5 Other factors influencing mining MFP

Key points

- Yield declines due to ongoing resource depletion and the effects of production lags in response to new capital investment are estimated to have contributed substantially to both longer-term and shorter-term movements in mining MFP. Failing to account for these factors when considering changes in mining MFP can lead to errors in interpretation.
- Recently released data indicate that mining industry MFP has fallen again in 2007-08, by just under 8 per cent. Production lags are estimated to explain just over 5 percentage points of this decline. While data limitations preclude an estimate of the extent to which resource depletion contributed to the decline, it is likely that reductions in oil and gas flow rates have occurred. In this case, resource depletion is likely to emerge as an important explanatory factor of the decline in mining MFP in 2007-08 as well.
- A number of other factors are likely to have influenced multifactor productivity (MFP) growth in mining in recent years, including the effect of increased effort by miners in response to record commodity prices, changes in technology, changes in work practices, infrastructure constraints, and ad hoc factors such as the weather. Although it is difficult to quantify the individual effects of most of these factors, it is estimated that these and other factors collectively made a net positive contribution to MFP in the mining industry between 2000-01 and 2006-07.

In chapters three and four the effects on mining MFP of resource depletion and capital investment surges were examined both qualitatively and quantitatively. The results suggested that both of these factors made substantial contributions to the decline in mining MFP between 2000-01 and 2006-07. This chapter reviews a range of other factors that influence productivity in the mining industry, and that may also have contributed to the recent decline in mining MFP. The focus of these reviews is qualitative.

The factors addressed in the chapter are the effects of increased effort to overcome short-run capacity constraints in response to price rises, advances (and failures) in new technology, changes in work practices, random events such as weather, and problems with infrastructure.

The chapter concludes with a review of the quantitative evidence regarding the key explanatory factors behind changes in mining MFP, with emphasis on the contributions of the various factors in explaining the recent decline in mining MFP.

5.1 Increased effort and changes in the quality of inputs

In chapter 3 it was shown that depletion has a powerful negative impact on MFP in mining. Depletion represents a decline in the quality of the unmeasured natural resource input essential to all mining operations. Implicitly, the intensity of use of other inputs compensates for the declining quality of the resource input. This is particularly likely to occur during periods of high prices as in recent years. The high prices make it profitable to continue to mine deposits that have reached such low quality that they might otherwise be abandoned. High prices can also impact on MFP through other indirect effects on the quantity and quality of inputs used in mining. Since changes in the quantity or quality of resource inputs are not generally taken into account when measuring inputs, the result of such changes is apportioned to the residual — that is, to productivity.

Demand-driven fluctuations in the price of mining products are common and often large. It is still most profitable to exploit the highest quality deposits as these yield the greatest differences between price and production cost, even after allowing for the implicit value of the resource input as measured by the discounted value of the resource rent along the optimal depletion path. However, when prices rise unexpectedly there is also an incentive to exploit lower quality deposits. This includes re-opening ‘mothballed’ mines, and exploiting mine ‘tailings’. The critical constraint is being able to get the mined product to market while prices are high.

Some evidence of the extent to which high prices are encouraging the exploitation of lower quality deposits can be found in the form of industry and other reports of old mines being reopened in order to take advantage of the current period of higher prices. For example, in the coal industry the Elouera coal mine in NSW was re-opened, while in iron ore mining the Koolan Island and Frances Creek mines were re-opened. In gold mining, significant depletion has led to the re-working (and in the case of some mines re-re-working) of old mines to extract pockets of remaining reserves, generally in response to the recent higher prices. According to industry analysts, the decline in aggregate gold production in Australia in recent years is due to the deliberate strategy of miners to temporarily target lower grade ores while output prices are high[1]. There are also reports of a significant number of old nickel mines having been reopened since 2001 due to high prices, including the Redross, Long-Victor, Miitel, Wannaway and Mariners mines. The Pillara lead and zinc mine at Lennard shelf was also reopened in response to higher prices, and a tailing re-processing operation was undertaken at the Hellyer zinc mine in Tasmania.[2]

Targeting lower quality resources may not be the only response to higher prices that has the potential to adversely affect mining MFP. In the short term to overcome the constraints imposed by shortages of specialist equipment and long construction lead times, miners may increase the effort they apply to extract output, and in so doing be forced to employ a less than optimal combination of inputs. This can lead to a decline in measured MFP.

During booms demand for mining inputs generally increases, leading to shortages and delays in obtaining key inputs. Anecdotally, this has become a problem in coal mining where waiting times for new draglines have increased from 18-24 months to over 30 months (BHPB Interim Report 2006), necessitating the use of lower 'quality' inputs such as trucks and shovels to remove overburden (figures 5.1 and 5.2).

Skilled labour shortages are also pushing out waiting times for key mining activities, including maintenance and repairs to machinery.

To the extent that mining companies have been unable to use the least cost combinations of inputs due to the mining boom, or have been subject to greater delays in completing maintenance and other key mining activities, the net effect of the boom on measured productivity is likely to be negative.

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[1] Analysts reviewing the reduction in Australian gold production during 2006 described the decline as one 'consequence' of higher gold prices, which induced a move by producers to treat lower grade ores (The Age, 27 November 2006). Moreover, according to the analysts, mining lower grade gold ores in response to the higher prices was a 'perfectly reasonable and rational response'.

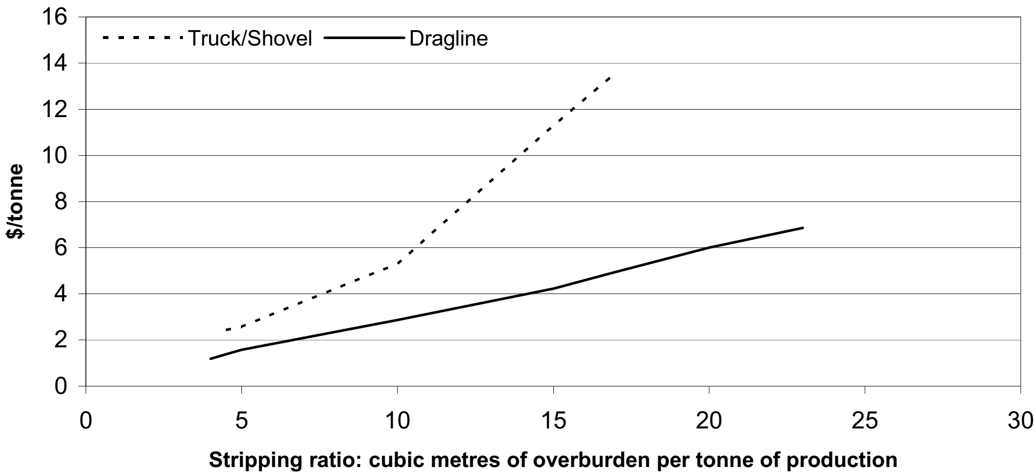
[2] Many of these 're-opened' mines have since 're-closed' since the economic downturn at the end of 2008. The effects of these re-closures and of the downturn in general are discussed in section 6.3 in chapter 6.

Figure 5.1 **Dragline versus trucks and shovels**

An illustrated example[a]

[a] The large crane-like machine in the background is a dragline, designed to strip and remove overburden. The alternative is shown in the foreground: a truck being loaded with an electric shovel.

Figure 5.2 **Cost comparison in overburden removal technologies**



Data source: From Hartman and Mutmansky (2002).

Productivity versus profitability

In making the case that unexpectedly high output prices could be leading to less efficient production — either through the deliberate targeting of poorer quality resources, or the deliberate use of more costly or less efficient technologies and inputs — it is not intended to imply that this is a problem or negative outcome for the industry. On the contrary, it is expected that high output prices would induce an increase in production, and that this would generally only be achievable at a higher cost. Profitability, ultimately, is the goal of mining companies, rather than the maximisation of productivity.

5.2 Technology changes

Technology is a critical, long-run factor influencing productivity, and plays a major role in offsetting the effects of resource depletion. In a review of the debate regarding the long-term supply of minerals, Tilton (2003) describes the long-run availability of mineral commodities as, 'a race between the cost-increasing effects of depletion, and the cost-decreasing effects of new technology'.

There have been major technological advances in Australian mining since the 1960s. Some examples include the expansion of open-cut mining, the development of longwall operations in underground coal mining, and greater automation and scale of plant and equipment. Australia, with a long history of underground mining, has also employed innovations in hard-rock mining, such as block-caving and sublevel-caving technologies. [3]

The shift to open-cut methods in coal mining reflects its generally lower costs of production and greater flexibility in varying output with less of the hazards associated with underground mining (Hartman and Mutmansky 2002). In gold and copper ore mining, a shift to open-cut operations also became economic following the discovery of carbon-in-pulp and solvent extraction-electrowinning methods of ore extraction, which enabled metal to be produced from lower grades of ore. Other mining industries have also experienced an increase in the number of open-cut operations, especially those that target multiple products (figure 5.3).

In oil and gas production, developments in drilling technology saw an increase in the use of steeply inclined and even horizontal drilling during the past three decades, allowing access to resources that were not economic using standard vertical wells. Continued developments in drilling technology have also allowed oil to be extracted from wells in deeper and deeper water (see figure 5.4).

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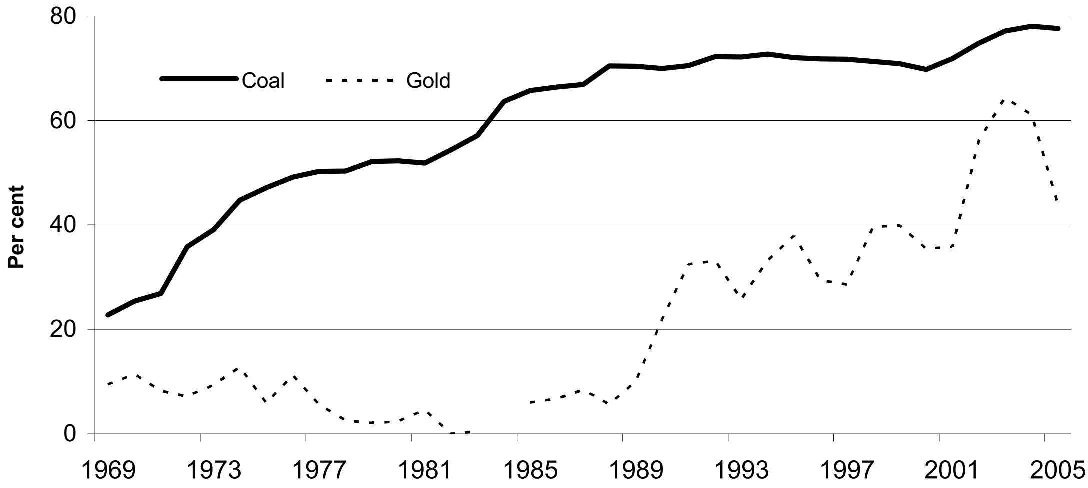
[3] For a description of longwall mining and more detail regarding trends and developments in coal mining technology (see Pinnock 1997).

Figure 5.3 **Open-cut share of total mine production**

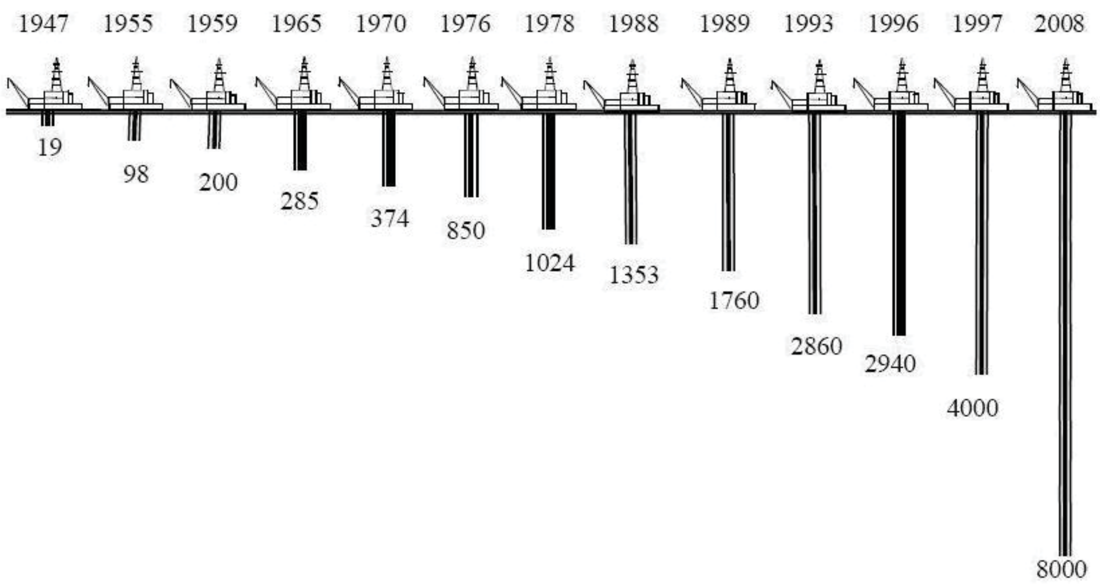
Gold and black coal



[a] The gold data represent a minimum of gold produced by open-cut mines. The proportion, especially in more recent years is likely to be higher.

Data source: Mudd (2007).

Figure 5.4 **Progress in deep offshore drilling technology** [a]



[a] Depth of water is given in feet.

Data sources: Bohi (1998) (in turn adapted from various Shell briefing notes). The data for 2008 added from Phillips (2008).

In relation to ore processing there have been a number of key technology changes, including the development and use of heap-leaching technologies which allow metal to be extracted from comparatively low-grade ore, and hydrometallurgical extraction processes such as electrowinning and pressure acid leach technologies in base metals production. In both cases the new technologies have allowed economic extraction of metals from relatively low grade ores (Hogan et al. 2002).

There have also been major advances in the technology used to explore and identify mineral resources in the first place. Off-shore oil and gas exploration and production has been significantly enhanced through the development and use of three-dimensional seismic reflection surveys. In metals production, developments in aeromagnetic and gravimetric survey technology have contributed to some major discoveries, including Olympic Dam in 1975 (Hogan et al. 2002). Airborne surveys in general have lowered the cost of much exploration activity, and overcome difficulties in access and environmental impacts for exploration.

Recent developments in mining technology and their effect on productivity

It is difficult to gauge the extent to which changes in technology may have influenced recent developments in mining MFP. There was a surge in the proportion of coal produced in open-cut mines after the year 2000, which should in principle have added to productivity growth. The general increase in gold production from open-cut mines following the development of new ore-processing technologies should also have acted to boost productivity, although the open-cut share of gold production did fall quickly between 2003 and 2005.

Perhaps most notable during the period of interest was the implementation of High Pressure Acid Leach (HPAL) techniques in nickel mining to extract nickel from more difficult laterite deposits. Despite considerable enthusiasm and investment in a number of HPAL mines in the late 1990s — early 2000s, the technology was an expensive failure (FD Capital 2007).

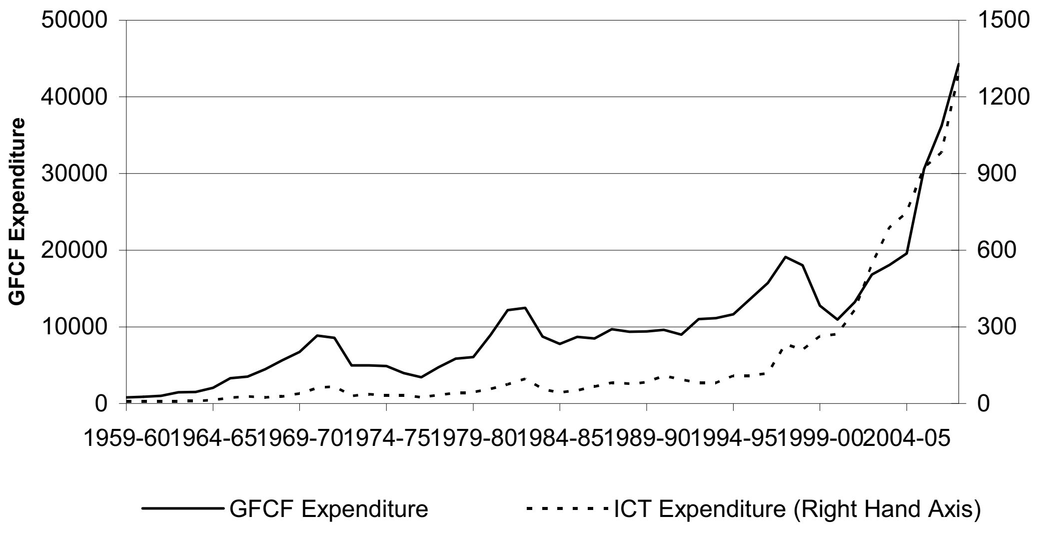
There have also been difficulties with some longwall underground mining operations in the coal sector, particularly adapting technologies developed in the United States to Australian conditions. Although some of these issues have now been overcome, the uniqueness of many Australian deposits means that longwall technology sometimes has to be adapted, and this can lead to productivity problems as new ideas and methods are trialled and assessed. According to the CRC for Mining:

> ‘most Australian longwall equipment is significantly underutilised by international standards’ (quote from CRCMining website, May 2008).

Information and communications technology (ICT) expenditure in the mining industry has also surged with the record levels of investment in the recent period (see figure 5.5). ICT has played an important role in all stages of mining activity, especially in the field of exploration and three-dimensional seismic surveys (Neal et al. 2007). Improved ICT technology has allowed mining services companies to undertake activities previously performed by miners (leaving them to specialise in mining alone). ICT investment has also led to the automation of many mining processes, facilitated more accurate targeting of ore bodies (via GPS) and improved communication between different stages of the mining process. ICT penetration in the mining industry was found to be greater than that of the market sector as a whole in 2000-01 and with record levels of investment in ICT, and this trend is unlikely to have been reversed. Of interest, however, is that ICT investment takes longer to be fully utilised in the mining industry compared to the rest of the market sector, with investment taking on average four years to yield results (PC 2004). The associated productivity benefit of increased take-up of ICT technology within the mining industry will likely explain some of the 'other factors' productivity growth identified at the beginning of the chapter.

Figure 5.5 **Gross fixed capital formation and ICT investment in the mining industry[a]**

Chain volume measure with a reference year of 2005-06



a ICT Expenditure defined as expenditure on computers and peripherals, computer software, electronics and electrical equipment.

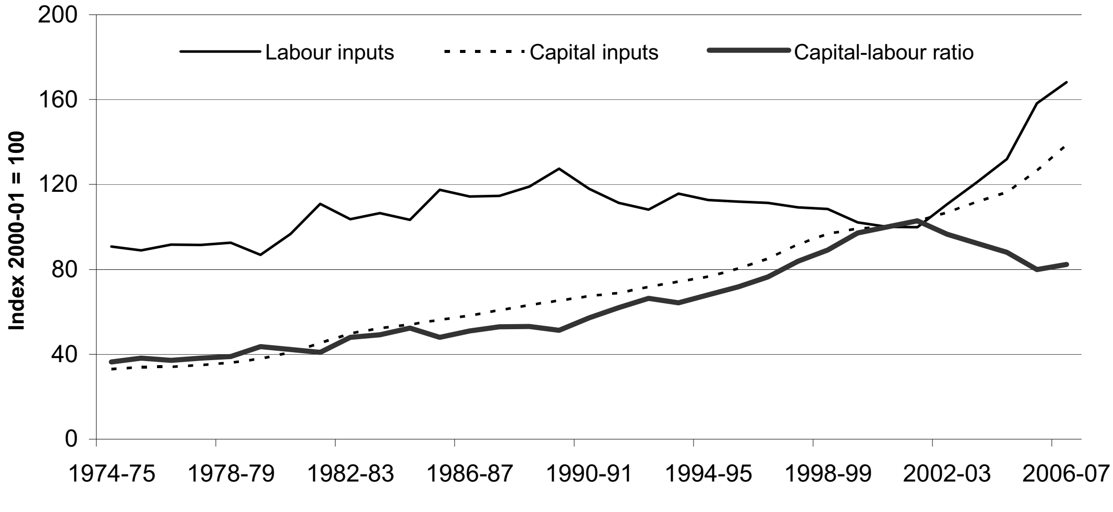
Data source: ABS (*Australian System of National Accounts 2007-08,* Cat. no. 5204.0).

5.3 Work practices

Changes in work arrangements and management practices have also had an important influence on mining productivity over the longer term. In a capital-intensive industry, work arrangements can have a crucial influence on capacity utilisation. This was particularly apparent in a number of mining industries, especially coal, during the 1990s. Lower commodity prices had squeezed profitability, placing pressure on regulatory arrangements, wages and employment conditions (Heiler and Pickersgill 2001). Large scale retrenchments and restructuring took place within the industry in the 1990s, and this led to a decrease in labour inputs and an increase in the ratio of capital to labour in mining (figure 5.6).

Among full-time employees (the dominant form of labour used in mining), working hours grew strongly in the 1980s and 1990s, and by 1997 mining recorded both the longest hours profile of any industry and the most rapid increase in weekly hours (Heiler and Pickersgill 2001, p. 23). The introduction of 12-hour shifts was a key factor in labour and capital utilisation in mining, and by the end of the 1990s it was estimated that around one half of all production and maintenance employees were working 12-hour shifts (Heiler and Pickersgill 2001, p. 30).[4]

Figure 5.6 **Labour inputs and the capital to labour ratio in mining**



Data source: ABS (*Experimental Estimates of Industry Multifactor Productivity 2006-07*, Cat. no. 260.0.55.002)

4 Possible adverse consequences for productivity associated with changed labour arrangements in mining, including long daily hours, inadequate recovery time between shifts, night work and long commuting times are mentioned in Heiler and Pickersgill (2001) and discussed in more detail in Heiler, Pickersgill and Briggs (2000, pp. 37-44).

An early example of labour rationalisation leading to improved utilisation of capital (capital-deepening) and subsequent productivity growth was the case of the Robe River iron ore mine (Schmitz 2005). A sudden change was made to workplace practices at the mine in 1986 aimed at ending 'status quo' work practices, and yielded a sharp increase in labour productivity and a more modest (yet significant) increase in production (figure 5.7).

Figure 5.7 **Robe River iron ore mine: labour productivity and production, 1973-74 to 1990-91**

Data source: Schmitz (2005).

In more recent years a major change to labour use in mining has been the rise in long-distance commuting in the form of 'fly-in, fly-out' mining (see box 5.1). However, additional costs have been incurred by mining companies to attract labour to mining (such as wage premiums, and the transport costs associated with 'fly-in, fly-out' operations), which may have had a detrimental effect on productivity as firms cannot use the desired roster pattern, but must rely on patterns that are more attractive to labour.

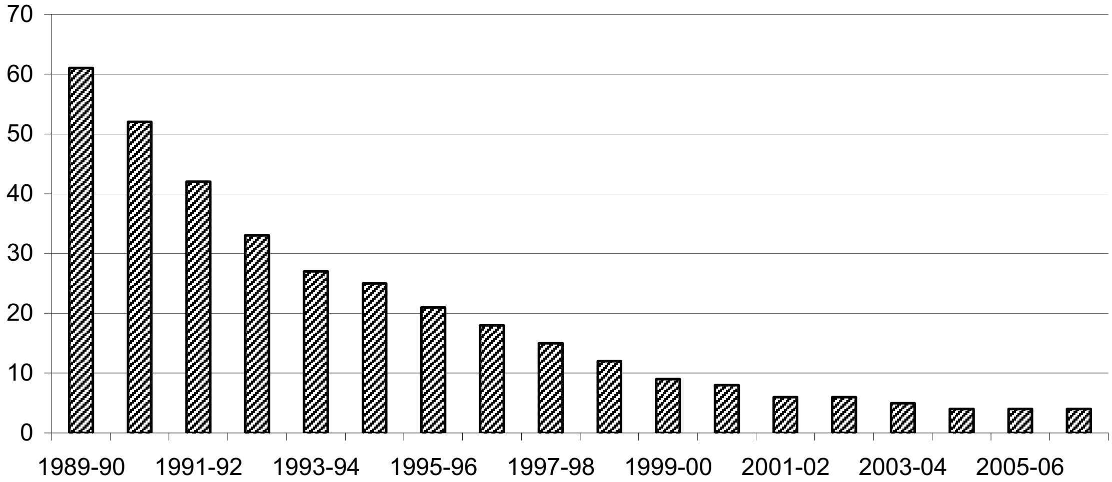
Safety

A positive development in the Australian mining industry has been the decline in the lost time injury frequency rate (LTIFR), a measure of the number of lost time injuries[5] per million hours worked (figure 5.8)

[5] A lost time injury is one where an injury results in a minimum of one full shift's absence.

The extent to which the decline in lost time injury rates has had a positive effect on mining MFP is not well documented. The decline in LTIFR, especially in recent years, has been the result of changes to a 12 hour roster system, which in turn generally provides for longer periods of time off. It is this longer time off that promotes recovery and reduces fatigue, which are major causes of injuries in the mining industry (AMMA 2004). It would be expected that a reduction in the number of time-lost injuries per million hours worked would have a positive effect on productivity, if for no other reason than the number of shutdowns at mine-sites due to injuries has declined, reducing the amount of idle capital and the potential for lost production.

Figure 5.8 **Lost time injury frequency rate[a]**



[a] LTIFR = The number of lost time injuries per one million hours of work.

Data sources: Minerals Council of Australia, (*Safety Performance Report of the Australian Minerals Industry,* 2007); Minerals Council of Australia, (*Safety & Health Performance Report of the Australian Minerals Industry,* 1999).

Box 5.1 **Fly-in, fly-out operations**

Fly-in, fly-out (FIFO) operations are where the workforce does not reside permanently on the mine site or in a nearby township, but instead are flown in and out of the mine site on a roster basis. FIFO operations are prevalent in the more remote mines and newer mines in Western Australia. Approximately 47 per cent of mines in Western Australia were using FIFO to meet their labour requirements in 2000. FIFO has been more attractive to mining companies in order to overcome labour shortages and poor perceptions of living permanently in remote areas.

A question that arises out of this relatively new labour supply mechanism is how it affects productivity. A study by the Centre for Social Responsibility in Mining in 2003 found that FIFO operations have a higher rate of turnover compared to residential counterparts. As a result of this, the study suggests that FIFO operations face lower operational efficiency and greater opportunity costs of jobs needing to be filled. The increased use of FIFO means that revenues generated in remote areas that go to wages are not being spent in those areas, as well as anecdotal evidence of social impacts, especially with regard to disruption of family life.

There are exceptions to this rule, and a critical factor seems to be the roster schedule used at FIFO sites. Those mines that give a longer time-off ratio appear to have lower turnover, and fewer of the problems listed above. Regardless, as companies increasingly rely on FIFO, there is an expectation that there will be a corresponding effect on labour productivity and MFP in general.

Source: Beach, Brereton and Cliff (2003), Chamber of Minerals and Energy Western Australia (2005)

5.4 Poor weather

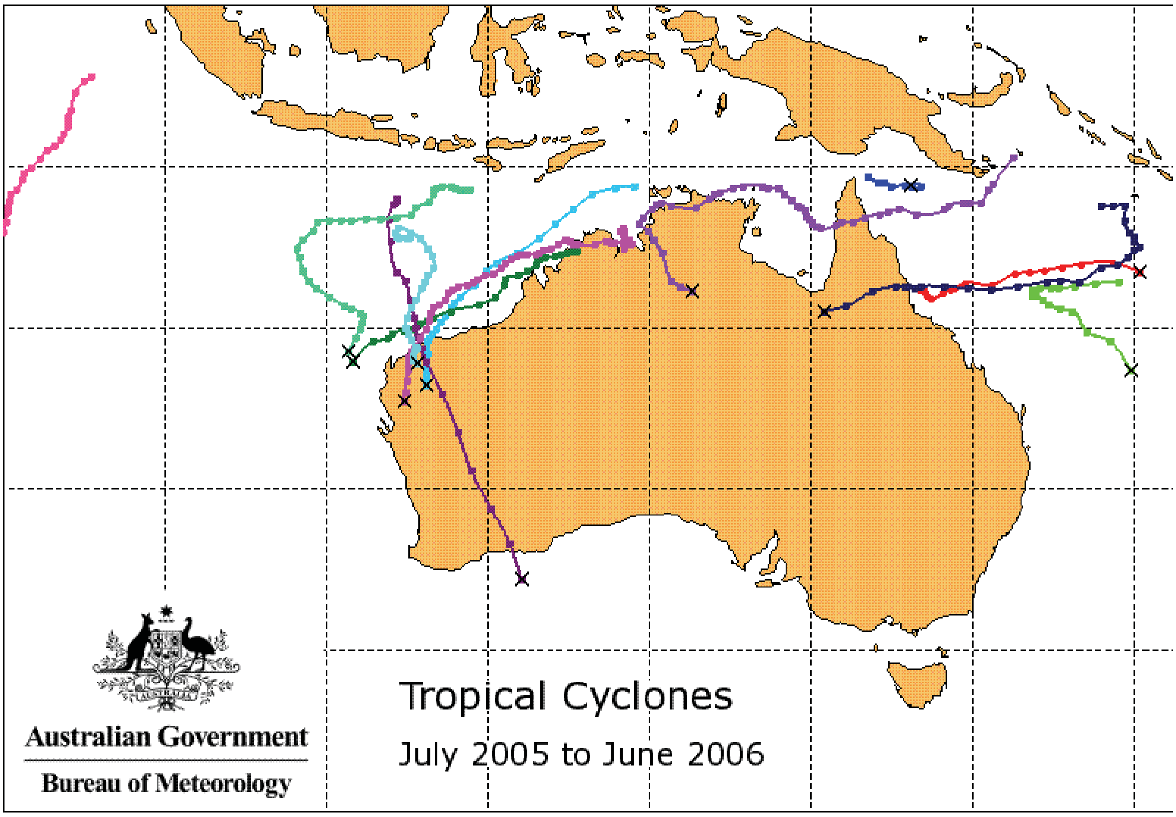
The weather can also have a significant impact on mining operations, and hence on measured productivity. Underground mines can become flooded and require elaborate pumping systems in order to remove water. Open-cut pits can become minor lakes under heavy rainfall, with pumping and evaporation required to remove water. Poor weather can also hamper loading and shipping operations that, when combined with long vessel queues, can result in disaster, such as the stranding of the Pasha Bulk bulk carrier off the coast of Newcastle in 2007. If production time lost to bad weather events cannot be recouped, there will be negative flow-on effects to measured productivity.

Conversely, a lack of rain can also lead to problems in mining operations. While mines do not account for a large proportion of water use in Australia (around 3 per cent), water inputs are vital for operation. For example, water is used for dust suppression and washing of raw coal in coal mining, to liquify concentrate in copper mining, and in gravity separation to sort metal ores and to filter impurities in metal ore mining.

Over a long enough time period however, it is likely that the effect of weather on productivity calculations would tend to average out. The question in relation to the downturn in mining MFP between 2000-01 and 2006-07 is whether adverse climatic events were worse or more frequent compared with the preceding period?

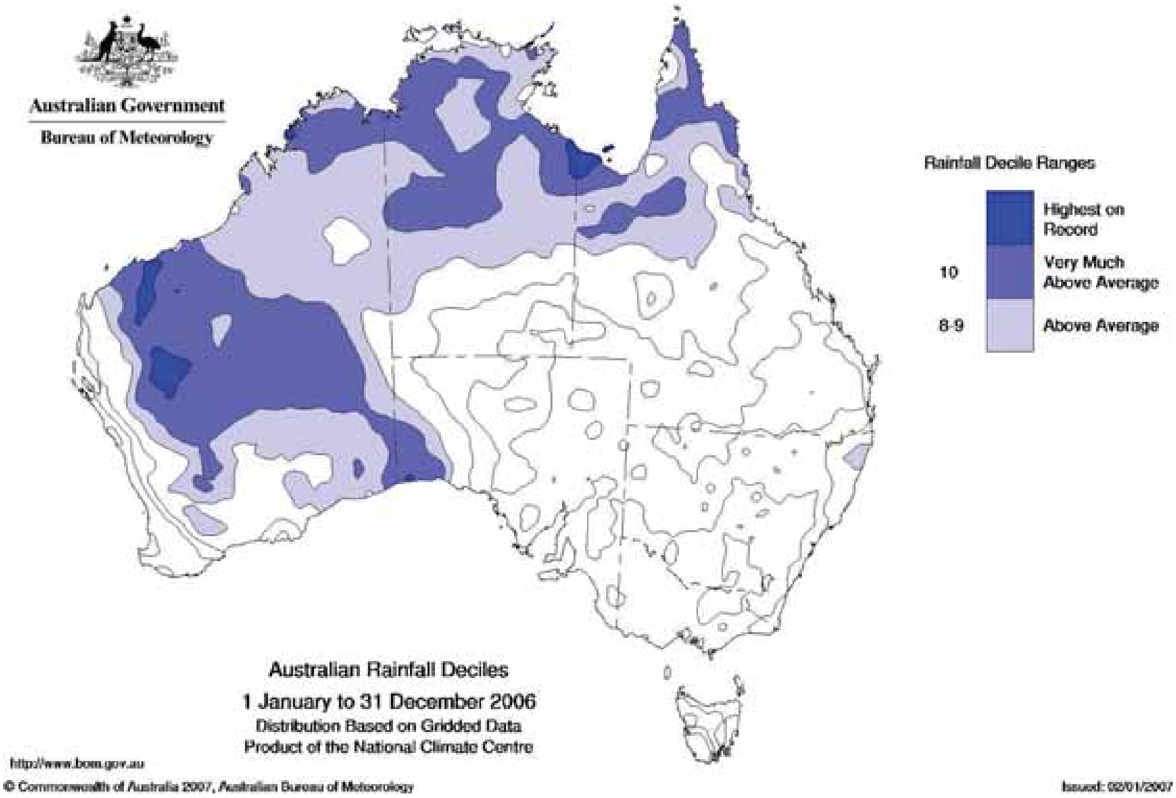
From a mining productivity perspective some significant climate events over the 2000-01 to 2006-07 period were heavy cyclonic activity in northern Australia, and very dry to drought conditions in many parts of southern Australia. For example, cyclonic activity around the Pilbara region in north western Australia was exceptionally bad in early 2006, leading to flooding of many iron ore open cut mines and the Telfer gold mine pit. Oil and gas extraction in the North-West Shelf was also adversely affected by the severe weather, with 13 per cent of annual production lost in 2005-06 (ABARE 2006). The severe rain caused by tropical cyclones (figure 5.9), many of which crossed the coast and proceeded through the Pilbara region, had a significant impact on mining activities, and probably impacted on productivity in the 2005-06 financial year (figure 5.10).

Figure 5.9 **Tropical cyclone activity 2005-06**



Data source: Bureau of Meteorology (accessed 2008): Tropical Cyclone Information

Figure 5.10 **Rainfall deciles — high rainfall areas, 2006**



Data source: Bureau of Meteorology Annual Australian Climate Statement 2006 (modified by PC).

In contrast to northern Australia, prolonged dry to drought conditions for most of this decade to date are impacting adversely on some mines. For example, the Cadia Hill copper-gold mine in New South Wales is having to develop new infrastructure to source water, while the Tarong coal mine in Queensland reduced output and employment in 2007 as a result of water shortages. Continued conditions of lower rainfall in southern Australia will put further pressure on mine economics, and may adversely affect productivity.

5.5 Infrastructure constraints

The final factor considered as a possible contributor to the major reduction in mining industry productivity between 2000-01 and 2006-07 are problems with export infrastructure.

Infrastructure in mining primarily refers to the network of public, private and third-party owned transport links that allow mine production to be moved to its final destination or port-of-exit. As the export-orientated mining industry has become larger (both in terms of value and volume of production) capacity constraints on transport supply chains have become more apparent, especially with respect to coal mining, and to a lesser degree with iron ore mining.

The rail and port infrastructure associated with coal exports has achieved a degree of notoriety in recent years as supply chains have become more congested. A review of the capacity of Queensland's Goonyella Coal Chain commissioned by the Queensland Government and the Queensland Resources Council in late May 2007 found that the current bottleneck to increased exports of coal was rail operations (O'Donnell 2008). A number of recommendations were made regarding ways in which the capacity and overall efficiency of the supply chain could be improved, including with respect to the rail transport component. In response to the review, the Queensland Government approved an additional $113 million investment from Queensland Rail to purchase 510 (additional) new coal wagons (Department of Resources, Energy and Tourism 2008).

The rail 'bottleneck' identified in the May 2007 review is consistent with an earlier finding by ABARE in a study of Australia's export infrastructure published in 2006. The authors found that despite improvements in regulatory arrangements in Queensland, 'mine capacity continues to exceed system capacity, with mines such as Blair Athol ramped back because of system constraints' (ABARE 2006, p. 368).

The congestion in east coast coal handling systems resulted in the implementation of queue management schemes, where coal companies in loose coalition allocated rail network quota between them as a short-term measure to provide surety regarding export capacity. While such schemes were only envisioned as temporary as improved rail and port infrastructure was constructed, and put in place in 2003, they are still in effect today (although it has been suspended on occasion). The scheme has also led to apparent inefficiencies, whereby companies that did not fill their quota were not always able to reallocate unused quota to other companies, resulting in the chains occasionally being *under*utilised. It is reasonable to assume that uncertainty and congestion on transport links would have a negative effect on coal mining productivity, although it is difficult to estimate the extent to which this is the case.

The authors of the ABARE report cautioned, however, that (supply system) capacity usage is also a function of mine throughput and the overall demand for commodities, and that the existence of capacity rationing systems does not *always* imply that mine production is being held back because of post-mine capacity constraints. The example they use to illustrate the point is that of coal exports out of the Port of Newcastle, where from January to May 2006 the annualised outloading rate was 81.7 million tonnes — significantly below system capacity, and 'possibly representing constraints on mine capacity' (ABARE 2006).

With respect to iron ore, the recent decision to grant third-party access to the Goldsworthy, Robe River and Hammersely lines may affect productivity is but the impact is beyond the scope of this paper. What is of interest is the degree of congestion now being experienced on the Pilbara supply chains as a result of rapid mine expansion projects in north-west Australia. This too could have productivity implications, if not now, then at some point in the future.

5.6 Putting the pieces together

Chapter 3 contained a review of the important role played by natural resource inputs in mining, and the problems that arise in interpreting productivity changes when changes in the quality or quantity of resource inputs are not taken into account. Using detailed information regarding changes in the quality of resource inputs arising from changes in ore grades, oil and gas flow rates, and the ratio of saleable to raw coal, it was found that declining resource quality contributes significantly to the rate of productivity growth in mining over the longer term. After accounting for the measured declines in resource quality, MFP growth in mining is large and significant, and above the longer-term growth rates in other sectors and the market sector as a whole (table 5.1).

Table 5.1 **Average annual growth in MFP, 1974-75 to 2006-07**

	Per cent
Mining	0.01
Mining with depletion effects removed	2.5
Mining with depletion and capital effects removed	2.3
Manufacturing	1.3
Agriculture	1.8
Market sector	1.1

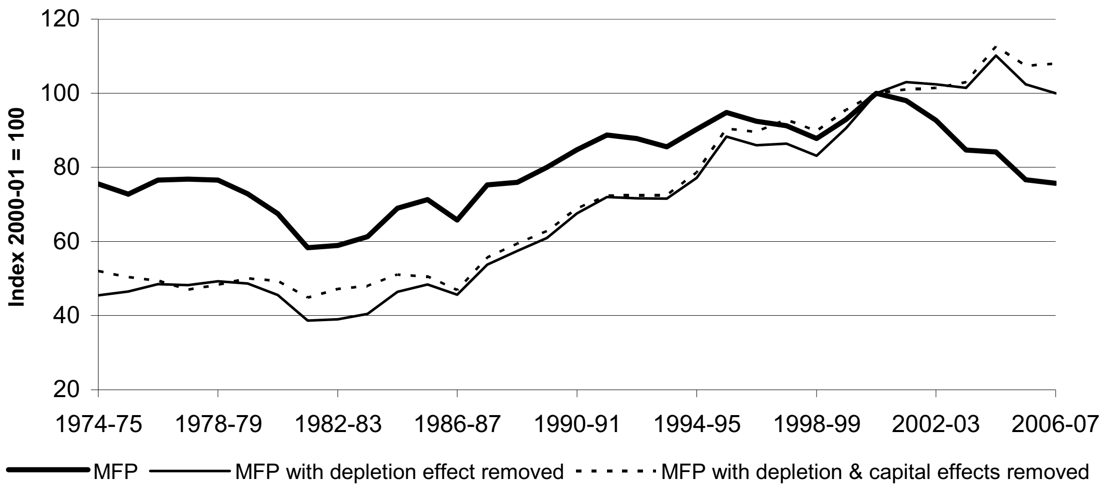
Sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity 2006-07*, Cat. no. 5260.0.55.002)

The other key factor influencing productivity in mining and for which quantitative estimates have been made in this paper is the issue of lags between investment in new or expanded mine capacity and full production from these investments. Mining has a history of new capital investment occurring in cycles or surges, and the surges can have immediate adverse consequence for measured productivity due to lags in output responses. Chapter 4 contained estimates of the size of these effects, and showed that improved measurement of capital services inputs in mining MFP calculations removes a significant degree of variability in the measured MFP data series.

By subtracting from MFP the influence of these two factors — that is, the effects of yield declines and production lags — the balance or remainder is a measure of the extent to which mining output is not explained by changes in conventionally measured inputs – that is, labour and capital. It is this component of the original MFP estimate that is a measure of the influence of 'other' factors on MFP, including such things as technology changes, changes in work practices, changes in effort or input combinations due to unexpected output price changes, and ad hoc factors like poor weather.

When added together, the effects of resource depletion and production lags are estimated to explain a large part of both longer-term and shorter-term changes in mining MFP (figure 5.11).

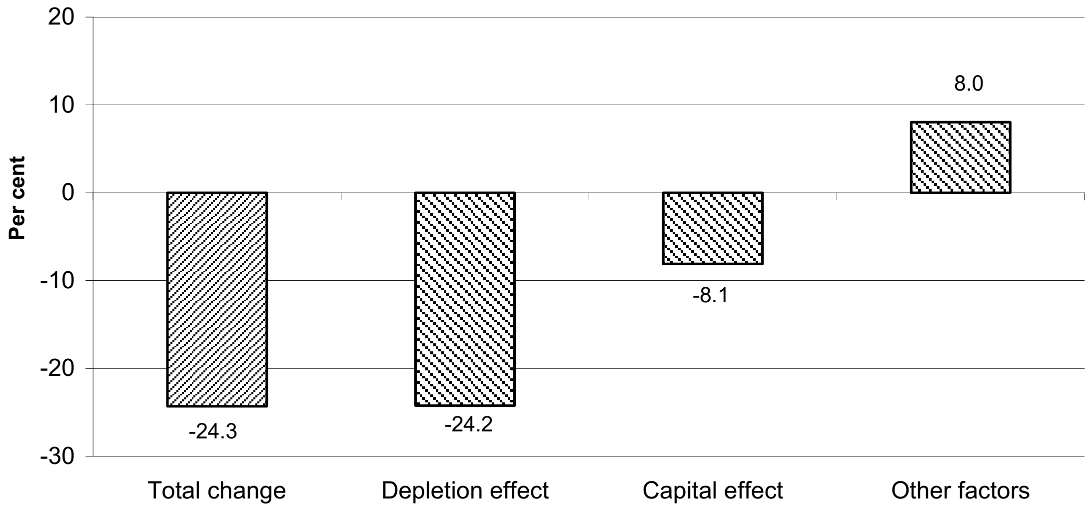
Figure 5.11 **Impact of yield declines and production lags on mining MFP**



Data sources: Authors estimates, ABS (*Experimental Estimates of Industry Multifactor Productivity 2006-07*, Cat. no. 5260.0.55.002)

In particular, the large decline in mining MFP in the late 1970s is much less apparent once yield changes and the capital investment surge that occurred at that time are taken into account. And in relation to the key issue motivating this study in the first place — the sharp and sustained decline in mining MFP between 2000-01 and 2006-07 — yield declines since 2000-01 and the surge in capital spending from around 2004-05 onwards are estimated to have contributed just over (negative) 33 percentage points to the total decline in MFP of around 24.3 per cent (figure 5.12).

Figure 5.12 **Contributions to the decline in mining MFP between 2000-01 and 2006-07**



Data sources: Authors' estimates, ABS (*Experimental Estimates of Industry Multifactor Productivity*, 2006-07, Cat. no. 5260.0.55.002).

As noted in earlier chapters, recently released data from the ABS indicate that mining industry MFP has fallen again in 2007-08, by just under 8 per cent. Production lags are estimated to explain just over 5 percentage points of the decline. Unfortunately, data limitations mean that we cannot estimate the extent to which resource depletion contributed to the decline. However, it seems likely that the decline in aggregate production of crude oil and condensate in 2007-08 reflects on-going reductions in oil and gas flow rates in some fields. To the extent this turns out to be the case, resource depletion is likely to emerge as an important explanatory factor of the decline in mining MFP in 2007-08 as well.

Positive effects on mining productivity

The implications of the quantitative assessments of yield effects and the surge in capital spending is that 'other factors' have contributed a positive amount (8.0 percentage points) to productivity growth in the mining industry between 2000-01 and 2006-07. Given that a number of the 'other' factors considered earlier are more likely than not to have made an adverse contribution to mining MFP since 2001 — for example, poor weather, infrastructure constraints, and shortages of skilled labour and machinery — the implication is that there must have been strong positive contributions to productivity growth in recent years from other sources, particularly technology.

An international perspective

In the long term, another mature mining nation, Canada, has experienced slow mining MFP growth. A study by the Canada-based Centre for the Study of Living Standards (CSLS) found that mining MFP growth in Canada over the period 1973 to 2000 was negative 2.2 per cent (Arsenault and Sharp 2008). Over the more recent period, Canada has experienced a more severe decline in MFP, negative 5.5 per cent over the period 2000 to 2006 (Arsenault and Sharp 2008). In explanation of this trend, the authors of the study state:

> Since 2000 and especially since 2004, increasing commodity prices have allowed the exploitation of reserves yielding much lower productivity levels. Through a compositional effect, this has led to increasingly negative labour productivity and MFP growth… Because the falling productivity of the sector is both the result of a rapid increase of its labour force and of the sudden increase in the exploitation of the oil sands, we may expect future labour productivity performance to be better (even if still negative) as the sector adjusts to its new reality and as the rate of increase in the oil sands share of total production levels falls off… Yet, if oil prices remain high, extraction activities in deeper oil sand deposits might grow significantly and continue to put downward pressure on the sector's productivity growth. (Arsenault and Sharp 2008)

The Canadian experience is one brought about by compositional changes in the industry, which is unlike the events that have occurred in Australia. Nonetheless, the response of mining poorer quality natural resources in response to higher prices is common, and has played a part in the declining productivity in the mining industry of both nations.