4 Understanding productivity in mining: purchased inputs

Key points

- Mining is a capital intensive industry with large sunk costs. While productive capacity is often fixed (particularly in the short term), annual production can vary significantly due to the natural characteristics of individual mines and wells.
- The fixity of productive capacity in the short term implies that permanent expansions to production can only come about with substantial new investment.
- There is a lag between investment in new capacity in mining and the associated output of around three years. Lags in the response of mining production to new capital investment mean that there can be a negative short-term relationship between capital investment in mining and mining MFP.
- Accounting for the lag between capital investment and output in mining explains a considerable amount of the year to year variability in mining MFP. After removing these effects, mining MFP is considerably less variable over time, although the trend rate of growth is unchanged.
- The lag between new investment and output accounts for around one third of the observed decline in mining MFP between 2000-01 and 2006-07, with the effects concentrated in the last three years of the period. A positive effect on multifactor productivity (MFP) would be expected over the next few years as production associated with recent capital investments comes on stream.

As discussed in the previous chapter, resource depletion plays a significant role in explaining changes in mining MFP. Another important reason that movements in mining MFP need to be interpreted carefully is that there are usually long lead times between investment in new capacity in the mining industry (whether in the form of new mines or mine expansions) and the corresponding production. This chapter examines the nature and extent of the relationship between investment in new capacity in mining and changes in MFP.

4.1 The structure of mining costs

The variety in activities, commodities and techniques of production in mining (chapter 2) means that there is not a unique, or even typical, set of input requirements. There are nevertheless some input characteristics that are of general relevance to the nature of productivity trends in the sector.

Mining is a capital intensive industry. Table 4.1 shows that capital inputs account for about half the total costs in mining production (or around 80 per cent of value added). The average for the economy as a whole is 21 per cent (or approximately 44 per cent of gross value added).

Labour inputs account for a relatively small share — approximately 12 per cent — of total costs (table 4.1 and figure 4.1) and around 23 per cent of value added in mining. In contrast, labour inputs in the economy as a whole are around 25 per cent of total costs, and around 52 per cent of gross value added. Mining employees are generally better paid than other workers however, which is partly a function of higher average skill levels among miners, and partly a function of the hazards and hardships of mine work, including remoteness. Apart from higher wages and salaries, mining companies also typically face higher on-costs associated with their employees, including accommodation costs for remotely located workers, and transport costs associated with moving mine workers to and from mine sites. The latter have risen considerably in recent times with the move among many mine operators to a 'fly-in, fly-out' approach to their on-site labour force.

There are also major differences in cost structures within the mining industry, with oil and gas producers in particular relying to an even greater degree on capital inputs compared with the other mining industries (figure 4.1). In general however, mining industries use more capital and less labour than the rest of the economy. The use of intermediate inputs in mining is also lower than the national average, mainly due to the very low use of these inputs in oil and gas extraction.

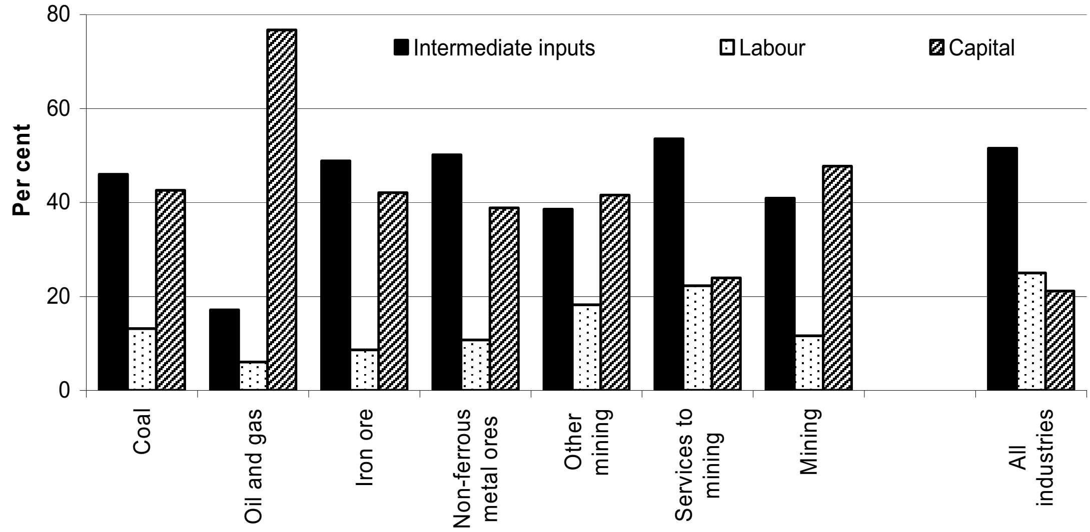
Table 4.1 **The cost structure of mining, 2004-05**
$million[a]

	Mining industry	Coal	Oil & gas	Iron ore	Non-ferrous metals	Other mining	Services to mining
		Industries					
Intermediates:							
Mining products	10 487	2908	1108	2032	3885	380	175
	(14)	(15)	(6)	(25)	(21)	(13)	(2)
- Services to mining	6814	1659	578	1579	2751	73	174
	(9)	(9)	(3)	(20)	(15)	(3)	(2)
Manufactured goods	8219	2503	779	816	2566	372	1184
	(11)	(13)	(4)	(10)	(14)	(13)	(13)
- Petroleum & coal products	2919	761	145	301	1091	140	482
	(4)	(4)	(1)	(4)	(6)	(5)	(5)
Energy	834	244	80	94	408	3	6
	(1)	(1)	(0)	(1)	(2)	(0)	(0)
Trade services	2643	785	338	306	543	149	522
	(3)	(4)	(2)	(4)	(3)	(5)	(6)
- Construction	544	199	89	115	44	25	73
	(1)	(1)	(0)	(1)	(0)	(1)	(1)
- Wholesale	1155	342	118	113	359	62	160
	(2)	(2)	(1)	(1)	(2)	(2)	(2)
Transport & storage	2467	1231	369	168	292	72	335
	(3)	(6)	(2)	(2)	(2)	(2)	(4)
Professional & other services	5745	1028	440	446	1261	134	2436
	(8)	(5)	(2)	(6)	(7)	(5)	(27)
- Banking	492	123	89	75	147	24	35
	(1)	(1)	(0)	(1)	(1)	(1)	(0)
- Other prop. services	1074	406	160	205	210	34	58
	(1)	(2)	(1)	(3)	(1)	(1)	(1)
Total intermediates	**30 858**	**8785**	**3144**	**3926**	**9114**	**1125**	**4764**
	(41)	(46)	(17)	(49)	(50)	(39)	(54)
Labour costs	**8767**	**2509**	**1107**	**690**	**1949**	**530**	**1982**
	(12)	(13)	(6)	(9)	(11)	(18)	(22)
Capital [b]	**36 003**	**8144**	**14 086**	**3383**	**7049**	**1211**	**2130**
	(48)	(43)	(77)	(42)	(39)	(42)	(24)
Production [c]	**75 524**	**19 135**	**18 361**	**8039**	**18 171**	**2917**	**8901**
	(100)	(100)	(100)	(100)	(100)	(100)	(100)

[a] Numbers in brackets are proportions of the value of production. [b] Defined as value added less labour costs. [c] Discrepancy in summation is due to indirect taxes.

Source: ABS (*Australian National Accounts: Input-Output Tables 2004-05*, Cat. no. 5209.0.55.001).

Figure 4.1 **Total cost shares in mining, by industry, 2004-05**



Data source: ABS (*Australian National Accounts: Input-Output Tables*, *2004-05,* Cat. no. 5209.0.55.001).

4.2 The nature of mining capital

As noted above, mining is a capital intensive industry, and the composition or mix of capital used in mining is also different to that of other sectors (figure 4.2). For one thing, the capital stock in mining includes exploration expenditure, which is a type of capital stock unique to mining. The ABS treats exploration expenditure as a capital input rather than an intermediate input on the basis that exploration activity, whether successful or not, is required to acquire new reserves (ABS 2006).

Of the remaining types of capital stock, mining also has a comparatively large share of construction capital. This reflects the large capital costs associated with the development and construction of open-cut and underground mines, and the high cost of off-shore drilling platforms in the oil and gas sector. Private infrastructure assets owned by mining companies such as roads, railways and port infrastructure, are also significant, and contribute to the large amount of non-dwelling construction capital used in the sector.

Table 4.2 **Net capital stock in selected industries, by capital type, in 2006-07**

$million (% of total)

	Machinery and equipment	*Non-dwelling construction*	*Computer software and other*	*Exploration*	*Total*
Mining	52.1 (23.8)	130.1 (59.4)	1.2 (0.5)	35.7 (16.3)	219.1
Agriculture, forestry & fishing	34.3 (40.5)	40.9 (48.3)	9.5 (11.2)	0.0 (0.0)	84.8
Manufacturing	72.9 (53.6)	60.4 (44.4)	2.6 (1.9)	0.0 (0.0)	135.9
Construction	17.6 (61.1)	10.4 (36.1)	0.8 (2.8)	0.0 (0.0)	28.8

Source: ABS (*Australian System of National Accounts 2007-08*, Cat. no. 5204.0, Table 88).

Variability in mining capital investment

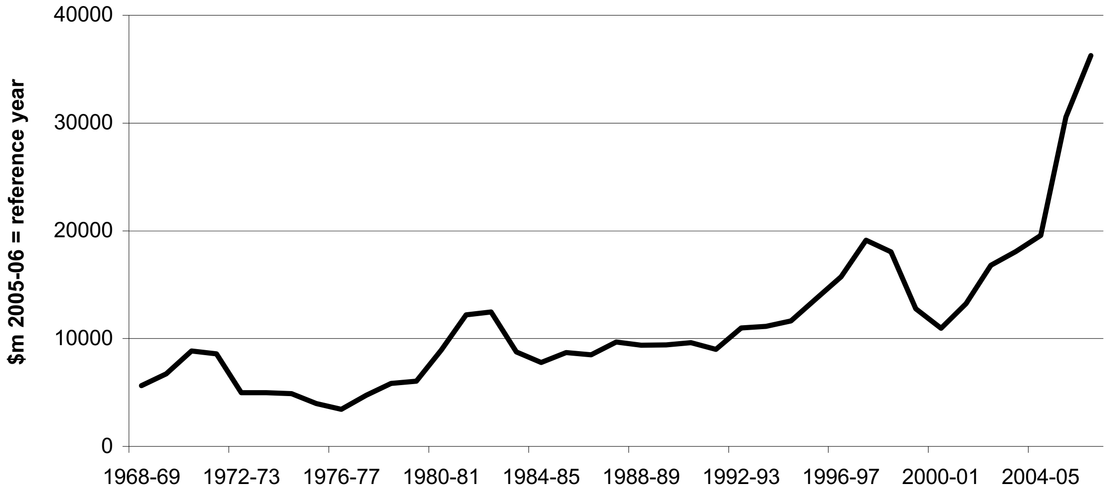
Annual investment in new capital in the mining industry also shows significant year to year variability, and there is clear evidence of cycles in investment behaviour over time (figure 4.2). For example, between 1968-69 and 2006-07 there appear to be four major investment cycles — peaking in the early 1970s, in the early 1980s, in the late 1990s, and an investment surge beginning around 2004-05 the peak of which is yet to be determined. As important as the investment surges may be, it is also important to note that each surge in new investment is accompanied by a significant drop-off in new investment following the peak. So while capital investment has risen dramatically since 2000-01, the increase is from a very low base. In fact, real mining capital investment in 2000-01 was below the levels reached in the early 1980s.

The specific nature of capital in mining

The nature of capital investment in the mining industry tends to be quite specific to the circumstances of individual mines. The way a mine is developed needs to take account of the characteristics of a deposit (for example, its depth, dispersion, distribution of ore grades and the nature and stability of surrounding material), the engineering and economic feasibility of different extraction techniques, associated plant and equipment requirements, infrastructure needs (access roads, power sources, transport systems, processing facilities, waste disposal areas), future rehabilitation requirements and so on.

Many, if not most, of the capital expenditures are sunk costs. Once incurred, they cannot be recovered by sale or transfer of the corresponding assets. However, there are sometimes opportunities for new mines that are being developed in close proximity to existing mines to take advantage of pre-existing capital, such as transport facilities and processing plants.

Figure 4.2 **Gross fixed capital formation in mining**
Chain volume measures with 2006-07 as the reference year



Data source: ABS (*Australian System of National Accounts 2007-08*, Cat. no. 5204.0, Table 91).

The technology chosen for use in an individual mine can also be considered largely fixed once the decision to build the mine in a particular way is locked in. In this event, major changes to market conditions after a mine is developed can have little effect on the way a mine operates, including its production capacity. While there are important technological advances in mining, major advances in technique or changes that entail different infrastructure requirements are more readily adopted when new mines are developed, rather than through retro-fitting existing mines.

The characteristics of mining that dictate the type and nature of new mine developments also apply to mine expansions and upgrades. The capacity and technology adopted in relation to mine expansions and upgrades tend be site specific, and projects are developed and built with a longer-term view in mind regarding production and production targets.

Capacity selection and utilisation

The circumstances of individual deposits also influence the scale of a project. Part of the pre-development phase of a new mine is to determine an optimal rate of extraction among feasible options and to set the scale of mine and associated infrastructure accordingly. For example, small but high-quality deposits may permit comparatively small-scale mining operations, while deposits of lower quality ore will generally demand larger-scale investments in order to extract larger volumes of material, and to transport and process it.

The ‘Hotelling rule’ and its various elaborations give some theoretical guidance on the optimal strategy for miners to extract non-renewable resources (chapter 3). These considerations suggest that the rate of production is set to maximise net returns over time and that the highest quality deposits are mined first. Given commodity prices, mining costs and interest rates, the rate of mining activity and the rate at which commodity outputs are produced from extracted material will essentially be determined by the quality of available deposits, where quality reflects not only ore grade but other characteristics.

In practice, of course, there is considerable uncertainty about the quantity and quality of resource reserves and uncertainty about the future course of prices over what can be long-life projects. Because many resource deposits are in remote locations, the availability of supporting infrastructure (and who pays for it) is also a vital cost issue.

The time scale for mine development is generally quite long — some mines taking decades to progress from initial resource discovery to full production. Once the decision is made to construct a new mine however, the length of time until production begins varies from mine to mine, although mine construction can be reasonably fast. It is also important to note that while production from a new mine can occur reasonably quickly after construction first begins, there may be a further lag until maximum production levels are reached. Typically, production starts at a low rate during the development phase and can take some years to work up to full capacity.

Fixed capital in the ‘short’ run

The characteristics of mining investment mean that capacity at individual mines tends to be fixed and fully utilised, once fully operational. Additional capacity can only be installed at high cost and with considerable time lag. Because of sunk costs, individual mines are often run at full capacity even if there is a downturn in prices, so long as variable costs are covered. On the other hand, some mines can and do record comparatively large changes in production from one year to the next. This occurs in both coal mining and metal ore mining, and can reflect natural factors and random events, as well as explicit management decisions to increase or decrease production.

In the oil and gas sector, the issue of production is largely determined by flow rates, which can vary substantially over time as a result of the natural characteristics of oil wells. Price and market conditions can induce managers to start or stop secondary or tertiary production, and this can temporarily alter the production profile of individual wells. Over the longer term however, production is largely determined by the natural characteristics of each oil and gas field.

In general, it seems reasonable to conclude that mines have limited capacity to expand production significantly in the short term, although clearly there is some capacity to boost (or cut) output in the very short term according to market and other conditions. For example, the length or number of production shifts can be changed, maintenance schedules can be adjusted, and machinery can be run harder or left idle until market or other conditions change once again. Decisions to permanently increase output at individual mines — say through mine expansions — involve longer-term commitments, and generally take a minimum of two to three years to achieve. They also involve the investment of significant amounts of new capital. At the same time, large and unexpected increases in output prices may make it feasible to revisit old or 'mothballed' mines, including the possibility of revisiting mine tailings as a source of short-term supply increases.[1]

4.3 Capital investment and MFP changes

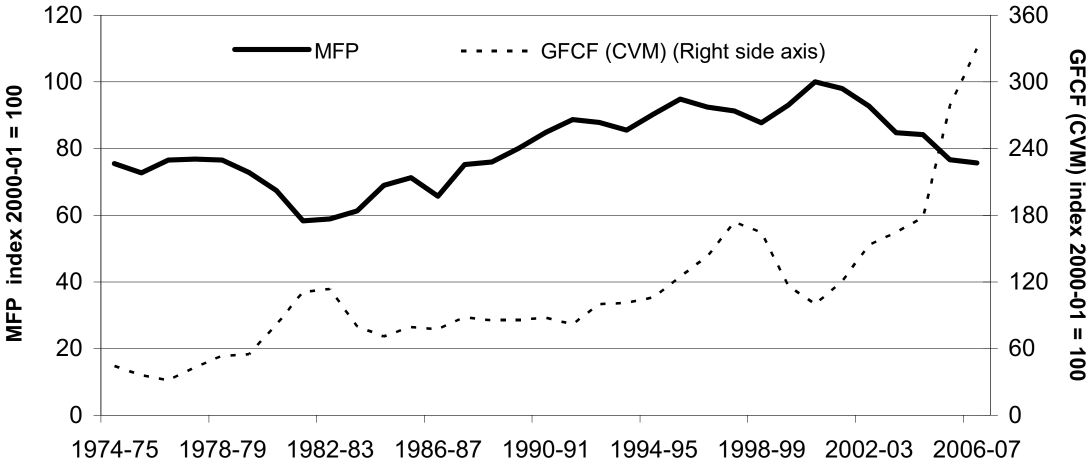
The importance of the nature and characteristics of capital used in mining can be seen more clearly when we consider the relationship between changes in capital investment in mining and changes in mining multifactor productivity (MFP). In general, there is an inverse relationship between changes in gross fixed capital formation (GFCF) and changes in mining MFP (figure 4.3). Increases in new capital investment are typically associated with lower or negative MFP growth in mining, and conversely. The most obvious explanation for the inverse relationship is that, while a surge in new capital investment leads to an immediate increase in capital inputs in mining, the corresponding output growth in the sector can be slower to eventuate because of lags between when investment takes place and when production from completed developments comes on stream. As a result, investment surges and declines can lead to short-term inverse changes in MFP.

Over the longer term we would not expect higher (or lower) capital investment to influence the rate of MFP growth except through the introduction of improved technology or management practices. Hence the observed inverse relationship between capital investment and MFP is likely to be a short-term or temporary phenomenon. Indeed, as is illustrated in figure 4.3, both capital investment and MFP have trended upwards over the longer term, albeit at different rates. Moreover, during a period when there was sustained but moderate growth in capital investment

[1] These issues and the implications for productivity estimates are explored in more detail in the next chapter.

— from the mid-1980s to the mid-1990s — mining MFP grew comparatively strongly.

Figure 4.3 **Mining MFP and gross fixed capital formation**



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

The existence of lead times between when capital investment in new mining developments is initiated and when full production from these developments is reached is only likely to be notable from a productivity point of view during periods of abnormally high or low growth in new investment. During periods of comparatively steady growth in new investment, the effects of lags in production on MFP changes are likely to be small. However, when investment is rising or falling relatively quickly, the effects on MFP are likely to be larger.

The current period of booming capital investment in Australia is exactly the type of event that is likely to lead to substantial short-term, transitory effects on MFP. Gruen and Kennedy (2006) compare the current mining boom with a mining boom in the late 1970s to show that, in the former, production lagged the surge in investment by a number of years, but eventually grew strongly. They argue that a similar result will occur in the current boom, leading to an eventual turnaround in mining MFP. Similarly, Sibma and Cusworth (2006) conclude that lags and long lead times in capacity expansion account for much of the recent decline in mining industry productivity observed in Western Australia.

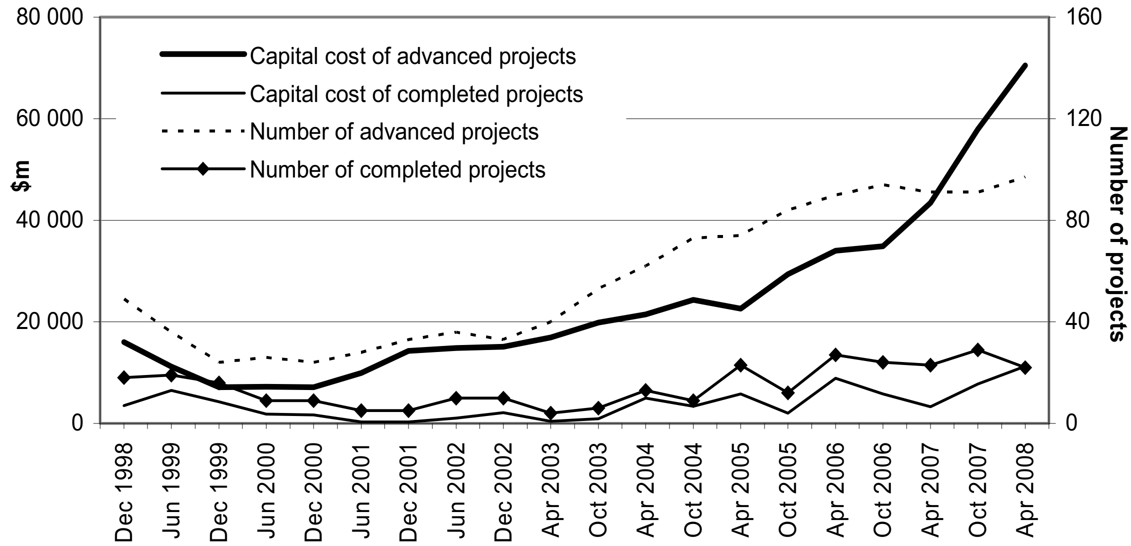
The remainder of this chapter contains a quantitative assessment of the effects on MFP of production lags associated with rapid changes in the rate of growth in new capital investment in mining. While the results presented are not intended to be definitive estimates of the effect of production lags on mining MFP, it is important that some attempt is made to put credible orders of magnitude around what is frequently referred to as a possible factor influencing mining MFP.

The surge in new investment

As discussed in chapter 2 and illustrated in figure 4.3 above, capital investment in mining is currently at historically high levels. Recently released data from the ABS indicate that capital investment in mining rose further in 2007-08, by around 28 per cent in nominal terms and by 22 per cent in real terms.

In line with the increase in capital investment, information released by the Australian Bureau of Agricultural and Resource Economics (ABARE) regarding the number of major mining projects under construction shows a significant increase in recent years in terms of both the number of new projects and the expected capital cost of those projects (figure 4.4).

Figure 4.4 **Number and capital cost of advanced mining projects and completed mining projects**



Data source: ABARE (*Australian Commodities 2008b* (2)).

The apparent blow-out in the capital cost of 'advanced' projects since 2006 is consistent with anecdotal evidence reported by mining companies regarding major increases in project costs due to shortages of specialised mining equipment and skilled labour brought about by the global mining boom.

Length of production lags in mining

In order to be able to measure the extent to which mining MFP is influenced by lags between capital investment and output, it is necessary to measure the length of the lags. Empirical analysis suggests a lag of three years between changes in capital investment in mining and changes in value added (output), although in statistical terms the relationship is not particularly strong (in part due to a lack of data).

There is other evidence, however, to support the view that the average production lag in mining is around three years. This includes detailed information published by ABARE regarding the number, capital cost, output capacity, and time between initiation and commissioning of all major new mining projects and developments in Australia since 1994 (see box 4.1). The ABARE data indicate an average time to commissioning of major mining developments of 2.1 years, although there can be large differences from project to project. For example, the new Ravensthorpe nickel mine took around 3.5 years between first appearance on the ABARE list to first production, while many smaller projects take less than one year to move from 'under construction' to 'completed'. Mine expansions also typically take less time to begin production than new mines (1.7 years on average versus 2.3 years), but expansions of some existing mines — such as large iron ore project expansions in the Pilbara region of Western Australia — can take much longer than many smaller, new projects.

In measuring the time taken between the 'commitment' phase of a new project and the commissioning of a project, it is important to note that there can be a considerably longer period of time between the initial discovery or identification of a new resource and the 'commitment' to develop the resource. Also, some amount of capital investment or cost will generally have been incurred in the activities that take place in the lead up to the 'commitment' to new projects. It is assumed, however, that the majority of capital costs involved in the development of new mining projects is expended during the period between the commitment to the new project and the completion of that project. It is also important to note that there is usually a further lag between initial production from a new development and 'full' production, although the length of this lag is less clear.

Based on the empirical data regarding changes in investment in mining and changes in output, and the information gleaned from the ABARE 'advanced projects' list regarding average project developments times, it is assumed for the purposes of this report that there is, on average, a lag of three years between investment in new productive capacity in mining and the associated output from that investment.

Box 4.1 **Estimating production lags in mining**

The Australian Bureau of Agricultural and Resource Economics (ABARE) has been compiling and publishing a list of major new mineral and energy projects under development in Australia since the late 1990s. The list contains details of major minerals and energy projects that are expected to be developed over the medium term. The state of progress of each project is recorded on the list, and this generally categorises projects as either ‘committed to’, ‘under construction’, or in a more preliminary state. The list also includes information on the expected capital expenditure of each project, and the new production capacity associated with each project. The list is currently published by ABARE on a bi-annual basis (generally released in the June and December editions of ABARE’s *Australian Commodities* journal) but has previously been published on an annual basis (ABARE 2008b). While the list is not intended to be a complete picture of every new development in the mining industry at a particular point in time (projects must meet minimum size requirements to appear on the list), all of the major new projects in Australian mining are covered.

By observing the entry and exit of individual projects from the list, estimates can be made of the average length of time it takes for mineral and energy projects to be constructed. In estimating the project completion times, only projects that are ‘committed to’ or ‘under construction’ are used, and projects are not counted if they fall off the list due to a change in status — for example, if projects move off the list because they are suspended or abandoned. For projects that are still under construction, the predicted project completion date is assumed to be the actual completion date. In all other cases the project length is determined by the entry of the project to the list, and the date of project completion.

The average project construction times reported below are weighted averages, where the weights are given by the amount of capital expenditure on each project. As there are very large differences in capital costs and productive capacity from project to project. Hence we give greater weight to projects with larger capacity (and potentially longer lead times), and less weight to smaller projects (that may have shorter lead times to full production). Capital expenditure is used as the weight variable rather than physical capacity or output on the basis that the latter is not always reported, and because it can sometimes be difficult to aggregate output quantities across different industries (gas production versus metal production etc). Also, expected output is often reported in the ABARE project lists in the form of a comparatively wide range, rather than as a precise figure.

Results

The estimated project construction times are presented in table 4.3. As expected, new mines tend to take longer to construct than mine expansions, with the difference being around six months.

(continued next page)

Box 4.1 **(continued)**

Table 4.3 **Average construction time of new mining projects[a]**

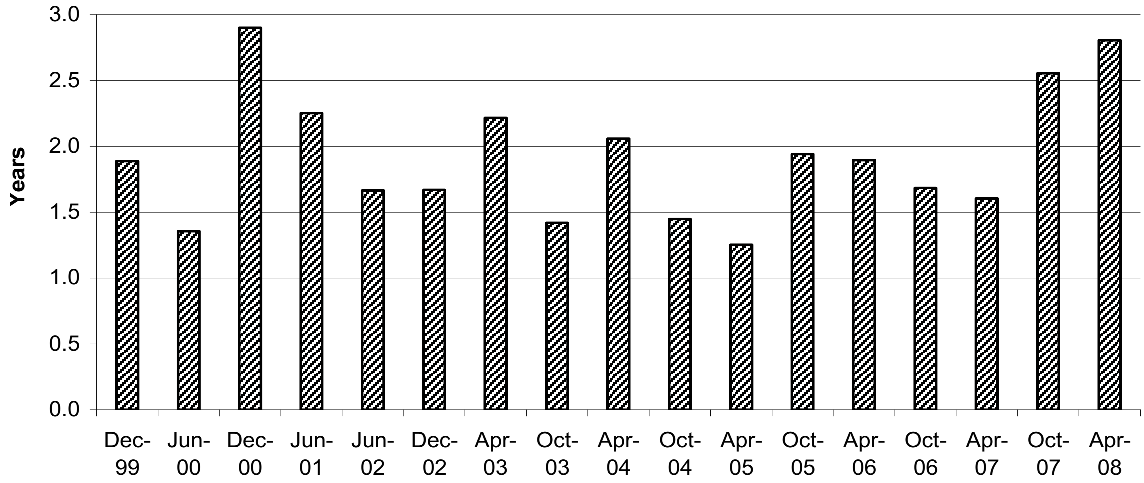
	Number of new projects	*Construction time in years*
All projects	341	2.1
New mines/developments	211	2.3
Mine expansions	130	1.7

a Based on project lists from December 1998 to April 2008.

Source: Authors' estimates using ABARE data (*Australian Commodities* , various issues).

The ABARE list can also be used to examine whether or not there has been any change in the average time taken to construct new projects in recent years. The evidence suggests that there has been an increase in the average length of projects in the last year or so (figure 4.5). For new projects appearing on the list in October 2007 and in April 2008, the average project length has risen by up to one year compared with projects started earlier this decade.

Figure 4.5 **Average construction time of new mineral and energy projects**



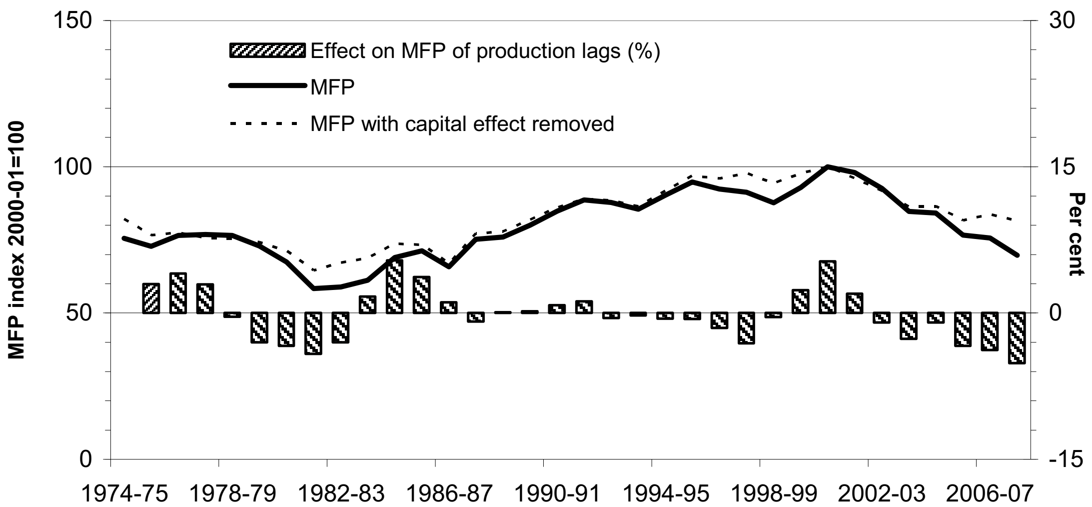
Data source: Authors' estimates using data from ABARE (*Australian Commodities,* various issues).

Adjusting capital inputs and measuring the effect on MFP

To estimate the size of the effects that production lags may be having on mining MFP we re-estimate the MFP series using a capital inputs index that is lagged three years, rather than using contemporaneous capital inputs.[2] By using a lagged capital services series we reduce the influence on mining MFP of the major cycles in investment by matching changes in productive capital capacity more closely to changes in output.

The results show that lags between capital investment and production have a significant effect on short-term changes in MFP (figure 4.6). The surge in capital investment in mining that occurred in the late 1970s led to MFP falling more rapidly than would otherwise have been the case, while the subsequent period of lower capital investment caused MFP to rise faster than it would otherwise have done. A similar result occurs in the late 1990s when capital investment surged and then fell, while the more recent surge in capital investment has again contributed to a decline in MFP growth. As expected, removing the influence of short-term changes in capital investment has little effect on the long-term trend rate of growth in mining MFP, while the variability of the series is lessened somewhat.

Figure 4.6 **Mining industry MFP and the effect of production lags**



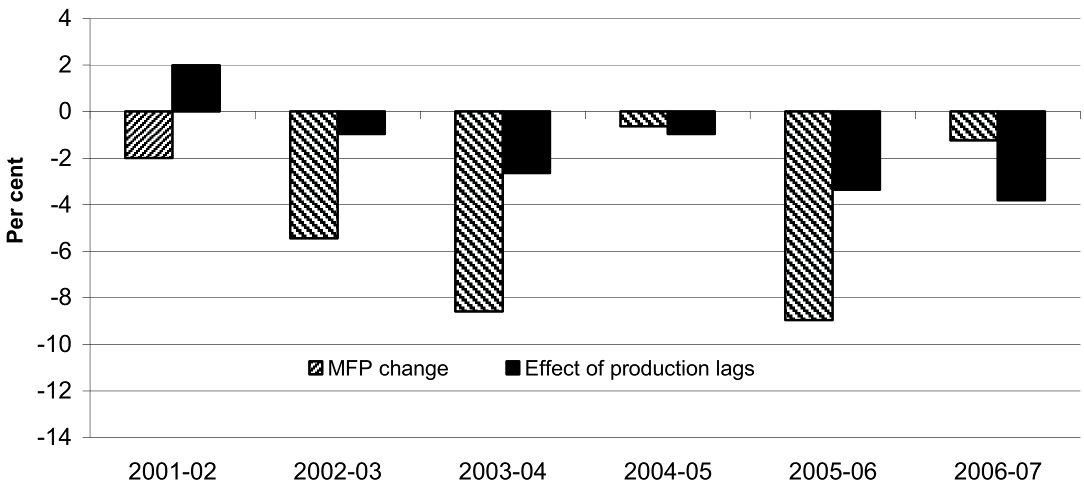
Data sources: ABS (*Experimental Estimates of Industry Multifactor Productivity 2006-07*, Cat. no. 5260.0.55.002); Authors' estimates.

2 Three years is chosen based on the empirical analysis and conclusions drawn from analysis of the ABARE data detailed above. While the ABARE data suggests a lag between two and three years, the longer lag is chosen in order to reflect the additional time a mine faces to 'ramp-up' to full production. The sensitivity of results to different selections of lag length is discussed below.

Effect of the capital surge on mining MFP from 2000-01 to 2006-07

Between 2000-01 and 2006-07 production lags are estimated to have had a substantial effect on the changes in mining MFP, although not all of the annual changes are negative. Figure 4.7 shows annual changes in mining MFP since 2000-01, along with estimates of the extent to which lags in the response of production to new capital investments contributed to the annual MFP changes. Hence, between 2002-03 and 2003-04 when mining MFP fell by around 8.5 per cent, production lags are estimated to have contributed around 2.5 percentage points to the decline, or just under one third of the total decline in MFP in that year.

Figure 4.7 **Annual changes in MFP and the contribution of production lags 2001-02 to 2006-07**



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

The effect of production lags on annual MFP changes is largest in more recent years, in line with the fact that capital investment is at record levels. Importantly, the slowdown in capital investment in the late 1990s/early 2000s actually had a positive effect on mining MFP in 2001-02. That is, the slowdown in capital investment prior to the recent boom meant that mining MFP was higher in 2001-2002 than it would otherwise have been. For the period from 2000-01 to 2006-07 as a whole, production lags accounted for an estimated 8.1 percentage points of the overall decline in MFP of 24.3 per cent, or around one third of the fall.[3]

[3] Estimates of the effect of capital lags on MFP at the mining sub-sector level are contained in appendix A.

Sensitivity of results to the length of the production lag

The sensitivity of mining MFP to the effects of production lags has been tested using shorter (two year) and longer (four year) lags. In both cases there was little change in the size of the effects on MFP compared with an assumed lag of three years. Using a two-year lag means that the adverse effects on MFP of the recent surge in capital investment are slightly smaller, while a four-year lag assumption has very little impact on the magnitude of the production lag effects.

Capital effects on mining MFP in 2007-08

Recently released data from the ABS indicate a decline in mining MFP in 2007-08 of 7.9 per cent. Based on the methodology described above, capital effects are estimated to have contributed around 5.1 percentage points to this decline. That is, after making allowance for production lags associated with the 22 per cent increase in real capital investment in 2007-08, the decline in mining MFP is 2.8 per cent. Perhaps more importantly, the results continue to show that a large share of the decline in mining MFP since 2004-05 has been due to the effects of the surge in capital investment in the sector, and the substantial lead times between investment and output in mining. If the lead times for new mining developments are matched to the changes in mining industry investment, the implication is that there should be a surge in mining industry output between 2008-09 and 2011-12 in response to the surge in capital investment from 2005-06 to 2007-08. This should have a strong positive effect on mining MFP over the next few years.

Questions and implications

Our results, while exploratory in nature, suggest that in environments where capital investment is changing quickly, MFP estimates are prone to potentially larger swings than might otherwise be the case. And while the short-term effects on MFP from investment surges or contractions are always, ultimately, offset by an associated production response, it is not always clear whether the final impact on MFP is positive or negative. The new developments may be inherently more productive than existing mines, meaning that the positive effects on aggregate MFP of new investments (once they are producing) may more than offset the negative effects on MFP of the initial investments. In general, there is no reason to expect that the short-term negative effects of a surge in investment will be symmetric with the longer-term positive effects on MFP, except in those cases where the productivity of new investments is exactly the same as the productivity of existing capacity.

A consequence of long lead times in the development of new mining capacity is that declines or increases in MFP may be attributed to changes in mining industry efficiency, when in fact the short-run changes are the result of the way inputs and output are measured.

Ideally the capital services estimates used in the formula for estimating MFP would be based on 'utilised' capital stock, rather than capital per se. In this case the issue of production lags would not arise. However, it seems unlikely that reliable or comprehensive capital utilisation estimates will ever be available, in which case the issue of production lags will continue to be of concern, particularly in periods of rapidly changing levels of capital investment.

Over the longer term production lags do not affect the trend rate of growth in MFP. However, the mining MFP series is shown to be more volatile over time because of production lags, and this is an important result in terms of how mining industry MFP changes are interpreted. Unless and until a capacity or utilisation-adjusted measure of capital services inputs is available, problems involved in measuring and interpreting short-term changes in mining MFP will persist.