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## 2 Mining and its measured productivity

### Key points

- Mining is an important production activity within the Australian economy and has a relatively high level of labour productivity as measured using conventional national accounts. Its relatively high capital intensity is a major factor contributing to its high level of labour productivity.
- Mining tends to exhibit large swings in productivity over long periods of time, compared with other industries. Variations in labour productivity are due to a combination of variations in capital intensity and variations in multifactor productivity (MFP).
- Labour productivity in mining has grown over the longer term on average, but there has been comparatively little long-term growth in MFP.
- Mining MFP fell by 24.3 per cent between 2000-01 and 2006-07. The proximate cause of the decline is falling productivity within the major mining sub-sectors.
- Structural changes within the mining industry between 2000-01 and 2006-07 are not the cause of the marked decline in mining productivity during the period. Other factors are more important.

This chapter provides background on the mining industry and its productivity performance. It places the sector in its national economy context, and outlines the nature and structure of the sector. It reviews the characteristics of mining productivity and the sector's contribution to national productivity.

### 2.1 Australia's mining industry

Mining activity has been booming in recent years and has been a major driver of nominal economic growth in Australia. Even under 'normal' conditions, mining is a major part of the Australian economy.

## Contributions to the national economy

According to Australian Bureau of Statistics (ABS) data, Australia's mining industry typically accounts for around 5 per cent of Australia's nominal GDP. Higher prices for mining industry commodities in recent years mean that this share had increased to 8.5 per cent by 2006-07 (table 2.1).

Table 2.1 **Sector contribution to total market sector output, investment, capital stock, exports, and employment**

Per cent

	<i>Share of gross value added<sup>a</sup></i>		<i>Share of gross fixed capital formation<sup>a</sup></i>		<i>Share of net capital stock<sup>a</sup></i>	
	2000-01	2006-07	2000-01	2006-07	2000-01	2006-07
Agriculture, forestry & fishing	4.0	2.4	4.8	3.2	3.3	2.7
<b>Mining</b>	<b>5.5</b>	<b>8.5</b>	<b>6.2</b>	<b>12.7</b>	<b>6.5</b>	<b>7.1</b>
Manufacturing	12.7	10.7	8.5	6.9	5.1	4.4
Services & other	77.8	78.4	80.4	77.2	85.1	85.8
Total economy	100.0	100.0	100.0	100.0	100.0	100.0

	<i>Share of exports<sup>a</sup></i>		<i>Share of hours worked</i>		<i>Share of employed persons</i>	
	2000-01	2006-07	2000-01	2006-07	2000-01	2006-07
Agriculture, forestry & fishing	18.7	11.7	6.1	4.4	4.1	2.9
<b>Mining</b>	<b>31.8</b>	<b>40.7</b>	<b>1.2</b>	<b>1.8</b>	<b>0.9</b>	<b>1.3</b>
Manufacturing	17.5	13.6	14.0	12.0	12.3	10.2
Services & other	32.0	34.1	78.8	81.8	82.8	85.6
Total economy	100.0	100.0	100.0	100.0	100.0	100.0

<sup>a</sup> In current prices. Errors due to rounding.

Sources: ABS (*Australian System of National Accounts 2007-08*, Cat. no. 5204.0 Table 11); ABS (*International Trade in Goods and Services 2008*, Cat. no. 5368.0 Table 3); ABS (*Australian Labour Market Statistics 2008*, Cat. no. 6105.0).

Mining is export oriented, with around one half of total mining output being exported each year. For some mineral resource commodities — notably iron ore, alumina and uranium — the share of total output that is exported is particularly high, approaching 100 per cent (table 2.2 and figure 2.18).

Table 2.2 **Estimated proportion of total mining commodity production exported<sup>a</sup>**

Per cent

	2000-01	2006-07
Coal	75	75
Crude Oil and Condensate <sup>b</sup>	62	56
Liquefied Petroleum Gas <sup>b</sup>	69	62
Natural Gas	31	51
Iron ore	90	89
Gold <sup>c</sup>	87	101
Nickel	95	87
Copper	79	81
Zinc	98	96
Lead	93	99
Silver	22	26
Alumina	96	98
Uranium	102	99
Manganese	78	92

<sup>a</sup> Numbers can exceed 100 if exports included a rundown in stocks. <sup>b</sup> Australia imports and exports significant quantities of petroleum products. As such, the *net* exports as a share of production may be of relevance. For crude oil and condensate, this figure is -6 per cent and -33 per cent for 2000-01 and 2006-07 respectively. For LPG, the figure is 53 per cent and 46 per cent for 2000-01 and 2006-07 respectively. <sup>c</sup> Significant amounts of gold are imported into Australia for refining. This figure is an estimate of how much gold produced in Australia is exported.

Sources: Authors' estimates using data from ABARE (*Australian Commodity Statistics 2007*); ABARE (*Australian Mineral Statistics, various issues*).

Mining exports make a major contribution to Australia's total export revenue (table 2.1). Between 2000-2001 and 2006-07, the mining industry's share of the value of total Australian exports of goods and services increased from 31.8 per cent to 40.7 per cent. It is useful to note, however, that depletion of key Australian crude oil reserves has led to an increase in imports of oil and petroleum products during this period, meaning that 'net' mining exports have not increased by as much as 'gross' exports.

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The mining industry is comparatively capital intensive<sup>1</sup>, and accounts for a significant share of aggregate investment in Australia. For example, during the last ten years the mining industry has accounted for just under 9 per cent of aggregate capital investment in Australia, although the nature of mining means that there can be fairly large swings in the share from year to year. With the surge in commodity prices in recent years and a general sense of economic prosperity in the sector, capital investment also surged, accounting for 12.7 per cent of aggregate capital investment in Australia in 2006-07.

The flipside of its high capital intensity is that mining employs a small proportion of the Australian workforce. Mining accounted for 0.9 per cent of total employment in the early 2000s (table 2.1). While mining employment has grown substantially in recent years (around 9.5 per cent a year, on average, between 2000-01 to 2006-07), the employment share remains relatively low at 1.3 per cent.

In terms of regional location, mining accounts for a higher share of economic activity in the economies of Western Australian, the Northern Territory and to a much lesser extent Queensland, than in other state and territory economies (box 2.1). Recent boom conditions have therefore been most prominent in these economies.

## **The structure of the mining industry**

Mining is a diverse and heterogeneous production sector. It encompasses:

- a range of distinct activities;
- extraction of a diverse range of commodities, the deposits of which are distributed unevenly in terms of:
  - geographic location;
  - qualities or grades; and
- a variety of techniques of extraction and processing.

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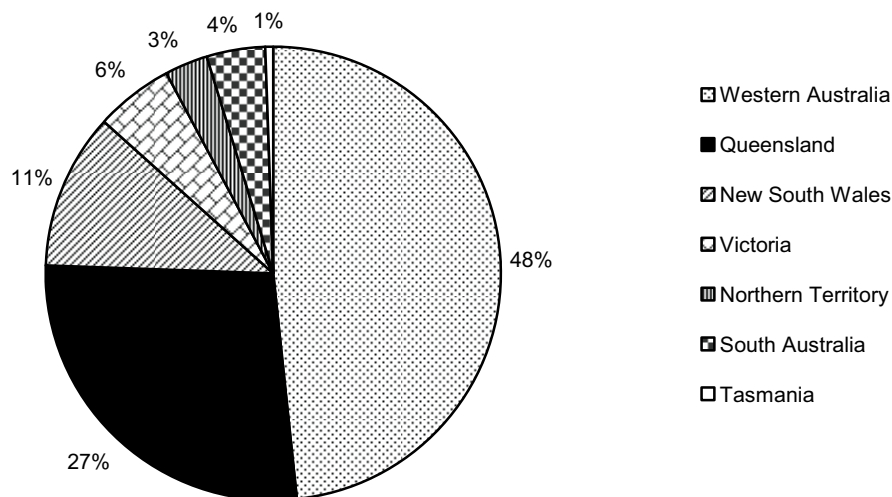
<sup>1</sup> Mining has a capital income share averaging around 76 per cent, compared with 38 per cent in manufacturing, 30 per cent in the construction sector, and 60 per cent in agriculture. The capital intensive nature of mining and the implications for productivity calculations is discussed in more detail in chapter 4.

### Box 2.1 The regional dimension of mining

Mining activity is not distributed uniformly among the states of Australia and, even within states, most mining activity takes place in rural and remote areas, including in off-shore locations. Hence developments in the mining industry can have particularly strong effects on sub-state or regional economic activity.

In terms of the value of production, the vast majority of mining activity in Australia takes place in Western Australia and Queensland (figure 2.1). Between them the two states account for nearly three quarters of total production. This apparently disproportionate share is less anomalous given that the two states also account for well over one half of Australia's total land area.

Figure 2.1 State shares of total mining production<sup>a</sup>, 2005-06



<sup>a</sup> Measured in terms of industry value added.

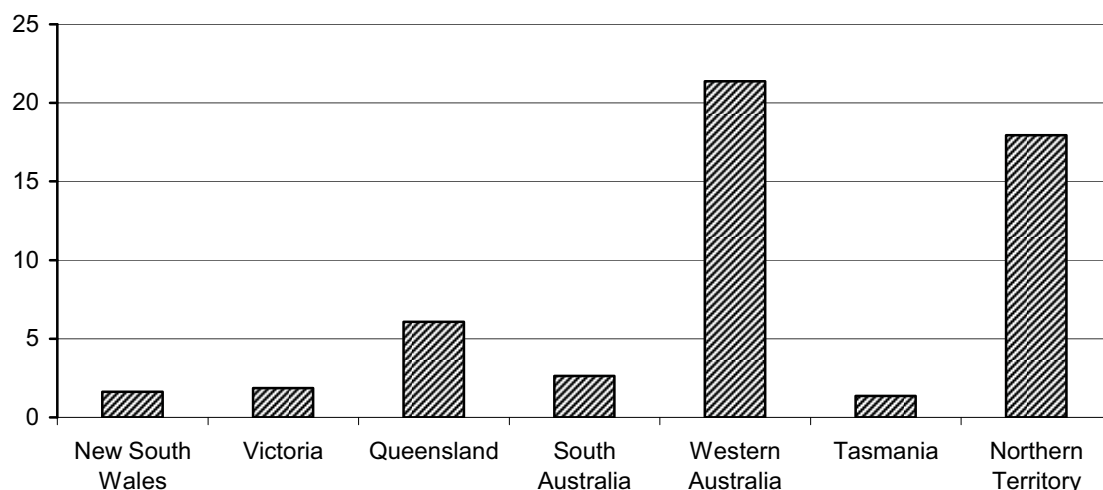
Data source: ABS (*Mining Operations, Australia, 2005-06*, Cat. no. 8415.0).

Mining is particularly important to the economies of Western Australia and the Northern Territory, and is also important to the economy of Queensland (figure 2.1)

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Box 2.1 (continued)

Figure 2.2 **Mining share of state output<sup>a</sup>**  
Average 2001-02 to 2005-06



<sup>a</sup> Mining value added as a share of gross state product (in current prices).

Data sources: ABS (*Mining Operations, Australia 2005-06*, Cat. no. 8415.0); ABS (*Australian National Accounts: State Accounts 2006-07*, Cat. no. 5220.0).

*Mining activities, who undertakes them, and how they are measured*

Table 2.3 summarises major activities undertaken in the mining industry. ‘Mining’ consists of a number of quite distinct components — exploration, mine development, extraction, processing, transportation and restoration of land. The component activities can all be undertaken by mining companies, although the sector has become more specialised in recent times. Increasingly, mining companies have specialised in extraction and have contracted out exploration to mining services companies and mine development to construction companies. Depending on the circumstances of individual mines, processing and transport may also be contracted out.

The distinction between in-house and contracted-out activities can be important for statistical purposes. The ABS assigns data to industries according to the principal activity of a ‘management unit’ (usually a business division within conglomerates). Thus, some construction activity would be allocated to the mining industry if it was undertaken by a mining company incidental to its prime extraction activity, but would be allocated to the construction industry if it was undertaken under contract by a construction company. Other examples are listed in table 2.3. Any processing

or refining of a resource by a miner at the mine site is included in the mining industry, whereas processing and refinement undertaken elsewhere (even if undertaken by the same company, but in a different division) is allocated to manufacturing (for example, manufacture of petroleum, coal or mineral products).

**Table 2.3 Overview of mining and related activities**

<i>Activity</i>	<i>Examples</i>	<i>Undertaken by</i>	<i>ABS industry classification</i>
Exploration	<ul style="list-style-type: none"> <li>• Prospecting</li> <li>• Determine characteristics of deposit</li> <li>• Feasibility analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Mining services companies</li> <li>• Mining companies</li> </ul>	<ul style="list-style-type: none"> <li>• Mining (Services to Mining)</li> </ul>
Mine development	<ul style="list-style-type: none"> <li>• Acquire mining rights</li> <li>• Construct access roads and infrastructure</li> <li>• Construct mine to access deposit</li> <li>• Install plant and equipment</li> </ul>	<ul style="list-style-type: none"> <li>• Contractors</li> <li>• Mining companies</li> </ul>	<ul style="list-style-type: none"> <li>• Construction (if contracted)</li> <li>• Mining (if in-house)</li> </ul>
Extraction	<ul style="list-style-type: none"> <li>• Remove deposit from the ground</li> </ul>	<ul style="list-style-type: none"> <li>• Mining companies</li> </ul>	<ul style="list-style-type: none"> <li>• Mining</li> </ul>
Processing	<ul style="list-style-type: none"> <li>• Crushing</li> <li>• Milling</li> <li>• Concentration</li> </ul>	<ul style="list-style-type: none"> <li>• Mining companies (at mine head)</li> <li>• Processors</li> </ul>	<ul style="list-style-type: none"> <li>• Mining (if in-house at mine head)</li> <li>• Manufacturing (if at another site)</li> </ul>
Transport	<ul style="list-style-type: none"> <li>• Move extracted material or milled product to transport head</li> </ul>	<ul style="list-style-type: none"> <li>• Mining companies</li> <li>• Transport contractors</li> </ul>	<ul style="list-style-type: none"> <li>• Transport (if contracted)</li> <li>• Mining (if in-house)</li> </ul>
Reclamation	<ul style="list-style-type: none"> <li>• Remove buildings, plant and equipment</li> <li>• Treat waste and tailings</li> <li>• Environmental rehabilitation</li> </ul>	<ul style="list-style-type: none"> <li>• Mining services companies</li> <li>• Mining companies</li> </ul>	<ul style="list-style-type: none"> <li>• Mining</li> </ul>

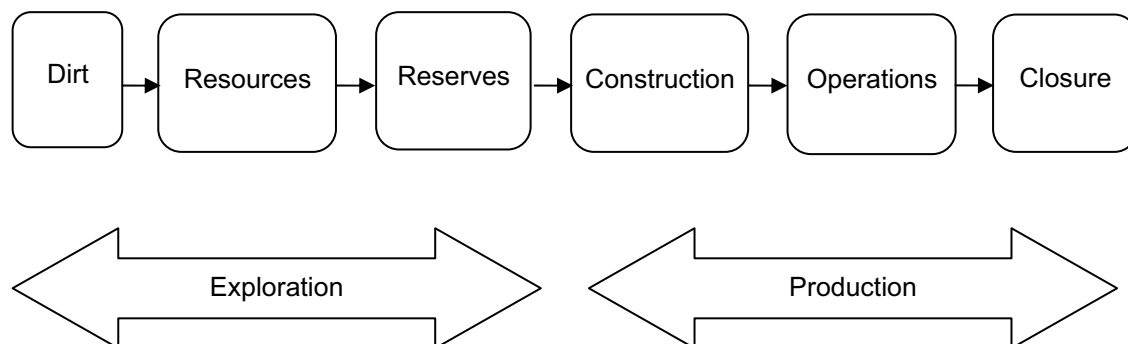
### **The life cycle of mines and the measurement of mining productivity**

The life cycle of most mines involves the various activities listed in table 2.3 above, and is represented schematically in figure 2.3.

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Figure 2.3 **Stages in the life cycle of mines**

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The first three phases in this process — dirt to resource to reserve — are the outcome of exploration activity, and reflect the transformation of a physical location (a place on the earth or a place under water in the case of off-shore oil and gas extraction) into first a ‘resource’, and subsequently a ‘reserve’.<sup>2</sup> Market conditions also influence the transition of a ‘resource’ into a ‘reserve’, in the sense that price changes may encourage further drilling and development activity that turn a known but unprofitable ‘resource’ into a profitable ‘reserve’, and vice versa. But exploration is the basic activity that identifies resources in the first place.

Once the decision is made to develop a reserve, the next three phases of the cycle — construction, operation, and, ultimately, closure — characterise the production stage of mining.

The ABS measurement of productivity in the mining industry effectively covers the productivity of all of the stages shown in figure 2.3. Hence, changes over time in measured productivity reflect not just changes in the amounts of labour and capital inputs used to extract and process mineral and energy resources, but also changes in the quality of new reserves as discovered through exploration. The latter may vary as a consequence of improved tools and techniques in exploration, but may also be adversely affected by the possibility that as time goes by and existing reserves are depleted, the probability of finding new reserves of comparable quality to those already in production generally declines. The idea that systematic changes in the quality of natural resources used in mining can have an impact on conventional

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<sup>2</sup> A ‘resource’ in this context is loosely defined as a significant but imprecisely measured deposit that may be profitable to mine at current and expected future prices, while a ‘reserve’ is a more precisely measured deposit that is profitable to mine at current and expected future prices. It is important to note that the terms ‘mineral resource’ and ‘ore reserve’ have a formal definition according to the Australasian Joint Ore Reserves Committee (JORC), which can be found on their website: [www.jorc.org](http://www.jorc.org).

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measures of productivity in mining is a key outcome of this paper, and is covered in detail in chapter 3.

Changes in market prices — particularly unexpected changes — influence miners decisions about what is valuable material and what is waste (the ‘resource’ to ‘reserve’ stage shown above). Hence, changes in market prices can also influence mining productivity through changes in the average quality of natural resources being targeted by miners. This is another important issue raised in this paper, and is taken up in more detail in chapter 5.

### *Commodities produced*

In global terms, Australia is a significant world producer of a number of mineral resources, including alumina, iron ore and lead (table 2.4). While Australian coal production is only a comparatively small proportion of global coal production, Australia is the world’s largest exporter of coal, accounting for around 30 per cent of global trade in recent years. This is because many large coal producing countries, such as the United States and China, do not export significant quantities of coal.

More broadly however, the Australian mining industry produces a vast range of commodities. Table 2.5 contains estimates of production in 2005-06 of a range of individual mineral and energy commodities, along with the percentage breakdown of total production by state.

**Table 2.4 Australian share of world minerals production in 2006**

	<i>Per cent</i>
Copper	6
Silver	9
Gold	10
Nickel	13
Zinc	13
Manganese	15
Lead	18
Iron ore	19
Ilmenite	20
Uranium	22
Alumina	31
Rutile	44

Source: Authors’ estimates using data from ABARE, (*Australian Commodity Statistics 2007*).

**Table 2.5 Production of selected mineral and energy commodities**

Quantity produced and state shares of Australian production, 2005-06

	Australia	State shares						
		NSW	Vic	Qld	SA	WA	Tas	NT
	Qty	%	%	%	%	%	%	%
<b>Fuel minerals</b>								
Black coal ('000t)	310 101	40.2		56.4	1.1	2.2	0.1	
Brown coal ('000t)	67 737		100.0					
Crude oil (ML)	19 029		25.3	2.2	3.9	60.6		7.9
Condensate (ML)	8 109			2.8	3.3	69.4		24.6
Shale oil (ML)								
Natural gas (Mm <sup>3</sup> )	23 838		38.1	13.3	9.4	32.4	0.0	6.8
Coal seam methane ('000m <sup>3</sup> )	1 662 448			100.0				
Liquefied natural gas (t)	12 543 261					93.1		6.9
Liquefied petroleum gas – propane (t)	n.a.							
Liquefied petroleum gas – butane (t)	n.a.							
Total liquefied petroleum gas (t)	1 740 091			9.6	8.2	50.1		32.1
Ethane (t)	n.a.							
Carbon dioxide (t)	12 959				100.0			
<b>Metallic minerals</b>								
Antimony (metal content) (t)	-							
Bauxite (t)	60 729 597			26.4		64.7		8.9
Cadmium (metal content) (t)	-							
Cobalt (metal content) (t)	5 069					100.0		
Copper (metal content) (t)	910 089	22.4		44.3	21.8	7.8	3.6	0.0
Gold (metal content) (kg)	241 780	12.0	2.6	8.2	2.7	66.6	2.9	5.0
Iron ore and concentrate (t)	247 281					1.5	98.5	
Iron ore pellets (t)	2 132 232						100.0	
Lead (metal content) (t)	711 862	15.3		71.2		8.3	5.2	
Nickel (metal content) ('000t)	191					100.0		
Palladium (metal content) (kg)	622					100.0		
Platinum (metal content) (kg)	n.p.							
Silver (metal content) (kg)	2 002 816	4.8		84.2	1.3	5.0	4.6	0.0
Tin (metal content) (t)	1 548					39.4	60.5	
Uranium oxide (t)	9 949				47.9			52.1
Zinc (metal content) (t)	1 213 035	14.7		69.0	0.3	8.9	7.2	
Zinc/lead concentrate (t)	224 276							100.0

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Table 2.5 (continued)

	State shares							
	Australia	NSW	Vic	Qld	SA	WA	Tas	NT
	Qty	%	%	%	%	%	%	%
<b>Industrial minerals</b>								
Barite (t)	18 466	4.2			95.8			
Chromite (t)	105 951					100.0		
Bentonite (t)	n.a.							
Attapulgate (t)	n.a.							
Kaolin (t)	n.a.							
Structural clays (t)	n.a.							
Total clays (t)	n.a.							
Diamond (ct)	29 263 869					100.0		
Diatomite (t)	23 442	82.5		17.5				
Basalt (t)	21 552		100.0					
Granite (t)	n.p.							
Limestone (dimension stone) (t)	15 158				100.0			
Marble (t)	n.p.							
Sandstone (t)	120 798	42.4	4.2	48.3	4.8		0.2	
Slate (includes flagstone) (t)	9 703		3.4	0.8	95.7			
Other dimension stone and/or unspecified rock (t)	25 905			41.6			52.4	5.9
Total dimension stone (t)	226 819	27.3	12.2	32.5	20.4	0.8	6.1	0.7
Feldspar (t)	n.a.							
Garnet (t)	278 577					100.0		
Staurolite (t)	n.a.							
Gypsum (t)	4 249 286	4.0	12.7	1.1	45.0	37.1		
Iron oxide – magnetite (t)	130 550	49.6					50.4	
Iron oxide – other (t)	n.a.							
Total iron oxides (t)	n.a.							
Limestone for cement (t)	6 671 151		9.3	31.4	32.2		27.1	
Limestone for lime (t)	802 583		25.6	45.9	22.5		6.0	
Limestone for agricultural use (t)	742 333		66.0	2.4	15.7		15.8	
Limestone for metallurgical flux (t)	142 597			60.1	0.2		39.6	
Limestone for chemical uses (t)	667 943				100.0			
Limestone for other and/or unspecified uses (t)	n.p.							
Total Limestone (t)	n.p.							
Limesand (t)	n.p.							
Total limestone and limesand (t)	18 279 900	26.6	7.2	16.2	17.1	21.4	11.1	0.5
Magnesite (t)	482 027			92.7	0.3			
Dolomite (t)	716 178		1.1	3.5	94.5			
Serpentinite (t)	130 397	100.0						
Total magnesium-rich materials (t)	1 328 602	13.0		35.5	51.1			
Manganese ore (t)	3 825 730					23.2		76.8
Mica (t)	-							

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Table 2.5 (continued)

	State shares							
	Australia	NSW	Vic	Qld	SA	WA	Tas	NT
	Qty	%	%	%	%	%	%	%
Peat (t)	1 559			100.0				
Perlite (t)	12 057			100.0				
Phosphate rock (t)	2 083 454			100.0	0.0			
Pyrophyllite (t)	-							
Salt (t)	11 467 399				5.5	94.5		
Silica – lump (quartz, quartzite, chert) (t)	207 091	100.0						
Silica – sand (t)	n.p.							
Silica – unspecified (t)	n.p.							
Total silica (t)	4 386 311	15.1	7.7	47.6	7.7	17.7	4.2	
Sillimanite (t)								
Spodumene (t)	193 229					100.0		
Spongolite (t)	n.a.							
Talc (t)	n.a.							
Tantalum (t)	871					100.0		
Ilmenite (t)	708 197			21.7		78.3		
Synthetic rutile (t)	n.a.							
Leucosene (t)	75 663					100.0		
Rutile (t)	n.a.							
Total titanium minerals (t)	n.a.							
Vanadium (t)	n.a.							
Vermiculite (t)	9 392							100.0
Zeolite (t)	3 405	67.3		32.7				
Zircon (t)	423 911	0.0		12.3		87.7		
Total industrial minerals	81 939 958	9.6	4.3	11.9	8.8	58.8	2.9	3.7
<b>Construction materials</b>								
Total crushed and broken rock (t)	81 071 514	17.4	34.6	36.7	5.4	1.8	3.4	0.7
Total construction sand (t)	31 220 695	25.9	24.2	23.4	12.9	11.5	1.8	0.3
Total gravel (t)	8 702 081	45.5		24.7	2.3	1.1	24.3	2.1
Total soil, loam & garden sand (t)	801 444	36.0		18.9	42.8			2.4
Total other construction materials (t)	23 682 264	15.7	33.1	26.7	24.5			
Total construction materials (t)	145 77 998	20.8	29.9	31.4	10.1	3.5	3.7	0.6

n.a. Not available. n.p. not available for publication but included in totals where applicable.

Source: ABS (*Mining Operations, Australia 2005-06*, Cat. no. 8415.0).

### *Mining industries within the sector*

Table 2.6 lists the major subdivisions and classes within the mining industry as defined by the ABS for the purposes of many of their statistical reports. Output in this table is measured by value added, and covers production in both primary and incidental activities.

The coal mining and the oil and gas extraction industries are by far the two largest sub-sectors in the mining industry, with each accounting for around a quarter or more of the value of total mining output. Iron ore mining accounts for around 15 per cent of industry value added, meaning that the three industries — coal, oil and gas, and iron ore — account for around 70 per cent of the value of mining industry output.

**Table 2.6 Value added in the mining industry, by subdivision and class, in 2006-07**

		Industry output	
		\$m	per cent
11	<i>Coal mining</i>		
	110 <i>Coal mining</i>	16 364	22.8
12	<i>Oil and gas extraction</i>		
	120 <i>Oil and gas extraction</i>	22 420	31.2
13	<i>Metal ore mining</i>		
	131 <i>Metal ore mining</i>		
	<i>Iron ore mining</i>	11 208	15.6
	<i>Bauxite mining<sup>a</sup></i>		
	<i>Copper ore mining</i>	3 699	5.2
	<i>Gold ore mining</i>	2 629	3.7
	<i>Mineral sand mining</i>	373	0.5
	<i>Nickel ore mining<sup>a</sup></i>		
	<i>Silver-lead-zinc ore mining</i>	4 339	6.0
	<i>Metal ore mining nec</i>	5 141	7.2
14	<i>Other mining</i>	2 034	2.8
15	<i>Services to mining</i>	3 563	5.0
<b>B</b>	<b>MINING</b>	<b>71 770</b>	<b>100.0</b>

<sup>a</sup> Bauxite mining and nickel ore mining results are included in 'Metal ore mining nec'.

Source: ABS (*Mining Operations, Australia 2006-07*, Cat. no. 8415.0).

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## 2.2 Measured productivity of mining

The ABS has recently commenced publication of productivity estimates for industry sectors, including mining. The estimates cover the period 1985-86 to 2006-07. A further backcast to 1974-75 is possible through estimates constructed by the Productivity Commission.

The ABS does not publish equivalent productivity estimates for individual classes or sectors within the mining industry. However, it was possible to construct estimates for some mining sub-sectors as part of this project. These estimates are of lesser quality than the mining industry estimates published by the ABS and are used only as a means of indicating whether there are industry differences within the sector.<sup>3</sup>

### Productivity levels

Mining has a high level of productivity in comparison to other industries. Figure 2.4 shows that labour productivity, measured by value added per hour worked, in Australian mining greatly exceeds the corresponding measure for the manufacturing industry, and that of the market sector of the economy as a whole.<sup>4</sup>

Labour productivity in mining is high because the sector is relatively capital intensive. At the same time, labour productivity in mining is also more variable over time, again because labour represents a comparatively small share of total inputs to mining. Hence even relatively small changes to output or labour inputs from year to year can lead to comparatively large changes in the level of labour productivity.

Figure 2.5 shows the ratio of physical capital to labour for the mining and manufacturing industries in Australia as well as for the market sector as a whole. (Note that this is a dollar measure of net capital stock, rather than the capital services measure used in index form in ABS productivity calculations.) The extra capital per unit of labour input in mining provides the means to produce more output per unit of labour input.

Differences in labour productivity can also be due to differences in MFP. However, estimates of comparable MFP *levels* are not available and are not easily constructed.

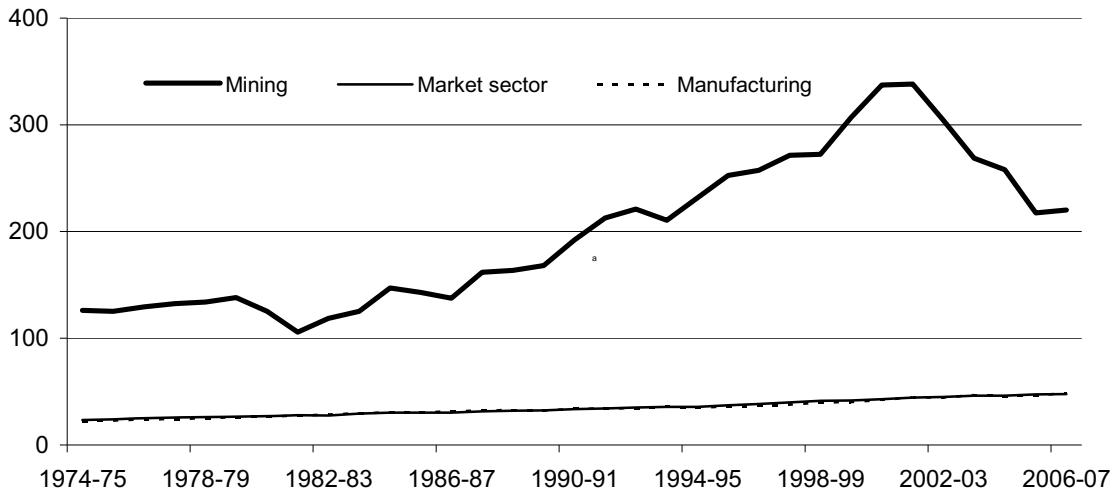
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<sup>3</sup> The industry estimates are of lesser quality for two main reasons. First, any errors in the allocation of mining outputs and inputs to individual industries are likely to ‘wash out’ in aggregation to the sector level. Second, there are methodological differences in input measures — persons employed, rather than hours worked, as the labour input measure, and differences in age-efficiency profiles used to estimate capital services. The methodology used to derive the mining sub-sector productivity estimates presented in this report is described in appendix B.

<sup>4</sup> The market sector includes mining and manufacturing.

**Figure 2.4 Labour productivity (value added per hour worked), 1974-75 to 2006-07<sup>a</sup>**

Dollars per hour (2005-06 prices)

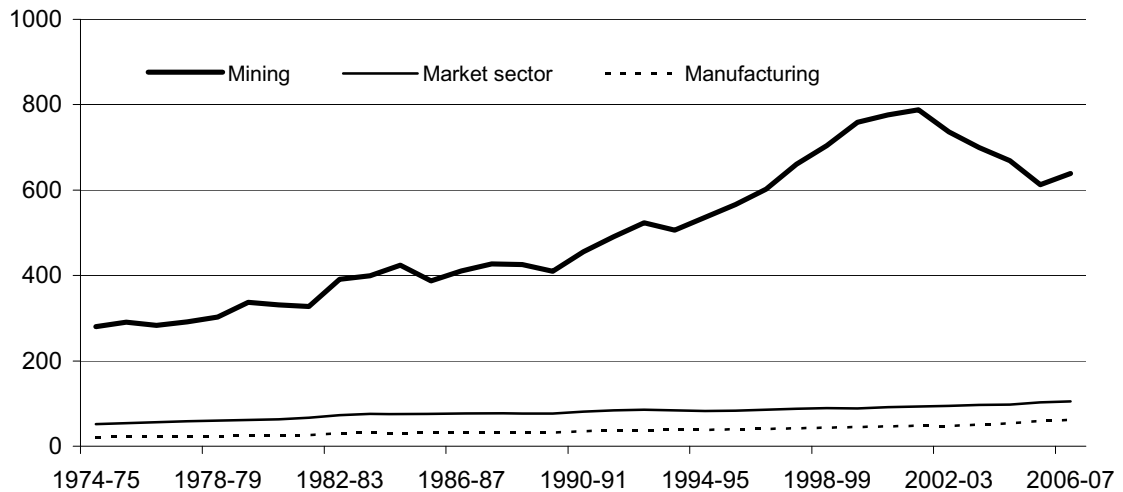


<sup>a</sup> Value added is measured in chain volume terms in 2005-06 prices.

Data sources: ABS (Australian System of National Accounts 2007-08, Cat. no. 5204.0); ABS (Experimental Estimates of Industry Multifactor Productivity 2006-07, Cat. no. 5260.0.55.002).

**Figure 2.5 Capital stock per hour worked, 1974-75 to 2006-07**

Dollars per hour (2005-06 prices)



<sup>a</sup> Capital stock is measured in chain volume terms with a base year of 2005-06.

Data source: ABS (Experimental Estimates of Industry Multifactor Productivity 2006-07, Cat. no. 5260.0.55.002).

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### Sub-sectors within the mining industry

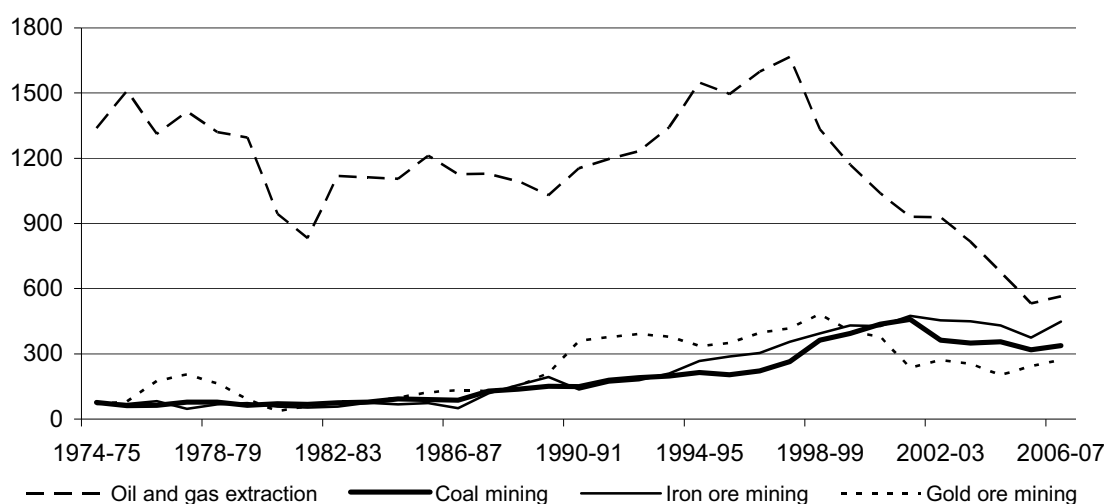
Figure 2.6 shows labour productivity (measured as value added per *employee*) in important sub-sectors of Australian mining, while figure 2.7 shows corresponding capital-to-labour ratios (net capital stock per employee).

Oil and gas production has traditionally had the highest *level* of labour productivity among the different mining sub-sectors (figure 2.6). In 1998-99, for example, value added per employee was \$1.7 million in oil and gas extraction, whereas it was below \$500 000 per employee in coal mining, iron ore mining and gold mining. The high level of labour productivity in the oil and gas extraction industry is primarily because this sub-sector uses very little labour relative to physical capital. However, since the late 1990s labour productivity in oil and gas extraction has fallen dramatically, partly as a result of the rapid depletion of key oil reserves.<sup>5</sup>

There has also been a reduction in the amount of capital stock per employee in the oil and gas extraction sector since the late 1990s, although this is primarily due to faster growth in labour inputs relative to capital inputs, rather than a decline in capital inputs (figure 2.7).

Figure 2.6 **Value added per employee — key mining sub-sectors, 1974-75 to 2006-07<sup>a</sup>**

Thousands of dollars (1998-99 prices)



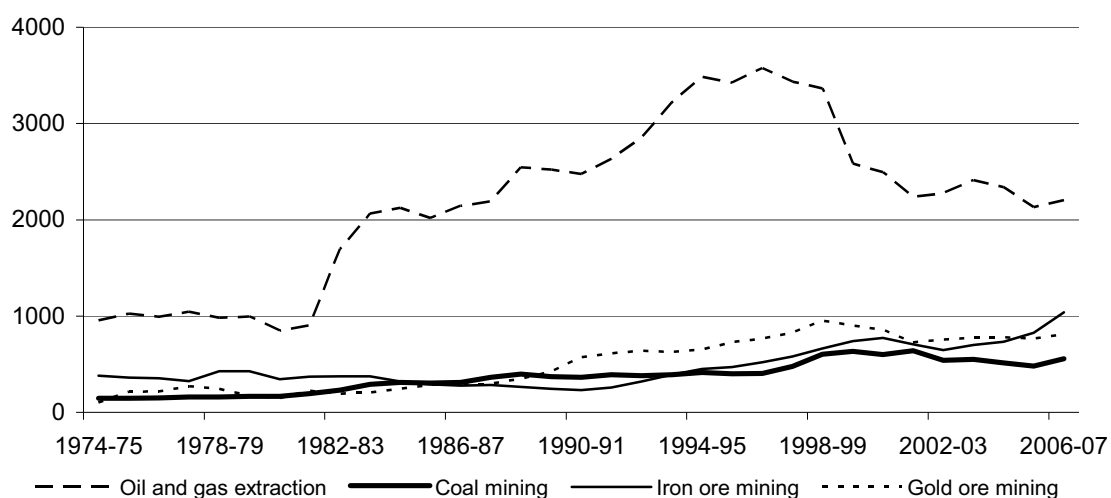
<sup>a</sup> Value added is measured in constant prices with a base year of 1998-99.

**Data source:** Authors' estimates using data from ABS (*Mining Operations, Australia, various issues, Cat. no. 8415.0*).

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<sup>5</sup> Issues associated with the depletion of resources in the oil and gas sector are taken up in more detail in chapter 3.

**Figure 2.7 Capital stock per employee<sup>a</sup>**  
Thousands of dollars (1998-99 prices)



<sup>a</sup> Capital stock is measured in constant prices with a base year of 1998-99.

**Data source:** Authors' estimates using data from ABS (*Mining Operations, Australia, various issues, Cat. no. 8415.0*).

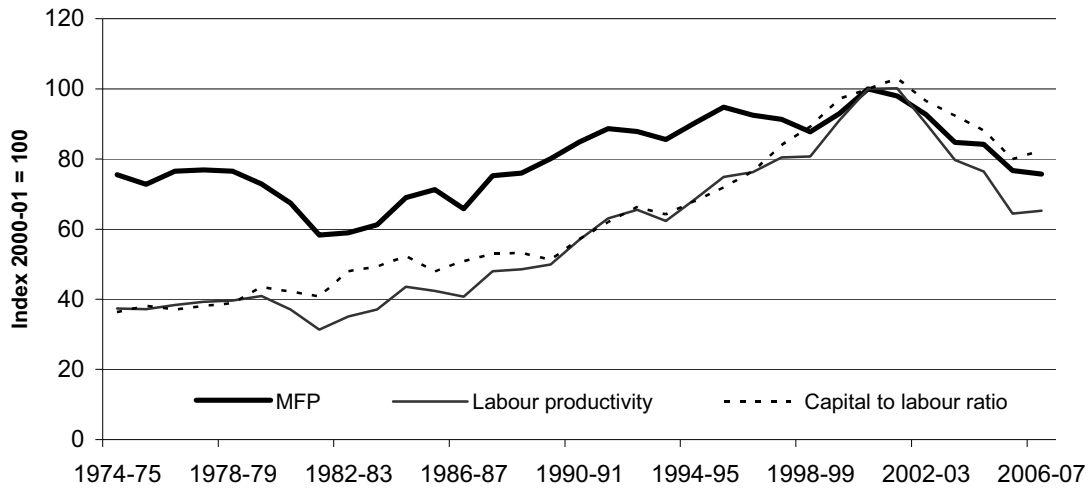
## Productivity growth

### *Mining industry*

Mining has shown reasonably strong labour productivity growth over the long term, although the downturn in productivity since 2001 has tempered the overall gains somewhat (figure 2.8). The longer-term growth in labour productivity in mining is mostly due to capital deepening (more capital available per worker hour). In contrast, there have been large fluctuations or cycles in MFP growth but very little overall growth over the longer term.

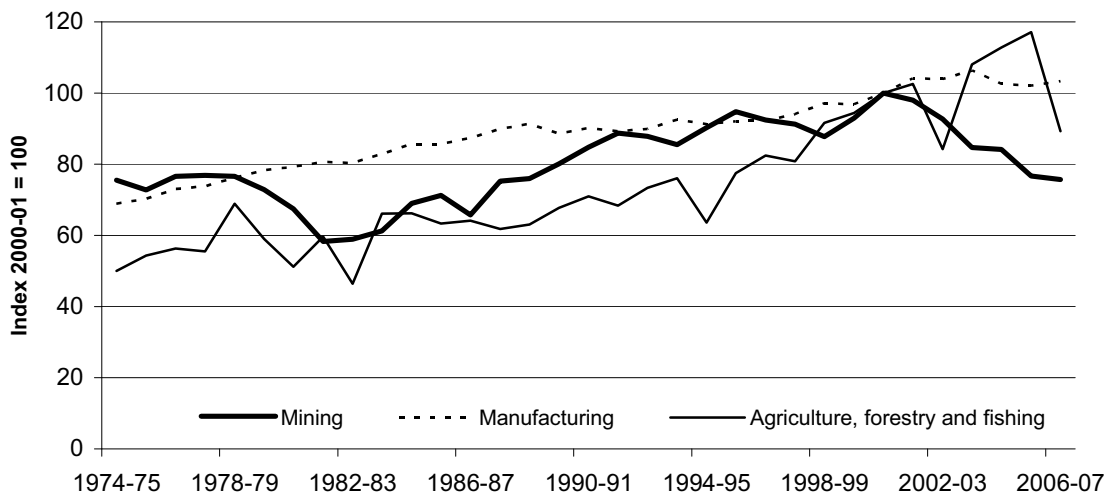
The cyclical behaviour of mining productivity means that there is greater year to year variability in mining MFP than is found in most other industries. In fact, the year to year variability of MFP in mining is second only to annual variability in MFP in agriculture, an industry known for large swings in measured productivity due to fluctuating weather conditions. In general, mining lies between agriculture and manufacturing in terms of the volatility of measured productivity (figure 2.9).

**Figure 2.8 Mining MFP, labour productivity and capital/labour ratio, 1974-75 to 2006-07**



Data source: ABS (Experimental Estimates of Industry Multifactor Productivity 2006-07, Cat. no. 5260.0.55.002).

**Figure 2.9 MFP in selected industries, 1974-75 to 2006-07**



Data source: ABS (Experimental Estimates of Industry Multifactor Productivity 2006-07, Cat. no. 5260.0.55.002).

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### *Sub-sectors within the mining industry*

Longer-term trends in productivity growth among the individual sub-sectors that make up the mining industry are largely consistent with movements in the industry average (figures 2.10 to 2.17). However there is generally greater year-to-year variability in the sub-sector productivity estimates, partly reflecting the fact that some of the sectors are comparatively small, and their results can be affected by changes occurring within a relatively small number of individual mines.<sup>6</sup> For example, the entry or exit of large mines can influence the estimates, as can investment decisions regarding large developments.

Labour productivity within most mining sub-sectors grew particularly strongly between 1980 and 2000, with associated capital deepening and MFP growth (table 2.7). An exception to the rule was oil and gas extraction, where MFP fell during the period, and there was little growth in labour productivity. The mineral sands sub-sector also showed little growth in labour productivity over the period.

The marked decline in sub-sector labour productivity between 2000-01 and 2006-07 is generally associated with falling MFP, and a decline in the amount of capital available per employee. The exception to this is iron ore mining, where a large increase in the capital to labour ratio over the period partially offset the negative effect on labour productivity of falling MFP.

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<sup>6</sup> As noted earlier, measurement errors may also contribute to greater variability of mining sub-sector productivity estimates.

**Table 2.7 Productivity measures by mining sub-sector**

Annual compound percentage change

	1974-75 to 1979-80	1979-80 to 2000-01	2000-01 to 2006-07
<b>Labour productivity</b>			
Coal mining	-3.6	9.6	-4.2
Oil and gas extraction	-0.6	-1.0	-9.7
Iron ore mining	0.4	8.8	0.8
Other metal ores (including bauxite)	-7.2	11.1	-11.9
Copper ore mining	10.7	6.7	-2.1
Gold ore mining	6.0	7.0	-5.3
Mineral sand mining	11.7	1.4	0.1
Silver-Lead-Zinc ore mining	-0.6	9.6	-13.0
<b>MFP</b>			
Coal mining	-6.5	5.5	-4.6
Oil and gas extraction	-2.2	-5.5	-8.1
Iron ore mining	-1.9	5.9	-5.5
Other metal ores (including bauxite)	-10.4	3.8	-2.0
Copper ore mining	7.5	5.0	-2.7
Gold ore mining	2.6	1.1	-5.0
Mineral sand mining	5.9	-2.5	4.3
Silver-Lead-Zinc ore mining	-2.2	3.7	-6.1
<b>Capital to labour ratio</b>			
Coal mining	4.9	6.4	0.5
Oil and gas extraction	1.7	4.9	-1.8
Iron ore mining	3.2	3.3	7.5
Other metal ores (including bauxite)	4.9	9.1	-12.1
Copper ore mining	8.2	2.6	0.8
Gold ore mining	10.1	8.0	-0.9
Mineral sand mining	10.9	5.2	-5.7
Silver-Lead-Zinc ore mining	2.6	9.3	-7.9

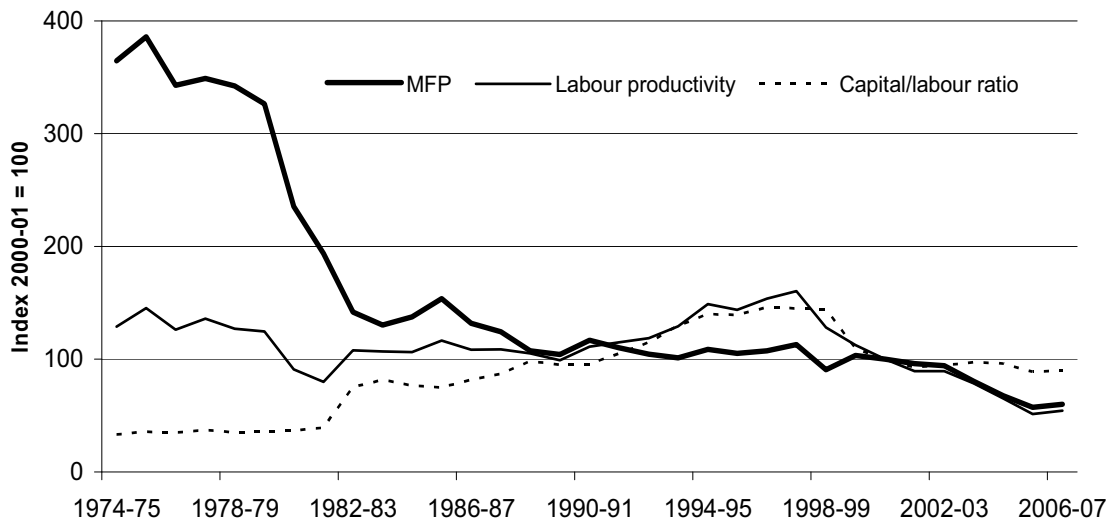
Source: Authors' estimates using data from ABS (*Mining Operations, Australia*, various issues, Cat. no. 8415.0).

**Figure 2.10 Coal mining: MFP, labour productivity and capital/labour ratio, 1974-75 to 2006-07**



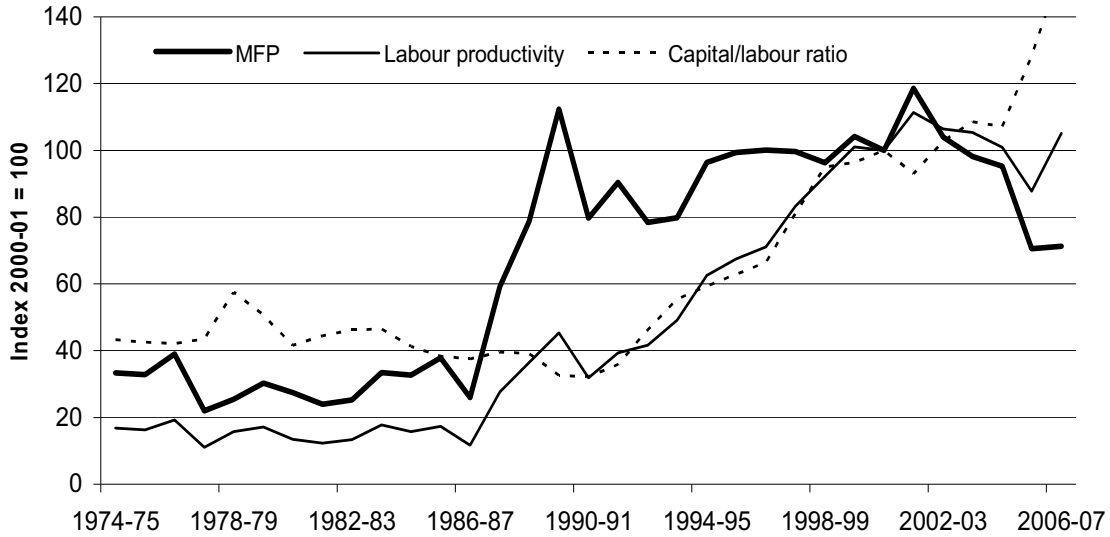
Data source: Authors' estimates.

**Figure 2.11 Oil and gas extraction: MFP, labour productivity and capital/labour ratio, 1974-75 to 2006-07**



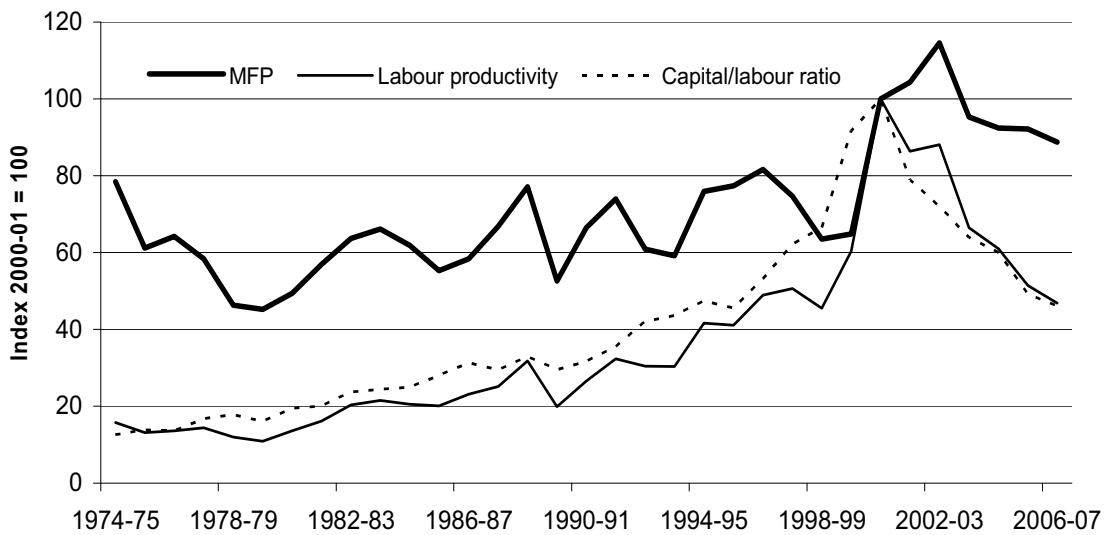
Data source: Authors' estimates.

**Figure 2.12 Iron ore mining: MFP, labour productivity and capital/labour ratio, 1974-75 to 2006-07**



Data source: Authors' estimates.

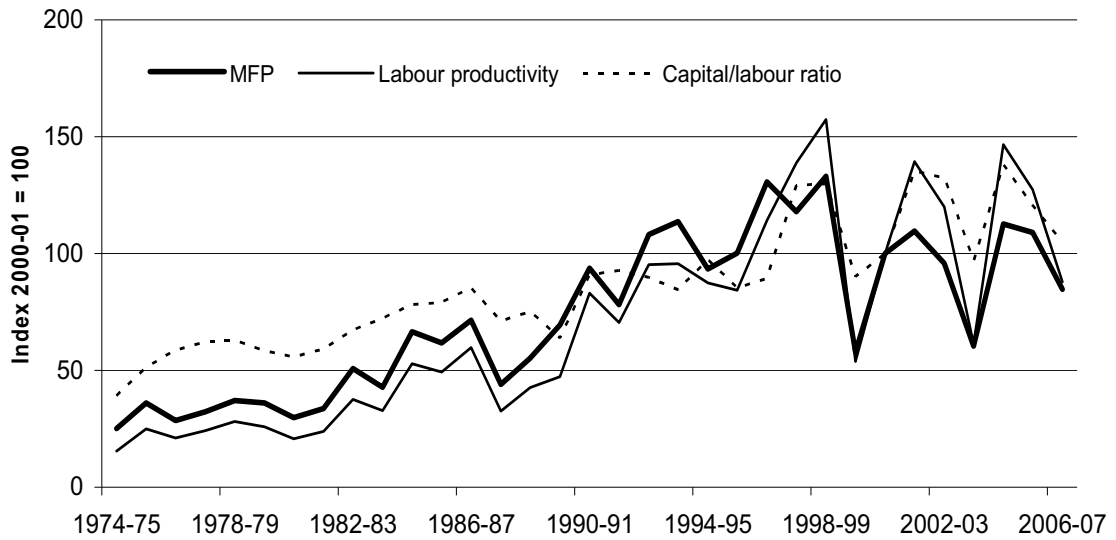
**Figure 2.13 Non-ferrous metal ores n.e.c. mining<sup>a</sup>: MFP, labour productivity and capital/labour ratio, 1974-75 to 2006-07**



<sup>a</sup> The major commodities included within this group are nickel, bauxite, manganese ore, and uranium

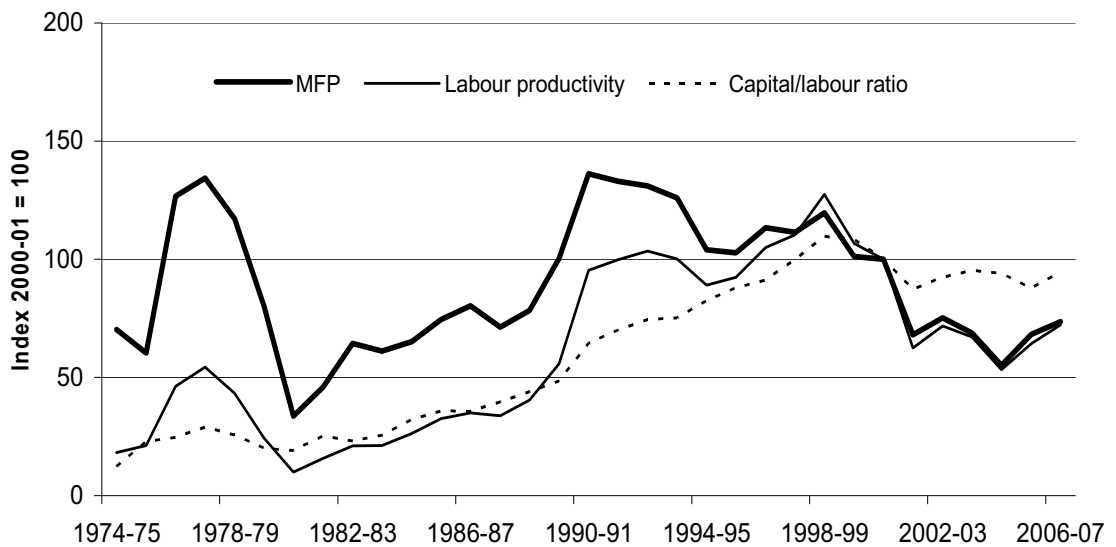
Data source: Authors' estimates

**Figure 2.14 Copper ore mining: MFP, labour productivity and capital/labour ratio, 1974-75 to 2006-07**



Data source: Authors' estimates.

**Figure 2.15 Gold ore mining: MFP, labour productivity and capital/labour ratio, 1974-75 to 2006-07**



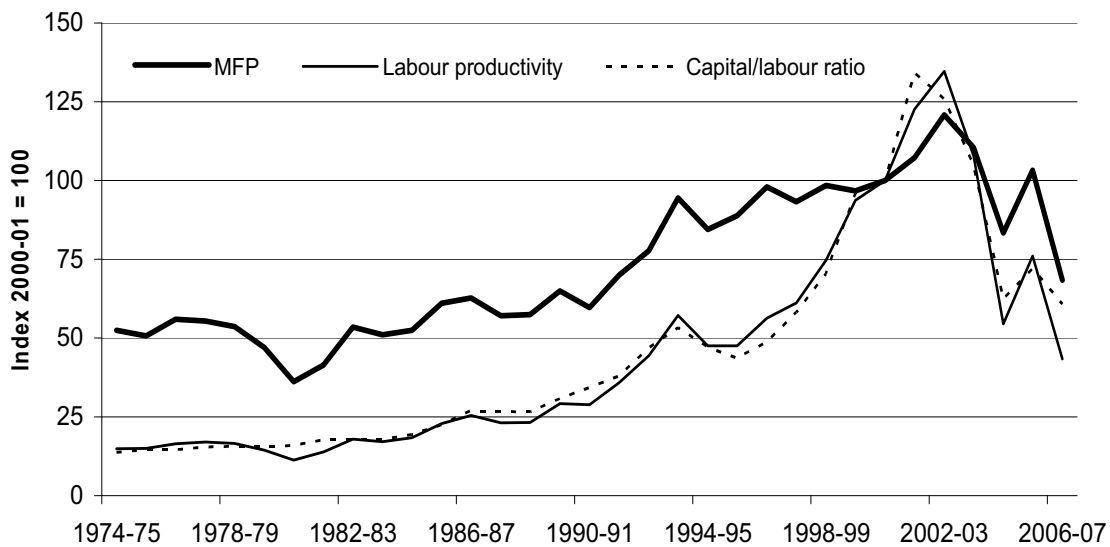
Data source: Authors' estimates.

**Figure 2.16 Mineral sands mining: MFP, labour productivity and capital/labour ratio, 1974-75 to 2006-07**



Data source: Authors' estimates.

**Figure 2.17 Silver/Lead/Zinc ore mining: MFP, labour productivity and capital/labour ratio, 1974-75 to 2006-07**



Data source: Authors' estimates.

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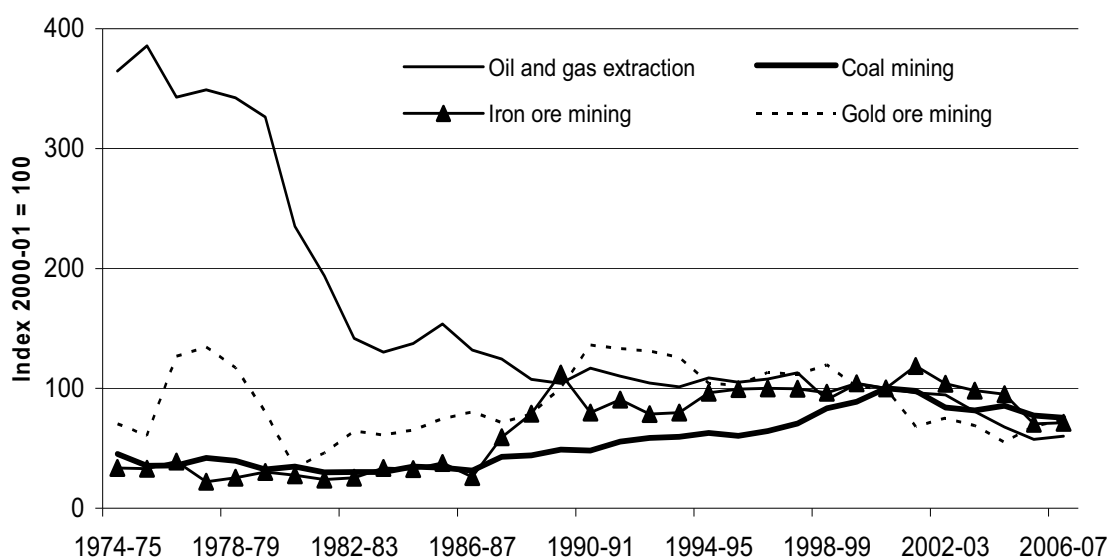
## Industry composition effects

As table 2.7 and figures 2.10 to 2.17 illustrate, there are significant differences among the individual mining sub-sectors in terms of their levels of labour productivity, and in their productivity growth rates over time. It is possible that changes in the composition of the mining industry could have contributed to the decline in overall productivity in the sector since 2001. Compositional changes have an adverse effect on aggregate mining productivity if less productive sub-sectors expand relative to more productive sub-sectors, or if resources shift towards sub-sectors where productivity is falling more quickly.

Figures 2.18 and 2.19 indicate that the decline in mining industry productivity since 2001 can largely be explained by declining productivity in the larger sub-sectors — that is, coal, oil and gas, iron ore and gold — as productivity trends in the smaller sub-sectors (as defined by share of value added) such as copper and mineral sands mining were less clear.

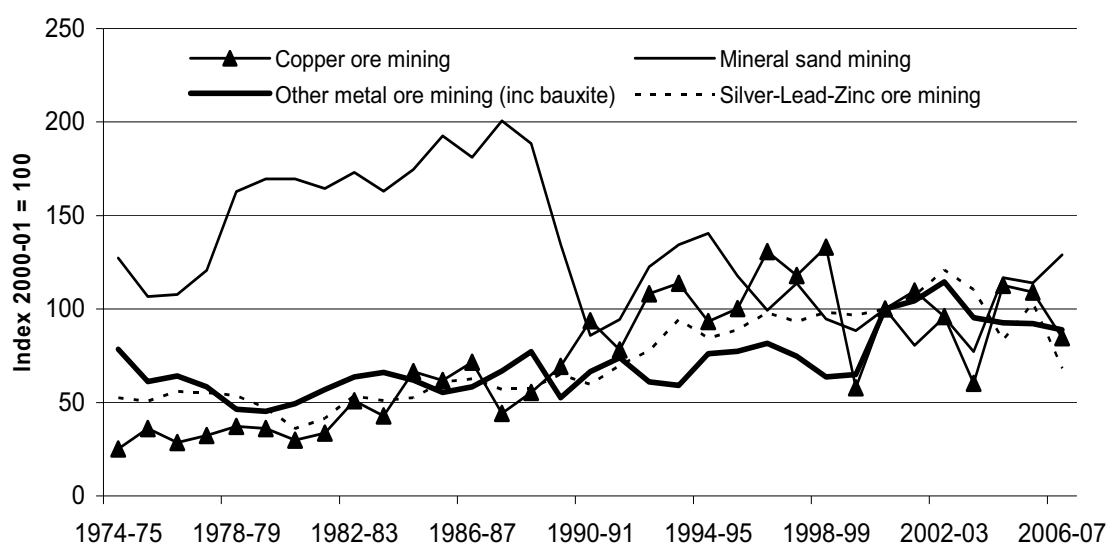
Figure 2.18 MFP by sub-sector, 1974-75 to 2006-07

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Data source: Authors' estimates.

Figure 2.19 MFP by sub-sector, 1974-75 to 2006-07



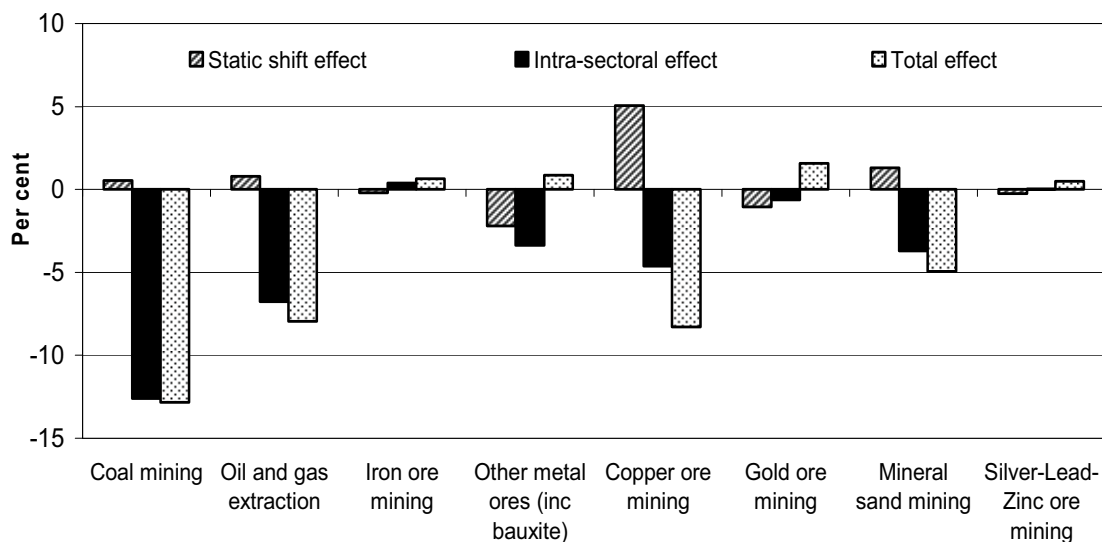
Data source: Authors' estimates.

A shift-share analysis<sup>7</sup> of the decline in labour productivity in the mining industry between 2000-01 and 2006-07 shows that changes in the composition of the sector actually made a *positive* contribution of around four percentage points to the change in labour productivity over the period (figure 2.20). Declines in the labour shares of the other metal ore, silver-lead-zinc ore, coal, and oil and gas sub-sectors acted to improve overall labour productivity, and more than offset the negative effect on productivity of increases in the labour shares of the gold, copper, and mineral sands sub-sectors.

But the positive effect on labour productivity of changes in the composition of the mining industry are far outweighed by the negative effects of declining productivity growth during the period within many of the mining sub-sectors. That is, the overall decline in mining productivity over the period was primarily due to reductions in labour productivity *within* the major sub-sectors (figure 2.20). The results in figure 2.20 also illustrate the significance of the oil and gas sub-sector in explaining the overall decline in labour productivity in the mining industry between 2000-01 and 2006-07. Specifically, just over two fifths (42 per cent) of the decline was due to reduced productivity in the oil and gas sub-sector. Other large contributors to the decline in labour productivity were coal mining and other metal ore mining.

<sup>7</sup> Shift-share analysis decomposes the change in total mining industry labour productivity into a component due to productivity changes within the various sub-sectors of mining, and a component due to changes in the relative size of different sub-sectors of the industry. For a more detailed description of the shift-share analysis methodology and the interpretation of results see OECD (2002).

**Figure 2.20 Shift-share analysis of mining industry productivity<sup>a</sup>**  
 Labour productivity change from 2000-01 to 2006-07



<sup>a</sup> This analysis is based on the eight mining industries described in chapter 1, and for which labour productivity and MFP estimates have been made. Excluded in the analysis are 'Services to mining' and 'Other mining', which collectively account for approximately 8 per cent of mining industry output. The 'intra-sectoral effect' is the contribution of labour productivity growth within individual industries to aggregate labour productivity growth. The 'static shift effect' measures the contribution from changes in the allocation of labour from low labour productivity level sectors to high labour productivity level sectors.

Data source: Authors' estimates.

## Developments in mining MFP in 2007-08

Data released by the ABS in November 2008 show that productivity in the mining industry has deteriorated further in 2007-08. Labour productivity is estimated to have fallen by 4 per cent, while MFP has fallen by 7.9 per cent. As was the case in the period from 2000-01 to 2006-07, the proximate reasons for the most recent decline are comparatively strong growth in inputs coincident with weak growth in output. While productivity growth estimates for 2007-08 are not available at the mining sub-sector level, it is likely that the decline in MFP has occurred as a result of poorer productivity performances in the individual industries, rather than as the result of changes in composition of the mining industry. The decline in output in the oil and gas sector in 2007-08 supports this line of reasoning.