# 2 Aggregate Manufacturing productivity

This chapter provides some background on the size of Manufacturing, both now and over time. An examination of the productivity performance of Manufacturing in aggregate (as measured by the ABS), is followed by a high-level analysis of some of the possible influences on Manufacturing productivity.

## 2.1 Manufacturing in context

Despite some misleading popular perceptions, Manufacturing has steadily increased its level of real value added over the long term, before plateauing over the last decade (figure 2.1). Although the greater growth of other sectors has resulted in Manufacturing recording a relative decline, it remains a significant part of the market sector of the Australian economy.

Figure 2.1 Manufacturing value added: level**a** and share**b** of market sector

2009-10 $m (LHS); Per cent (RHS)

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|  |

a Chain volume measure of gross value added at basic prices. b Share of current price market sector gross value added at basic prices. Current price value added is not available from the National Accounts prior to 1989-90.

*Data source*: ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0).

In 2010-11, Manufacturing contributed 13.4 per cent of market sector value added (table 2.1) and 8.3 per cent of that for the economy as a whole — the third largest share after Financial and insurance services, and Mining.

Manufacturing’s share of market sector hours worked in 2010-11 was 16.2 per cent, or 9.7 per cent of hours worked for the total economy — the third largest share after Construction, and Health care and social assistance. Similarly, Manufacturing’s share of the number employed in the market sector was 15.1 per cent or 8.7 per cent of employment for the total economy — the fourth largest share after Health care and social assistance, Retail trade, and Construction.

In terms of capital, in 2010-11, Manufacturing had the fourth largest share of investment and the net capital stock of the market sector (both around 10 per cent), and the sixth largest share of investment and the net capital stock for the total economy (around 5 per cent). This ranks Manufacturing behind industry sectors like Mining, Transport, postal and warehousing, and Electricity, gas, water and waste services.

Table 2.1 Shares of market sector output, labour and capital, 2010‑11

Per cent

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Industry sector | Value addedb | Hours workedc | Number employed | Investmentd | Net capital stocke |
| Agriculture, forestry & fishing | 4.4 | 6.4 | 5.4 | 6.0 | 6.1 |
| Mining | 15.2 | 4.0 | 3.1 | 32.2 | 19.5 |
| ***Manufacturing*** | ***13.4*** | ***16.2*** | ***15.1*** | ***10.4*** | ***10.2*** |
| Electricity, gas, water & waste services | 3.8 | 2.5 | 2.3 | 12.3 | 16.1 |
| Construction | 12.3 | 17.1 | 15.8 | 2.8 | 2.4 |
| Wholesale trade | 7.0 | 6.9 | 6.3 | 3.7 | 4.0 |
| Retail trade | 7.5 | 15.4 | 18.8 | 3.4 | 3.6 |
| Accommodation & food services | 3.9 | 9.4 | 11.8 | 1.7 | 3.2 |
| Transport, postal & warehousing | 9.1 | 9.6 | 8.9 | 16.0 | 18.9 |
| Information, media & telecoms | 5.0 | 3.4 | 3.3 | 5.1 | 6.7 |
| Financial & insurance services | 17.0 | 6.4 | 6.2 | 4.5 | 6.2 |
| Arts & recreation services | 1.4 | 2.7 | 3.1 | 1.9 | 2.9 |
| **Market sector**a | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

a The ABS measures multifactor productivity only for the market sector of the economy. In this paper, the market sector refers to the 12 industry sectors for which a long time series of multifactor productivity estimates is available (*Australia and New Zealand Standard Industrial Classification 2006* (ANZSIC06) Divisions A to K and R). The ABS has recently added 4 industry sectors to its market sector but data are not available for an equivalent period and the productivity estimates for those industry sectors need to be interpreted with care due to additional conceptual and data issues (ABS 2010a). b Gross value added at current basic prices. c Annualised and adjusted for public holidays and changes in survey methodology (appendix A). d Gross fixed capital formation in current prices. e Net capital stock in current prices.

*Sources*: Authors’ estimates based on ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0); ABS (*Labour Force, Australia, Detailed, Quarterly*, *August 2011*, Cat. no. 6291.0.55.003); and ABS (unpublished Labour Force Survey data).

The size of Manufacturing relative to the rest of the market sector in terms of hours worked and investment has also changed over time. Hours worked in Manufacturing has declined in absolute terms, as well as a share of the market sector (figure 2.2).

Figure 2.2 Manufacturing hours worked: level**a** and share of market sector

Index 2009-10 = 100 (LHS); Per cent (RHS)

|  |
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|  |

a Index of number of hours worked. ABS has annualised hours worked and adjusted for public holidays, and adjusted the series for changes in survey methodology (appendix A).

*Data sources*: ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002); authors’ estimates based on ABS (unpublished Labour Force Survey data).

Investment in Manufacturing grew at a real average rate of 3.7 per cent a year between 1985-86 and 2010-11 (solid line in figure 2.3). There was particularly strong growth in investment from 2001-02, peaking in 2004-05. Investment subsequently declined, particularly around the global financial crisis. However, in 2010-11, it was still higher than in 2001-02. Manufacturing investment as a share of total investment by the market sector fluctuated within a band of 15–20 per cent until 2005-06, before falling to just above 10 per cent in 2010-11. Strong growth elsewhere in the market sector, particularly in Mining, contributed to this more rapid relative decline.

Figure 2.3 Manufacturing investment: level**a** and share**b** of market sector

2009-10 $m (LHS); Per cent (RHS)

|  |
| --- |
|  |

a Chain volume measure of gross fixed capital formation (GFCF). b Share of current price GFCF for the market sector.

*Data source*: ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0).

### Linkages with other parts of the economy

Another aspect of Manufacturing’s place in the overall economy is its linkages to other sectors. Table 2.2 summarises these linkages using data from the ABS input-output table for 2008-09. The Manufacturing column shows that, to produce $100 of output in 2008-09, manufacturers on average required $55.50 worth of inputs from other Australian industries ($20.50 from the service sector; $19.50 from other manufacturers; $8.30 from mining; and $7.20 from agriculture); and $16.20 of imported inputs. (Linkages at a more detailed level are outlined in appendix B.)

Manufacturing includes a wide range of activities, so there is significant variation in intermediate input use between different industries within Manufacturing. Some parts of Manufacturing are resource-processing industries with strong links to primary industries — for example, manufacturing of meat and dairy products is strongly linked to agriculture, while metal refining is linked to mining.

Table 2.2 Input-output linkages between sectors,**a** 2008-09

Percentage shares of total output

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **… to the output of these sectors** | | | |
| **These sectors provide inputs …** | Agriculture | Mining | Manufacturing | Servicesc |
| Agriculture | 18.4 | 0.1 | **7.2** | 0.4 |
| Mining | 0.1 | 9.2 | **8.3** | 0.4 |
| Manufacturing | **8.3** | **5.1** | **19.5** | **6.7** |
| Servicesc | 23.7 | 18.9 | **20.5** | 36.6 |
| Total domestic intermediate inputs | 50.4 | 33.2 | **55.5** | 44.0 |
| Value added | 41.9 | 62.8 | **27.7** | 51.1 |
| Importsb | 7.1 | 4.0 | **16.2** | 4.3 |
| Total output | 100.0 | 100.0 | **100.0** | 100.0 |

a Based on direct allocation of imports, so the percentages for intermediate inputs refer only to domestically produced inputs. Percentages do not sum to 100 because the row for taxes less subsidies on products is not shown. b Imports refer to imported intermediate goods used by column (use) industries and can be products or services from any industry. c Services includes: Electricity, gas, water and waste services; Construction; Wholesale trade; Retail trade; Accommodation and food services; Transport, postal and warehousing; Information, media and telecommunications; Financial and insurance services; Rental, hiring and real estate services; Professional, scientific and technical services; Administrative and support services; Public administration and safety; Education and training; Health care and social assistance; Arts and recreation services; and Other services.

*Source*: Authors’ estimates based on ABS (*Australian National Accounts: Input-Output Tables, 2008-09,* Cat. no. 5209.0.55.001).

Other industries within Manufacturing that produce more elaborately-transformed manufactures, such as pharmaceuticals, have weaker linkages to primary sectors and stronger linkages with other parts of Manufacturing and the service sector. Around 70 per cent of domestically-sourced intermediate inputs used in pharmaceuticals were from the service sector in 2008-09, compared with a 37 per cent share for Manufacturing in total (ABS 2012a). Some industries within Manufacturing use higher shares of imported intermediate inputs than others — for example, in 2008-09 a greater proportion of intermediate inputs used in Petroleum and coal product manufacturing were imported compared with Manufacturing in total (ABS 2012a).

While the service sector supplied the largest share of domestic intermediate inputs used by other sectors of the economy, Manufacturing provided around 15 per cent of those inputs used by Agriculture, Mining and Services in 2008-09.[[1]](#footnote-1) There was also intra‑industry trade within Manufacturing — over a third of the intermediate inputs used by manufacturers were provided by other manufacturers.

## 2.2 Productivity growth in Manufacturing in aggregate

There are two commonly used measures of productivity — labour productivity (LP) and multifactor productivity (MFP). LP is a measure of the quantity of output produced per unit of labour and MFP is a measure of the quantity of output per unit of combined inputs of capital and labour.

Both productivity measures are useful. MFP growth measures the growth in output over and above that explained by growth in *both* primary factor inputs (capital and labour). LP growth is a partial productivity measure — it measures growth in output over and above that explained by growth in labour, and it is influenced by changes in the ratio of capital to labour inputs. Both measures are presented in this paper, but the focus of the analysis is on explaining MFP growth.

MFP growth estimates are compiled using the ‘growth accounting framework’ — MFP growth is derived as the residual from output growth minus growth of combined capital and labour inputs. Although MFP growth is sometimes interpreted as a measure of technical progress,[[2]](#footnote-2) in practice it measures much more than this. Other influences on annual MFP growth include: economies of scale; changes in management practices and the skill of the labour force; climate, water and other natural resource availability; variations in capacity utilisation; and any errors in the measurement of inputs and outputs. (See appendix A for further details.)

In the ABS official estimates of MFP growth for Manufacturing in Australia (and throughout this paper):

* output is measured as value added (that is, gross output less intermediate inputs such as energy, raw materials and services)
* labour is measured as hours worked
* capital is measured as the flow of services from the productive capital stock.[[3]](#footnote-3)

Both outputs and inputs are measured in quantity or volume terms, that is with the effects of price changes removed.[[4]](#footnote-4) (The measurement of outputs and inputs is discussed further in appendix A.)

Given these definitions, MFP growth is equal to value added growth less a weighted average of capital services growth and hours worked growth.[[5]](#footnote-5) Labour productivity growth (value added per hour worked) is equal to MFP growth plus capital deepening. Capital deepening is an increase in the capital intensity of the production process (measured as growth in the ratio of capital to labour, weighted by capital’s share of total income).[[6]](#footnote-6)

### LP growth

Manufacturing LP has followed a fluctuating, but upward, trend over the period 1985-86 to 2010-11 — with average growth of 1.9 per cent a year compared with 2.3 per cent a year for the market sector (figure 2.4). After a period of growth that was a little faster than the market sector from the late 1990s to 2003-04, growth in Manufacturing LP is now more consistent with the broader sector.

Figure 2.4 LP in Manufacturing and the market sector

Index 2009-10 = 100

|  |
| --- |
|  |

*Data source*: ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

Productivity growth is best examined over cycles since year-to-year changes can reflect temporary influences rather than changes in underlying productive efficiency. The ABS identifies cycles that start and end at productivity peaks that are less likely to be affected by temporary influences (box 2.1) — these cycles are also used to examine LP growth. Cycles for individual industry sectors can vary from that for the market sector as a whole but, as shown in previous research, Manufacturing cycles coincide with the ABS market sector cycles over this period.[[7]](#footnote-7)

There have been four productivity cycles for the market sector over the period 1985-86 to 2010-11 — in addition to incomplete cycles at the beginning and end of the time series. Table 2.3 presents average annual LP growth over the completed productivity cycles, along with the decomposition of LP growth into MFP growth and capital deepening.

|  |
| --- |
| Box 2.1 Examining productivity growth over cycles |
| Year-to-year changes in MFP reflect not only technical progress, but also many temporary influences. Changes in the rate of capacity utilisation can be particularly influential — this is not measured as a change in inputs but instead appears as a change in MFP. If the economy goes into a downturn, MFP growth is likely to be depressed as a result of underutilised inputs that are still fully included in measured inputs. In an upturn, MFP growth can rebound, in part, as a result of previously underutilised inputs being used to generate new output growth.  A common approach when interpreting movements in MFP is to attempt to abstract from these temporary influences through longer-term averaging of measured growth. The ABS identifies periods over which to best examine market sector MFP. These are called ‘MFP growth cycles’ or ‘peak-to-peak periods’. By analysing average annual MFP growth between selected peaks, the ABS aims to minimise the effects of some of the short-term influences that are captured in year-to-year changes in measured productivity (ABS 2008a). In particular, the peaks are assumed to be periods of comparable capacity utilisation and therefore provide the basis for *more* consistent comparisons (although the rate of utilisation still may not be exactly the same). Nonetheless, the rate of growth over a MFP cycle should also be interpreted carefully as it can reflect the influence of other factors, such as unmeasured quality change in inputs and outputs.  Apart from the general business cycle, there can be specific factors that affect capacity utilisation. For example, Agriculture is affected by droughts, Mining by resources booms, and Electricity, gas and water by droughts and by an evolving policy and regulatory environment. Barnes (2011) identified industry-specific cycles as an aid to analysis of technical progress within specific industries over time and found that Manufacturing’s cycles coincided with those of the market sector. But there may still be differences in cycles across different parts of Manufacturing — this is discussed in chapter 3 and appendix C. |
|  |
|  |

Table 2.3 Growth in LP, MFP and capital deepening, Manufacturing**a**

Average annual growth rate (per cent)

|  |  |  |  |
| --- | --- | --- | --- |
|  | LP growth | MFP growth | Capital deepening |
| Cycle 1: 1988-89 to 1993-94 | 1.7 | 0.0 | 1.8 |
| Cycle 2: 1993-94 to 1998-99 | 2.1 | 0.6 | 1.5 |
| Cycle 3: 1998-99 to 2003-04 | 3.3 | 1.3 | 1.9 |
| Cycle 4: 2003-04 to 2007-08 | 0.8 | -1.4 | 2.3 |
| Incomplete cycle: 2007-08 to 2010-11 | 0.9 | -0.8 | 1.7 |
| *Full period: 1985-86 to 2010-11* | *1.9* | *0.3* | *1.7* |

a LP growth is equal to MFP growth plus capital deepening. Components do not add to total due to rounding.

*Source*: ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002).

There has been considerable variation in Manufacturing LP growth over these cycles. The average rate of LP growth increased in successive cycles to reach its highest rate of 3.3 per cent a year in cycle 3 (1998-99 to 2003-04), before declining considerably to 0.8 per cent a year in cycle 4 (2003-04 to 2007-08). There has been a slight increase to 0.9 per cent a year in the incomplete cycle (2007-08 to 2010-11).

Although capital deepening makes a larger contribution than MFP growth to LP growth in each cycle, it is relatively stable across cycles. The variation in the rate of LP growth across the different cycles is mainly being driven by changes in MFP growth.

### MFP growth

Average growth in Manufacturing MFP over the full period from 1985-86 to 2010‑11 was modest at 0.3 per cent a year, compared with 0.9 per cent a year for the market sector[[8]](#footnote-8) (figure 2.5). As mentioned in chapter 1, the declining trend in Manufacturing MFP from 2003-04 to 2010-11 is the longest sustained decline in Manufacturing MFP since 1985-86.

Over most productivity cycles (denoted by the vertical lines in figure 2.5), Manufacturing MFP growth has risen more slowly or declined more steeply than that for the market sector. The exception is cycle 3, in which Manufacturing MFP growth was marginally higher than the market sector rate. In the current incomplete cycle, Manufacturing MFP has fallen marginally less than that for the market sector as a whole although it dipped during the global financial crisis.

For Manufacturing, the largest difference in the average rate of MFP growth was *between* cycle 3 (1998-99 to 2003-04) and cycle 4 (2003-04 to 2007-08). There was a decline of 2.7 percentage points from the average growth of 1.3 per cent a year during cycle 3 to the average growth of ‑1.4 per cent a year during cycle 4. Hence, these two cycles are the main focus of this paper.

Figure 2.5 MFP in Manufacturing and the market sectorby cycle

Index 2009-10 = 100 and average annual growth rate (per cent)

|  |
| --- |
|  |

*Data source*: ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

### Contribution of Manufacturing to market sector MFP growth

The contribution of an industry to market sector MFP growth depends on both the industry’s size and its rate of MFP growth. Manufacturing is both a relatively large industry and one that has experienced a large decline in MFP growth.

Parham (2012) estimated that Manufacturing made the largest contribution to the decline in market sector MFP growth between the last two complete productivity cycles (cycles 3 and 4), contributing 0.5 of the 1.1 percentage points decline (table 2.4).

This was the result of its relatively large contributions to the market sector average in *both* cycles. Manufacturing was the second largest contributor to both the positive MFP growth in the market sector in cycle 3 at 0.26 percentage points (second behind Financial services at 0.37 percentage points), and to the negative MFP growth in the market sector in cycle 4 at -0.26 percentage points (second behind Mining at -0.43 percentage points).

Table 2.4 Contributions to average annual growth in market sector MFP

Percentage points

|  |  |  |  |
| --- | --- | --- | --- |
| Industry sector | Cycle 3:  1998-99 to  2003-04 | Cycle 4:  2003-04 to  2007-08 | Difference in contribution between  cycles 3 and 4 |
| Agriculture, forestry & fishing | 0.19 | -0.06 | -0.25 |
| Mining | -0.01 | -0.43 | -0.42 |
| ***Manufacturing*** | ***0.26*** | ***-0.26*** | ***-0.52*** |
| Electricity, gas, water & waste services | -0.08 | -0.18 | -0.10 |
| Construction | 0.03 | 0.07 | 0.04 |
| Wholesale trade | 0.11 | 0.01 | -0.10 |
| Retail trade | 0.06 | -0.07 | -0.13 |
| Accommodation & food services | 0.00 | 0.00 | 0.00 |
| Transport, postal & warehousing | 0.15 | 0.06 | -0.09 |
| Information, media & telecoms | -0.05 | 0.00 | 0.05 |
| Financial & insurance services | 0.37 | 0.81 | 0.44 |
| Arts & recreation services | 0.01 | -0.05 | -0.06 |
| *Aggregate of contributions*a | *1.0* | *-0.1* | *-1.1* |
| **ABS published market sector** | **1.2** | **0.0** | **-1.2** |

a Sum of the industry contributions. See Parham (2012, appendix A) for details of the contributions methodology and the source of the discrepancy between the aggregate of the contributions and the ABS published market sector estimates.

*Source*: Parham (2012, table 3.6).

## 2.3 Proximate causes of Manufacturing MFP growth

Some initial insight into the influences on MFP growth can be gained from examining its proximate causes — growth in the volumes of value added, hours worked and capital services. (What drives changes in the proximate causes is highly complex and is discussed later in this chapter and in subsequent chapters.) Positive MFP growth is associated with a faster rate of growth (or a slower rate of decline) in value added than in combined inputs, and vice versa for negative MFP growth.

Figure 2.6 shows indexes of MFP and its proximate causes over the full period from 1985-86 to 2010-11. A long-term decline in hours worked contrasts with a rapid long-term increase in capital services. The upwards trend in value added to 2003-04 flattened out in the following years — although there was volatility in the year-to-year growth over the latter period.[[9]](#footnote-9) As already indicated, the resulting trend in MFP was positive up to 2003-04 but negative thereafter.

Figure 2.6 MFP and its proximate causes**a**

Index 2009-10 = 100

|  |
| --- |
|  |

a Value added and capital services are chain volume measures.

*Data source*: ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

On average over the full period, the modest MFP growth (0.3 per cent a year) was associated with value added growth (1.4 per cent a year) slightly above combined input growth (1.1 per cent a year). Within the latter, the contribution of capital services grew at the same rate as value added (1.4 per cent a year) but was partially offset by an absolute decline in hours worked (-0.3 per cent a year).

The differences in the trends of capital services and hours worked can also be seen in their ratio. Manufacturing’s capital-labour ratio (the amount of capital per unit of labour) has generally risen over time (as noted in section 2.2). But the rate of change has increased considerably in recent years (figure 2.7). PC (2003) noted an increase in Manufacturing’s capital intensity from 1988-89 to 2001-02, driven by technological advances in the global production of capital equipment, making some capital items cheaper or, at given prices, increasing the productive capacity of capital. Since 2002-03 there has been a further increase in the rate of growth of Manufacturing’s capital-labour ratio, and it has far exceeded that for the market sector as a whole.[[10]](#footnote-10)

Figure 2.7 Capital-labour ratio in Manufacturing and the market sector

Index 1985-86 = 100

|  |
| --- |
|  |

*Data source*: Authors’ estimates based on ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

The dominant effect in recent years has been the increase in capital inputs, with the level of hours worked maintaining its slow long-term decline. The strong growth in capital is also reflected in the falling average age of the capital stock (figure 2.8).

Figure 2.8 Average age of the capital stock**a** in Manufacturing

Years

|  |
| --- |
|  |

a End of year average age of gross stock.

*Data source*: ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0).

An increase in the capital-labour ratio for Manufacturing in aggregate can result from the substitution of capital for labour in particular manufacturing activities; but it can also occur when there is a shift in the composition of Manufacturing towards more capital-intensive activities. The extent to which the rates of growth in capital and labour inputs have varied across different parts of Manufacturing, and the underlying influences, are examined later in the paper.

### Proximate causes over cycles

The proximate causes of MFP growth can also be examined over productivity cycles — figure 2.9 shows the last four complete productivity cycles and the current incomplete cycle. In this figure, capital growth and labour growth are weighted by their respective shares of factor income.[[11]](#footnote-11)

Figure 2.9 Growth in Manufacturing MFP and its proximate causes by cycle**a**

Average annual growth rate (per cent)

|  |
| --- |
|  |

a Capital services and hours worked weighted by income shares.

*Data source*: Authors’ estimates based on ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

The proximate causes of Manufacturing MFP growth have varied over the cycles — although in each case capital services has grown faster than hours worked.

* Cycle 1 — zero growth in MFP associated with zero growth in value added *and* combined inputs. Positive capital services growth was entirely offset by the fall in hours worked.
* Cycle 2 — positive MFP growth associated with value added growth *greater than* growth in combined inputs. Capital services growth was lower than that of value added and hours worked was unchanged.
* Cycle 3 — positive MFP growth again associated with positive value added growth *greater than* growth in combined inputs. Capital services growth was lower than that of value added and there was offsetting negative growth in hours worked.
* Cycle 4 — negative MFP growth associated with positive value added growth *less than* growth in combined inputs. Capital growth was particularly strong and there was a small increase in hours worked.
* Incomplete cycle — negative MFP growth associated with an absolute decline in value added that was *greater than* the decline in combined inputs. Hours worked contracted at around the same rate as value added but capital services grew.

Comparing the periods of lowest average MFP growth in Manufacturing (0 per cent a year in cycle 1 and -1.4 per cent a year in cycle 4) reveals that the proximate causes were quite different (figure 2.9). In cycle 1, Manufacturing was not growing — there was no growth in output and growth in capital was entirely offset by the contraction in hours worked. By contrast, in cycle 4, Manufacturing was growing, but inputs (mainly capital) were growing at a faster rate than output.

#### Proximate causes of the decline in Manufacturing MFP between cycles 3 and 4

The large decline in Manufacturing MFP growth *between* cycle 3 and cycle 4 was exceptional and was associated with both a decline in value added growth *and* higher input growth (figure 2.10). The decline of 2.7 percentage points in the average annual rate of MFP growth between cycles was associated in nearly equal parts with: a decline in value added growth; an increase in growth in capital (the highest it had been in the last four cycles); and a reversal of negative growth in labour[[12]](#footnote-12) (the last set of columns).

At face value, this increase in the rate of input growth as value added growth slowed is a puzzle. However, there are numerous factors that can influence measured productivity, as discussed in the next section.

Figure 2.10 Growth in Manufacturing MFP and its proximate causes in cycles 3 and 4**a**

Average annual growth rate (per cent)

|  |
| --- |
|  |

a Capital services and hours worked weighted by income shares.

*Data source*: Authors’ estimates based on ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

## 2.4 Influences on productivity

At one level, an industry’s productivity growth performance simply reflects the rate of growth of outputs relative to inputs (the ‘proximate’ causes). But what drives changes in the proximate causes, and ultimately influences productivity, is highly complex.

This section uses data for Manufacturing in aggregate to take an initial look at whether some of the commonly cited influences were likely to be the drivers of the *negative* growth in MFP over cycle 4. However, before doing that it is useful to consider what negative MFP growth means.

### What does negative productivity growth mean?

MFP growth is sometimes interpreted as a measure of technical progress — and in that context a negative rate of MFP growth might be thought to suggest technical regress (which would be unusual). However, as noted earlier in the chapter, many other factors affect the real cost of production and hence the rate of MFP growth, including: economies of scale; changes in management practices and the skill of the labour force; and climate, water and other natural resource availability; and variations in capacity utilisation. In addition, there can be errors in the measurement of outputs and inputs. Given this range of factors, the possibility of negative rates of growth in the MFP measure is easier to understand.[[13]](#footnote-13)

* A fall in capacity utilisation can lead to a decline in output without any commensurate decrease in measured inputs, so MFP growth can be negative.
* Errors (or limitations) in measurement — for example:
* output growth may be understated if there have been improvements in the quality of output that are not well measured, or where the benefits of new product standards that businesses need to meet (which require higher levels of measured inputs) are not reflected in measured output
* capital growth may be overstated where there is a lag between when investment is recorded and when the capital starts producing output (as has been amply demonstrated in Mining in recent years).

Also, aggregate measures of MFP, such as those for an industry sector, can be affected by changes in the composition of that sector. A shift in the relative size of industries within Manufacturing toward those with relatively lower productivity growth could result in negative MFP growth for Manufacturing in aggregate, without any change in the productivity of the individual industries.

It is also worth bearing in mind that some of these factors are likely to be more pronounced during periods of more rapid adjustment. For example, a period of structural change in the economy that involved an increased rate of business creation and destruction could temporarily lower measured productivity — through decreases in average capacity utilisation. Similarly, shifts to new technologies and organisational structures, which are aimed at increasing future productivity, may temporarily disrupt output or lead to an increase in inputs ahead of any increase in output. However, structural change is a response to long-term changes in relative prices. The resulting improvement in allocative efficiency, or how well resources are allocated to production that meets the preferences of the population, is an important source of economic welfare.

### Possible influences on the recent decline in Manufacturing productivity

Some influences are commonly cited as important for Manufacturing productivity. But it is not clear from the *aggregate* data whether these influences played a major role in the recent negative growth in Manufacturing MFP.

#### Technical progress and innovation

Research and development (R&D) is an underlying driver of productivity growth as it is an input into innovation, which leads to new products and more efficient production processes. Hence, declines in the amount of R&D undertaken are often raised as a possible source of productivity slowdown.

This explanation for the decline in Manufacturing MFP over cycle 4 is doubtful as there was no significant fall in R&D expenditure in the period preceding cycle 4 (figure 2.11, left panel). Manufacturing R&D investment (in real terms) increased over both cycles 3 and 4, and the average level of the R&D capital stock was higher in cycle 4 than in cycle 3.

Figure 2.11 Manufacturing R&D**a** and MFP

|  |  |
| --- | --- |
|  |  |

a R&D investment measure is R&D gross fixed capital formation (chain volume measure). R&D capital stock measure is R&D net capital stock (chain volume measure). R&D intensity is R&D gross fixed capital formation as a percentage of value added (current prices).

*Data sources*: ABS (*Australian System of National Accounts, 2010-11,* Cat. no. 5204.0); ABS(*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

Manufacturing’s ‘R&D intensity’ (R&D investment as a share of value added) was also higher in cycle 4 than cycle 3 — 2.9 per cent on average compared with 1.8 per cent (figure 2.11, right panel). Moreover, R&D intensity increased at a faster rate in cycle 4 (13.0 per cent a year) than in cycle 3 (8.4 per cent a year), due to stronger growth in R&D investment *and* slower growth in value added.[[14]](#footnote-14)

Given that the rate of growth of R&D investment and R&D intensity has been strong over both cycles, this would tend to diminish the argument that a decline in recent R&D activity by Manufacturing is a major driver of the steep decline in MFP during cycle 4. However, this does not rule out insufficient R&D in previous cycles, or in some parts of Manufacturing, as being potentially associated with a decline in MFP.

Also, domestic R&D expenditure is one of many sources of technological innovation for Australian businesses. Much of the technological innovation occurs outside Australia and is imported either directly as knowledge or embedded in equipment.

#### Capacity utilisation

The rate at which Manufacturing capacity is utilised for production can fluctuate in response to changes in the business operating environment. These changes may be economy- or industry-wide (such as those related to their business cycles) or more specific to particular activities (such as the availability of raw materials for a manufactured product). One possible explanation for a decline in *measured* productivity is a decrease in the average rate of capacity utilisation over the cycle.

While there are no official ABS measures of capacity utilisation, two industry associations collect capacity utilisation data in their Manufacturing surveys (figure 2.12). The Australian Industry Group (Ai Group) measure (top panel) is the average capacity utilisation rate of surveyed manufacturers. There is an increasing overall trend in average capacity utilisation over that part of cycle 3 for which data are available and a slightly decreasing trend over cycle 4. But, in both cycles, the change in average capacity utilisation is small.

The Australian Chamber of Commerce and Industry and Westpac (ACCI-Westpac) measure identifies the share of firms surveyed whose capacity utilisation is above normal, at normal or below normal. Figure 2.12 (bottom panel) shows the share of firms at normal capacity (solid line) and the net balance of firms above and below normal (dashed line). Where the net balance is negative the percentage of firms operating below normal is more than that above normal.

Figure 2.12 Manufacturing capacity utilisation measures

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| *Ai Group: Rate of utilisation*a | |
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| *ACCI-Westpac: Capacity utilisation categories*b | |
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a Ai Group capacity utilisation measure is the survey average of percentage utilisation rates reported by firms. b ACCI-Westpac capacity utilisation measure is based on the percentages of firms surveyed that report working in each of the following categories — above ‘normal’ capacity, ‘normal’ capacity, and below ‘normal’ capacity. The net balance of the firms working above their ‘normal’ capacity and below their ‘normal’ capacity is the percentage of firms working above capacity less the percentage of firms working below capacity.

*Data sources*: Authors’ estimates based on Ai Group Performance of Manufacturing Index (database); and ACCI-Westpac Survey of Industrial Trends (database).

The share of firms at normal capacity has increased fairly steadily in both cycles. Over cycle 3, this trend of increase in ‘normal’ utilisation was reinforced by an upward trend in the net balance. During most of cycle 4, the shares of firms above and below normal utilisation were broadly offsetting, so that the net balance was fairly stable. In the incomplete cycle, the net balance fell to the level of the late 1990s.

Overall, the evidence from these measures of capacity utilisation is mixed. Both measures suggest there may have been some increase in capacity utilisation during the period of relatively strong MFP growth in Manufacturing (cycle 3). However, during the period in which Manufacturing MFP declined in absolute terms (cycle 4), only the Ai Group measure shows a decline in capacity utilisation and it is small. But neither the Ai Group nor the ACCI-Westpac measure is weighted for the size of the firm or, in the case of the ACCI-Westpac measure, the extent to which the firm is above or below ‘normal’ capacity. Therefore, the average rate of utilisation may have changed more or less than is apparent from these measures. Some parts of Manufacturing may be more affected by changes in utilisation than others. Unfortunately, more disaggregated utilisation data are not available from these surveys.

The drivers of the change in capacity utilisation are likely to vary across parts of Manufacturing — some subsector-specific factors are discussed in the following chapters. But the appreciation of the Australian dollar is one factor that may have affected capacity utilisation in many parts of Manufacturing.

##### Exchange rate and trade exposure

The adverse effects of the appreciation of the Australian dollar on Australian Manufacturing are commonly raised (for example, Prime Minister’s Taskforce on Manufacturing 2012). An appreciation of the dollar can affect Manufacturing in several ways. For example, a higher dollar (all else being equal) makes imports of manufactured goods cheaper than domestically-produced goods, and makes exports less competitive. This, in turn, reduces demand and output in the domestic industry, which may also reduce capacity utilisation and MFP. Change in the composition of output of the Australian economy is an essential part of the process of structural change. As the supply of factors of production is not unlimited, expansion in one industry or sector can only occur if some other contracts in relative or absolute terms.[[15]](#footnote-15)

However, drawing a link between changes in trade volumes, the exchange rate and productivity is not simple. Apart from the value of the Australian dollar, imports and exports will also be influenced by other factors that affect the competitiveness of domestically produced goods, including changes in domestic input costs.

Apart from increased price competitiveness, imports may increase to supply domestic demand where domestic production is constrained because of reduced availability of agricultural inputs during drought or where current domestic capacity is insufficient to meet a steep rise in demand. Of course, some goods are not produced in Australia, in which case imports will not directly compete with domestic production. A higher dollar may also benefit domestic manufacturers through cheaper imported intermediate inputs and capital goods, in addition to the benefits to consumers of cheaper imported consumption goods.

The effects of an increase in competing imports on MFP can be quite complex and may differ across industries within Manufacturing. While ultimately productivity might be expected to rise in response to an increase in competitive pressure, in the short term, as firms adjust, measured productivity may be reduced (box 2.2).

Recent changes in trade volumes for manufactures in aggregate and in the trade-weighted index (TWI) of exchange rates are shown in figure 2.13. The TWI increased over both cycles 3 and 4 — but at a higher rate of 3.2 per cent a year over cycle 4 (the period of MFP decline) compared with 2.4 per cent a year over cycle 3 (the period of higher MFP growth). Import volume growth was also significantly higher in cycle 4. Export volumes grew marginally in each cycle at just under 2 per cent a year on average. For Manufacturing as a whole, therefore, the change in the exchange rate between the two cycles appears to have had a larger effect on imports than exports.[[16]](#footnote-16)

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| Box 2.2 Gains to trade and productivity |
| Foreign trade helps support higher living standards by ensuring that an economy plays to its comparative strengths, exporting what it is comparatively good at producing and importing goods and services that are either not produced locally or where other countries have the comparative advantage. (For a detailed discussion of the effects of trade on income and welfare in the domestic economy, see, for example, PC 2000.)  Trade volumes can change over time for a variety of reasons, including exchange rate movements. In this study, changes in trade are examined solely from the perspective of their effect on measured productivity. This can be quite complex.  In most years since 1988-89, the volume of imports of manufactured goods has grown (figure 2.13) and, stimulated by an appreciating Australian dollar, that growth accelerated in cycle 4. The share of imported products in domestic consumption was also higher in this cycle, compared with previous periods (figure 2.14).  What is the likely impact of increased imports on the long-run productivity of domestic manufacturing?   * Imports of products similar to those produced by domestic firms will expose those firms to additional pressures of competition. Market competition encourages cost reductions and product and process improvements, including potentially through higher rates of innovation and diffusion (PC 2009). This suggests that competing imports are likely to have positive impact on the productivity of domestic firms. * To the extent that imports intensify competition in the domestic market, some domestic businesses may not be able to compete and may exit the industry. Less productive firms are more likely to leave the industry and, if this is the case, the average productivity of the industry increases.   However, there may be an adjustment period during which the effects on measured productivity may be different from those outlined above. The short-term impact is likely to be complex and vary from firm to firm. But the effect for productivity can be negative in the short term, in some circumstances. For example:   * When a firm closes, the decline in output will be measured immediately but some of its capital may continue to remain ‘on the books’ in the statistics as an input even though it is not being utilised — thus depressing measured productivity. * When a firm alters its production process to improve its efficiency and competitiveness, this adjustment process may require additional inputs and/or disruptions to production ahead of any improvements — thus initially depressing measured productivity. |
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Figure 2.13 Manufacturing trade volumes**a** and the exchange rate**b**

2009-10 $m (LHS); Index 2009-10 = 100 (RHS)

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a Chain volume measures. b TWI (trade weighted index) is the multilateral exchange rate $A against trade-weighted average of trading partner currencies.

*Data sources*: Authors’ estimates based on ABS (*International Trade in Goods and Services, Australia*, various issues, Cat. no. 5368.0); and ABS (*International Trade Price Indexes,* various issues, Cat. no. 6457.0).

‘Import penetration’ and ‘export propensity’ measures provide another perspective on exchange rate effects. Import penetration measures the value of imported manufactures as a share of domestic consumption of manufactured goods. Export propensity measures the value of Australia’s manufactured exports as a share of total production. Import penetration in Manufacturing rose steadily until just after the beginning of cycle 3, declined over cycle 3 and then rose again over cycle 4 (figure 2.14). Export propensity has a similar pattern, although its decline over cycle 3 was more pronounced and it began to taper off in the incomplete cycle.

Comparing these patterns of trade exposure with MFP gives a mixed picture for Manufacturing in aggregate. There does not appear to be a consistent correlation between rising import penetration and falling MFP (this did occur over cycle 4 but not prior to cycle 3). Nor is there a clear correlation between falling export propensity and falling MFP. However, it is likely that the aggregate measures conceal differences across industries within Manufacturing — this is examined in later chapters.

Figure 2.14 Import penetration**a**, export propensity and MFP in Manufacturing

Shares (LHS); Index 2009-10 = 100 (RHS)

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a Domestic consumption is derived as the sales of manufactured goods less the value of exports plus consumption of imports.

*Data sources*: PC (2003); authors’ estimates based on ABS (*International Trade in Goods and Services,* Australia, various issues, Cat. no. 5368.0); ABS (*International Trade Price Indexes,* various issues, Cat. no. 6457.0); and ABS (*Australian Industry*, various issues, Cat. no. 8155.0).

#### Change in the composition of Manufacturing

Negative productivity growth may also occur if there is compositional change within Manufacturing towards activities with relatively low measured productivity. One reason for a production shift to lower-productivity activities can be that, in the short term, these activities have become more profitable. For example, Topp et al. (2008) found this to be the case within Mining, with lower grade deposits being mined (with greater input use per unit of output) in response to increases in the prices of some commodities. In other cases, profitable activities may appear to have lower productivity because output is understated as a result of difficulties in measuring improvements in the quality of the output.

The data for Manufacturing as awhole, however, suggest that the decline in MFP growth in cycle 4 (and subsequently) coincided with a decline, rather than an increase in profitability (figure 2.15).

The importance of particular influences on productivity (including compositional change) may be masked in the aggregate level data by offsetting changes in different parts of Manufacturing. The remainder of this paper examines Manufacturing at a more disaggregated level. Chapter 3 presents new estimates of MFP for subsectors within Manufacturing. The effects of particular influences on the productivity of some of these individual subsectors are then examined in the later chapters.

Figure 2.15 Manufacturing MFP and profitability**a**

Index 1989-90 = 100

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a Profitability can be measured in different ways. In this figure the ‘profitability’ measure is the ratio of gross operating surplus (GOS) to net capital stock (both at current prices). GOS is gross operating surplus of the corporate sector plus gross mixed income from ABS National Accounts, adjusted to exclude the labour share of gross mixed income. Gross operating surplus of the corporate sector is the excess of gross output over the sum of intermediate consumption, compensation of employees, and taxes less subsidies on production and imports. It is calculated before deduction of consumption of fixed capital, dividends, interest, royalties and land rent, and direct taxes payable, but after deducting the inventory valuation adjustment.

*Data sources*: ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002); authors’ estimates based on ABS (*Australian System of National Accounts, 2010-11,* Cat. no. 5204.0).

1. These proportions are calculated from table 2.2 by dividing the intermediate inputs supplied from Manufacturing to the different sectors by the total intermediate inputs used by each sector (that is, dividing the ‘Manufacturing’ row by the ‘Total domestic intermediate inputs’ row). [↑](#footnote-ref-1)
2. In this case disembodied technical change. Technical change can also be embodied in capital equipment. See Dowrick (2004) for a discussion. [↑](#footnote-ref-2)
3. R&D and computer software, which are intangible assets, are included in the measure of capital. For a discussion of Manufacturing investment in other intangible assets and productivity, see Barnes (2010). [↑](#footnote-ref-3)
4. In this paper, value added, labour, and capital refer to volume (real) measures unless otherwise specified. [↑](#footnote-ref-4)
5. The terms multifactor productivity (MFP) and total factor productivity (TFP) are often used interchangeably. Some authors, however, distinguish between the terms by referring to TFP growth as the growth in *gross output* not explained by the combined input growth of *intermediate inputs*, labour and capital; and referring to MFP growth as the growth in *value added* not explained by the combined input growth of labour and capital. The two measures are closely related as value added is defined as gross inputs less intermediate inputs but growth rates may differ. This paper uses MFP in order to be consistent with the main productivity measures reported by the ABS, and because sufficient data are not readily available to estimate TFP for subsectors within Manufacturing. [↑](#footnote-ref-5)
6. Capital deepening is positive when capital services grow faster (or contract more slowly) than hours worked. Negative rates of capital deepening (also called capital shallowing) occur when hours worked grow faster (or contract more slowly) than capital services. [↑](#footnote-ref-6)
7. Barnes (2011) examined the period 1985-86 to 2008-09. Applying the same methodology to revised ABS MFP estimates for Manufacturing from 1985-86 to 2010-11 confirms this result. [↑](#footnote-ref-7)
8. The ABS MFP time series used in this paper is from the 2010-11 issue of ABS *Experimental Estimates of Industry Multifactor Productivity* (Cat. no. 5260.0.55.002), which covers 1985-86 to 2010-11. 1985-86 is the earliest year for which official ABS MFP estimates are available for Manufacturing as defined in the current ABS industry classification, ANZSIC06. [↑](#footnote-ref-8)
9. Including higher growth in 2007-08 followed by contraction in 2008-09 (a year affected by the global financial crisis). [↑](#footnote-ref-9)
10. This is consistent with technical change embodied within capital, in addition to disembodied technical change (which is captured within MFP growth). Complementarities between capital and labour may also lead to additional spillovers that are captured in MFP growth. [↑](#footnote-ref-10)
11. As noted above, MFP growth is derived as the difference between growth in value added and growth in combined inputs (hours worked and capital services). Growth in combined inputs is equal to the sum of the growth rates of the two inputs weighted by their average shares of total factor income (effectively a weighted average of the growth rates of the two inputs). The income share weights are the average of all years in the cycle. Growth in value added less growth in hours worked and capital services do not add exactly to MFP growth due to approximation errors. [↑](#footnote-ref-11)
12. In this paper, hours worked is not adjusted for any change in the quality of labour (which as a consequence is captured in the measure of MFP growth). However, recent ABS estimates of change in the quality of labour in Manufacturing show that the difference in the rate of change in the quality of labour between cycles 3 and 4 was not a significant factor in the decline in MFP growth over this period. See ABS (2012b) for details. [↑](#footnote-ref-12)
13. See PC (2013a) for a discussion of a framework for examining the influences underlying positive productivity growth. [↑](#footnote-ref-13)
14. Manufacturing R&D measures in this chapter are based on R&D expenditure by Manufacturing businesses. Other R&D activity, such as that carried out by the government and education sectors, may lead to technological ‘spillovers’, which could also affect Manufacturing productivity. However, there has not been a major change in the level of non-business R&D relative to value added for the total economy over the last two complete productivity cycles (ABS 2011). Information on the proportion of non-business R&D that may be relevant to Manufacturing is not readily available. [↑](#footnote-ref-14)
15. See PC (2013b) for a discussion of structural change over the last decade in the Australian economy and the effects of the mining boom. [↑](#footnote-ref-15)
16. For manufactures in total, it is not possible to distinguish imports for industry use from imports for final consumption (data are only available for some selected goods, including food and beverage products). [↑](#footnote-ref-16)