region recorded the highest growth at 70.2%, followed by a 22.5% growth in the Appalachian region. In the Interior region, production fell by 13.2%.

While output is almost identical, the Appalachian region has 1,602 mines, nearly 20 times more than the 77 mines in the Western region (1997).



Source: internet-based data of the U.S. EIA.

Fig. 2-5 Numbers of U.S. Mines and Per Mine Output

Table 2-2 U.S. Numbers of Mines and Output

		1986	1991	1994	1997	1997/1986
National	Number of mines	4,424	3,022	2,354	1,828	-59%
	Production (Million short tons)	890	996	1,034	1,090	+23%
	Output/mine (Million short tons)	0.201	0.330	0.439	0.596	+196%
Appala-chian	Number of mines	3,990	2,676	2,068	1,602	-60%
	Production (Million short tons)	429	458	445	468	+9%
	Output/mine (Million short tons)	0.108	0.171	0.215	0.292	+172%
Interior	Number of mines	313	248	198	149	-52%
	Production (Million short tons)	197	195	180	171	-13%
	Output/mine (Million short tons)	0.629	0.786	0.909	1.148	+82%
Western	Number of mines	121	98	88	77	-36%
	Production (Million short tons)	265	343	408	451	+70%
	Output/mine (Million short tons)	2.190	3.500	4.636	5.857	+167%

Source: internet-based data of the U.S. EIA.

Because the Appalachian region produces coking and steaming coals of good qualities, which are priced higher as shown in Table 2-3, even small mines can be profitable. This accounts for the fact that there are many small mines in this region. However, with the price becoming lower, the process of selection of mines is going ahead rapidly in this region too.

In the Western region, subbituminous coal from the Powder River Basin dominates regional output and sends the coal price falling at a steeper rate than in the other two regions, which is also noteworthy. In other words, the two-way combination of output increases and price falls, which characterizes the U.S. coal market, is most conspicuous in this region.

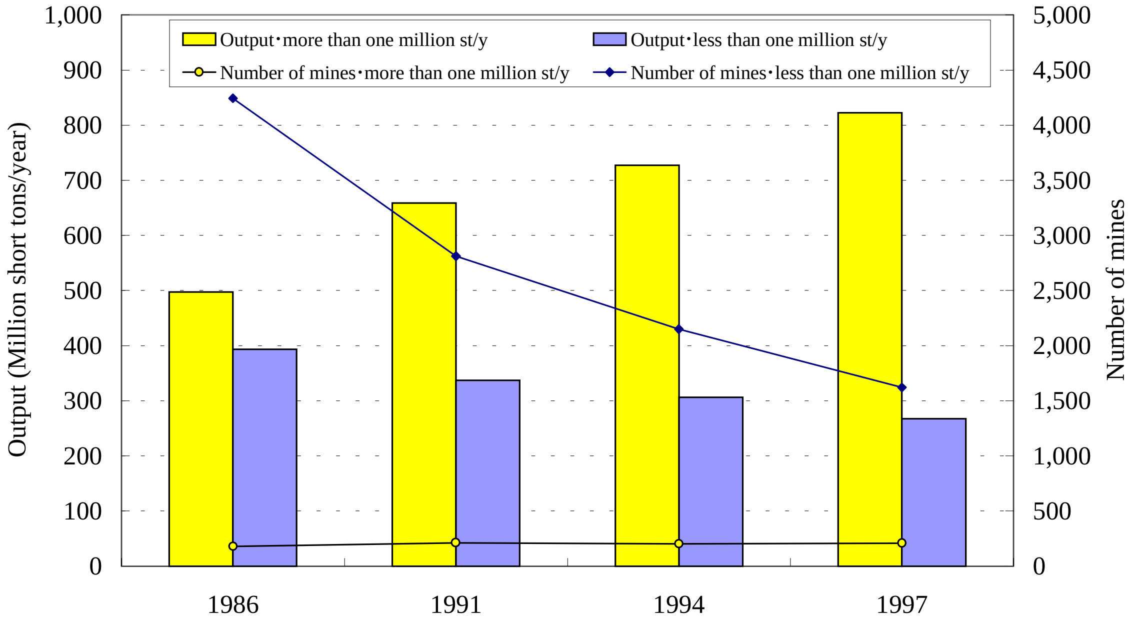
Table 2-3 U.S. Coal Prices by Region (US$/t)

	1989	1994	1995	1996	1997	1998	1998/1989
Appalachian	28.74	27.36	27.45	26.78	26.55	26.85	-7%
Interior	21.31	19.87	18.81	18.41	17.91	18.45	-13%
Western	12.12	10.57	10.15	10.03	9.52	8.76	-28%
National	21.82	19.41	18.83	18.5	18.14	17.67	-19%

Source: internet-based data of EIA

2-2-3 Trends by mine production size

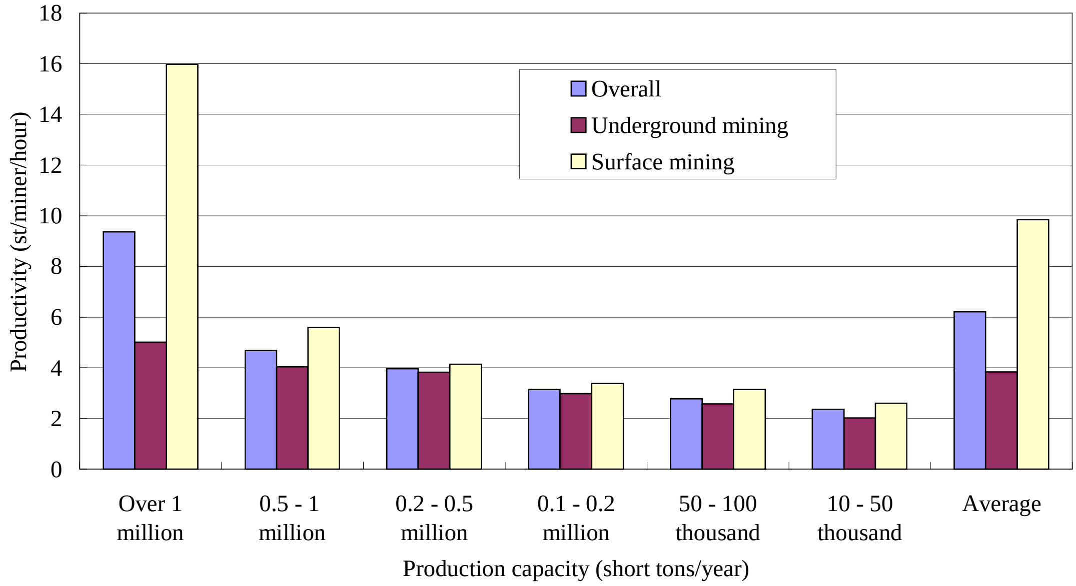
As already stated, the total number of mines is falling. However, trends by production size are different from the overall flow. As shown in Fig. 2-6, with the mines divided into those producing over a million short tons/year and the others producing less, the former group has been increasing gradually from 180 mines in 1986 to 208 mines in 1997. On the other hand, the latter group plunged sharply from 4,244 to 1,620 mines over the same period. Coals produced by the over-a-million-tons-a-year mines increased from 497.00 million short tons to 822.40 million short tons in 1986 – 1997, while output from the under-a-million-tons-a-year mines shrank from 393.30 million short tons to 267.60 million short tons during the same period.



Source: internet-based data [5)] of the U.S. EIA.

Fig. 2-6 Numbers of U.S. Mines and Output by Production Size

Fig. 2-7 shows the productivity of mines by production size in 1997. Productivity of the over-a-million-tons-a-year mines far exceeded that of the under-a-million-tons-a-year mines. Thus, against the background of advancing selection of mines, large mines having an overwhelming advantage in productivity become winners and gradually increase in number. When combined, coal output from large mines is increasing faster than the pace of their growing numbers. On the other hand, small mines disadvantaged in productivity become losers. The number of small mines is falling sharply, and their combined output is decreasing also.



Source: internet-based data of the U.S. EIA.

Fig. 2-7 Productivity by Coal Production Capacity (1997)

2-2-4 Price falls caused by shift in producing regions

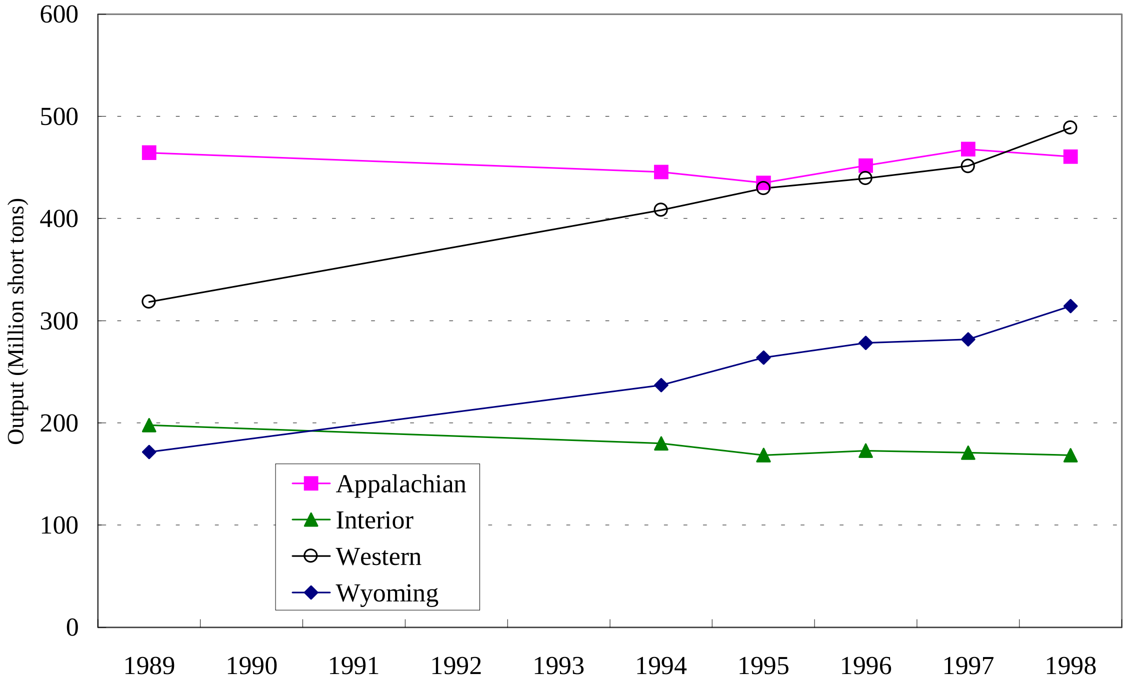
As already noted, coal production is growing in the Western region. By rank, of the 489 million short tons of Western coals produced in 1998, 79% was subbituminous coal. Then, out of the 386 million short tons of subbituminous coal produced in the Western region, 311 million short tons, or 81%, came from Wyoming. Subbituminous coal accounts for 99% of coal production in Wyoming (Table 2-4).

Table 2-4 Coal Output by Rank (1998)

		Bituminous	Subbituminous	Lignite	Anthracite	Total
National	Output	640	386	86	5	1,118
	Share (%)	57%	35%	8%	0%	100%
Appalachian	Output	455			5	460
	Share (%)	99%			1%	100%
Interior	Output	113		56	0	168
	Share (%)	67%	0%	33%	0%	100%
Western	Output	72	386	30		489
	Share (%)	15%	79%	6%		100%
(Of Western) Wyoming	Output	3	311			314
	Share (%)	1%	99%			100%

Source: internet-based data of the U.S. EIA (Note) Output in million short tons

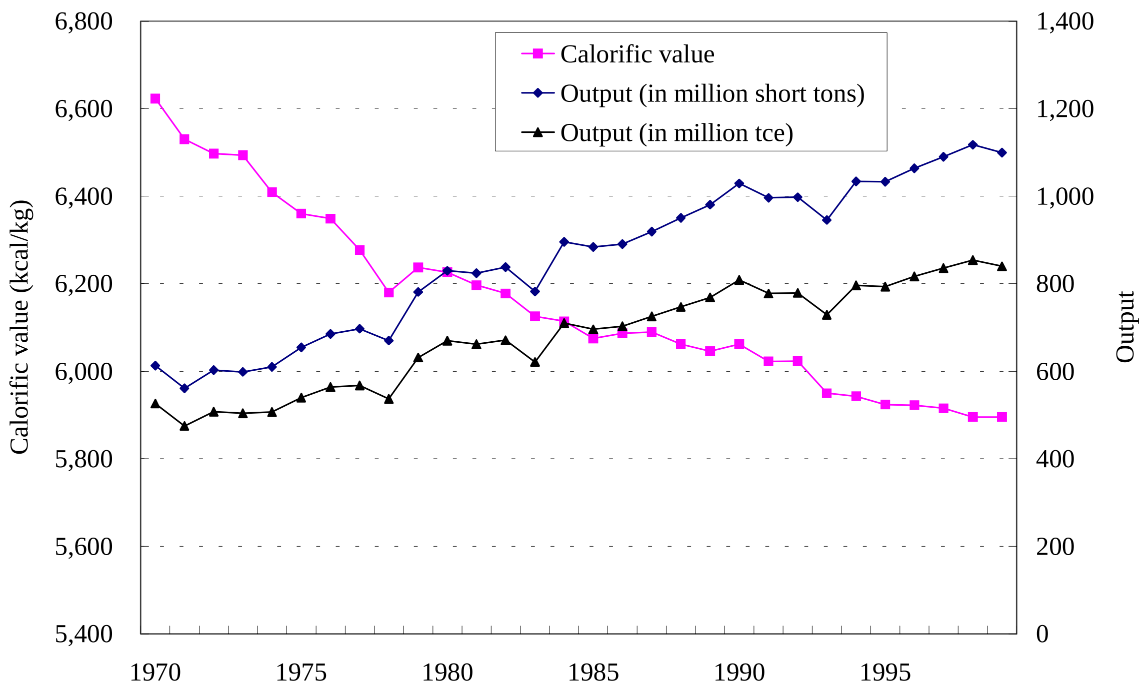
Plotted in Fig. 2-8 are changes in U.S. coal production by region and in Wyoming's coal output. The constant growth of Western coal production clearly reflects the growth of subbituminous coal production in Wyoming.



Source: internet-based data of the U.S. EIA.

Fig. 2-8 Output by Regions

The higher growth of Wyoming subbituminous coal, characterized by a low calorific value, affects the average calorific value of coals produced in the U.S. nationwide. As shown in Fig. 2-9, the average calorific value of U.S. coals has declined year by year. In terms of total moisture content (as shipped basis), the average calorific value, above 6,500 kcal/kg in the early 1970s, fell to below 6,500 kcal/kg by 1972 and further to below 6,000 kcal/kg by 1993. Given these facts, in terms of heat quantity equivalent, the U.S. coal output and productivity has to be revised downward, and the coal price upward (Table 2-1).



Source: internet-based data the U.S. EIA.

Fig. 2-9 Average Calorific Values of U.S. Coals (Total Moisture Content Basis)

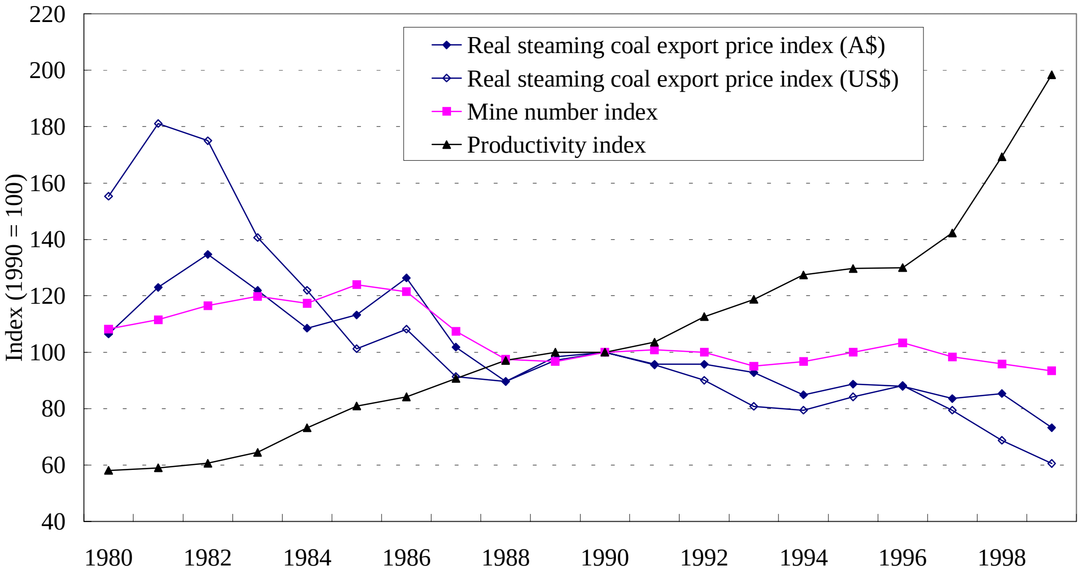
2-3 Interaction of coal price falls and supply cost cuts in Australia

The preceding sections have shown clearly that, on the U.S. coal market, productivity gains have a massive impact on coal price and investment. In the following, the Australian coal market is examined along similar lines.

2-3-1 Coal price and productivity

Changes in coal productivity and price, both in index terms, are plotted in Fig. 2-10. Australia's coking coal exports began in the 1960s. As from 1982, however, when steaming coal exports got fully under way, it is noted that productivity improved remarkably, particularly from 1995 onward. Productivity doubled between 1990 and 1999 (Table 2-5).

In real terms, the coal export price peaked in 1981 or 1982. Subsequently, the price has remained volatile in the short run but has continued to fall in the long run. In terms of the 1999/1990 ratio, the price was down 39% in U.S. dollars and 27% in Australian dollars. Because the exchange rate of the Australian dollar against the U.S. dollar has been slipping in the long run, the coal price in Australian dollars has fallen less than that in U.S. dollars. Generally, this is economically advantageous for the Australian coal firms, whose costs are reckoned in Australian dollars.



Source: JCB, “Australian Black Coal,” etc

Fig. 2-10 Australian Coal Prices, Productivity and Number of Mines

Table 2-5 Australian Coal Prices, Productivity and Number of Mines

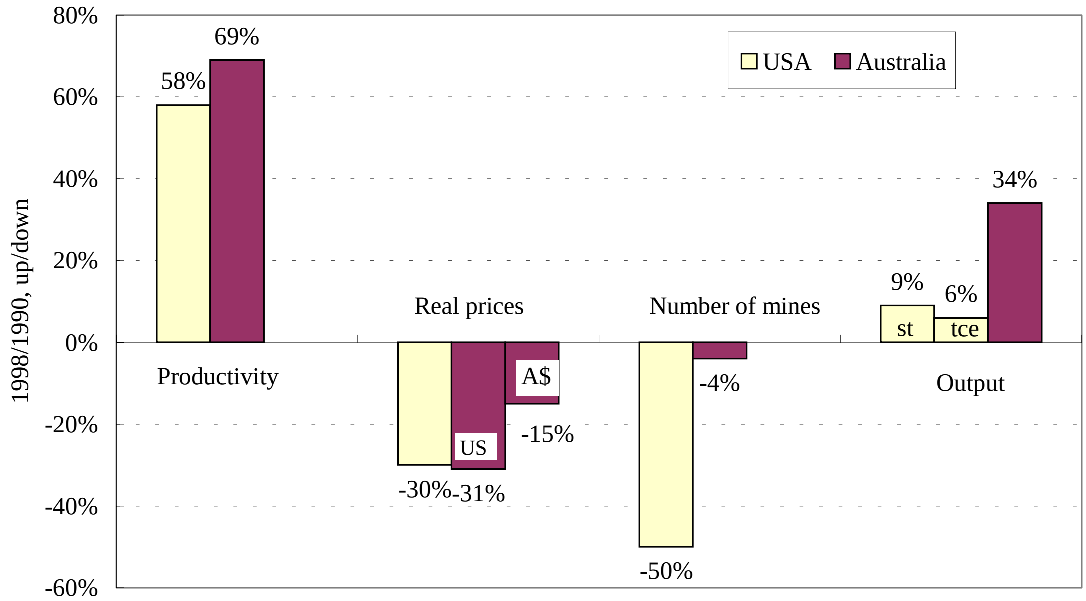
	Productivity	Average steaming coal export price		Average steaming coal export price (1990 price)		Number of Mines
	tons/miner/ hour	A$/ton	US$/ton	A$/ton	US$/ton	
1990	3.10	49.35	38.52	49.35	38.52	121
1991	3.21	48.59	37.85	47.25	36.81	122
1992	3.49	49.20	36.13	47.24	34.69	121
1993	3.68	48.60	33.05	45.80	31.15	115
1994	3.95	44.71	32.69	41.88	30.62	117
1995	4.02	47.71	35.37	43.75	32.43	121
1996	4.03	48.33	37.82	43.41	33.97	125
1997	4.41	46.54	34.54	41.23	30.60	119
1998	5.25	47.88	30.11	42.14	26.49	116
1999	6.15	41.16	26.57	36.15	23.34	113
1998/1990	69%	-3%	-22%	-15%	-31%	-4%
1999/1990	98%	-17%	-31%	-27%	-39%	-7%

Source: JCB, “Australian Black Coal,” etc

In Australia, the number of mines peaked at a record high of 150 in 1985, and then gradually shrank to 113 mines as of 1999. In terms of the 1999/1990 ratio, the number of mines dropped by 7%.

A comparison between the U.S. and Australia in productivity, real price, number of mines and output during the period 1990 – 1999 is shown in Fig. 2-11. In order to avoid distortion from the falling calorific value, the U.S. figures for productivity and price are expressed in terms of coal equivalent (tce). Also, the U.S. price is the price at mine, while the Australian price is the steaming coal export price (FOB).

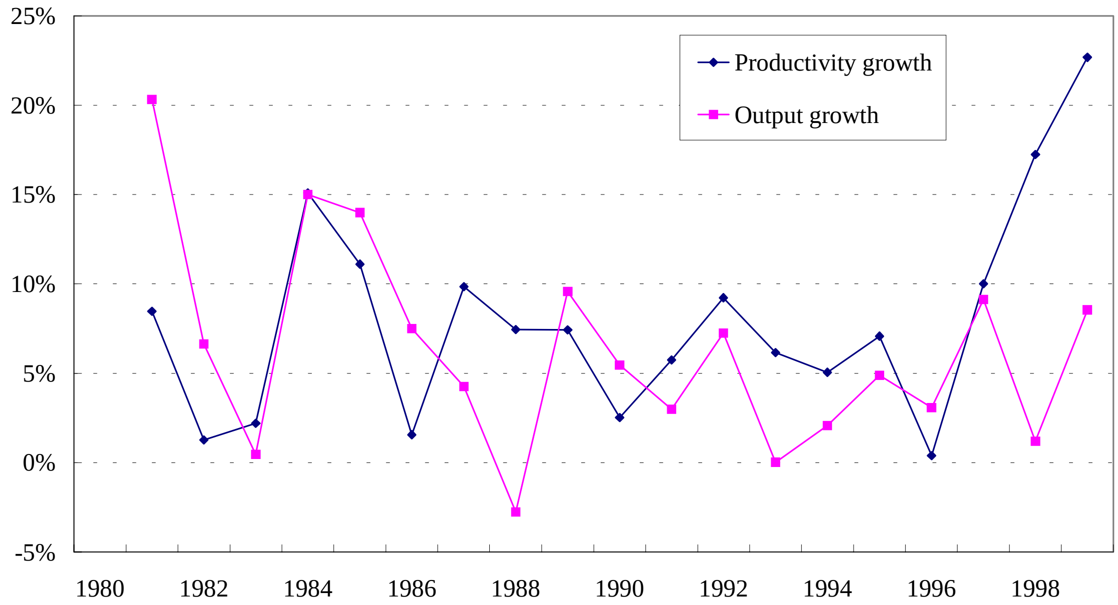
In productivity gains, a 69% rise in Australia surpassed the U.S. record by 11%. The coal price records are virtually identical, down by about 30%. In Australian dollars, however, the rate of decline is 15%, or half of the U.S. record. With regard to the number of mines, the U.S. figure fell by 50%, while in Australia the fall was a mere 4%. Australian coal production, 162.99 million tons in 1990, increased to 219.47 million tons, up 34%. Over the same period, the U.S. output grew by only 9% (up 6% in tce). It can thus be seen that the big differences between Australia and the U.S. lie in the rate of decrease in the number of mines and production growth.



Source: prepared from Tables 2-1 and 2-5 and Fig. 2-9

Fig. 2-11 Up/Down in 1990-1998 in U.S. and Australia

Fig. 2-12 shows the growth of productivity and output in Australia since 1981. During the 1980s, output increases exceeded productivity gains five times, and the cases were reversed in the remaining four years. From 1980 through 1989, productivity grew by 84.9%, while output increased by 102%. Under these conditions, output should run short even if all productivity gains contributed to output increases, and newly developed mines had to fill the shortage. Perhaps this is the primary cause of the growth in the number of Australian mines in the 1980s. In the 1990s, output increases surpassed productivity gains in two years, but were themselves surpassed eight times. Under such circumstances, productivity gains cannot be fully absorbed by output increases, which lead to personnel cuts and then to mine closures. This can be taken as the principal reason why the number of mines began to fall drastically in the 1990s. This trend, which has been particularly conspicuous since 1996, can have a massive impact on future developments of Australian coal.



Source: JCB, "Australian Black Coal," etc

Fig. 2-12 Growth of Australian Coal Productivity and Output

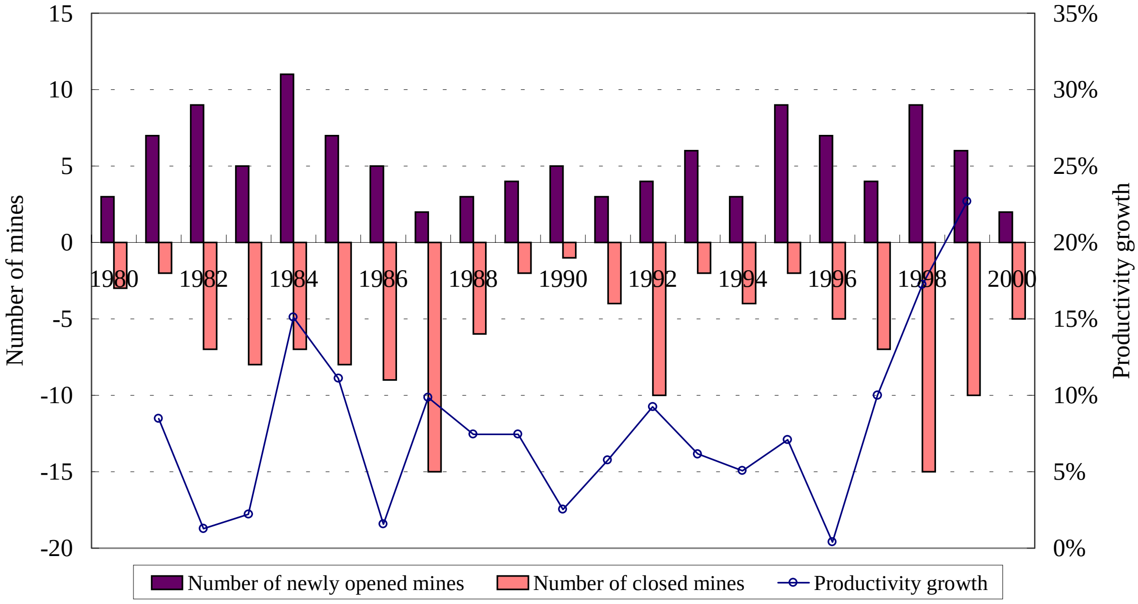
2-3-2 Actual state of selection of mines

It has already been mentioned that the productivity improvement cycle precipitated the selection of mines in the U.S. Is this true of Australia as well?

In the 1980s the production expansion cycle of Route 4 shown in Fig. 2-3 was selected, because productivity gains were exceeded by the growth of demand (= coal output) during the decade. Also, because production increases did not lead to oversupply, there was little room for selecting either R1, R2 or R3 as a productivity improvement cycle. The coal price, falling in terms of U.S. dollars but not of Australian dollars, also provided few incentives for cost reduction. As a result, little progress was made in weeding out high-cost mines with low competitiveness.

As from the beginning of the 1990s, productivity gains started to outpace output (demand) increases. Particularly, in view of the fall in the number of mines and the declining prices that have been seen since 1996, Australia is likely to enter a productivity improvement cycle, as was the case in the U.S. However, because further weakening of the Australian dollar is easing the price falls, incentives for formation of the cycle appear to be less strong than in the U.S.

As already mentioned, the number of mine closures has been smaller in Australia than in the U.S. Fig. 2-13 shows the numbers of mines opening and closing each year. After 1980, the years in which a large number of mines opened are 1984 (11 mines), and 1982, 1995 and 1998 (9 mines each), while the years in which a large number of mines closed are 1987 and 1995 (15 mines each), and 1992 and 1999 (10 mines each). The years having many shutdowns, namely 1987, 1992, 1998 and 1999, recorded productivity gains, which means that low-productivity mines were closed. With the total number of mines not significantly changed, productivity has improved rapidly since 1996. At the same time, the selection of mines has been advancing steadily. By 1998, a total of 24 mines, equivalent to 21% of all mines, were opened (9 mines) or closed (15 mines).

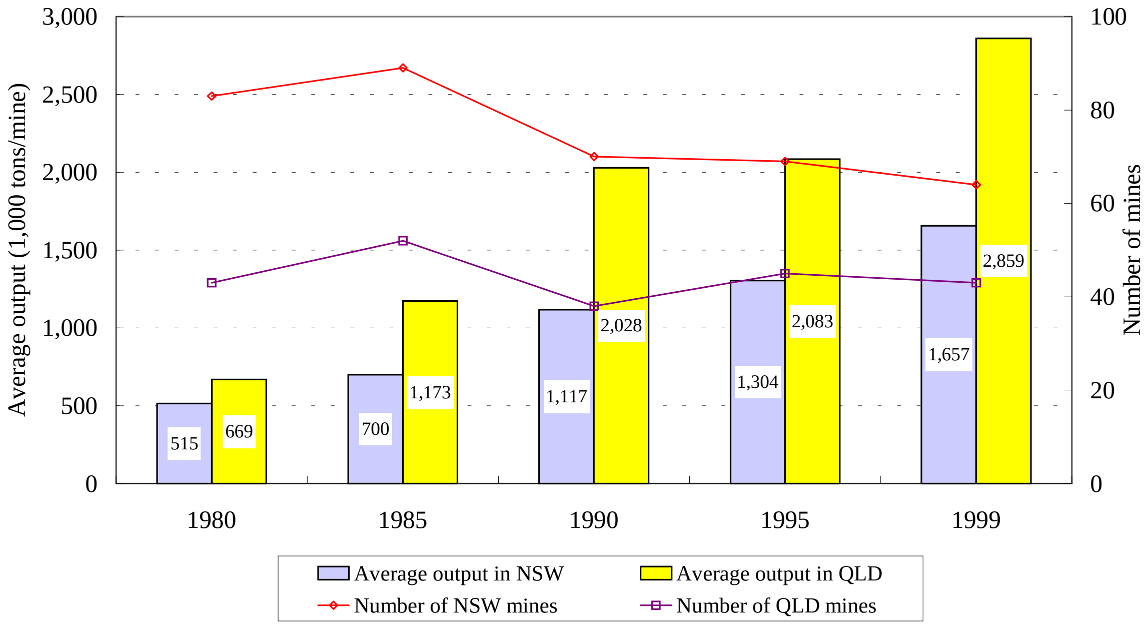


Source: NSW Mineral Resources[6], and JCB, QLD and DME survey data.

Fig. 2-13 Up/Down in Number of Australian Mines

2-3-3 Trends by average coal output

Fig. 2-14 shows the average output per mine in Australia. Between 1980 and 1999, the average output increased 3.2 times from 515,000 tons to 1,657,000 tons in NSW, and was also up 4.3 times from 669,000 tons to 2,859,000 tons in QLD.

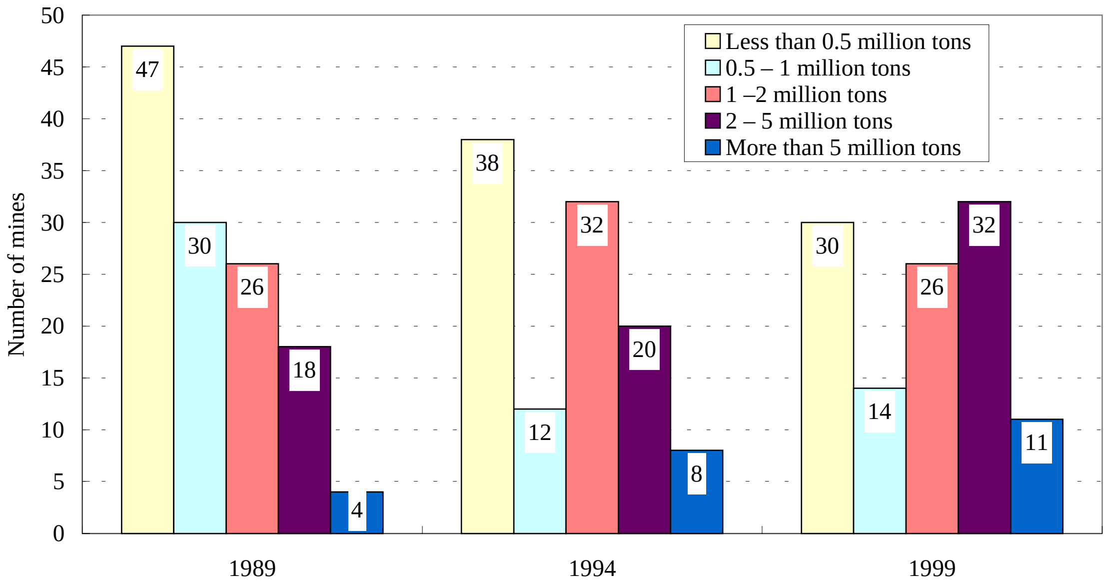


Source: JCB, "Australian Black Coal."

Fig. 2-14 Australia's Average Coal Output

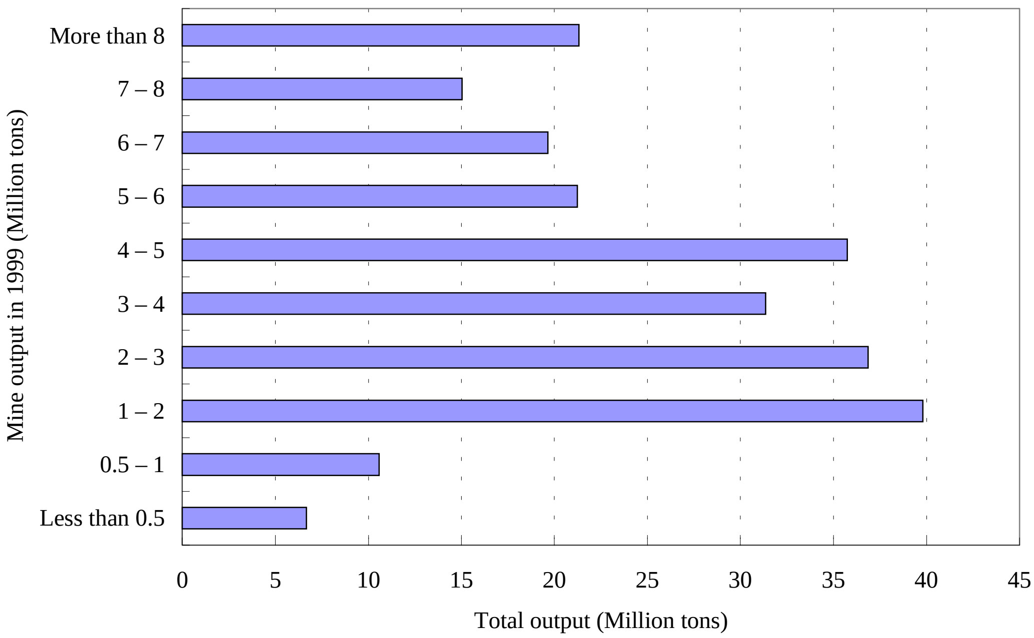
Fig. 2-15 shows the changes in numbers of mines by production size. During the decade from 1989 to 1999, there was a fall in the number of mines having annual output of less than a million tons. The number of mines of which annual output is within the range of 1 – 2 million tons remained balanced after temporary rises and falls. The only mines that increased in number were those producing more than two million tons a year. As in the U.S., smaller mines that produce less than a million tons a year are disappearing.

Fig. 2-16 shows the total output in 1999 by production size. The largest portion of coal output came from mines having an annual production size within the range of 1 – 2 million tons, followed by those with capacities of 2 – 3 million tons, 4 – 5 million tons, and 3 – 4 million tons, in that order. In the U.S., the average output per mine in 1998 was 670,000 tons nationwide, and 6.07 million tons in the Western region. In that year, the Western region had 73 mines, which produced a total of 488 million short tons (= 443 million tons). In Australia, meanwhile, coal output totaled 238 million tons in 1999. There were 113 mines, meaning that the average output per mine was 2.11 million tons. Australia's average output by far exceeded the all-America average, but remained below half of U.S. Western figures. Similarly, Australia remained at about half of the U.S. Western total output, while the Australian mines outnumbered their U.S. counterparts. These figures suggest there is ample room for the selection of mines in Australia, and more than in the U.S. Western region.



Source: JCB, "Australian Black Coal."

Fig. 2-15 Numbers of Australian Mines by Coal Production Size



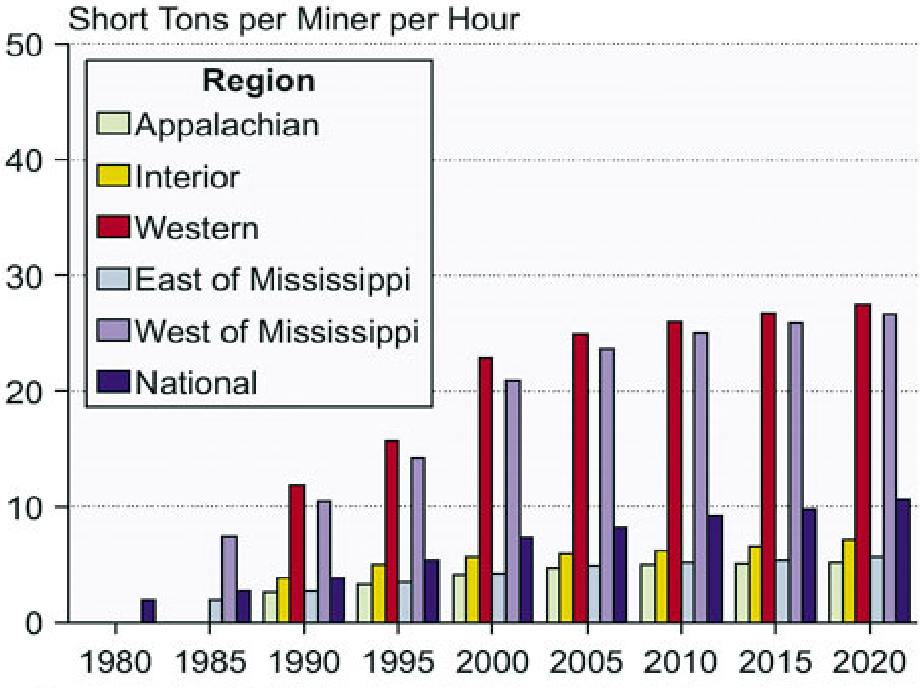
Source: JCB, "Australian Black Coal."

Fig. 2-16 Australian Coal Output by Production Size in 1999

3. Prospects for Coal Productivity

3-1 U.S.A.

According to a report prepared by E. J. Flynn[3] of the U.S., productivity of the American coal industry is forecast to keep increasing constantly up to 2020, as shown in Fig. 3-1 and Table 3-1. The report also puts the growth of productivity at 2.3% nationwide between 1998 and 2020.



Source: U.S. AEO 2000 National Energy Modeling System

Fig. 3-1 U.S. Coal Productivity Outlook

Table 3-1 U.S. Coal Productivity Outlooks

(Unit: short tons/miner/hour)

Producing regions	1998	2020	Average growth (%/year)
Appalachia	3.91	5.19	1.3
Interior	5.59	7.15	1.1
Western	19.58	27.42	1.5
National	6.47	10.61	2.3

Source: U.S. AEO 2000 National Energy Modeling System

The report cites the technological advances described below as a primary contributor to continued improvement of productivity in the future (Table 3-2).

Table 3-2 Contributing Factors to Improvement of U.S. Coal Productivity

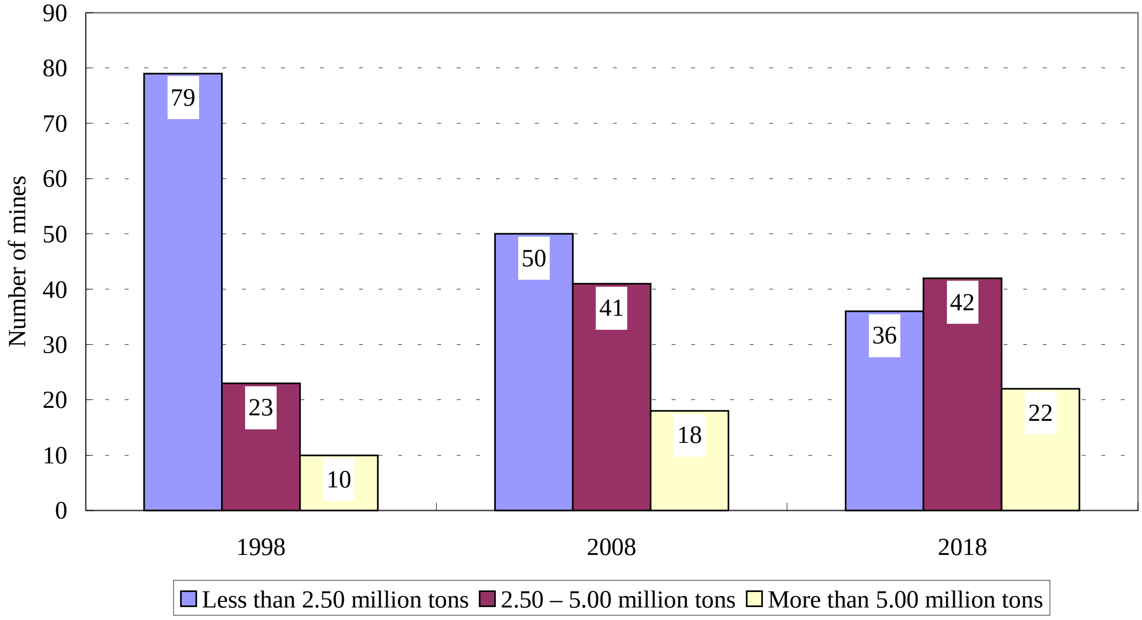
Under-ground mining	1) Longwall drum cutter with larger motor, improved continuous miner 2) Enlarged faces in width and panel length 3) Increased depth of cutting by drum cutter 4) Shift from the room -and- pillar system to the longwall system 5) Wider belt resulting from introduction of larger conveyor motor
Surface mining	1) Draglines and shovels with larger capacities and better performances 2) Trucks with larger tonnage capacities and higher driving speeds 3) Increased blasting capacity and improved blasting system
Automated monitoring	1) Increased operating rates of instruments by sensor improvements and computer control 2) Computerized automation and increased accuracy of control 3) Increased utilization factor of instruments by satellite tracking
Mine plan	1) Improved computer software for coal mine management 2) Satellite-based map drawing 3) Speedup of mining plan
Introduction of new technology	1) R&D on new technologies

Source: E.J. Flynn, [3)]

The U.S. EIA predicts in its Annual Energy Outlook 2001 that U.S. coal output will increase by 0.9%/year from 1999 onward and will reach 1,331 million short tons by 2020. During the same period, the coal price at mine is projected to fall by 1.4%/year to US$13.31/st (in 1999 price) by 2020. The prediction of price falls is perhaps based more on the higher growth of productivity (= 2.3% based on AEO2000 data) than on that of output (= 0.9%), as described in this report.

3-2 Australia

In his report, Robert D. Humphris[7)] of Australia forecast that over the next 20 years the numbers of longwall mines and large opencast mines will increase, particularly in QLD, and that the output from these mines will also grow. At the same time, Australia as a whole is likely to see the number of its mines fall to 100 by 2018. In particular, a conspicuously sharp fall can be expected in the number of mines with an annual capacity of 2.50 million tons or less (Fig. 3-2). On the other hand, mines capable of producing over 2.50 million tons a year are likely to increase in number.



Source: Robert Humphris, [7].

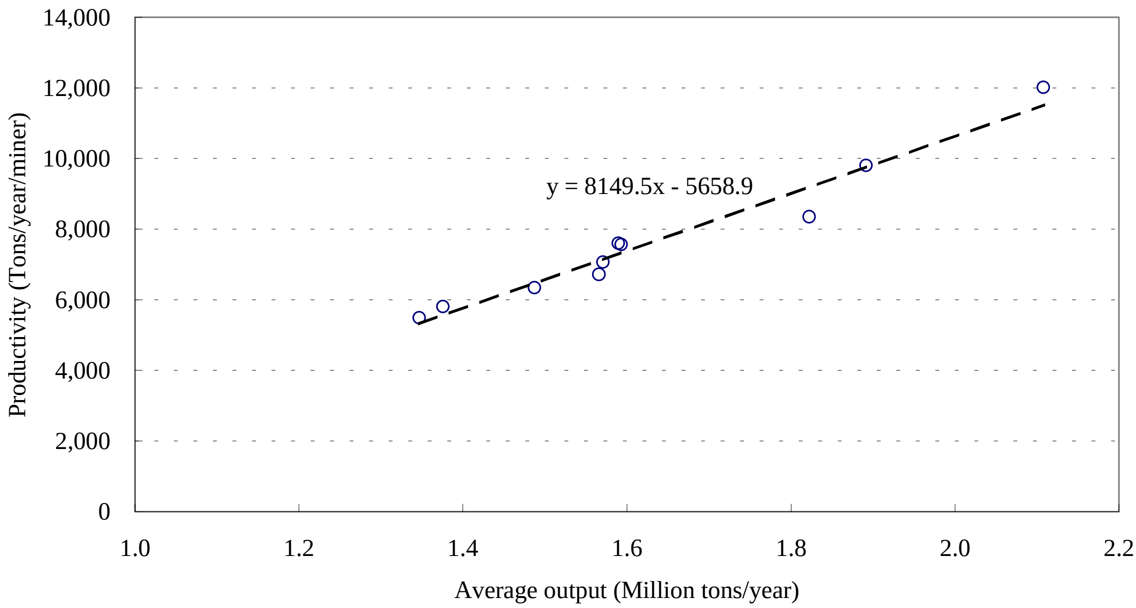
Fig. 3-2 Projected Numbers of Australian Mines by Annual Capacity

As for Australia's average production capacity, according to the data in Humphris' report, this will be 2.90 million tons a year in 2008, and 3.22 million tons in 2018 (Table 3-3).

By making a regression analysis, we attempted to find an interrelation between average output and productivity in the 1990 – 1999 period, and came up with the following regression equation.

Productivity (ton/year/miner) = 8,149.5 X average output (one million tons/mine) – 5,658.9

With this equation in use, productivity is estimated at 17,967 tons/year/miner for 2008, and 20,582 tons/year/miner for 2018. Productivity is also expected to grow by 2.9% in the period 1999 – 2018 (Table 3-3). Judging from the U.S. productivity gains (= 2.3%, see Table 3-1), 2.9% growth in Australia appears achievable.



Source: JCB, "Australian Black Coal."

Fig. 3-3 Relation between Average Output and Productivity of Australian Coals

Table 3-3 Outlooks for Australian Coal Productivity

	Production capacity* (mil. t/y)	No. of mines	Average production capacity (mil. t/y/mine)	Productivity (t/y/miner)
1999 (actual production)	238	113	2.11	12,010
2008	318	109	2.90	17,967
2018	322	100	3.22	20,582
2018/1999 (growth)		-0.6%	2.2%	2.9%

(Note) *: The 1999 figure represents actual production, not production capacity.

Source: prepared from (aforementioned) Robert Humphris' report, etc.

In its Coal Information 2000, the IEA projects that Australian coal production will reach 261.50 million tons coal equivalent by 2015, up 1.8% a year in the period 1999 – 2015. Also, in its International Energy Outlook 2001, the EIA puts Australian coal exports at 271.10 million short tons in 2020, up by an average of 1.7% since 1999 (Table 3-4). In either case, Australia's expected productivity gains (= 2.9%) stated in Table 3-3 exceed the growth projected for the country's coal output or exports. On the grounds of these production and productivity growth rates, it appears most likely that stable supplies of Australian coals will remain attainable from now on.

Table 3-4 Outlooks for Australian Coal Production and Exports

Year	1999	2005	2010	2015	2020	Growth 2015/1999	Source.
Output (Million tce)	196.0	222.2	245.2	261.5		1.8%	IEA, Coal Information 2000
Export (Million tce)	171.6	178.7	201.3	216.9		1.5%	*ibid*
Export (Million st) (Million mt)	 189.4 171.8		 254.2 230.6		 271.1 245.9	 1.7% 1.7%	EIA, International Energy Outlook 2001

Source: IEA, Coal Information 2000, EIA, International Energy Outlook 2001

4. Future Investment Trends (Conclusions)

This section summarizes the analysis results gained from our study. Coal mine development investment, generally linked to a given coal price, is frequently affected by corporate profits, the source of investment funds. It also became clear that cost reduction, namely improvement in productivity, would contribute significantly to securing corporate profits. Among other findings, coal production in both the U.S. and Australia has been constantly on the rise despite sluggish development investment, which can be explained by the fact that productivity gains contributed to boosting production capacity. In other words, productivity is closely linked to development investment.

As mentioned in the preceding chapter, in an attempt to predict Australia's development investment trends 10 – 15 years into the future, we compared productivity gains with production increases and determined that the former would outgrow the latter. Hence, without the need for hasty investment to cover short supplies, Australia should be able to concentrate its development investment on promising mines that can show strong competitiveness on the market.

Table 4-1 shows capacity expansion plans by major mines currently operating in Australia. When combined, the additional capacities of these mines amount to 57 million tons a year. This is equivalent to the incremental output in the years to 2010, estimated at 49.20 million tce/year (approx. 56 million tons/year) in Table 3-4. Thus, in the years up to 2010, entrants will not have many chances. Apart from production declines resulting from depletion of resources (coal deposits) or mine closures, one of the few chances will be vacancies occurring when less cost-competitive mines are driven out of the market.

Table 4-2 shows Australia's principal coal projects awaiting start of development. When combined, their capacities amount to some 90 million tons/year. Market participation of these projects is capable of causing fierce price competition, which in turn may lead to a productivity improvement cycle, as described earlier. If so, the worrying possibility is that such a cycle could send the coal price sliding, spur concentrated investments in extension of existing mines (brown field), and limit investments in new mines (green field).

Table 4-1 Capacity Expansion Planned by Major Australian Mines

Name of mine	Ultimate production capacity (million tons/year)	Incremental capacity (million tons/year)
Blackwater O/C	13.5	6.8
Kestrel U/G	7.0	5.4
Ensham-Yongala O/C	9.0	5.3
Howick O/C	8.0	4.3
Bengalla O/C	6.0	4.1
Foxleigh O/C	4.0	4.0
North Goonyella U/G	4.7	3.2
Moranbah North U/G	5.8	2.5
Crinum U/G	5.0	2.1
Curragh O/C	6.5	2.0
Coppabella O/C	3.7	1.9
Peak Downs O/C	8.5	1.9
Moura O/C	5.8	1.8
Southland U/G	2.7	1.8
Warkworth O/C	7.0	1.8
Mount Owen O/C	5.0	1.6
South Walker Creek O/C	3.7	1.3
Oaky Creek U/G	7.5	1.3
Baal Bone U/G	2.5	1.1
Norwich Park O/C	5.2	1.1
West Cliff U/G	2.0	1.0
West Wallsend U/G	3.5	1.0
Total	126.6	57.4

Source: prepared from materials of Robert Humphris, Barlow Jonker, AME and others.

Table 4-2 Major Newly Developed Mines in Australia

Name of mine	Production capacity (Million tons/year)
Clermont	10.0
Mount Pleasant Proposal	7.6
Maules Creek Proposal	7.0
Suttor Creek Proposal	7.0
Mount Arthur North Prospect	6.0
Hail Creek Prospect	5.5
Theodore Prospect	5.0
Togara North	5.0
Boggabri Proposal	4.5
Saddlers Creek Prospect	4.0
Glendell Proposal	3.6
German Creek Grasstrees	3.6
Wyong Prospect	3.5
Moranbah South	3.3
Acland Proposal	3.0
Wards Well	3.0
Nardell Proposal	2.5
Donaldson O/C	2.0
Kayuga Prospect	1.5
Duralie Proposal	1.2
Minerva/ Gindie	1.0
Total	89.8

Source: materials of Robert Humphris, Barlow Jonker, AME and others.

Acknowledgements

This study report is based on a revision of part of "FY2000 Works to Advanced Overseas Coal Development (The Challenges of Coal Supply and Demand, A Consideration of Stable Coal Supply)," a study project awarded to IEEJ by the New Energy and Industrial Technology Development Organization. Acknowledgements are due to the NEDO for their kind permission for this publication.

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7) Robert D. Humphris, “The future of coal: mining costs & productivity”, “IEA, The Future Role of Coal, 1999”