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Productivity in Manufacturing: Measurement and Interpretation

Productivity Commission
Staff Working Paper

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The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Productivity Commission, or of the external organisations or people who provided assistance.

Abbreviations and explanations

AAC	Australian Aluminium Council
ABARE	Australian Bureau of Agricultural and Resource Economics
ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ACCI	Australian Chamber for Commerce and Industry
AFFA	Agriculture, Fisheries and Forestry Australia
Ai Group	Australian Industry Group
AIHW	Australian Institute of Health and Welfare
AIP	Australian Institute of Petroleum
ANZSIC06	Australian and New Zealand Standard Industrial Classification, 2006 edition
ANZSIC93	Australian and New Zealand Standard Industrial Classification, 1993 edition
ASIC	Australian Standard Industrial Classification
ATO	Australian Taxation Office
BERD	business expenditure on research and development
BREE	Bureau of Resource and Energy Economics
BT	Beverage and tobacco manufacturing
CVM	chain volume measure
DAFF	Department of Agriculture, Fisheries and Forestry
EAS	Economic Activity Survey
FBT	Food, beverage and tobacco products
GFC	global financial crisis
GFCF	gross fixed capital formation
GOS	gross operating surplus
GVA	gross value added
HoRSCE	House of Representatives Standing Committee on Economics
IO	input-output
IOIG	Input-Output Industry Groups
LFS	Labour Force Survey
LHS	left-hand side

LP	labour productivity
ME	Machinery and equipment manufacturing
MFP	multifactor productivity
MP	Metal products
M&E	machinery and equipment (asset type)
NDC	non-dwelling construction
NM	Non-metallic mineral products
NZTE	New Zealand Trade and Enterprise
OECD	Organisation for Economic Co-operation and Development
PC	Productivity Commission
PCCR	Petroleum, coal, chemical and rubber products
PIM	perpetual inventory method
PKS	productive capital stock
PNCE	private new capital expenditure
PPI	producer price index
PRM	Printing and recorded media
R&D	research and development
RHS	right-hand side
SITC	Standard International Trade Classification
TCO	Textile, clothing and footwear
TWI	trade weighted index
UN	United Nations
VA	value added
WP	Wood and paper products

Explanations

Billion	The convention used for a billion is a thousand million (10^9).

OVERVIEW

Key points

- Multifactor productivity (MFP) growth in Manufacturing was negative over the most recent complete productivity cycle (2003-04 to 2007-08), in contrast to the positive growth in the previous cycle. This large decline was atypical for Manufacturing, and since then MFP has continued to decline (although more slowly).
  - Manufacturing's MFP decline was a major contributor to flat market sector MFP.
- There is no overarching systemic reason for the large decline. Rather, various subsector-specific factors, such as lags between investment and output; unmeasured increases in quality; and lower capacity utilisation all contributed. Some factors reflect temporary responses to changing competitive conditions.
  - Faster rates of input growth (capital and hours worked) and slower output (value added) growth were the 'proximate causes' of this Manufacturing MFP decline.
  - Petroleum, coal, chemical and rubber products (PCCR), Food, beverage and tobacco products (FBT), and Metal products (MP) collectively accounted for two-thirds of the decline between cycles. Influences on each subsector were diverse.
- PCCR output declined in absolute terms over the most recent cycle (after growing over the previous cycle), and yet there was a large increase in capital investment.
  - Petroleum refineries invested to meet new environmental standards, but the improved fuel quality is not fully reflected in the output measure, and thus in MFP. Value added per unit of output also declined, as greater volumes of feedstock and refined fuel were imported in response to reduced output from domestic oilfields.
  - For plastic products, increased production by overseas firms with lower input costs and the appreciation of the Australian dollar led to strong import competition. Domestic production declined, leading to underutilised capacity. Higher demand for fertilisers and explosives led to very large investments to expand chemical production, but there was a lag before output increased.
- Food and beverages output growth slowed, yet hours worked increased significantly.
  - Slower output growth was associated with a decline in exports and a loss of domestic market share for some products — reflecting input cost pressures, appreciation of the Australian dollar, and, in cases such as wine, drought.
  - Consumer preferences also drove changes in the composition of output that increased the input intensity of production — for example, there was growth in smaller scale, more labour intensive, non-factory bakeries.
  - But the decline in MFP in FBT may have been overstated due to challenges in measuring improved output quality and reductions in the capital stock.
- Metal products was different, with faster output growth and even faster input growth.
  - Fabricated metals output grew strongly to meet increased demand from the Construction and Mining sectors.
  - Metal products was responsible for most of the capital growth in Manufacturing, largely to expand alumina refining capacity. However, the inevitable lag between investment and ensuing output led to lower measured productivity.
- The MFP decline in Manufacturing has slowed in the current incomplete cycle. MFP growth in PCCR and FBT remains negative and it is marginally positive in MP.

Overview

During the 1980s and 1990s, Manufacturing in Australia exhibited a rising trend for both real value added and multifactor productivity (MFP). In particular, real value added grew strongly over the 1990s. And although it has plateaued since, real value added is still larger now than it was at the turn of the century. Over the long term, hours worked (and therefore, broadly, jobs) have declined but Manufacturing investment has risen. Real investment rose strongly over the 2000s, before slowing since the global financial crisis.

Despite Manufacturing's value added growth performance, MFP has been declining since 2003-04. This has been one of the main contributors to the recent flat to declining productivity of the whole market sector of the Australian economy.

Manufacturing includes a wide range of activities, and thus an examination of its subsectors is key to understanding the drivers of its productivity decline. There have been changes in each of the subsectors over time, and thus this study examines the last four productivity cycles, starting from 1988-89. In particular, it focuses on changes over the last two complete cycles — 'cycle 3' (1998-99 to 2003-04) and 'cycle 4' (2003-04 to 2007-08). This study finds that almost two-thirds of the decline in Manufacturing's MFP growth, from its average rate in cycle 3 to its average rate in cycle 4, is accounted for by three of the eight subsectors: Petroleum and chemicals; Food and beverages; and Metal products.[1]

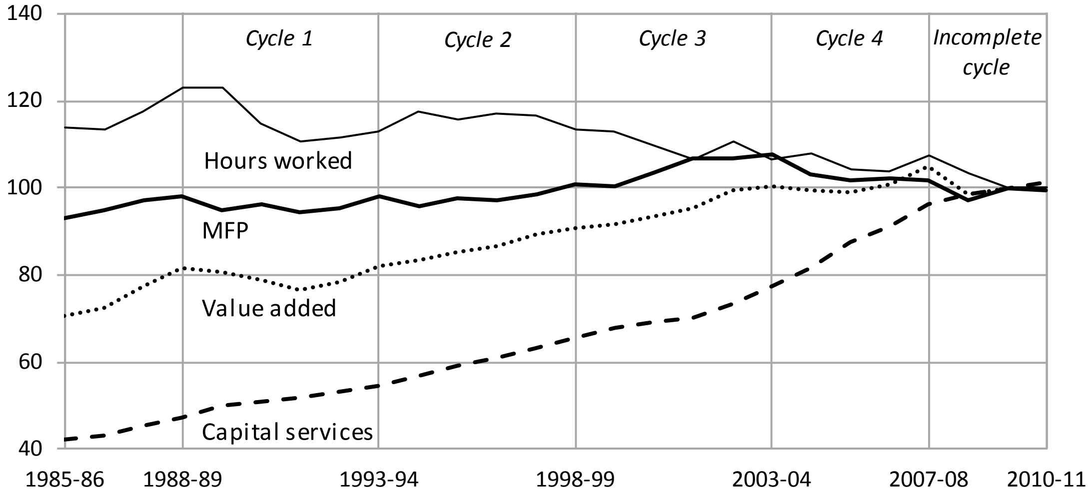
The influences on the productivity of manufacturers are diverse and vary over time. There is no single factor that explains the decline in Manufacturing MFP. In the subsectors examined in detail some of the varying factors were: the lead time between investment in new capital and associated output; unmeasured increases in output quality, in some cases in response to regulation; lower rates of capacity utilisation; and change in the composition of output demanded by consumers into products with higher labour-intensity and lower levels of measured productivity. Some of these factors are temporary in nature and the result of adjustment to changing competitive conditions and no simple policy inference can be drawn.

[1] 'Petroleum and chemicals' refers to Petroleum, coal, chemicals and rubber product manufacturing and 'Food and beverages' to Food, beverage and tobacco product manufacturing.

The long-term performance of Manufacturing in Australia

There was a shift in Manufacturing MFP and its proximate causes in the most recent complete productivity cycle (cycle 4), compared with trends going back to 1985-86 (figure 1).[2]

Figure 1 **Manufacturing MFP and its proximate causes[a] over the longer term**
Index 2009-10 = 100



[a] Value added is gross output less intermediate inputs used in producing that output. Intermediate inputs are the inputs used by the business other than capital and labour — for example, energy, raw materials and services, as well as semi-finished goods for assembly and transformation. The volume of value added refers to value added with the effect of price changes removed.

Manufacturing's trend of positive MFP growth turned negative in cycle 4.

- The long-term upward trend in value added became relatively flat during cycle 4 (and the current incomplete cycle[3]).
- The ongoing growth in capital inputs accelerated over cycle 4, before slowing more recently.
- Hours worked stabilised over cycle 4, after a downward trend, but the decline resumed more recently.

2 MFP growth is derived as the difference, in volume terms, between growth in value added and growth in combined factor inputs (hours worked and capital services). These components of MFP growth are known as its proximate causes.

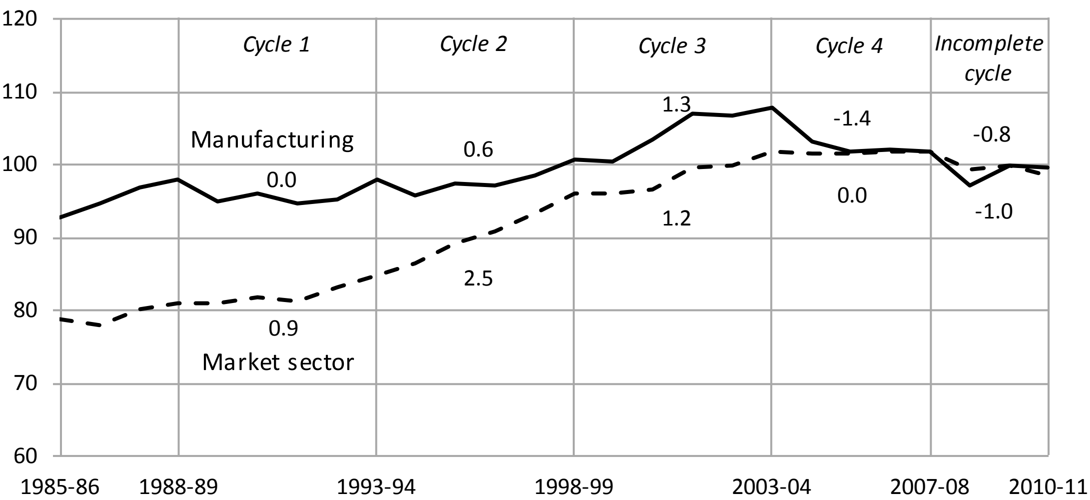
3 There was variability in year-to-year growth over the incomplete cycle, including higher growth in 2007-08, followed by contraction in 2008-09 (a year affected by the global financial crisis).

Decline in Manufacturing MFP since 2003-04

ABS estimates show a decline in Manufacturing MFP from 2003-04, and at a faster rate than for the market sector as a whole. While there was positive growth of 1.3 per cent a year over cycle 3 (1998-99 to 2003-04), Manufacturing MFP declined in absolute terms by 1.4 per cent a year over cycle 4 (2003-04 to 2007-08) (figure 2). This absolute decline has continued in the incomplete cycle (2007-08 to 2010-11), although at a slower rate of 0.8 per cent a year.[4]

Figure 2 **MFP in Manufacturing and market sector[a], by cycle**

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



[a] The term 'market sector' refers to 12 industry sectors under the ABS industrial classification (table 2.1).

Manufacturing is a significant part of the market sector (averaging 18 per cent of market sector value added over cycle 4). Accordingly, the turnaround in Manufacturing's MFP growth rate by 2.7 percentage points between cycles 3 and 4 (figure 2) had a considerable influence on the slowdown of MFP growth for the market sector overall.

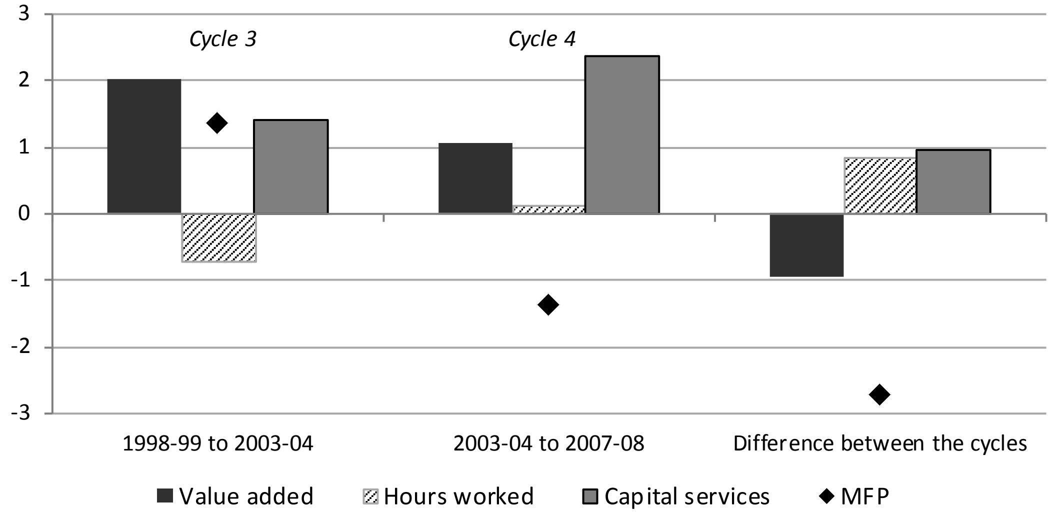
4 As this cycle is incomplete, this growth rate should be interpreted with caution because it may be the product of temporary factors. It should be noted that this paper examines Manufacturing MFP up to 2010-11, based on the 2010-11 ABS National Accounts (the latest available when the MFP estimates for the Manufacturing subsectors were derived for this study).

The fall in MFP was associated with slowing value added growth and rising input growth

The decline of 2.7 percentage points in the average annual rate of MFP growth between cycles 3 and 4 was associated with nearly equal parts of: a decline in value added growth; an increase in growth in capital services; and a reversal in the decline of hours worked (figure 3).

Figure 3 **Proximate causes of Manufacturing MFP growth[a] in cycles 3 and 4**

Average annual growth rate (per cent)



[a] Capital services and hours worked weighted by income shares. This means the sum of these growth rates is equal to the growth in combined inputs (effectively a weighted average of the growth rates in the two inputs).

What is meant by 'negative' MFP growth?

Just as MFP growth cannot be automatically interpreted as technical progress (measured as a residual it captures much more than this), negative MFP growth cannot be interpreted as technical regress. MFP growth can be negative for a range of reasons. These include changes in the composition of activities within a sector or industry, differences in the timing of input and output responses to particular changes in the economy, and measurement challenges that can lead to the understatement of outputs (where, for example, quality improvements are not measured as an increase in outputs, but require greater levels of inputs), or even the overstatement of inputs.

Some of these factors are likely to be more pronounced during periods of structural change in the economy. For example, an increased rate of business creation and destruction can temporarily lower measured productivity — through decreases in 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.

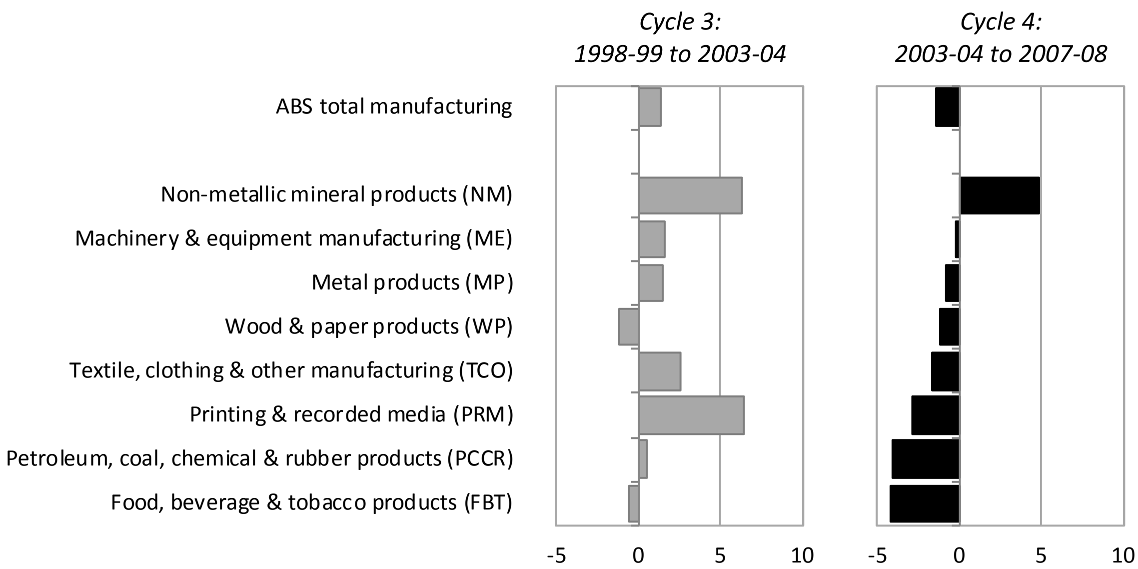
There are many forces driving structural change in Manufacturing — such as changing consumer preferences, domestic costs, international prices and the exchange rate — which have different implications for measured productivity, particularly in the adjustment phase.

Given the diverse range of activities within Manufacturing, this study estimates MFP for the subsectors within Manufacturing — a level of disaggregation for which ABS MFP estimates are not available. (The details of how these subsector estimates were derived, and steps taken to make them as consistent as possible with the ABS estimates for Manufacturing as a whole, are explained in a technical appendix.)

MFP growth varies across Manufacturing subsectors

Most subsectors of Manufacturing had positive MFP growth over cycle 3, and negative MFP growth over cycle 4, but there was considerable variation across the eight subsectors (figure 4).

Figure 4 **Subsector MFP growth in cycles 3 and 4[a]**
Average annual growth rate (per cent)



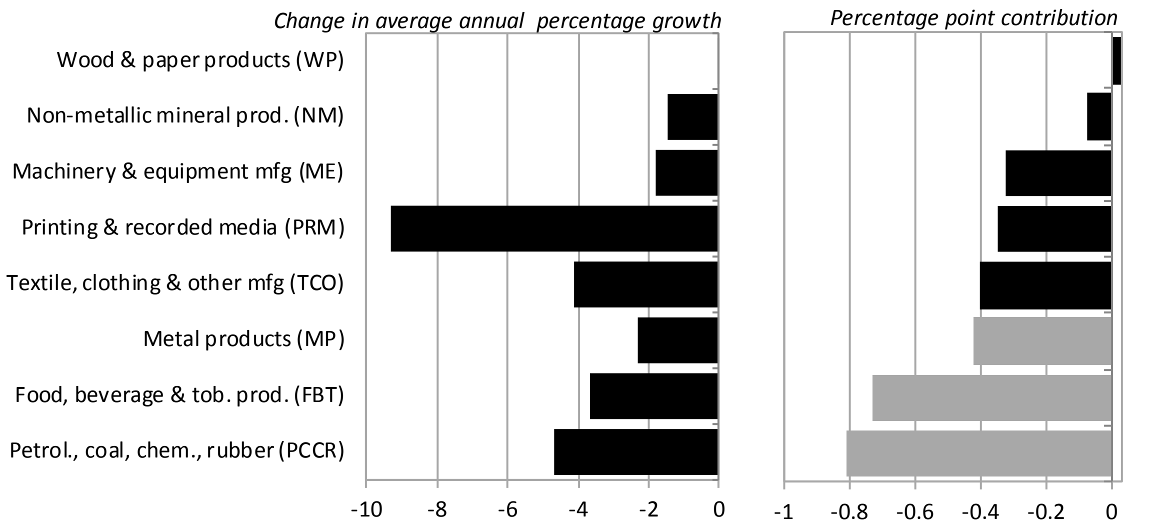
[a] Subsector estimates are of lesser quality than the ABS estimates for Manufacturing as a whole (due to data and methodological limitations) and will not necessarily aggregate to those ABS estimates. Therefore, the subsector estimates should be regarded as indicators of differences within the Manufacturing sector, rather than precise estimates. Some subsector estimates (such as Printing and recorded media, and Textiles, clothing and other manufacturing) are less well estimated because of changes in industry classification.

When the relative sizes of the subsectors are taken into account, three subsectors made the largest contributions to the total decline in Manufacturing MFP growth between cycles 3 and 4:

- Petroleum and chemicals
- Food and beverages
- Metal products.

These subsectors made a combined contribution of around two-thirds of the total decline (right panel, figure 5).

Figure 5 **Change in subsector MFP growth between cycles 3 and 4 and contributions to Manufacturing MFP growth in total[a]**



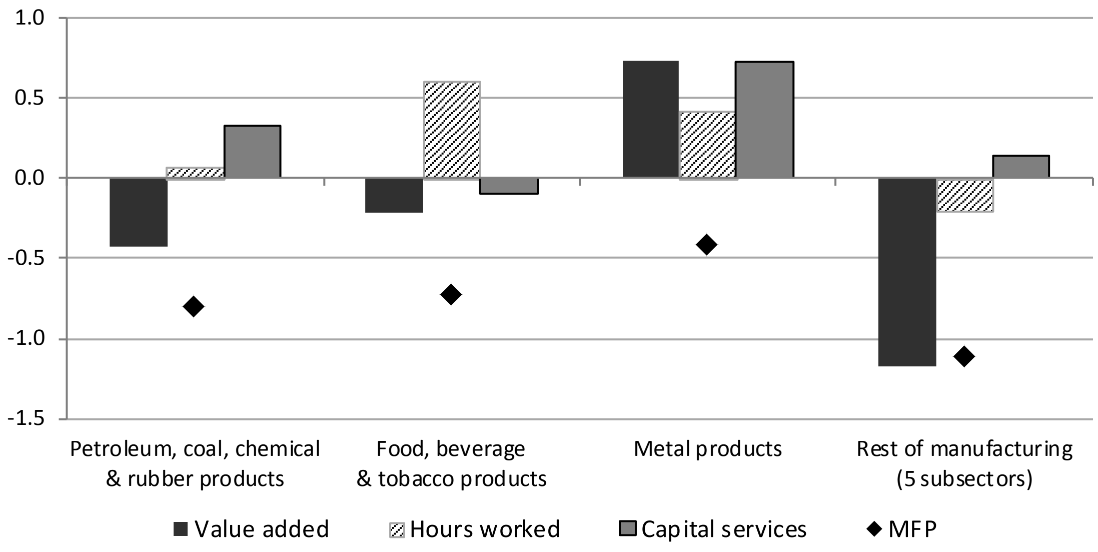
[a] FBT, MP, PCCR, and ME are of similar size (around 17-22 per cent each of Manufacturing value added on average in cycle 4). The other four subsectors are much smaller (around 4-8 per cent). Due to approximation errors and data limitations, there is a discrepancy between the sum of the subsector MFP contributions (-3.1 per cent a year) and the ABS aggregate Manufacturing estimate (-2.7 per cent a year). The combined contribution of PCCR, FBT and MP is based on the sum of the subsector contributions. The MFP decline for PRM is large, but this subsector is relatively small in size and is less well estimated than other subsectors due to major changes in industry classification over time.

Proximate causes of the decline in MFP growth also differ across subsectors

Most subsectors — with the exception of Metal products and Non-metallic mineral products — contributed to the decline in aggregate Manufacturing MFP growth between cycles 3 and 4 through declines in value added growth. On the input side, the three subsectors of Petroleum and chemicals, Food and beverages and Metal products made the largest contributions to the increases in labour and capital (figure 6).

- There was a large increase in value added in Metal products (0.7 of a percentage point). But this was more than offset by the declines in Petroleum and chemicals and Food and beverages (which contributed 0.4 and 0.2 of a percentage point to the decline in value added growth) and the rest of Manufacturing (which contributed a further 1.2 percentage points to the decline).
- Labour input growth was dominated by the large positive contributions from Food and beverages and Metal products. The rest of Manufacturing overall made a partially offsetting negative contribution (with a large negative contribution from Wood and paper products in particular).
- Metal products, followed by Petroleum and chemicals, made by far the largest contributions to the capital input surge between cycles 3 and 4. Food and beverages made a small negative contribution, broadly offsetting the small positive contribution from the rest of Manufacturing.

Figure 6 **Main subsectors contributing to change in total Manufacturing MFP growth and its proximate causes between cycles 3 and 4**
Percentage point change



Influences on MFP varied across Petroleum and chemicals, Food and beverages, and Metal products

A closer examination of the influences on these subsectors is needed to explain changes in the proximate causes of the decline in MFP growth.

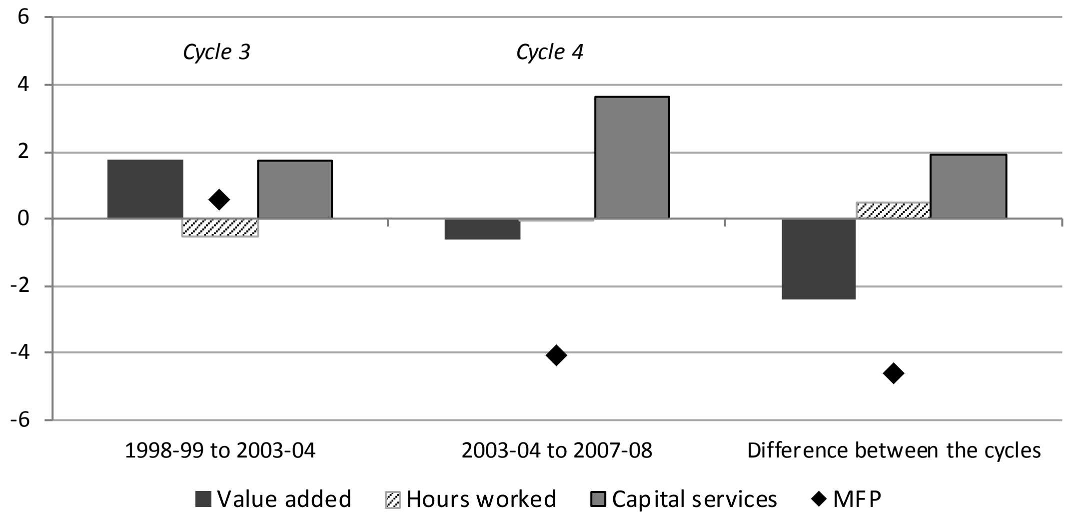
Petroleum and chemicals subsector was the largest contributor to the decline in Manufacturing MFP

A wide range of different activities fall within this subsector, including petroleum refining, pharmaceutical manufacturing, fertiliser production and manufacturing of plastics, amongst others. Formally, it is divided into three subdivisions — Petroleum refining, Chemical manufacturing and Polymer manufacturing.

The subsector had a low but positive rate of MFP growth over cycle 3 (0.6 per cent a year on average) — associated with value added growth in excess of combined input growth (figure 7). There was a reversal to strong negative MFP growth over cycle 4 (-4.1 per cent a year) — driven principally by a decline in value added growth and very strong growth in capital services.

Figure 7 **Petroleum and chemicals: proximate causes of MFP growth in cycles 3 and 4**

Average annual growth rate (per cent)



Value added decline driven by changes in petroleum refining and plastics

Most of the decline in value added growth from cycle 3 to cycle 4 occurred in the Petroleum refining and Polymer products subdivisions.

Value added of the domestic Petroleum refining industry fell for several reasons — even though the overall volume of domestic refined output remained relatively stable and domestic consumption grew.

- The greatest value added per unit of refined output comes from refining domestically-sourced crude oil. But the supply of crude oil available from domestic oilfields has been declining, necessitating increased imports of crude oil and refined petroleum.

- Less value added per unit of output comes from refining imported crude oil, as more intermediate inputs are required to process the different type of crude oil that is available from overseas.
- The least value added per unit of output comes from blending imported refined fuel to meet Australian standards, and the volume of refined fuel imports has been rising.

There has been increased demand for diesel fuel over cycle 4, as a result of the mining boom and changing consumer preferences. However, the increase in demand has been met mainly from imports of refined diesel as domestic refineries are better suited to producing petrol rather than diesel.

In the case of Polymers, domestic production declined. Finished plastic products faced stronger import competition as the result of increased production volumes of overseas firms with lower input costs and the appreciation of the Australian dollar. As firms adjust, *measured* productivity may fall, even though their productive efficiency may not. For example, where firms reduce output in response to decreased demand for their output, this can lead to unutilised capacity, which depresses measured productivity. More broadly, import competition should provide incentives for firms to improve their efficiency, but its impact on productivity, particularly in the short term, will also be influenced by industry-specific factors.

Rapid investment growth in Petroleum refining and Chemical manufacturing

The faster growth in capital services over cycle 4 is a product of very strong investment, particularly in the Petroleum and Chemicals subdivisions, but for different reasons. In the case of Petroleum refining, significant investments were required to upgrade refineries to meet new environmental standards relating to fuels. These investments appear as additional inputs, but the improvements in fuel quality are not completely accounted for in the measure of value added, thus depressing measured productivity.

In Chemicals, there was significant investment in expanding the production capacity of ammonia and ammonium nitrate — key inputs to fertilisers and explosives, which experienced heightened demand over cycle 4. The investment was made in that cycle, but some of the additional output was not realised until after 2007-08. As new capacity has come on stream since the end of cycle 4, the additional output has reversed some of the measured productivity decline.

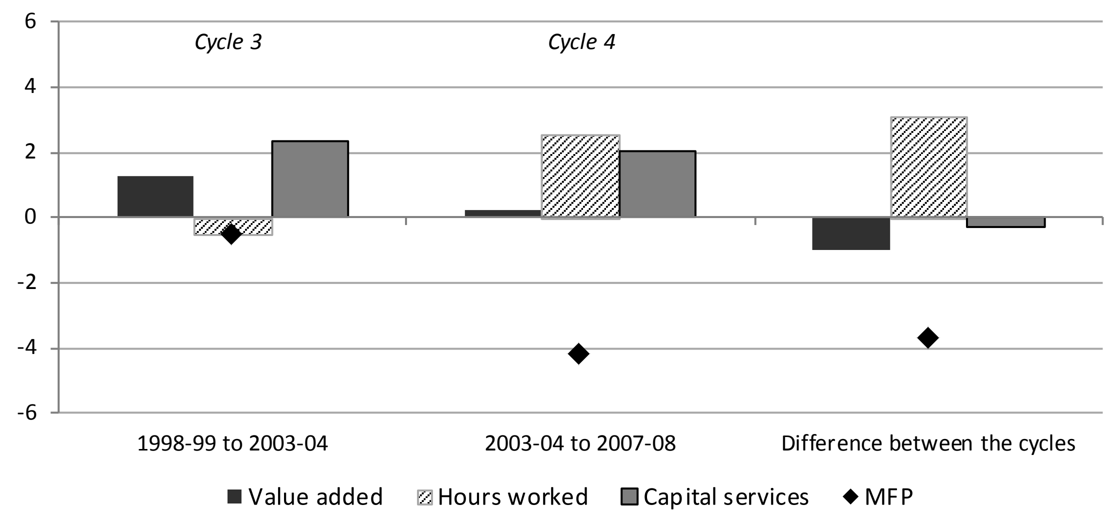
Food and beverages subsector made a considerable contribution to the decline in Manufacturing MFP

The Food and beverages subsector has two subdivisions: Food manufacturing, and Beverages and tobacco product manufacturing. There is a diverse range of manufacturing activities within each subdivision — from simple processing of agricultural products to the production of more complex products.

Food and beverages had a slightly negative rate of MFP growth over cycle 3 (-0.5 per cent a year on average) — associated with value added growth being lower than capital services growth (which was only partially offset by a small decline in hours worked) (figure 8). But, over cycle 4, the rate of MFP decline accelerated (-4.2 per cent a year). This was driven by value added growth slowing to almost zero and strong growth in hours worked (more than reversing the small fall over cycle 3).

Figure 8 **Food and beverages: proximate causes of MFP growth in cycles 3 and 4**

Average annual growth rate (per cent)



Slower value added growth, with declining net exports of food and beverage products and change in the composition of value added

During cycle 4, there was a slowdown in value added growth for Food and beverages in total and absolute declines for some products. There was a decline in exports and loss of domestic market share for some food and beverage products, reflecting input cost pressures, the appreciation of the Australian dollar and, in some cases, severe weather events including drought. As noted above for Polymers, in the short run, the effect on *measured* productivity of adjusting to lower levels of output of some products may be negative.

The slowdown in value added growth was most noticeable in Beverages and tobacco manufacturing — which grew over cycle 3 but declined in absolute terms over cycle 4. Wine manufacturing, in particular, appears likely to have been a significant contributor to this change. The amount of value adding per unit of output may have declined with a shift to a greater volume of bulk (rather than bottled) production in response to global market conditions. The drought in 2006 also led to some decline in grape production and wine output.

There have also been changes in the composition of output produced by Australian food and beverage manufacturers in response to changing consumer preferences. Those preferences relate to such factors as health considerations, quality, value, diversity and convenience. Estimates of value added growth may be understated given the challenges of measuring improvements in such factors as the quality and convenience of some outputs.

Different processes and higher input intensity

Change in the composition of output of Food and beverages may also affect the scale of production, the type of capital required and the labour intensity of production. For example, 'boutique' production, such as for artisan bakery products and craft beer, does not have the economies of scale of large factory production.

Within Bakery product manufacturing, for example, the growth of non-factory bakeries (such as hot bread shops) appears to have led to more labour intensive, smaller scale production with different capital requirements. The strong growth in hours worked in Bakery product manufacturing (which made a significant contribution to hours worked growth for the subsector as a whole) is consistent with such a shift in the composition of Bakery output.

The limitations of available data make it difficult to be more definitive about the extent to which changes in the composition of output may have reduced MFP growth in the Food and beverages subsector over cycle 4, compared with cycle 3.

Broader input measurement challenges

The decline in MFP for this subsector may also be overstated because of the challenges in measuring inputs. The comparability over time of labour input measures for Food and beverages may have been reduced by changes in survey methodology and industry classifications. In addition, changes in the composition of production that have altered capital requirements may have led to the early retirement of existing capital (that remains 'on the books' in statistical terms) or increased underutilised capacity. This may be part of the explanation for a larger decline in output growth than in capital growth between cycles 3 and 4.

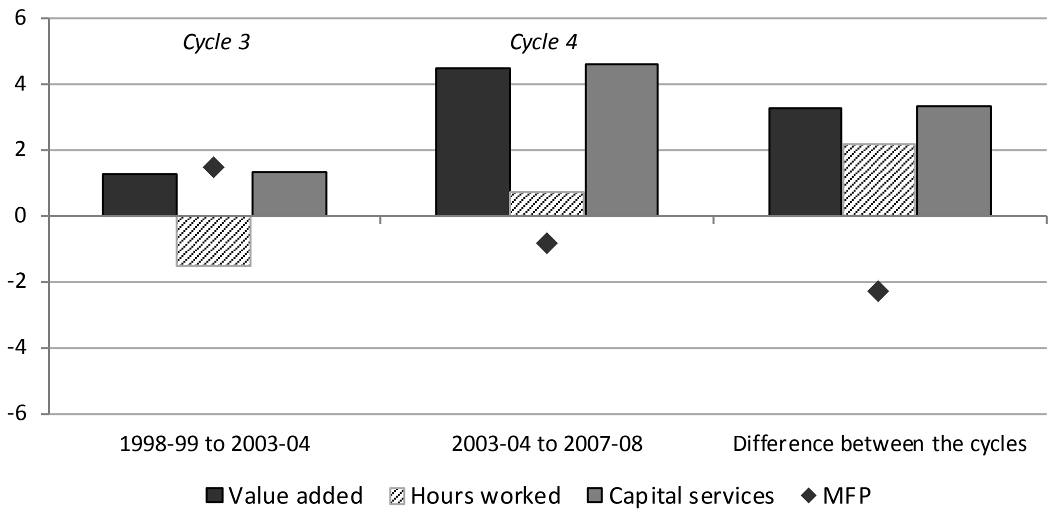
Metal products subsector contributed to the decline in Manufacturing MFP even though its value added growth strengthened

The Metal products subsector has two subdivisions — Primary metals (which includes the manufacture of basic steel, alumina, aluminium processing, and the smelting of other non-ferrous metals) and Fabricated metals (which includes the manufacture of structural metal products, metal coatings and other fabricated products).

Metal products had a positive rate of MFP growth over cycle 3 (1.4 per cent a year on average) which turned negative over cycle 4 (-0.9 per cent a year) (figure 9). This decline in MFP was driven by very strong growth in capital inputs over cycle 4 and a reversal of the decline in hours worked that had occurred in cycle 3. Value added growth was also stronger over cycle 4 than cycle 3, but it did not increase enough to offset the pace of input growth.

Figure 9 **Metal products: proximate causes of MFP growth in cycles 3 and 4**

Average annual growth rate (per cent)



Metal products was the third largest contributor to the decline in Manufacturing MFP between cycles 3 and 4. While its contribution was not much larger than some of the remaining subsectors, it is notable that, unlike most of the other subsectors, its value added growth strengthened between cycles. It was also responsible for most of the capital services growth for Manufacturing in total.

The productivity performance of the Metal products subsector can be explained by examining those parts of the subsector that experienced the strong value added growth and those that experienced the strong capital services growth.

Fabricated metal products and alumina smelting experienced value added growth

Most of the strong value added growth in cycle 4 occurred in Fabricated metals, particularly those metal fabricators associated with supplying materials to the Construction and Mining sectors. Stronger demand from these sectors saw Fabricated metal manufacturers expand output and supply a greater share of their output to these sectors. There was also faster growth of alumina production during cycle 4, as growth in world demand for aluminium was strong prior to the global financial crisis.

Large investment to expand alumina production capacity

Growth in capital services accounted for around two-thirds of Metal products' total input growth between cycles 3 and 4. Practically all of the investment growth was in Primary metals (and the bulk of that was in alumina refining). This investment was associated with building new metal refining assets and upgrading existing ones — in response to higher commodity prices during cycle 4 and in anticipation of strong demand in the future. There was also some investment growth in other parts of the subsector, including other metal refining and some fabricated metal products. The lag between investment and output associated with that investment led to lower measured productivity.

Hours worked growth in Fabricated metals

Growth in hours worked between the cycles accounted for the remaining third of the growth in total inputs. Fabricated metals, which also had value added growth, is likely to have contributed most of this growth. This rise in the number of hours worked during cycle 4 is significant as it reverses a trend of declining hours worked for the subsector.

Different parts of Metal products had different effects on MFP

Available evidence is consistent with Primary metals and Fabricated metals pulling MFP in Metal products in different directions between cycles 3 and 4. Primary metals played the main role in the decline in MFP and Fabricated metals offset the scale of the decline to some extent.

Manufacturing since the last complete productivity cycle

The decline in MFP in Manufacturing has continued since the last complete productivity cycle, with Textiles, clothing and other manufacturing making the largest contribution, followed by Printing and recorded media and Petroleum and chemicals. However, the rate of MFP decline has been slower than over cycle 4.

MFP growth in Petroleum and chemicals remained negative on average in the incomplete cycle, but the decline in MFP was slower (-1.1 per cent a year) than in cycle 4 (-4.1 per cent a year). While the decline in value added accelerated in the incomplete cycle, there was also some decline in combined inputs — a steep decline in hours worked and slower capital services growth.

Similarly, the rate of MFP decline in Food and beverages slowed in the incomplete cycle (from -4.2 to -1.1 per cent a year). But in that case, the rate of value added growth increased and the rate of combined input growth slowed. After the strong growth in hours worked in cycle 4, there was no growth in the incomplete cycle. And capital services growth also slowed.

Average MFP growth in Metal products was just above zero in the incomplete cycle (0.1 per cent a year). While value added growth fell to 0.3 per cent a year, combined input growth was also very low. Hours worked fell, almost offsetting growth in capital services, which slowed relative to the exceptional growth of cycle 4.

Food and beverages and Metal products made much smaller contributions to the decline in Manufacturing MFP in the incomplete cycle than over cycle 4 — reflecting a return to MFP growth rates closer to, but still below, their longer-term averages. Notwithstanding possible measurement issues, it appears likely that the significant declines in MFP growth in these two subsectors over cycle 4 were atypical.

1 Introduction and background

Growth in productivity is a key determinant of long-term economic growth and hence household income growth and living standards. Given this relationship, recent significant declines in multifactor productivity (MFP) growth in Australia are of concern.

Close analysis of industry productivity is key to understanding what underlies aggregate productivity performance and to providing policy-relevant insights. The Commission has previously identified Mining, Electricity, gas and water, Agriculture and Manufacturing as four industries with particularly large declines in MFP growth over the period 2003-04 to 2007-08 compared with the period 1998-99 to 2003-04 (PC 2009). More recent work by Parham (2012), based on revised ABS MFP estimates, identified Manufacturing as the largest contributor to the decline in market sector[1] MFP growth between these two periods.

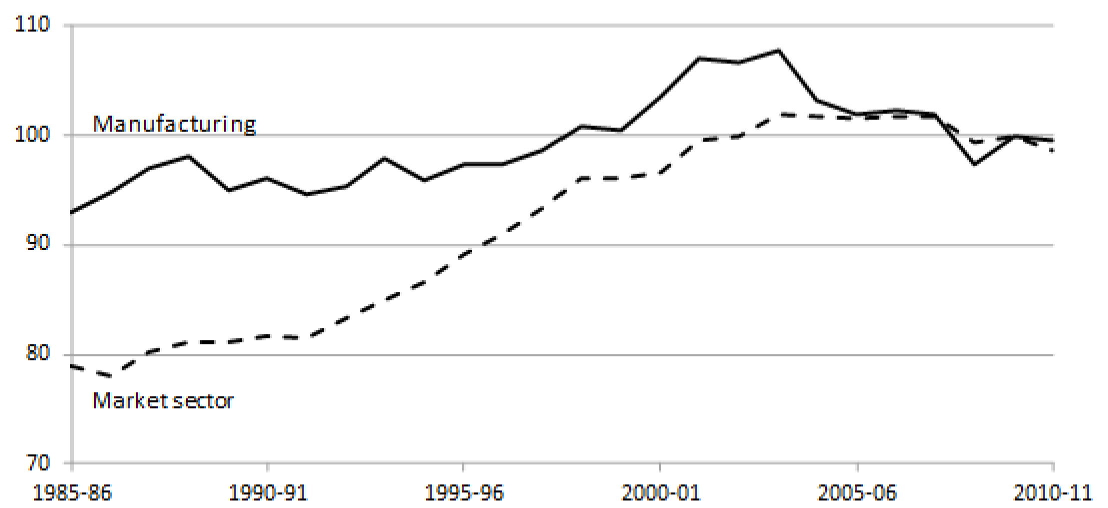
Manufacturing has been the subject of frequent studies and inquiries (including by the House of Representatives Standing Committee on Economics 2007; Victorian Competition and Efficiency Commission 2011; and the Prime Minister's Taskforce on Manufacturing 2012). However, these studies generally did not focus on Manufacturing MFP, or have been limited in their ability to examine MFP in different parts of Manufacturing by lack of data.

Manufacturing MFP declined over the period 2003-04 to 2010-11 at an average of -1.1 per cent a year, which was a faster decline than for market sector MFP (-0.5 per cent a year) (figure 1.1). This is the longest sustained decline in Manufacturing MFP recorded since 1985-86 (the period for which ABS Manufacturing MFP estimates are comparable).

The Commission has previously identified the factors which have been important in the interpretation of declining MFP growth in Mining (Topp et al. 2008), Electricity, gas and water (Topp and Kulys 2012), and Agriculture (PC 2009). This paper examines Manufacturing MFP growth in detail.

1 In this paper, the term market sector refers to the 12 industry sectors of the economy for which a long time series of MFP estimates is available (see table 2.1 for a list of these sectors). The ABS has recently expanded its market sector to cover 16 industry sectors (but only from 1994-95).

Figure 1.1 **MFP in Manufacturing and the market sector[a]**
Index 2009-10 = 100



[a] The market sector includes 12 industry sectors (table 2.1).

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

A previous Commission study of Manufacturing (PC 2003) included an examination of productivity up to 2000-01, which pre-dated the more recent downward trend in Manufacturing MFP. That study noted a slowing in productivity growth in the late 1990s, but found that the reason for this was not clear. It also noted considerable heterogeneity in the productivity performance of industries within the sector.

Since 2001, there have been a range of structural pressures and other influences on Manufacturing (including the appreciation of the Australian dollar, and adjustment pressures relating to the mining boom). It is likely that the impact of these factors on MFP has differed across parts of Manufacturing, but there are no official measures with which to examine this hypothesis.

1.1 Heterogeneous nature of the sector

Manufacturing covers a diverse and changing range of activities, but is often divided into eight subsectors:[2]

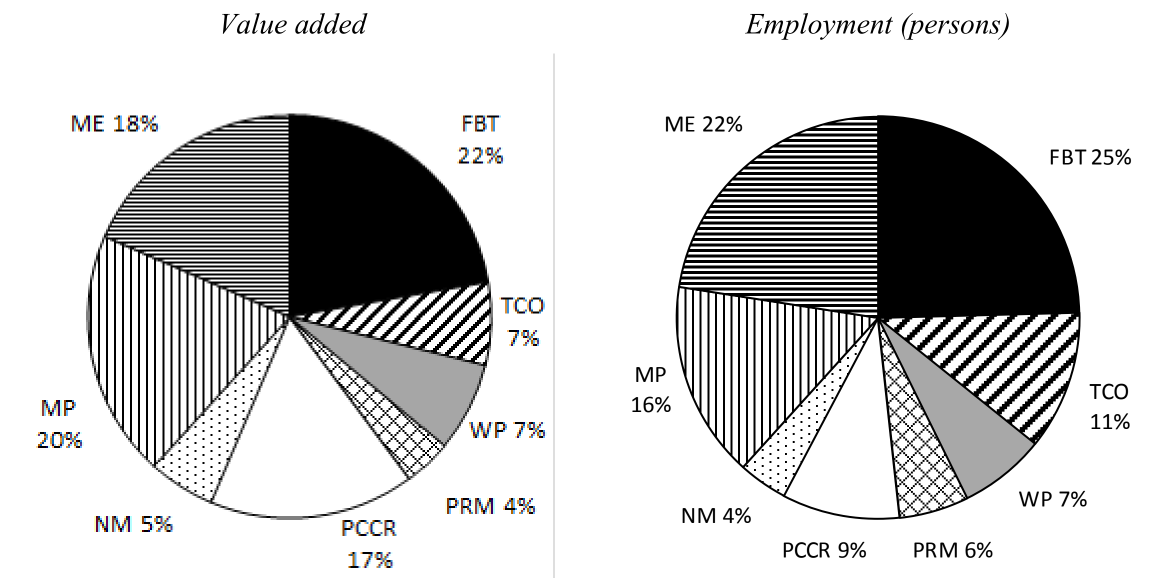
- Food, beverages and tobacco products
- Textile, clothing and other manufacturing

2 These are the subsectors used by the ABS in its National Accounts and for which it reports the volume of value added. Table A.1 shows how these subsectors relate to the subdivisions in the ABS *Australian and New Zealand Standard Industrial Classification 2006* (ANZSIC06).

- Wood and paper products
- Printing and recorded media
- Petroleum, coal, chemical and rubber products
- Non-metallic mineral products
- Metal products
- Machinery and equipment manufacturing.

Figure 1.2 shows the distribution of value added and employment across subsectors within Manufacturing in 2009-10. Four of the subsectors (Food, beverages and tobacco products, Metal products, Machinery and equipment manufacturing, and Petroleum, coal, chemical and rubber products) account for 77 per cent of the sector's value added (in fairly equal shares). The other four subsectors contribute the remaining 23 per cent (ranging from 4 to 7 percentage points each). Food, beverages and tobacco products, Machinery and equipment manufacturing and Metal products account for the bulk of Manufacturing employment (63 per cent), with the other five subsectors ranging from 4 to 11 percentage points each.

Figure 1.2 **Subsector[a] shares of Manufacturing value added[b] and employment, 2009-10**



[a] FBT is Food, beverage and tobacco products; TCO is Textile, clothing and other manufacturing; WP is Wood and paper products; PRM is Printing and recorded media; PCCR is Petroleum, coal, chemical and rubber products; NM is Non-metallic mineral products; MP is Metal products; ME is Machinery and equipment manufacturing. [b] Value added measure is gross value added at current basic prices.

Data sources: 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).

1.2 Objectives

The overall objective of this study is to examine recent productivity performance in Manufacturing, with particular focus on the causes of its decline.

In particular, this paper:

- analyses MFP change and its proximate causes (value added, labour and capital inputs) for Manufacturing as a whole
- estimates MFP change and its components at the subsector level within Manufacturing
- examines factors influencing the productivity performance of Manufacturing and three of its largest constituent subsectors (as they have contributed most to recent trends in aggregate performance).

The focus of this study is on productivity in Manufacturing, rather than on being a comprehensive industry study — the influences examined are those that shed light on productivity trends. Also, the main period examined is the decline in Manufacturing MFP since 2003-04 — with particular emphasis on the extent of the decline over the 2003-04 to 2007-08 productivity cycle, compared with the previous cycle (1998-99 to 2003-04).[3]

An improved understanding of productivity trends within Manufacturing should assist further analysis and interpretation of movements in official productivity statistics for Manufacturing and for the market sector more broadly. It should also inform the ongoing public debate and discussion on productivity outcomes and objectives.

This study is a continuation of the Commission's stream of research into measured MFP growth, including the program of detailed industry productivity studies. To date, Mining (Topp et al. 2008) and Electricity, gas and water (Topp and Kulys 2012) have been examined in detail.

3 It should be noted that this paper examines Manufacturing MFP up to 2010-11, based on the 2010-11 ABS National Accounts (the latest available when the MFP estimates for the Manufacturing subsectors were derived for this study).

1.3 Structure of the paper

The remainder of this paper is organised as follows.

- Chapter 2 outlines developments in productivity in Manufacturing in aggregate. Related appendixes examine: the data sources underlying these aggregate productivity estimates (appendix A); and the input-output linkages between Manufacturing and other sectors of the economy (appendix B).
- Chapter 3 presents estimates for productivity in the subsectors within Manufacturing. Related appendixes provide: details of the data sources and methodology used to construct these estimates (appendix A); an examination of productivity cycles at the subsector level (appendix C); further analysis of the subsector estimates (appendix D); and sensitivity testing of the estimates (appendix E).
- Chapters 4 to 6 examine productivity in the three selected subsectors that have contributed most to the overall decline in Manufacturing productivity: Petroleum, coal, chemical and rubber products; Food, beverage and tobacco products; and Metal products. Additional details about these subsectors are provided in appendixes F to H.

2 Aggregate Manufacturing productivity

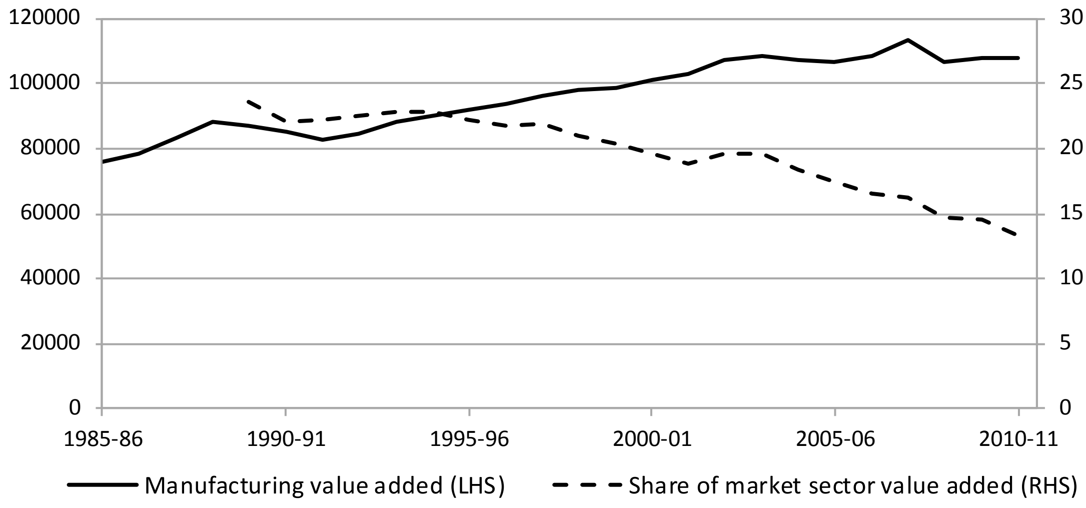
This chapter provides some background on the size of Manufacturing, both now and over time. An examination of the productivity performance of Manufacturing in aggregate (as measured by the ABS), is followed by a high-level analysis of some of the possible influences on Manufacturing productivity.

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)



[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 added*[b]	*Hours worked*[c]	*Number employed*	*Investment*[d]	*Net capital stock*[e]
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**

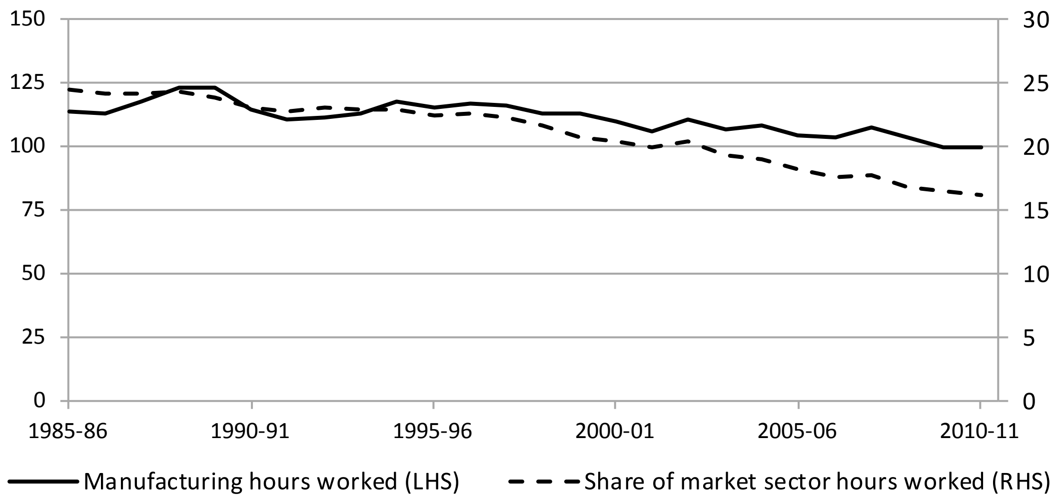
[a] The ABS measures multifactor productivity only for the market sector of the economy. In this paper, the market sector refers to the 12 industry sectors for which a long time series of multifactor productivity estimates is available (*Australia and New Zealand Standard Industrial Classification 2006* (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)



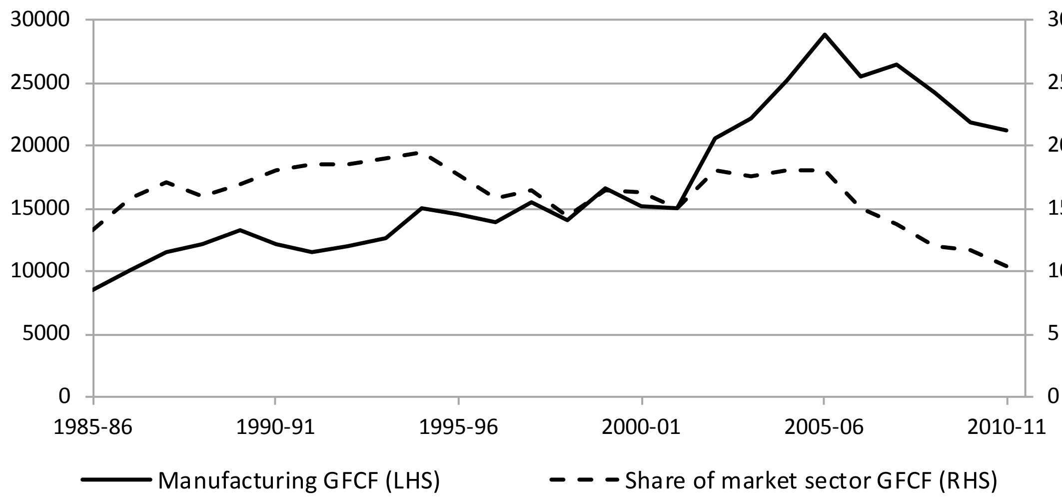
a Index of number of hours worked. ABS has annualised hours worked and adjusted for public holidays, and adjusted the series for changes in survey methodology (appendix A).

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

These sectors provide inputs …	*… to the output of these sectors* Agriculture	Mining	Manufacturing	Services[c]
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**
Services[c]	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
Imports[b]	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] There was also intra-industry trade within Manufacturing — over a third of the intermediate inputs used by manufacturers were provided by other manufacturers.

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).

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] 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]

2 In this case disembodied technical change. Technical change can also be embodied in capital equipment. See Dowrick (2004) for a discussion.

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).

Both outputs and inputs are measured in quantity or volume terms, that is with the effects of price changes removed.[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] 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]

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.

4 In this paper, value added, labour, and capital refer to volume (real) measures unless otherwise specified.

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.

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.

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]

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.

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.

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

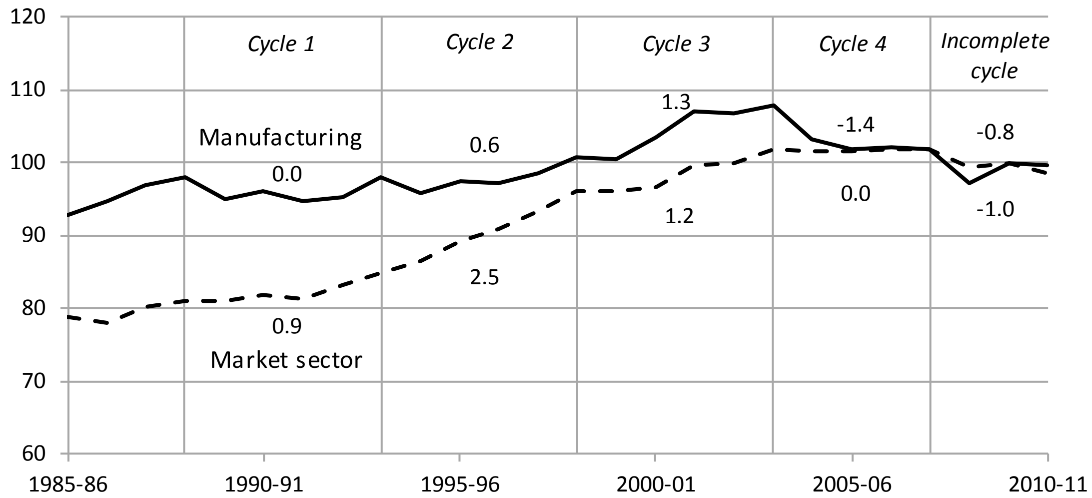
Average growth in Manufacturing MFP over the full period from 1985-86 to 2010-11 was modest at 0.3 per cent a year, compared with 0.9 per cent a year for the market sector[8] (figure 2.5). As mentioned in chapter 1, the declining trend in Manufacturing MFP from 2003-04 to 2010-11 is the longest sustained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

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.

Figure 2.5 **MFP in Manufacturing and the market sector by 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

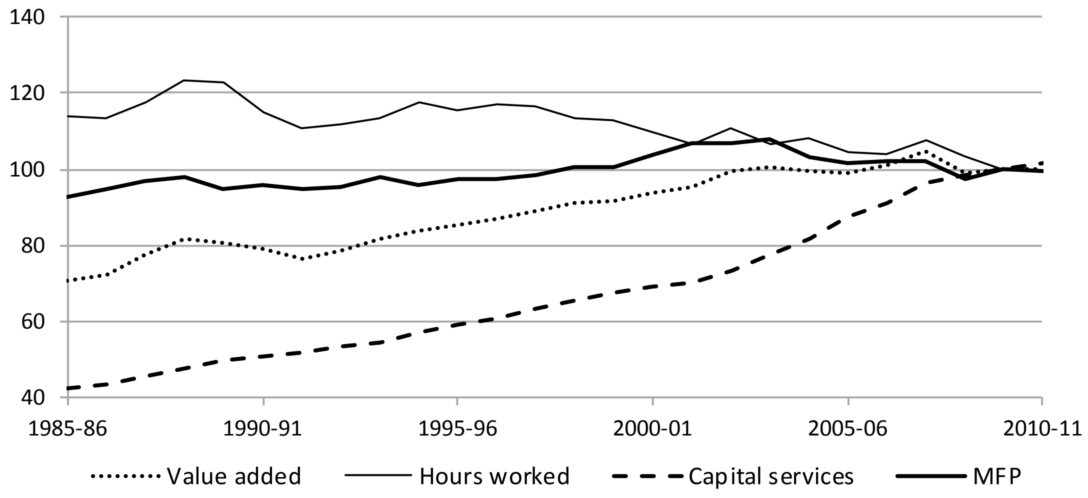
Some initial insight into the influences on MFP growth can be gained from examining its proximate causes — growth in the volumes of value added, hours worked and capital services. (What drives changes in the proximate causes is highly complex and is discussed later in this chapter and in subsequent chapters.) 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] As already indicated, the resulting trend in MFP was positive up to 2003-04 but negative thereafter.

[9] Including higher growth in 2007-08 followed by contraction in 2008-09 (a year affected by the global financial crisis).

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).

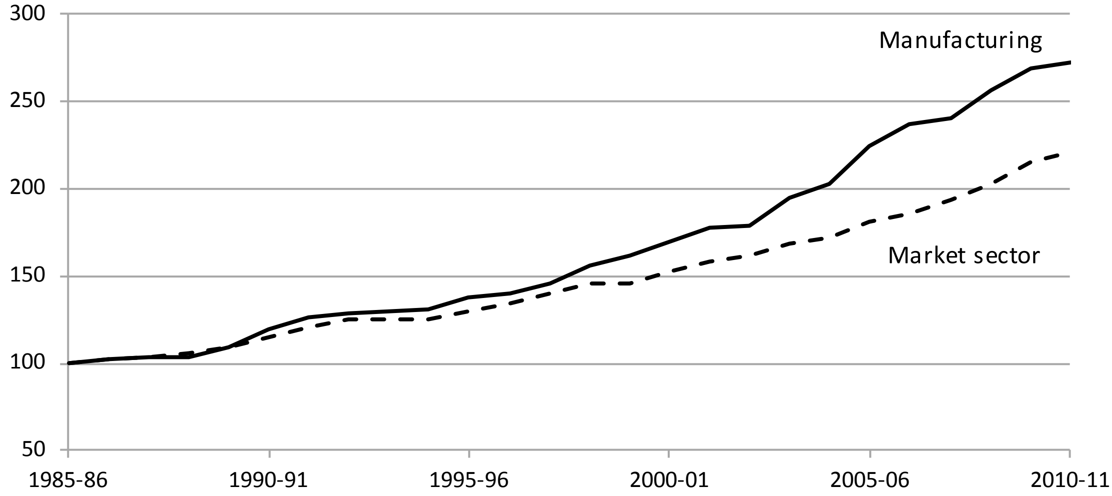
On average over the full period, the modest MFP growth (0.3 per cent a year) was associated with value added growth (1.4 per cent a year) slightly above combined input growth (1.1 per cent a year). Within the latter, the contribution of capital services grew at the same rate as value added (1.4 per cent 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]

[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.

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

Index 1985-86 = 100

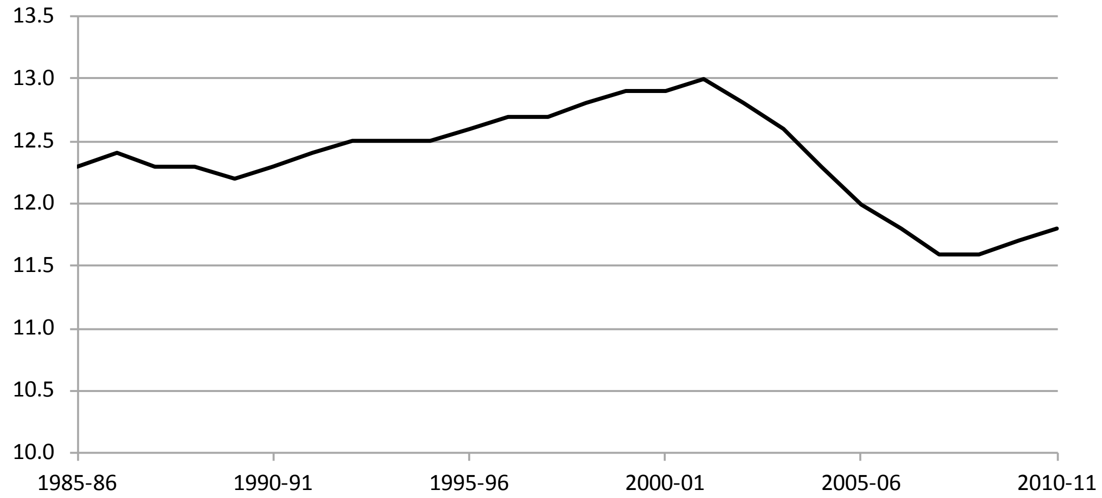


Data source: Authors' estimates based on ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

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).

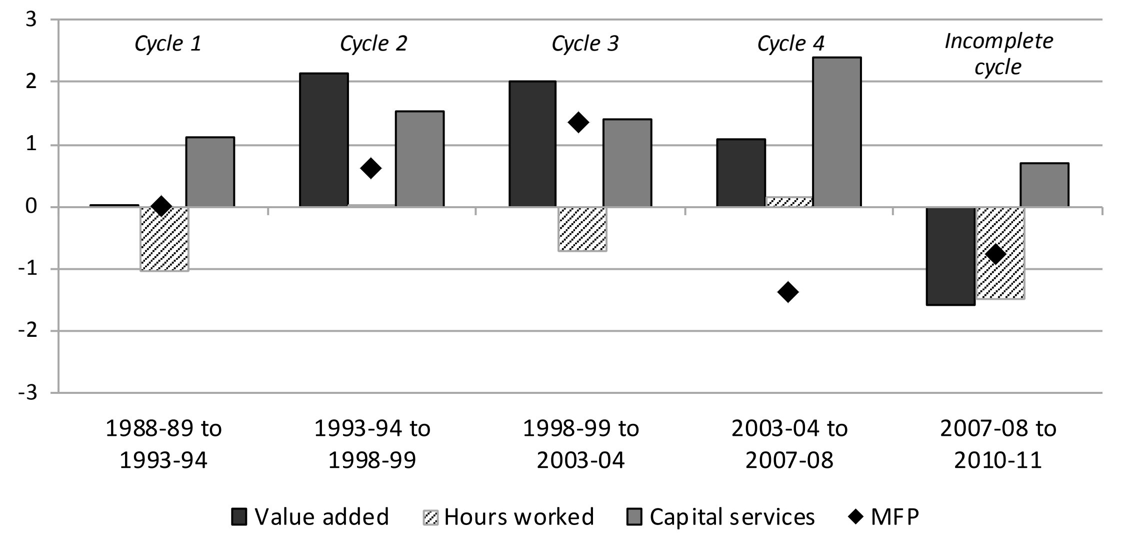
An increase in the capital-labour ratio for Manufacturing in aggregate can result from the substitution of capital for labour in particular manufacturing activities; but it can also occur when there is a shift in the composition of Manufacturing towards more capital-intensive activities. The extent to 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]

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).

[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.

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] (the last set of columns).

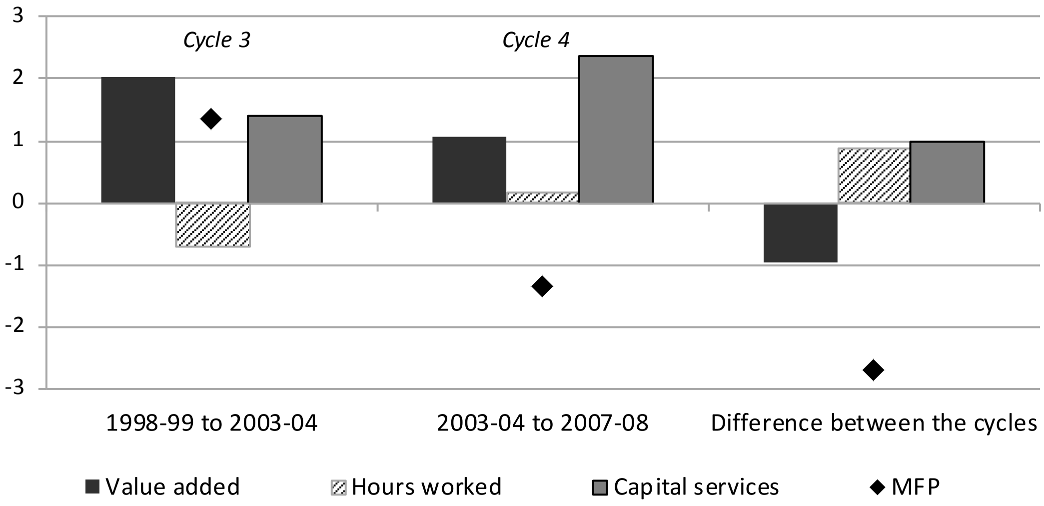
---

[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

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.

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.

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]

- 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

[13] See PC (2013a) for a discussion of a framework for examining the influences underlying positive productivity growth.

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

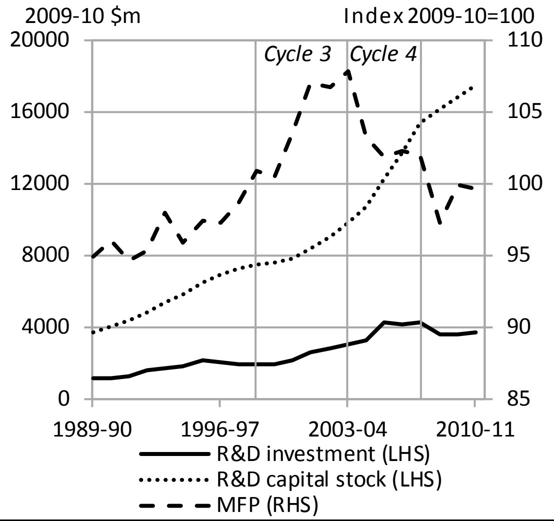
Some influences are commonly cited as important for Manufacturing productivity. But it is not clear from the *aggregate* data whether these influences played a major role in the recent negative growth in Manufacturing MFP.

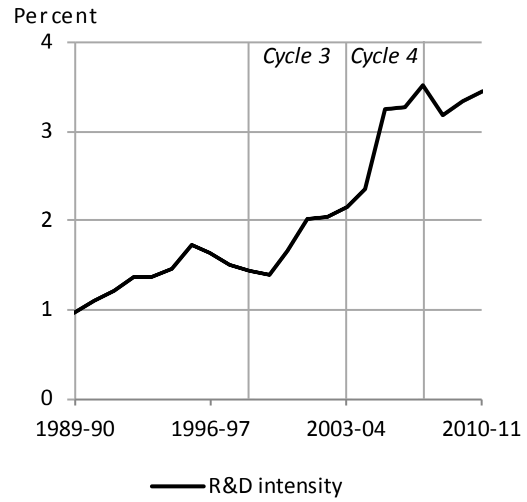
Technical progress and innovation

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]

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.

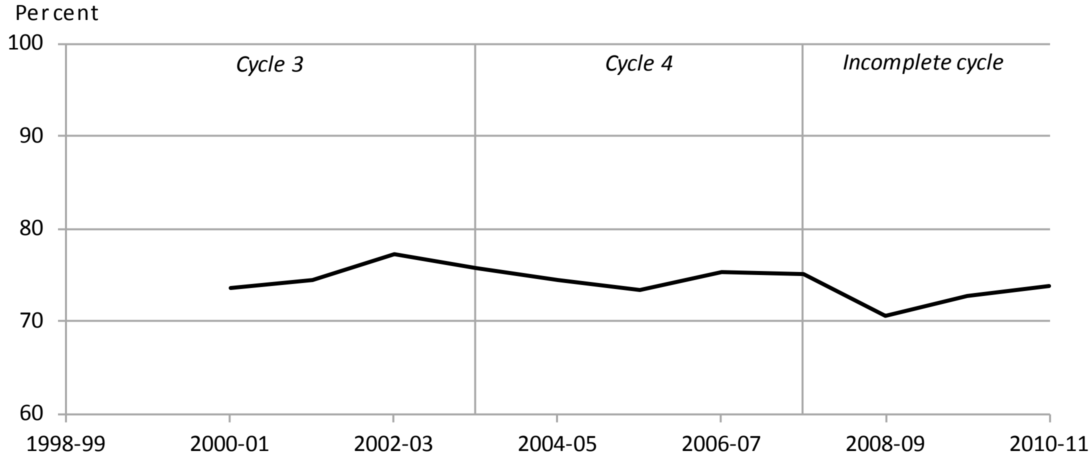
While there are no official ABS measures of capacity utilisation, two industry associations collect capacity utilisation data in their Manufacturing surveys (figure 2.12). The Australian Industry Group (Ai Group) measure (top panel) is the average capacity utilisation rate of surveyed manufacturers. 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.

[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.

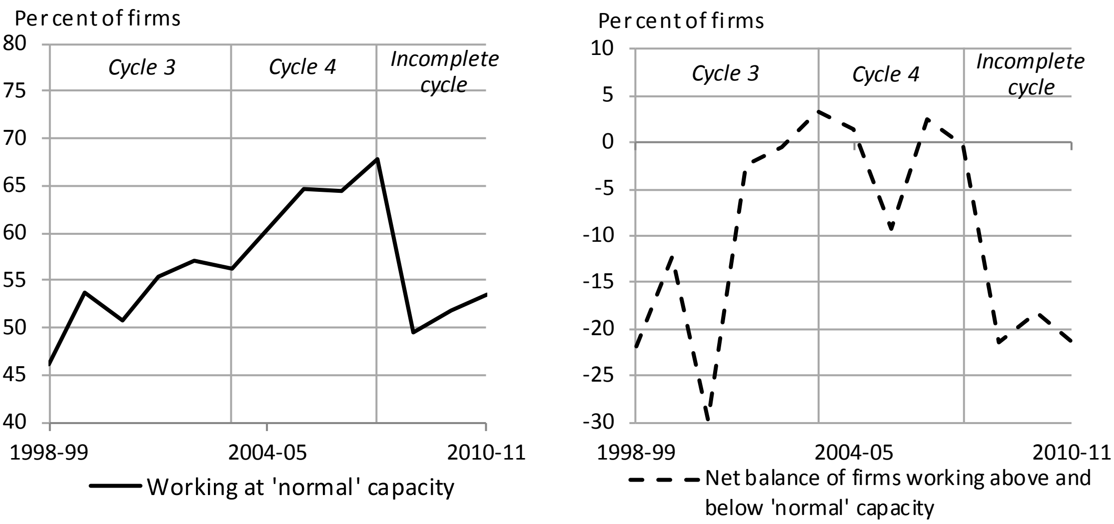
The Australian Chamber of Commerce and Industry and Westpac (ACCI-Westpac) measure identifies the share of firms surveyed whose capacity utilisation is above normal, at normal or below normal. Figure 2.12 (bottom panel) shows the share of firms at normal capacity (solid line) and the net balance of firms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

Ai Group: Rate of utilisation[a]



ACCI-Westpac: Capacity utilisation categories[b]



[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]

[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.

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]

[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).

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?

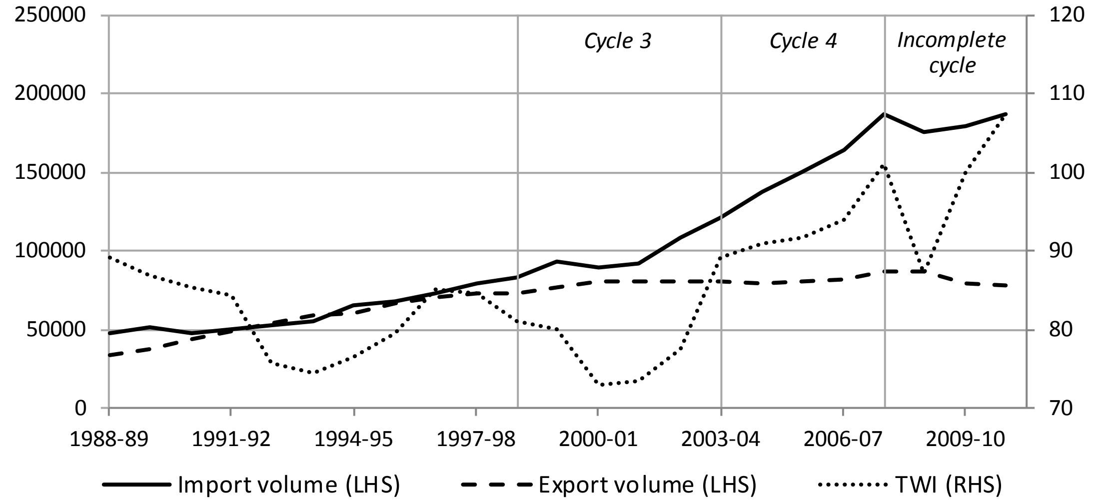
- Imports of products similar to those produced by domestic firms will expose those firms to additional pressures of competition. Market competition encourages cost reductions and product and process improvements, including potentially through higher rates of innovation and diffusion (PC 2009). This 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.

Figure 2.13 **Manufacturing trade volumes[a] and the exchange rate[b]**

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



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

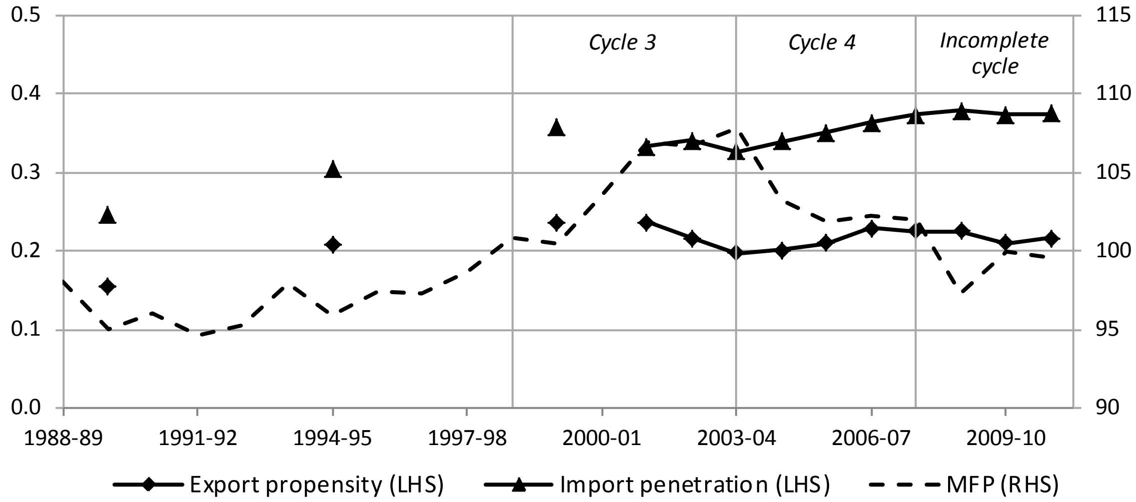
Data sources: Authors' estimates based on ABS (*International Trade in Goods and Services, Australia*, various issues, Cat. no. 5368.0); and ABS (*International Trade Price Indexes,* various issues, Cat. no. 6457.0).

'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)



[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

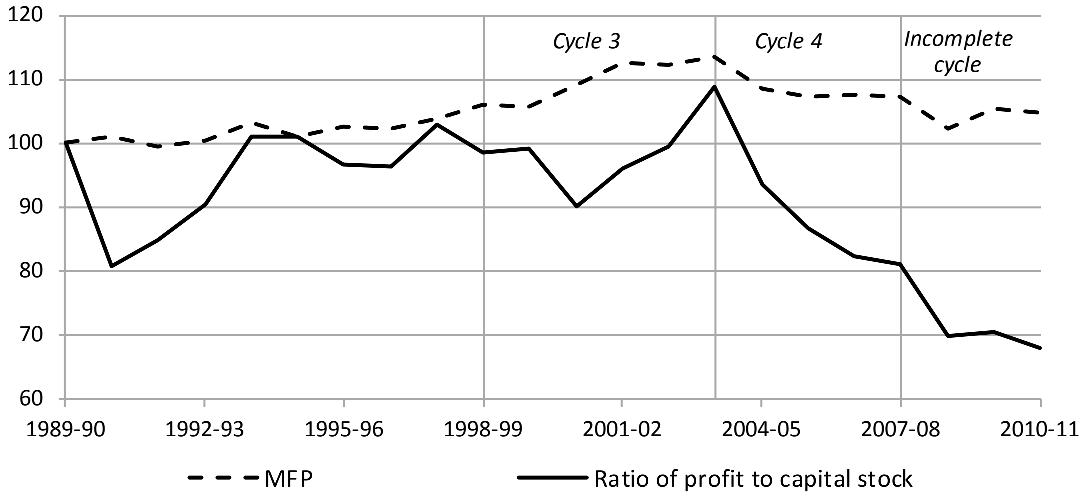
Negative productivity growth may also occur if there is compositional change within Manufacturing towards activities with relatively low measured productivity. One reason for a production shift to lower-productivity activities can be that, in the short term, these activities have become more profitable. 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 a whole, 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



[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).

3 Productivity growth at the subsector level

The productivity trends evident for Manufacturing as a whole are the net result of a potentially diverse range of trends for the individual industries in the sector. This chapter examines the productivity of Manufacturing at the subsector level and identifies the subsectors that contributed the most to the recent decline in Manufacturing productivity.

3.1 Subsectors within Manufacturing

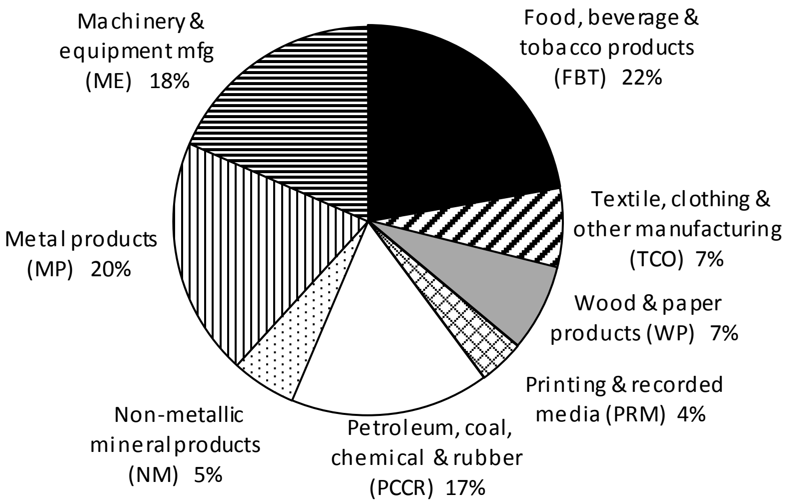
The ABS divides Manufacturing into eight subsectors for the purpose of estimating the volume of output (value added):

- Food, beverage and tobacco products
- Textile, clothing and other manufacturing
- Wood and paper products
- Printing and recorded media
- Petroleum, coal, chemical and rubber products
- Non-metallic mineral products
- Metal products
- Machinery and equipment manufacturing.[1]

Figure 3.1 shows the distribution of value added across Manufacturing subsectors in 2009-10. The larger subsectors are Food, beverage and tobacco products, Metal products, Machinery and equipment manufacturing and Petroleum, coal, chemicals and rubber products, which together make up almost three quarters of Manufacturing value added. The relative size of each of the subsectors has been fairly stable since 1985-86 (figure 3.2). This stability may mask changes in the mix of activities within the subsectors. However, insufficient data for value added volumes are available to be able to estimate productivity at a more disaggregated level in this study.

[1] Includes Motor vehicle and motor vehicle part manufacturing. See appendix A for further details on ABS industry classifications and the industries included each subsector.

Figure 3.1 **Subsector shares of Manufacturing value added, 2009-10[a]**

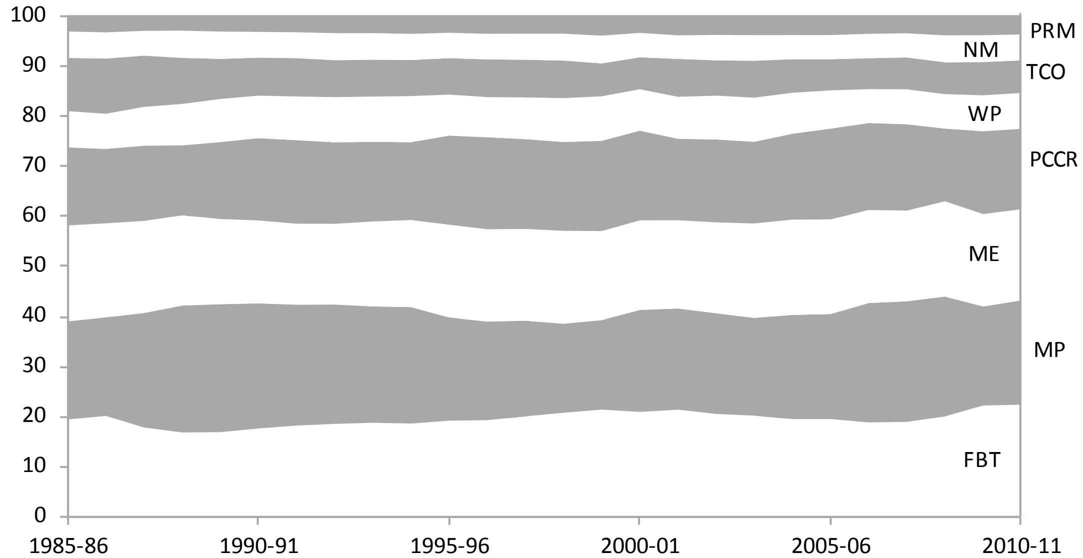


[a] Value added measure is gross value added at current basic prices.

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

Figure 3.2 **Subsector shares of Manufacturing value added, 1985-86 to 2010-11[a]**

Percentage shares of total



[a] Value added measure is industry value added at current prices from the ABS *Economic Activity Survey*. Data prior to 2006-07 have been converted onto an ANZSIC06 basis using a broad concordance and the series has been benchmarked to value added for 2009-10 from the ABS National Accounts (appendix A).

Data sources: Authors' estimates based on ABS (*Australian Industry,* various issues, Cat. no. 8155.0); ABS (*Manufacturing Industry*, *Australia*, various issues, Cat. no. 8221.0); ABS (*Enterprise Statistics*, various issues, Cat. no. 8103.0); and ABS (*Australian System of National Accounts*, *2010-11*, Cat. no. 5204.0).

3.2 Productivity growth in Manufacturing subsectors

The ABS estimates productivity growth for Manufacturing as a whole, but not for subsectors within Manufacturing. This section outlines the approach used in this study to estimate productivity at a more disaggregated level and presents estimates for the eight subsectors within Manufacturing.

Estimation methodology

As outlined in chapter 2, multifactor productivity (MFP) growth is derived as the difference between growth in value added and growth in combined inputs[2] (the average of growth in capital and in labour, weighted by their respective income shares). And labour productivity (LP) growth is defined as growth in value added per hour worked. Therefore, to construct subsector estimates of LP and MFP, subsector level data for value added, hours worked, capital services and factor income shares (as weights) are required.

Where possible, subsector MFP estimates were based on the same methodology and data sources used by the ABS in its estimates for Manufacturing MFP (in order to be consistent with those ABS estimates). However, data limitations necessitated the use of simplified methodology and different data sources for some variables.

In most cases, the required data were available from the ABS in a single industry classification, *Australian and New Zealand Standard Industrial Classification 2006* (ANZSIC06).[3] In a few cases, data were backcast into ANZSIC06 using a broad concordance between industry classifications.

Full details of the methodology, data sources and assumptions are provided in appendix A. In broad terms, the subsector estimates for value added and hours worked most closely match the ABS total for Manufacturing.

- Value added (volume) for the subsectors was available from the ABS National Accounts — the same source used by the ABS for estimating Manufacturing MFP.

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2 As noted in chapter 2, all outputs and inputs are measured in volume (real) terms.

3 Despite this approach, some subsectors are still less well estimated than others because of industry classification changes and practical limitations in backcasting. Textile, clothing and other manufacturing and Printing and recorded media have been particularly affected by the change from the 1993 edition to the 2006 edition of ANZSIC — MFP estimates for these subsectors are therefore likely to be of lower quality.

- Hours worked in each of the subsectors was derived from the specific measure of hours worked for Manufacturing in total that the ABS uses in its estimation of Manufacturing MFP. This specific measure is based on published data from the ABS quarterly *Labour Force Survey,* but has been adjusted by the ABS for changes in survey methodology over time and annualised (including adjustment for holidays). Information about the distribution of hours worked, also from the *Labour Force Survey,* was used to allocate this adjusted total across subsectors.

The subsector estimates of capital services and factor income shares required the use of different data sources and additional assumptions.

- Subsector capital services indexes were estimated using a range of data sources and assumptions. Where possible, subsector estimates for investment by asset type were benchmarked to the ABS estimates for Manufacturing in total (box 3.1). But, as a result of data limitations, there is a discrepancy between the sum of the subsector estimates for capital services and the ABS total for Manufacturing.
- Labour income and capital income shares for the subsectors were derived using data from the ABS *Economic Activity Survey*. These data were adjusted for changes in industry classification and survey methodology, to improve consistency over time. This data source is different to that used by the ABS for estimating Manufacturing in total and insufficient data were available to align the subsector shares with those for Manufacturing in total.

Given the data limitations, the subsector estimates presented in this paper are of lesser quality than the ABS estimates for Manufacturing as a whole, and will not necessarily sum to those ABS estimates. Therefore the subsector estimates should be regarded as indicators of differences within the Manufacturing sector, rather than as precise estimates.[4]

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4 Attempting consistency with the ABS total for Manufacturing has meant using subsector data for each variable from the survey used for that ABS total (or the closest available survey) rather than taking data for all variables from a single survey. Any errors in the allocation of outputs and inputs to individual Manufacturing subsectors are likely to be offsetting when aggregated to the sector level. But these errors may be more apparent at the subsector level and may vary across surveys, thus introducing some inconsistency between data taken from different surveys.

However, the most comprehensive ABS industry survey, the *Economic Activity Survey* (which underlies ABS publication *Australian Industry*, Cat. no. 8155.0) has insufficient data to calculate capital services indexes and includes only employment, not hours worked. Also, there are a number of breaks in series that hamper data comparability over time.

Box 3.1 Estimation of subsector capital services

An estimate of the annual flow of capital services is required for the estimation of MFP growth. For each capital asset, the services provided are directly proportional to the asset's productive capital stock. Aggregate capital services indexes are created using the volume index of the productive capital stock of each asset weighted using rental prices.

The *productive capital stock* of an asset is the real stock of capital, adjusted for retirement of capital and efficiency losses related to age. The productive capital stock is estimated using new investment data and an assumed decline in efficiency of previous investment that has aged.

The *rental price* of an asset type can be thought of as an estimate of the rate that the asset type would attract if leased under a commercial agreement. The use of rental prices as weights assumes that the rental price reflects the marginal product of an asset. More productive assets have a higher rental price and, therefore, a higher weight in the aggregate capital services measure.

The rental price of an asset includes: the expected return on the asset; depreciation; the capital gain or loss due to asset price inflation/deflation; and tax adjustments (particularly to correct for distortions in rental prices due to differential tax treatment across capital items). See ABS (2012c) for further details.

Data limitations lead to some differences in methodology and data sources to those used by the ABS for Manufacturing in total.

The main differences are:

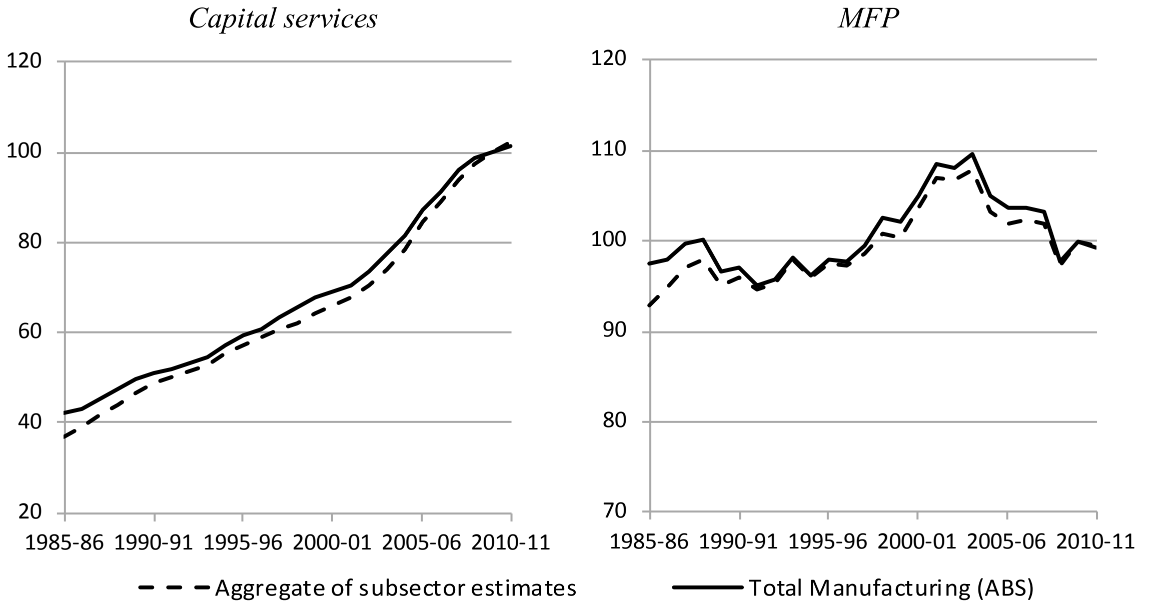
- fewer and less detailed asset types were included at the subsector level
- some parameters used in rental price estimation were not available on a subsector-specific basis — they were assumed to be the same as for Manufacturing in total
- a different primary data source was used for investment by subsector — but these data were benchmarked to ABS estimates for Manufacturing in total, by applying the subsector shares to that total.

The resulting discrepancy between the ABS Manufacturing estimates and the aggregate of the subsector estimates for capital services varies over time. But it is relatively small over the cycles that are the main focus in this study (cycles 3 and 4). Appendix A provides full details of the method and compares subsector estimates with the ABS Manufacturing estimates.

Consistency with ABS Manufacturing estimates.

The most significant of the discrepancies between the ABS estimates for Manufacturing in total and the aggregate of the subsector estimates is in capital services and this flows through to the MFP estimates (figure 3.3).

Figure 3.3 **Discrepancies in capital services and MFP**
Index 2009-10 = 100



Data sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

Nonetheless, the discrepancies are relatively small over the last two complete productivity cycles (appendix A), which are the focus of this paper. And the broad pattern of subsector MFP growth across cycles does not change substantially with the use of alternative capital data or alternative assumptions regarding R&D capital. The magnitude of the changes in inputs and outputs underlying the subsector productivity estimates makes it unlikely that the declines in subsector productivity are the result of statistical error in the data (appendix E).

In the remainder of the chapter, all tables include both the aggregate of the subsectors estimates and the ABS estimates for Manufacturing in total. But, for clarity, charts include only the ABS estimates for Manufacturing (unless otherwise specified).

Subsector-specific estimates

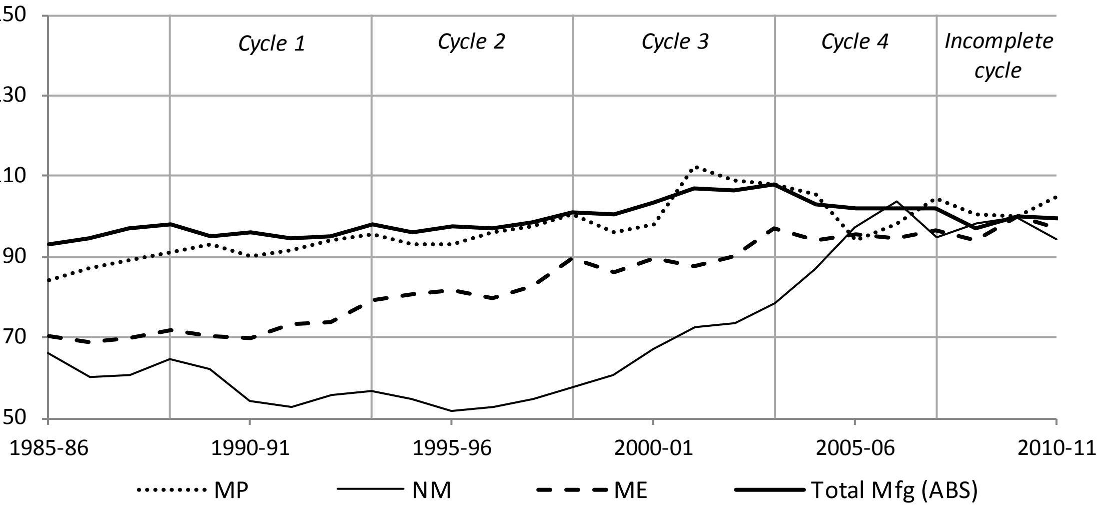
From 1985-86 to 2010-11, the MFP trend for Manufacturing as a whole was relatively flat (with average annual growth of around 0.3 per cent). However, this aggregate disguises considerable variation among the subsectors, with some subsectors experiencing positive growth and others experiencing negative growth in MFP, on average (figure 3.4). Over the period, Non-metallic mineral products had the highest average annual MFP growth at 1.4 per cent and Textile, clothing and other manufacturing the lowest at -1.4 per cent.

Three subsectors had MFP growth above the average for Manufacturing as a whole (figure 3.4, top panel) and five subsectors had below average growth (bottom panel). All the subsectors in the bottom panel experienced *negative* MFP growth on average over the full period. However, in most subsectors, the rate of MFP growth varied considerably over time.

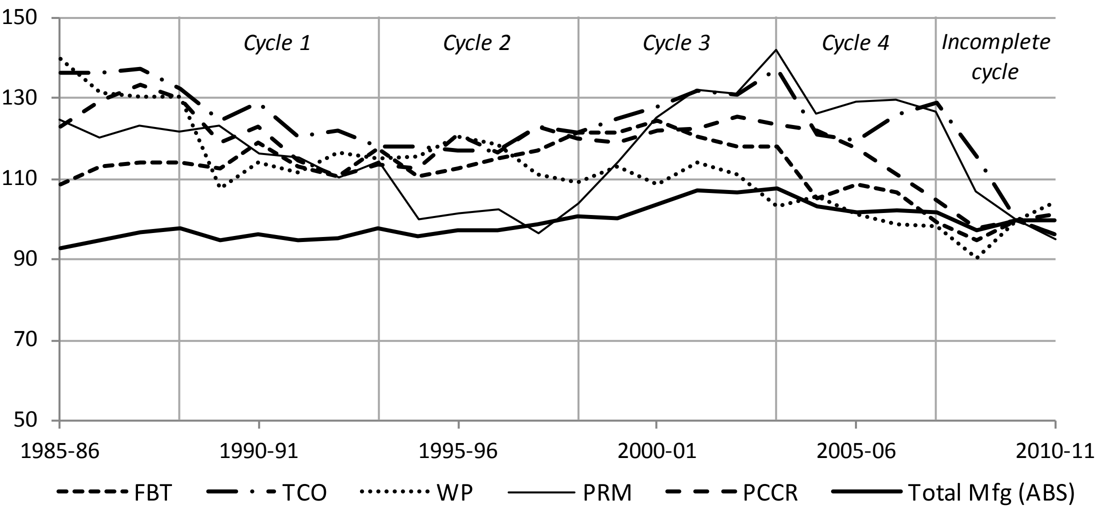
Figure 3.4 **MFP by Manufacturing subsector**[a]

Index 2009-10 = 100

Subsectors with above average MFP growth[b]



Subsectors with below average MFP growth[b]



[a] FBT is Food, beverage & tobacco products; TCO is Textile, clothing & other manufacturing; WP is Wood & paper products; PRM is Printing & recorded media; PCCR is Petroleum, coal, chemical & rubber products; NM is Non-metallic mineral products; MP is Metal products; ME is Machinery & equipment manufacturing. [b] As 2009-10 is the base year of the indexes, those subsectors with an index value below that for total Manufacturing in 1985-86 have higher average MFP growth than Manufacturing over the period 1985-86 to 2009-10 (and vice versa).

Data sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002).

MFP growth over productivity cycles

As noted in chapter 2, examining average productivity growth over cycles gives a better indication of underlying productivity performance.[5] Table 3.1 shows average annual MFP growth for the subsectors over the last four complete productivity cycles and the current incomplete cycle. (The growth rates over the incomplete cycle that are presented in this chapter should be interpreted with caution because they may be influenced by temporary factors.)

Table 3.1 **Manufacturing subsector MFP growth by cycle**
Average annual growth rate (per cent)

Subsectors	*Cycle 1: 1988-89 to 1993-94*	*Cycle 2: 1993-94 to 1998-99*	*Cycle 3: 1998-99 to 2003-04*	*Cycle 4: 2003-04 to 2007-08*	*Incomplete cycle: 2007-08 to 2010-11*
Food, beverage & tob. products	0.55	0.66	-0.53	-4.23	-1.12
Textile, clothing & other mfg	-2.27	0.53	2.53	-1.62	-9.28
Wood & paper products	-2.52	-1.00	-1.13	-1.19	1.91
Printing & recorded media	-1.28	-1.83	6.45	-2.84	-9.15
Petrol., coal, chem. & rubber	-2.64	1.13	0.57	-4.09	-1.15
Non-metallic mineral products	-2.54	0.32	6.33	4.89	-0.33
Metal products	0.97	1.05	1.44	-0.85	0.11
Machinery & equipment mfg	1.98	2.53	1.62	-0.21	0.29
Aggregate of subsectors	*-0.40*	*0.87*	*1.37*	*-1.52*	*-1.29*
Total Manufacturing (ABS)	**-0.02**	**0.59**	**1.34**	**-1.38**	**-0.79**

Sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

In most cycles, MFP growth has been quite variable across subsectors, with both positive and negative rates of growth coexisting in every cycle. In cycle 1, most of the subsectors had negative MFP growth, but three had positive MFP growth. In cycles 2 and 3, there was an improvement in MFP growth rates in most subsectors, with only two subsectors recording negative rates of MFP growth. (In each cycle, Wood and paper products had negative growth.)

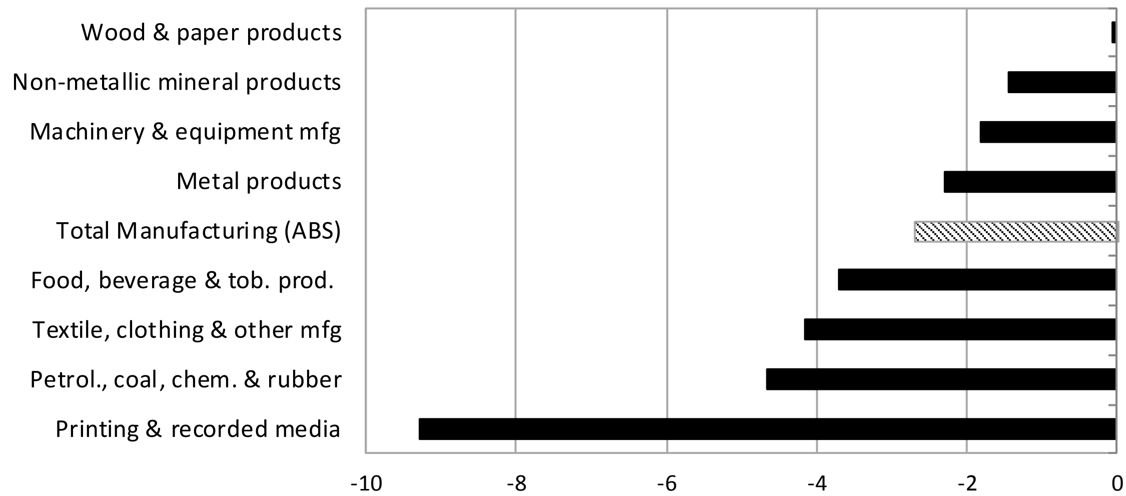
[5] The cycles used in this chapter are for Manufacturing in total (and are particularly relevant to identifying contributions of subsectors to changes in total Manufacturing over those periods). Subsector-specific cycles are examined in appendix C. These subsector-specific cycles may be a better basis on which to examine MFP growth *within* a subsector over time. However, in general, the pattern of increase/decrease in average MFP growth from cycle to cycle is not changed if subsector-specific cycles are used instead of total Manufacturing cycles (although the magnitudes of the average growth rates vary). Therefore, for simplicity, the total Manufacturing cycles are used throughout the main body of this paper. Nonetheless, there are particular implications of using industry-specific cycles for Petroleum, coal, chemical and rubber products as discussed in chapter 4.

In cycle 4, however, there was negative MFP growth in almost all the subsectors (the sole exception being Non-metallic mineral products, which was also strongly positive in cycle 3). And the rate of decline in some of the subsectors was particularly sharp. Food, beverage and tobacco products and Petroleum, coal, chemical and rubber products had MFP growth rates of around -4 per cent a year — higher rates of decline than in any of the subsectors in the previous three cycles.

In the incomplete cycle, the smaller subsectors of Textile, clothing and other manufacturing and Printing and recorded media had even sharper declines in MFP, with growth rates of around -9 per cent a year. By contrast, the larger subsectors improved their MFP growth rates, with some (such as Metal products and Machinery and equipment manufacturing) experiencing positive growth once again. For Manufacturing as a whole, the decline in MFP also became less severe.

Focusing on the most recent complete cycles, figure 3.5 shows that *between* cycles 3 and 4, MFP growth fell in all subsectors as well as for Manufacturing in total. In most subsectors, this was a fall from an average rate of MFP growth that was positive in cycle 3 to one that was negative in cycle 4.

Figure 3.5 **Change in subsector MFP growth rates between cycles 3 and 4[a]**
Percentage points



Data sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002).

LP growth over cycles

LP growth has also been quite variable across subsectors in each cycle (table 3.2). However, unlike MFP growth, LP growth remained positive in most subsectors in each cycle, supported by consistently positive capital deepening. (As noted in chapter 2, LP growth can be broken down into capital deepening and MFP growth. Capital deepening is an increase in the capital intensity of the production process.)

Table 3.2 **Manufacturing subsector LP growth by cycle**

Average annual growth rate (per cent)

Subsectors	*Cycle 1: 1988-89 to 1993-94*	*Cycle 2: 1993-94 to 1998-99*	*Cycle 3: 1998-99 to 2003-04*	*Cycle 4: 2003-04 to 2007-08*	*Incomplete cycle: 2007-08 to 2010-11*
Food, beverage & tob. products	1.97	2.11	2.12	-4.00	0.61
Textile, clothing & other mfg	-1.43	0.81	3.76	0.28	-7.82
Wood & paper products	-1.28	1.96	-1.68	2.60	5.31
Printing & recorded media	1.07	-0.83	8.26	-0.75	-9.09
Petrol., coal, chem. & rubber	0.13	2.79	2.91	-0.64	3.17
Non-metallic mineral products	0.08	2.16	7.39	5.12	4.31
Metal products	3.01	1.31	3.95	2.96	3.12
Machinery & equipment mfg	3.76	3.57	2.51	0.96	0.95
Total Manufacturing (ABS)[a]	**1.72**	**2.10**	**3.29**	**0.84**	**0.88**

a The sum of the subsector estimates is not shown as it is the same as the ABS Manufacturing estimates for LP at one decimal place.

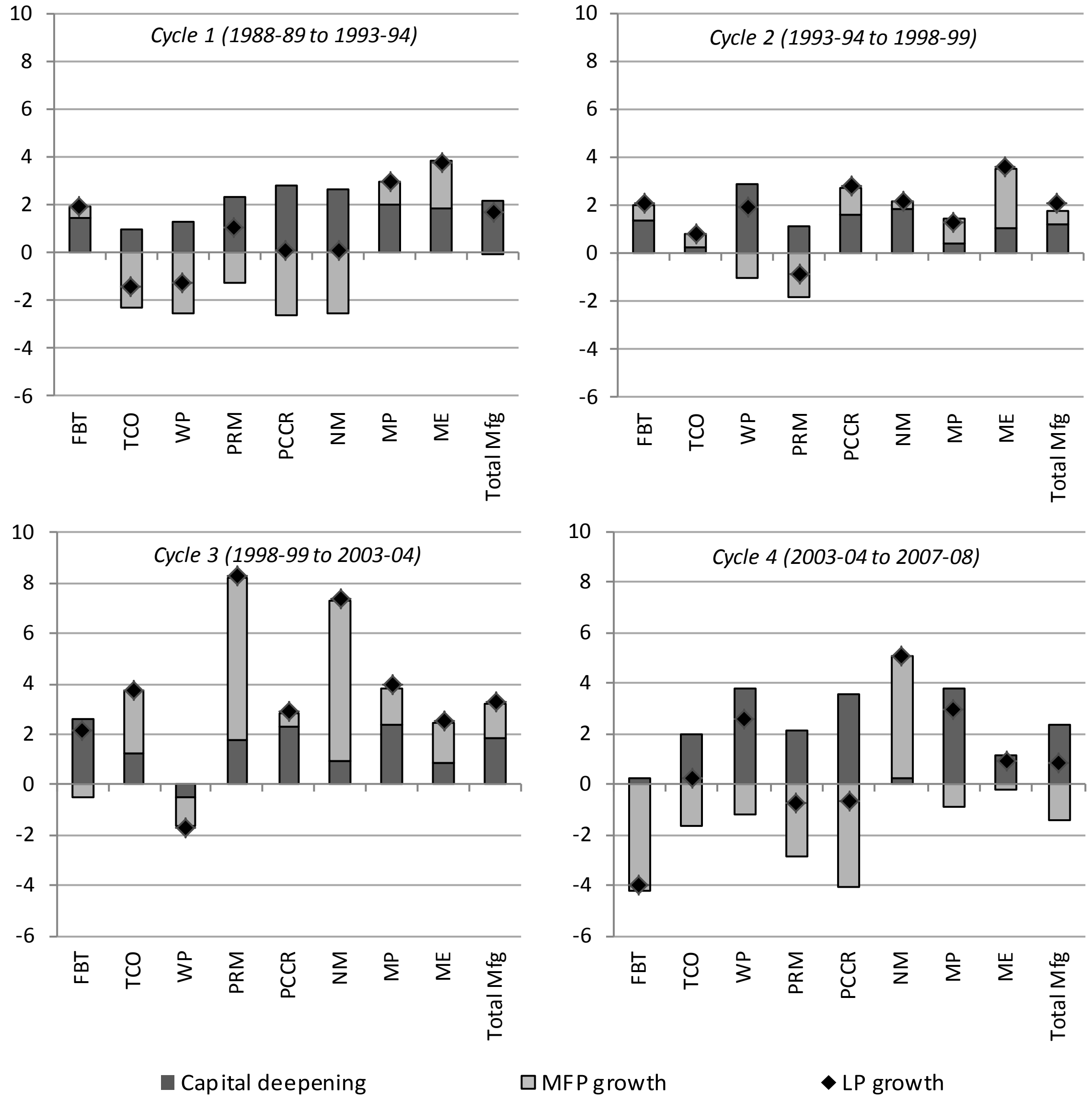
Sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002).

Figure 3.6 shows the breakdown of subsector LP growth (denoted by the diamond) into its additive component parts — MFP (pale column) and capital deepening (dark column). There were only a few cases where LP growth was negative, and this was because capital deepening was insufficient to offset negative MFP growth.

Focusing on recent cycles, Manufacturing and most subsectors experienced a decline in LP growth between cycles 3 and 4 (as was the case for MFP growth). In most subsectors, capital deepening intensified but this was more than offset by a decline in MFP growth. The exceptions were: Food, beverage and tobacco products and Non-metallic mineral products (for which the rate of capital deepening decreased rather than increased); and Wood and paper products (for which LP growth increased because capital deepening increased and MFP growth did not decline further). The relationship between growth in value added, inputs and productivity is discussed further in section 3.3.

Figure 3.6 **Breakdown of subsector[a] LP growth[b] by cycle**

Average annual growth rate (per cent)



[a] FBT is Food, beverage & tobacco products; TCO is Textile, clothing & other manufacturing; WP is Wood & paper products; PRM is Printing & recorded media; PCCR is Petroleum, coal, chemical & rubber products; NM is Non-metallic mineral products; MP is Metal products; ME is Machinery & equipment manufacturing. [b] LP growth equals the sum of MFP growth and capital deepening. Components do not sum exactly due to approximation errors arising from estimating an annualised growth rate from the start to the end year of productivity cycles and from the use of averaged weights across the cycles.

Data source: Authors' estimates.

Subsector contributions

Information on MFP growth for each of the subsectors does not indicate the contribution each subsector makes to the decline in MFP for the whole of Manufacturing. Two subsectors with the same subsector-specific MFP growth can make different percentage point contributions to Manufacturing MFP growth depending on their relative size. Table 3.3 presents estimates of the contribution made by each subsector, taking their relative size into account.

Table 3.3 **Subsector contributions to Manufacturing MFP growth by cycle**
Percentage points

Subsectors	*Cycle 1: 1988-89 to 1993-94*	*Cycle 2: 1993-94 to 1998-99*	*Cycle 3: 1998-99 to 2003-04*	*Cycle 4: 2003-04 to 2007-08*	*Incomplete cycle: 2007-08 to 2010-11*
Food, beverage & tob. products	0.08	0.16	-0.12	-0.85	-0.25
Textile, clothing & other mfg	-0.14	0.06	0.38	-0.02	-0.52
Wood & paper products	-0.21	-0.09	-0.11	-0.08	0.11
Printing & recorded media	-0.04	-0.10	0.25	-0.10	-0.37
Petrol., coal, chem. & rubber	-0.41	0.18	0.08	-0.73	-0.37
Non-metallic mineral products	-0.14	0.01	0.31	0.24	-0.04
Metal products	0.22	0.19	0.30	-0.12	-0.13
Machinery & equipment mfg	0.32	0.45	0.29	-0.04	0.08
Sum of the contributions[a]	-0.32	0.86	1.38	-1.70	-1.49
Aggregate of subsectors	*-0.40*	*0.87*	*1.37*	*-1.52*	*-1.29*
Total Manufacturing (ABS)	**-0.02**	**0.59**	**1.34**	**-1.38**	**-0.79**

[a] Using a methodology based on Parham (2012), the contribution of each subsector to Manufacturing MFP is derived by first estimating its contributions to the proximate causes (value added, capital inputs and labour inputs), and then by taking its contribution to Manufacturing value added less its contribution to total inputs (the sum of its contribution to capital and labour inputs). Due to approximation errors, there is discrepancy between the sum of the subsector MFP contributions and the aggregate of the subsector estimates of the MFP growth.

Source: Authors' estimates.

In cycle 3 (1998-99 to 2003-04) two of the smaller subsectors, Textile, clothing and other manufacturing and Non-metallic mineral products, made the largest contributions to the positive growth in Manufacturing MFP, followed by Metal products and Machinery and equipment manufacturing.

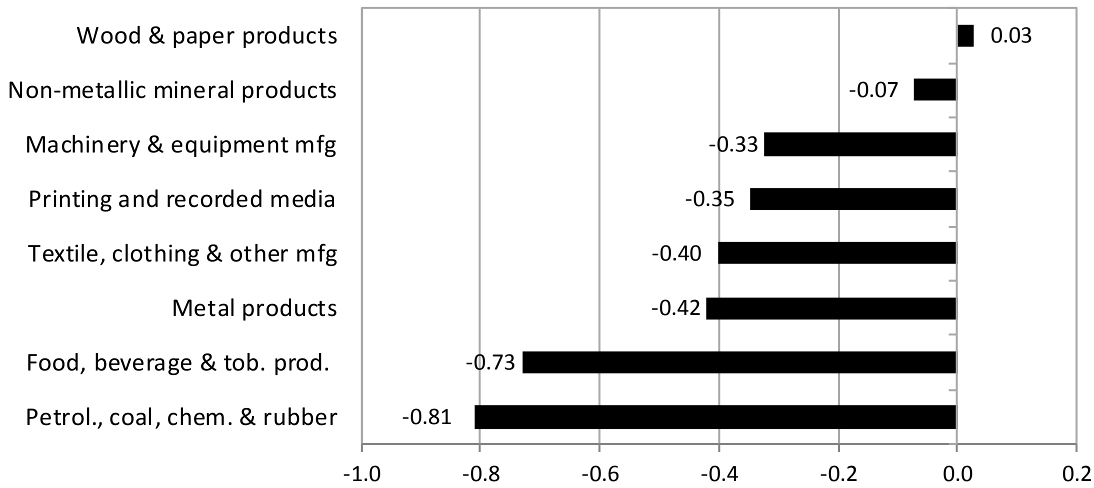
In cycle 4, where average MFP growth for Manufacturing was negative, Non-metallic mineral products was the only subsector to make a positive contribution. All other subsectors made negative MFP contributions, with Food, beverage and tobacco products, Petroleum, coal, chemical and rubber products and Metal products making the larger contributions to the decline.

Focusing on the change between cycles 3 and 4, all but one of the subsectors made a negative contribution to the decline in MFP for Manufacturing as a whole (figure 3.7). Petroleum, coal, chemical and rubber products, Food, beverage and tobacco products and Metal products were the most significant contributors to the

MFP decline in cycle 4. Collectively, they accounted for almost two thirds of the decline in Manufacturing MFP between the last two complete cycles.[6]

Petroleum, coal, chemical and rubber products and Food, beverage and tobacco products made large contributions principally because of poor performance in cycle 4, rather than falling from a strong performance in cycle 3. This is in contrast to the third largest contributor, Metal products, which had strong productivity performance in cycle 3, followed by a sharp decline in cycle 4.

Figure 3.7 **Subsector contributions to the change in Manufacturing MFP growth between cycles 3 and 4**
Percentage points



Data source: Authors' estimates.

The contribution of a subsector to the change in Manufacturing MFP growth is a combination of the change in its MFP growth and the change in its relative size (the latter reflecting changes in the subsector composition of the Manufacturing sector). Between cycles 3 and 4, however, change in the composition of Manufacturing between subsectors[7] made little contribution to the change in Manufacturing MFP, accounting for only 0.04 of a percentage point of the decline in total Manufacturing MFP (box D.1).

6 This is based on the contribution of the three subsectors, as a share of the sum of the estimated contributions for all eight subsectors, not of the ABS estimate for Manufacturing in total.

7 This does not indicate whether or not change in the composition of manufacturing activities *within* individual subsectors contributed to the change in MFP for Manufacturing in total. The effect of change in the composition of a subsector is captured in the measure of MFP growth for that subsector.

3.3 Proximate causes of subsector MFP growth

The Manufacturing subsectors have had different sources of positive and negative MFP growth over time. Table 3.4 shows growth in each of the proximate causes and MFP by subsector in cycles 3 and 4 and in the incomplete cycle.

In cycle 3, most subsectors had positive MFP growth through positive value added growth and labour shedding that offset positive growth in capital inputs. In cycle 4, the negative MFP growth in most subsectors was associated with low or negative value added growth in the face of strong growth in capital inputs, and, for some subsectors, positive growth in labour inputs. Some subsectors did experience a contraction in labour inputs, but this was generally to a lesser extent than in cycle 3.

In the incomplete cycle, there were mixed results for subsector MFP. Value added contracted in even more subsectors and capital continued to grow in all subsectors. But there was an offsetting fall in labour inputs in some subsectors. While some of the smaller subsectors experienced a sharp MFP decline, in other subsectors the MFP decline slowed or there was a return to positive rates of growth.

To relate these subsector-specific trends in proximate causes back to the whole of Manufacturing, figure 3.8 shows the *contributions* of each of the subsectors to the change in value added, labour and capital inputs for Manufacturing in total between the last two complete cycles.[8] While most subsectors contributed to the Manufacturing MFP decline through declines in value added growth, their contributions to the increase in capital and labour inputs were more concentrated.

- Most subsectors contributed between 0.2 to 0.4 of a percentage point to the decline in value added growth. These negative contributions were offset, to some extent, by a large positive contribution from Metal products (0.7 of a percentage point).
- Metal products and Petroleum, coal, chemical and rubber products made by far the largest contributions to the capital input surge between cycles 3 and 4. Food, beverage and tobacco products made a small negative contribution, but this largely offset the small positive contributions of the remaining subsectors.
- In terms of labour inputs growth, the spread of the subsector contributions was slightly wider, but still dominated by the larger positive contributions (from Food, beverage and tobacco products and Metal products), and a sizable, offsetting negative contribution from Wood and paper products.

8 The change between cycle 4 and the incomplete cycle is discussed in appendix D.

Table 3.4 **Proximate causes of subsector MFP growth by cycle**
Average annual growth rate (per cent)

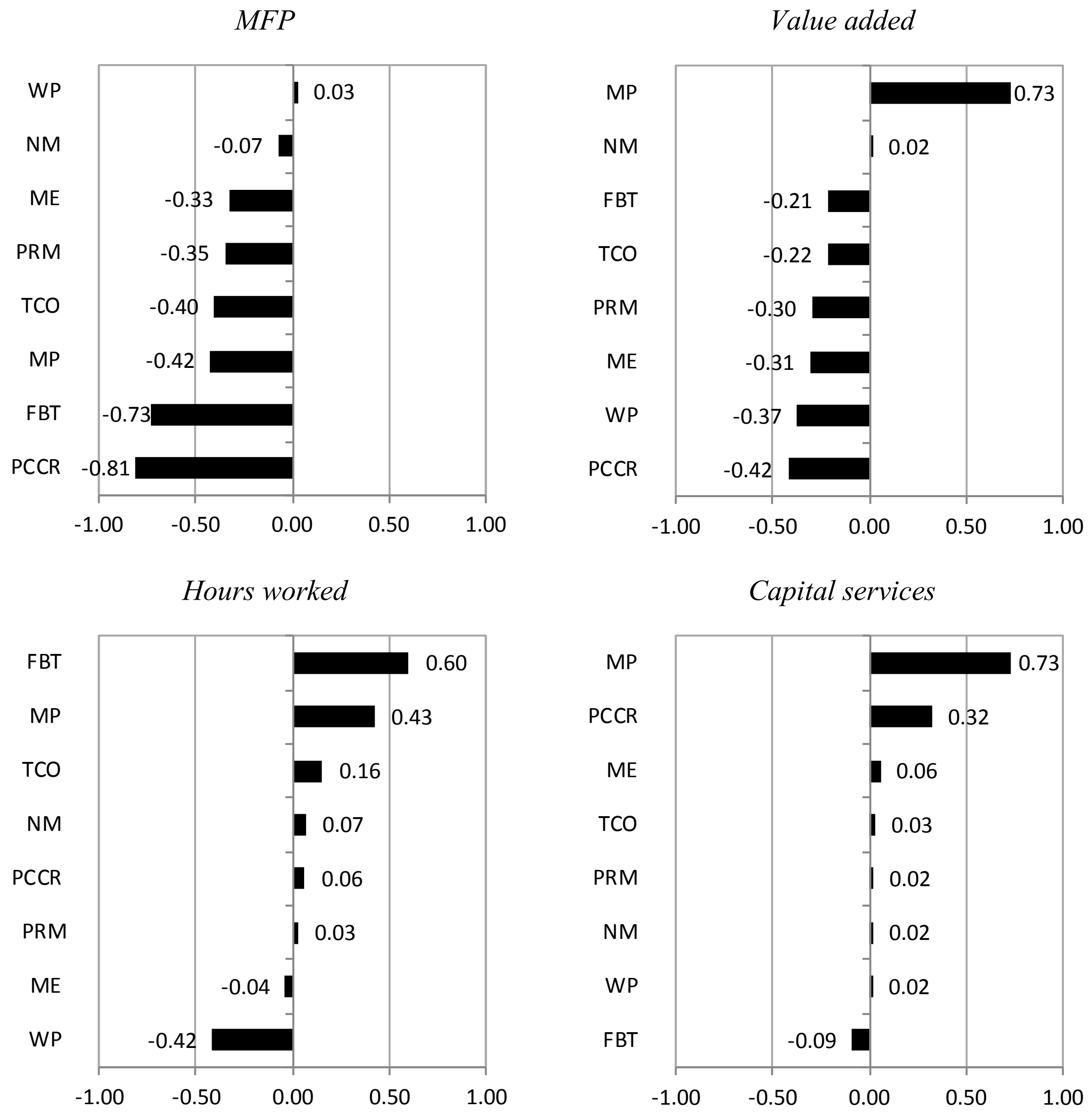
Subsectors	*Value added*	*Capital services*[a]	*Hours worked*[a]	*MFP*[b]
Cycle 3 (1998-99 to 2003-04)				
Food, beverage & tob. products	1.25	2.33	-0.53	-0.53
Textile, clothing & other mfg	-1.87	0.07	-4.35	2.53
Wood & paper products	2.27	1.28	2.14	-1.13
Printing & recorded media	6.25	1.18	-1.36	6.45
Petrol., coal, chem. & rubber	1.79	1.75	-0.52	0.57
Non-metallic mineral products	5.19	0.05	-1.12	6.33
Metal products	1.25	1.30	-1.47	1.44
Machinery & equipment mfg	3.58	1.14	0.79	1.62
Aggregate of subsectors	*2.02*	*1.41*	*-0.76*	*1.37*
Total Manufacturing (ABS)	**2.03**	**1.41**	**-0.72**	**1.34**
Cycle 4 (2003-04 to 2007-08)				
Food, beverage & tob. products	0.25	2.05	2.57	-4.23
Textile, clothing & other mfg	-4.61	0.54	-3.56	-1.62
Wood & paper products	-2.41	1.71	-2.89	-1.19
Printing & recorded media	-1.87	1.76	-0.75	-2.84
Petrol., coal, chem. & rubber	-0.63	3.65	-0.04	-4.09
Non-metallic mineral products	5.65	0.42	0.30	4.89
Metal products	4.50	4.61	0.76	-0.85
Machinery & equipment mfg	1.72	1.39	0.53	-0.21
Aggregate of subsectors	*1.07*	*2.50*	*0.13*	*-1.52*
Total Manufacturing (ABS)	**1.08**	**2.38**	**0.15**	**-1.38**
Incomplete cycle (2007-08 to 2010-11)				
Food, beverage & tob. products	0.68	1.79	0.04	-1.12
Textile, clothing & other mfg	-11.86	0.12	-2.95	-9.28
Wood & paper products	-2.13	0.45	-4.39	1.91
Printing & recorded media	-7.48	0.67	1.16	-9.15
Petrol., coal, chem. & rubber	-2.25	1.63	-2.71	-1.15
Non-metallic mineral products	-1.83	1.93	-3.37	-0.33
Metal products	0.33	1.64	-1.39	0.11
Machinery & equipment mfg	-0.60	0.17	-1.05	0.29
Aggregate of subsectors	*-1.56*	*1.18*	*-1.44*	*-1.29*
Total Manufacturing (ABS)	**-1.58**	**0.70**	**-1.47**	**-0.79**

[a] Capital services and hours worked weighted by income shares. [b] Growth in value added less growth in hours worked and capital services do not add exactly to MFP growth due to approximation errors.

Sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002).

Figure 3.8 Subsector[a] contributions to the change in Manufacturing MFP growth and its proximate causes between cycles 3 and 4

Percentage points



[a] FBT is Food, beverage & tobacco products; ME is Machinery & equipment manufacturing; MP is Metal products; NM is Non-metallic mineral products; PCCR is Petroleum, coal, chemical and rubber products; PRM is Printing & recorded media; TCO is Textile, clothing & other manufacturing; WP is Wood & paper products.

Data source: Authors' estimates.

3.4 Selection of subsectors for detailed analysis

Based on the above MFP estimates, the subsectors selected for detailed analysis in the remainder of the paper (chapters 4–6) are: Petroleum, coal, chemical and rubber products; Food, beverage and tobacco products and Metal products. (A brief discussion of the other subsectors is provided in appendix D.)

These three subsectors have been selected because they made the largest contributions to the decline in MFP for Manufacturing in total between the last two complete productivity cycles. Together, they accounted for almost two-thirds of the decline of 2.7 percentage points in Manufacturing MFP between cycles.[9]

Also, these subsectors contributed the majority of value added, hours worked and investment in Manufacturing. In 2009-10, Food, beverage and tobacco products, Petroleum, coal, chemical and rubber products and Metal products together accounted for around 60 per cent of value added, half of hours worked and two-thirds of investment for Manufacturing as a whole. The quality of the estimates for these subsectors is also likely to be better than for some of the other subsectors, because they are relatively unaffected by industry classification changes and related data issues.[10]

The above analysis shows that there is a range of different proximate causes for the contribution of these three subsectors to the aggregate MFP decline.

- The decline in the contribution of Food, beverage and tobacco products was related to some slowing in value added growth, much higher labour growth and fairly static capital growth.
- Petroleum, coal, chemical and rubber products had a large decline in value added growth (with an absolute decline in value added in the last complete cycle), along with moderate growth in capital and slight growth in labour.
- Metal products was quite different with very high value added growth, even larger capital growth (which accounted for the majority of capital growth for the entire Manufacturing sector), and an increase in labour growth.

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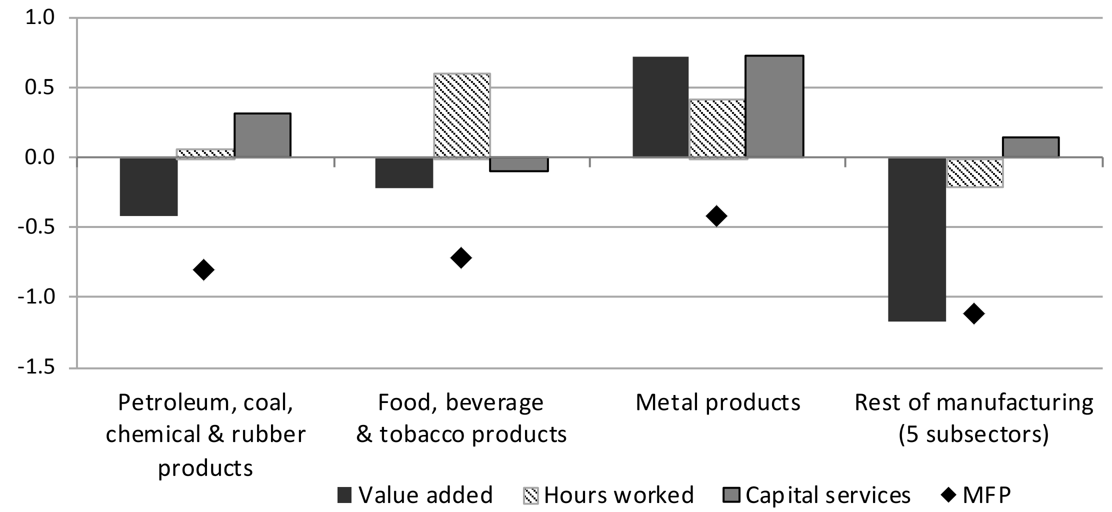
9 Calculated as the share of the sum of the subsector MFP contributions, which due to approximation error will differ from the aggregate of the subsector estimates of the MFP growth (table 3.3).

10 For example, Textile, clothing and other manufacturing and Printing and recorded media are more affected by industry classification changes and the grouping of industry subdivisions.

This is summarised in figure 3.9, which shows the percentage point contributions of these three subsectors to the change in total Manufacturing value added, inputs and MFP between cycles 3 and 4. The figure also shows that the rest of Manufacturing in aggregate contributed to the MFP decline through a slowdown in value added growth.

Figure 3.9 **Main subsectors contributing to change in the proximate causes of Manufacturing MFP growth between cycles 3 and 4**
Percentage points



Data source: Authors' estimates.

There is also a wide range of possible influences on productivity in these three subsectors. Some of these influences are explored for each of these subsectors in the following chapters.

4 Productivity in Petroleum, coal, chemical and rubber products

Multifactor productivity (MFP) growth in the Petroleum, coal, chemical and rubber products (PCCR) subsector of Manufacturing declined significantly between cycle 3 (1998-99 to 2003-04) and cycle 4 (2003-04 to 2007-08) — with the subsector making the largest negative contribution of any subsector to the overall decline in Manufacturing MFP. The decline in PCCR MFP was driven by a decline in the absolute level of value added (VA) coinciding with a strong growth in inputs, particularly capital.

This chapter examines the structure and characteristics of the PCCR subsector before detailing the pattern and factors that are likely to have influenced its MFP growth.

4.1 PCCR subsector structure and characteristics

The PCCR subsector consists of three *Australian and New Zealand Standard Industry Classification* (ANZSIC06) subdivisions: Petroleum and coal product manufacturing ('Petroleum'), Basic chemical and chemical product manufacturing ('Chemicals'), and Polymer product and rubber product manufacturing ('Polymers'). The primary activities within each of these subdivisions are summarised in table 4.1.

Table 4.1 **Activities within the Petroleum, coal, chemical and rubber products subsector**

Subdivision	*Primary activities*
Petroleum and coal product manufacturing	Includes the refining of crude oils into petroleum, diesel, liquefied petroleum gas and other fuels. Also includes the production of some oils and coke products.
Basic chemical and chemical product manufacturing	Includes the production of basic chemicals and simple polymers, as well as the manufacture of fertilisers, pesticides, pharmaceuticals, cleaning products, cosmetics and explosives.
Polymer product and rubber product manufacturing	Includes the production of polymer film and sheet packaging material, rigid and semi-rigid polymers, tyres, adhesives, paints, hoses and rubber products.

Source: ABS (*Australian and New Zealand Standard Industrial Classification, 2006,* Cat. no. 1292.0).

PCCR produces both intermediate inputs to other parts of the economy, as well as finished goods for final consumption. For example, Petroleum products are used as: inputs by chemical and polymer product manufacturers; inputs to the transport sector; and finished goods supplied by the retail sector for household consumption. Chemical manufacturers supply fertilisers to agriculture, explosives to mining and construction, and pharmaceutical products to retailers. Polymer manufacturers produce mainly packaging and finished products for sale.

PCCR is one of the larger subsectors within Manufacturing. PCCR was 17 per cent of Manufacturing VA in 2009-10, as well as 10 per cent of hours worked and 19 per cent of gross fixed capital formation (GFCF).

Relative sizes of the PCCR subdivisions

Chemical manufacturing is the largest part of PCCR in terms of VA, hours worked and investment. Petroleum manufacturing is the smallest in terms of VA and hours worked, while Polymer manufacturing is smallest in terms of investment (table 4.2).

Table 4.2 **Composition of PCCR, 2009-10**

Percentage shares of PCCR

ANZSIC06 subdivision/group[a]	*Value added*	*Hours worked*	*Investment*[b]
17 Petroleum and coal product manufacturing[c]	**8.9**	**7.1**	**22.8**
18 Basic chemical and chemical product mfg	**51.7**	**54.2**	**58.5**
181 Basic chemical manufacturing	11.1		
182 Basic polymer manufacturing	5.0		
183 Fertiliser and pesticide manufacturing	5.8		
184 Pharmaceutical and medicinal product mfg	18.7		
185 Cleaning compound and toiletry prep'n mfg	6.4		
189 Other basic chemical product manufacturing	4.7		
19 Polymer product and rubber product mfg	**39.4**	**38.7**	**18.7**
191 Polymer product manufacturing	37.1		
192 Natural rubber product manufacturing	2.3		

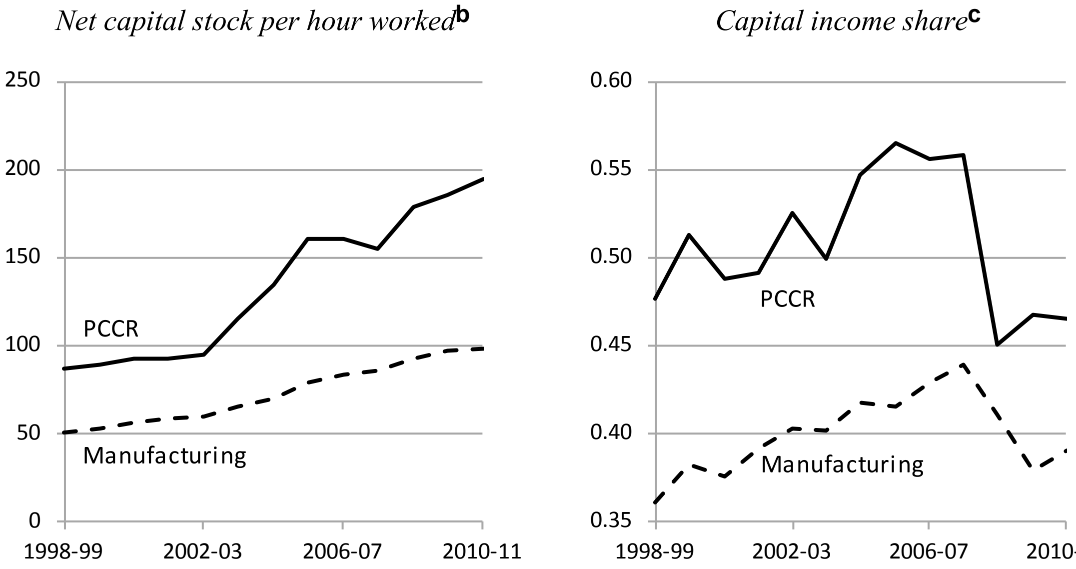
[a] Detailed disaggregation not available for hours worked and investment. [b] Private new capital expenditure. [c] There is only one ANZSIC group in Petroleum and coal product manufacturing.

Sources: ABS (*Experimental Estimates for the Manufacturing Industry, 2009-10,* Cat. no. 8159.0); ABS (unpublished Labour Force Survey data); ABS (*Private New Capital Expenditure and Expected Expenditure, Australia, June 2011*, Cat. no. 5625.0).

PCCR is a capital intensive subsector

An important characteristic of PCCR is that it is the most capital-intensive subsector within Manufacturing, both in terms of the share of income that accrues to capital and in terms of the volume of real net capital stock per hour worked (figure 4.1). This means that PCCR's MFP growth is particularly sensitive to growth in capital inputs (relative to labour inputs).[1] This observation is relevant for cycles 3 and 4, when the capital share of income within the sector was even higher than previously.

Figure 4.1 **Measures of capital intensity for PCCR[a]**



[a] Aggregate Manufacturing series presented here are those derived by the authors (appendix A). [b] 2009-10 dollars. [c] On a VA basis and includes some taxes attributable to capital (appendix A).

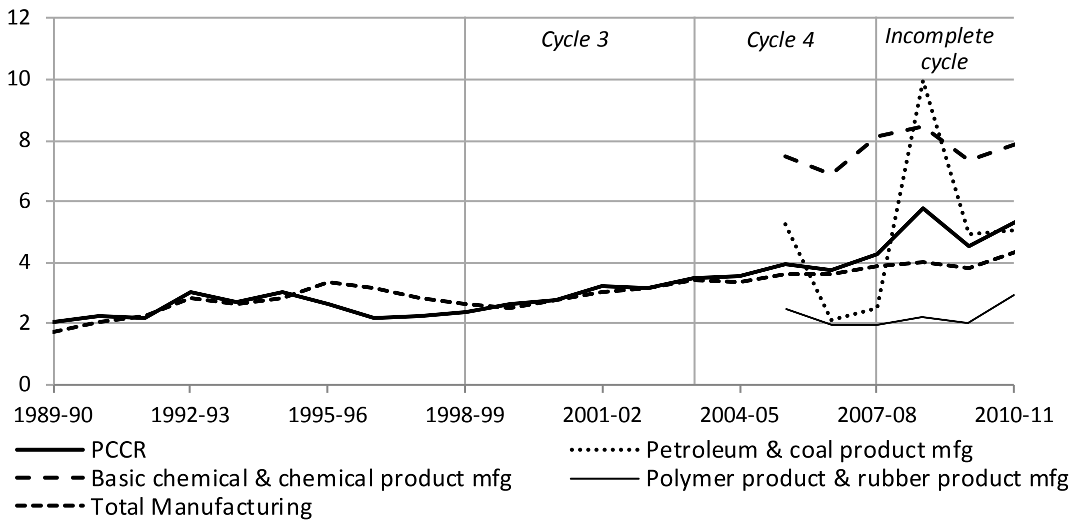
Data sources: Authors' estimates based on ABS (*Australian Industry,* various issues, Cat. no 8155.0); ABS (*Australian Manufacturing,* various issues, Cat. no. 8221.0); ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0); and ABS (unpublished Labour Force Survey data).

1 For example, for a given rate of VA growth, a 1 per cent growth in capital services would have a greater effect on MFP growth than a 1 per cent growth in hours worked.

Parts of PCCR are R&D intensive

PCCR has a similar research and development (R&D) intensity to Manufacturing on average, but the intensity varies markedly across subdivisions (figure 4.2). Chemicals has the highest intensity, mainly driven by the R&D-intensive nature of pharmaceuticals, while Polymers has the lowest within the subsector.

Figure 4.2 **R&D intensity[a] for PCCR and constituent subdivisions**
Per cent



[a] Total R&D expenditure (current and capital expenditure) as a percentage of industry VA.

Data sources: Authors' estimates based on ABS (*Research and Experimental Development, Businesses, Australia, 2010-11*, various issues, Cat. no. 8104.0); ABS (*Australian Manufacturing*, various issues, Cat. no. 8221.0); and ABS (*Australian Industry,* various issues, Cat. no. 8155.0).

One of the underlying drivers of productivity growth, as discussed in chapter 2, is innovation effort, of which R&D intensity is an indicator. However, as seen in the chart above, the relative stability of PCCR R&D intensity would tend to suggest that changes in R&D activity are not behind the decline in MFP for the subsector in aggregate over the last two complete productivity cycles.

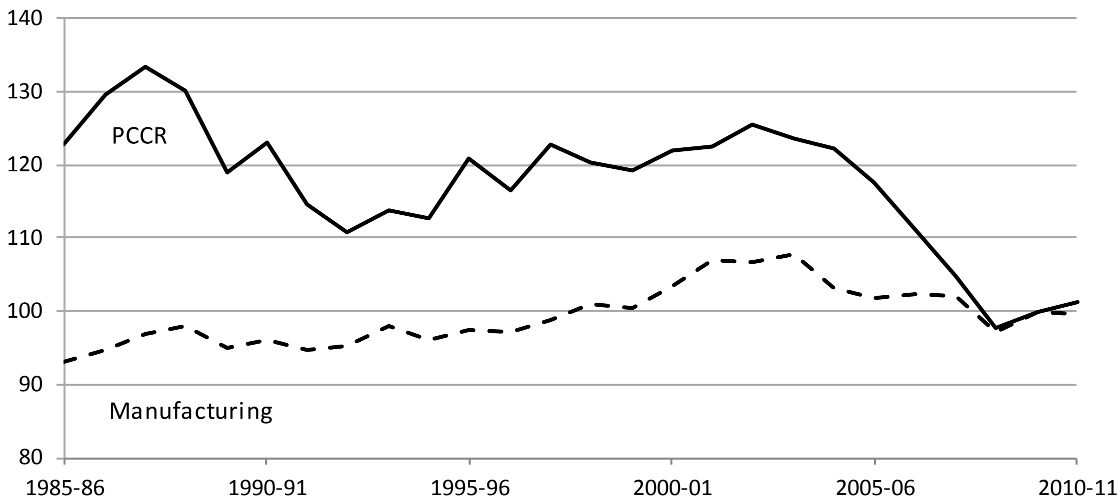
A closer look at the trends in PCCR MFP and the drivers of the proximate causes from an individual subdivision point of view is necessary to explain this performance.

4.2 PCCR's MFP growth and its proximate causes

The average rate of PCCR MFP growth between 1985-86 and 2010-11 was -0.8 per cent a year. MFP growth in PCCR was quite volatile up to the beginning of cycle 4 (2003-04), but then declined sharply at a rate greater than that of total Manufacturing (figure 4.3). It was this decline that made a significant contribution to the poor MFP performance of Manufacturing in cycle 4.

Figure 4.3 **PCCR and Manufacturing MFP**

Index 2009-10 = 100



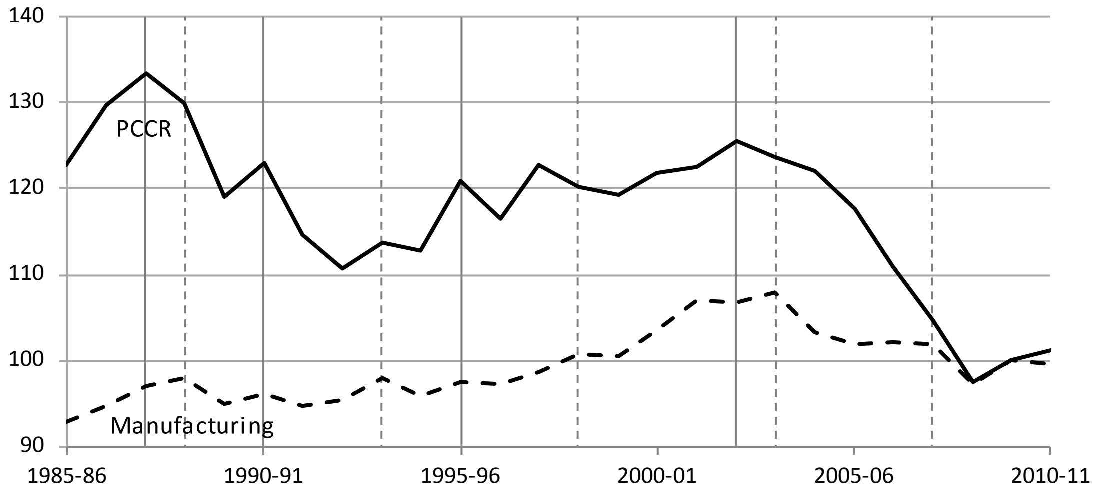
Data sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002).

For the purposes of identifying the contribution of a subsector to MFP for Manufacturing as a whole, the productivity cycles for Manufacturing in aggregate are used. However, it is worth noting that there are significant differences between PCCR cycles and those for Manufacturing (box 4.1).

Box 4.1 **Manufacturing productivity cycles and PCCR**

When examining the contribution of a subsector to total Manufacturing productivity performance it is reasonable to do this over the productivity cycles identified for the Manufacturing sector as a whole. However, individual subsectors may have different cycles, so it is also useful to consider the subsector-specific cycles when looking at subsector productivity performance over time.

MFP for PCCR and Manufacturing, alternative cycles
Index 2009-10 = 100. Solid vertical lines denote PCCR cycles and dotted vertical lines denote aggregate Manufacturing cycles.



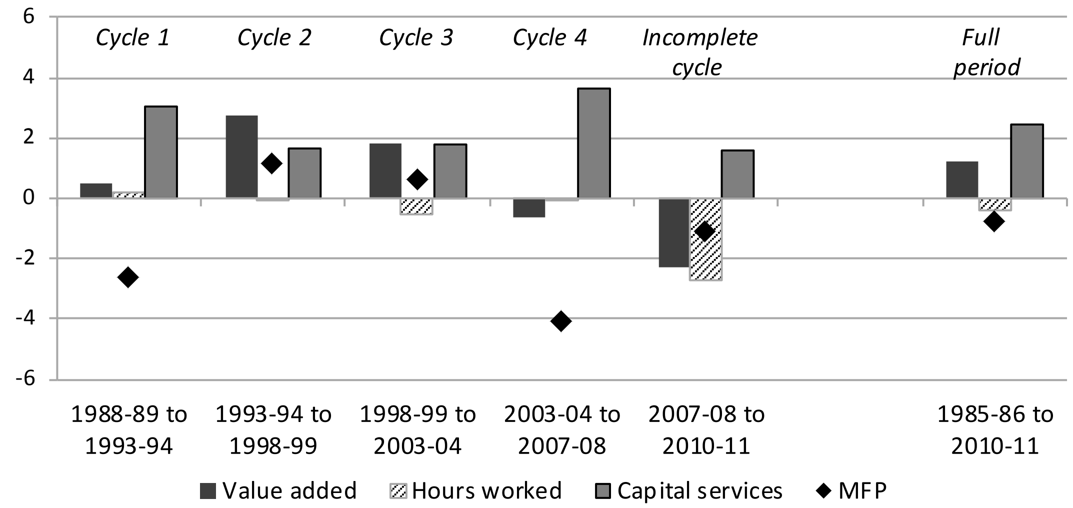
Data sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

None of the cycles identified for PCCR coincide with those for Manufacturing in aggregate (appendix C). Some cycle peak years for PCCR are close to those for Manufacturing (as shown in the figure). However, it is particularly notable that PCCR has no identifiable cycles after 2002-03 (compared with Manufacturing which has a cycle from 2003-04 to 2007-08). This is due to the steady decline of PCCR MFP to 2008-09, before a slight increase to 2010-11 (which is still insufficient to identify the end of a cycle).

The use of either set of cycles demonstrates a significant decline in MFP growth in PCCR in the period starting around 2003-04. For simplicity the Manufacturing cycles are used throughout the main body of this paper.

As for Manufacturing as a whole, MFP growth in PCCR for each cycle can be broken down into growth of the volumes of VA, hours worked and capital services. Examining these 'proximate causes' of MFP makes it easier to understand whether it was output growth, input growth or a combination of the two that drove the productivity trends in each cycle. Movements in PCCR MFP have largely been driven by changes in the rate of VA and capital services growth (with the exception of the incomplete productivity cycle) (figure 4.4). However, the scale and significance of these changes have varied considerably through time over the cycles.

Figure 4.4 **Growth in PCCR MFP and its proximate causes[a] by cycle**
Average annual growth rate (per cent)



[a] Capital services and hours worked weighted by income shares.

Data source: Authors' estimates.

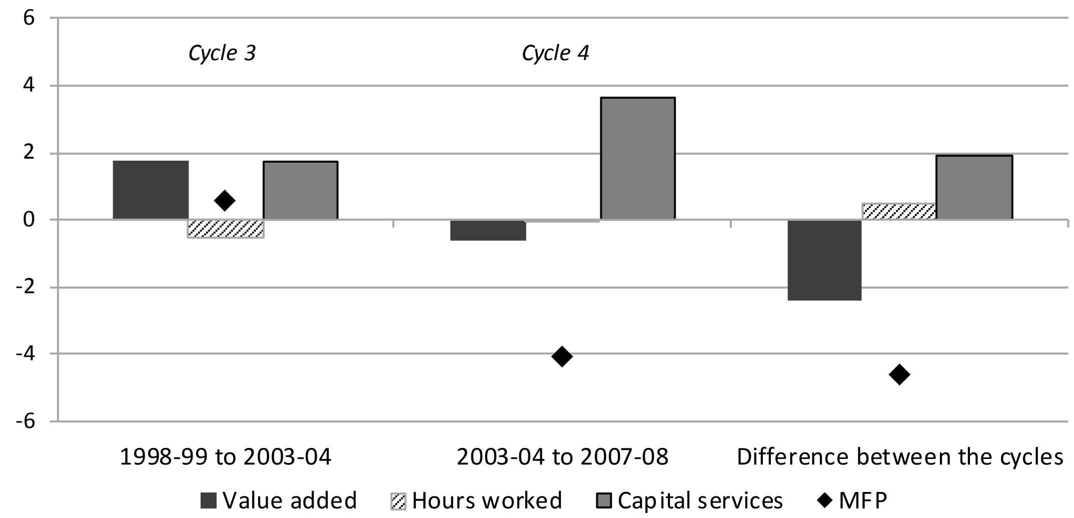
- Over cycle 1, negative MFP growth was associated with low VA growth and high capital growth.
- During cycle 2, there was a return to positive MFP growth as VA growth increased significantly and exceeded combined input growth (which, again, was almost entirely capital services growth).
- In cycle 3, MFP growth continued, although at a lower rate than in cycle 2. While VA growth was slower than in the preceding cycle, VA growth still exceeded growth in combined inputs.
- In cycle 4, MFP growth was strongly negative as a result of an absolute decline in VA and strong capital services growth.
- Over the current incomplete cycle, MFP growth has been negative, but to a lesser extent than over cycle 4. The pattern of change in the proximate causes is much different. There has been a much larger decline in VA. And while there has been an even stronger decline in hours worked, capital services growth has continued (although at a lower rate, just below the long-run average).

Significantly for this subsector, growth of capital services has been consistently positive (exceeding 1.5 per cent a year for the first three cycles), and it was particularly strong in cycle 4 (up to 3.8 per cent a year). Increases in capital services were sustained by strong investment in all cycles. At the same time, hours worked did not change substantially until the incomplete cycle. As a consequence, PCCR has become more capital-intensive (figure 4.5).

As discussed in chapter 1, the focus of this paper is on explaining the decline in average MFP growth between cycles 3 and 4. Figure 4.5 shows that, for PCCR, large changes (of opposite signs) in VA and capital services between these last two complete cycles accounted for around 90 per cent of that decline. The remainder of the chapter discusses influences that might underlie these large changes.

Figure 4.5 **Growth in PCCR MFP and its proximate causes[a] in cycles 3 and 4**

Average annual growth rate (per cent)



[a] Capital services and hours worked weighted by income shares.

Data source: Authors' estimates.

4.3 Influences on PCCR's MFP growth

Understanding why there has been a decline in VA and strong growth in capital services from cycle 3 to cycle 4 is key to explaining the poor MFP growth in PCCR.[2] As becomes clear below, however, it is difficult to provide a comprehensive picture of the contributions of different parts of PCCR to its overall trends in VA and capital.

2 The growth in the rate of hours worked also contributed to the faster input growth, but to a much smaller degree. Accordingly, it is not examined in as much detail as the trends in VA and capital.

Value added

VA in PCCR declined from cycle 3 to cycle 4 (VA growth having been positive in the former and negative in the latter).[3] The data that are available suggest that this was due in large part to a decline in the VA of Petroleum, while the VA in Chemicals and Polymers continued to grow, but at a slower rate (see box 4.2 regarding data limitations). However, parts of PCCR, such as paints and pharmaceuticals, experienced growth in output between cycles, but this growth was nowhere near strong enough to offset the decline in the rest of the subsector.

Box 4.2 **Limitations of VA data for PCCR**

Data on real VA for the PCCR subdivisions are not available from the ABS National Accounts. Accordingly, an alternative indicator must be used to identify which parts of PCCR drove the decline in VA between cycles 3 and 4. (A comparison of available indicators is presented in appendix F.)

The best available indicator of real VA growth at the subdivision level is real 'sales and service income' (although it will differ from real VA where there is a difference in the trend in the volume of intermediate inputs used). This matches fairly closely to the PCCR trend in real VA. Real sales and service income fell between cycles for each of the three PCCR subdivisions, with the strongest decline occurring in Petroleum and coal products and the smallest decline in Basic chemical and chemical products.

Growth in VA compared with growth in sales and service income
Average annual growth rate (per cent)

	Cycle 3	*Cycle 4*	*Incomplete cycle*
PCCR VA (real)[a]	**1.8**	**-0.6**	**-2.3**
Real sales and service income			
Petroleum and coal product mfg	-4.9	-9.8	-2.0
Basic chemical and chemical product mfg	9.0	7.0	0.6
Polymer product and rubber product mfg	7.0	2.6	-10.3
Sum of subdivisions	***1.9***	***-1.7***	***-2.5***

[a] National accounts data.

Sources: ABS (*Australian System of National Accounts, 2010-11,* Cat. no. 5204.0); ABS (*Business Indicators, Australia, June 2011,* Cat. no. 5676.0).

3 VA is gross output less intermediate inputs used in producing that output. Intermediate inputs are the inputs used by the business other than capital and labour — for example, energy, raw materials and services. The volume of VA refers to VA with the effect of price changes removed.

Petroleum-specific issues

Two issues specific to petroleum refining are likely to have contributed to the PCCR VA decline over cycle 4. The first is a trend towards importing a greater volume of refined fuel from overseas rather than refining crude oil domestically — a trend that reduces the amount of domestic value adding. The second is related to higher standards for clean fuels — VA is likely to be understated as the improvements in fuel quality are not fully measured.

Greater imports of refined fuel

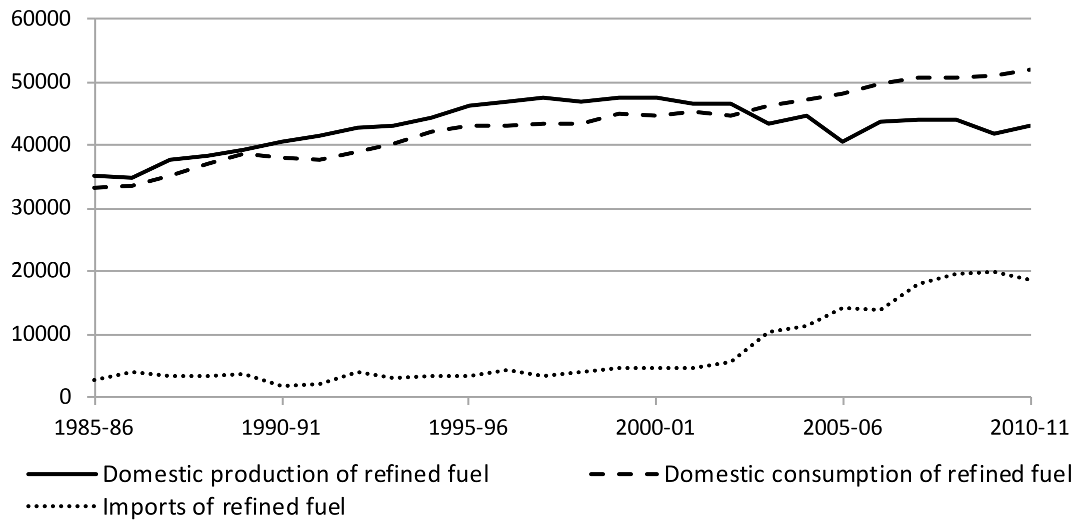
Domestic demand for fuel increased over cycle 4, but this demand was increasingly met from imported fuel. There were a number of supply- and demand-related reasons for this.

- The supply of crude from domestic oilfields was declining (ABARE 2008), requiring greater imports of crude oil and refined fuel.
- There was an increase in the supply of refined fuel available from Asian refineries (AIP 2011).
- Domestic refineries were built to process the domestic feedstock, which is typically of higher quality than imported crude oil (ACIL Tasman 2008).
  - Some imported refined fuels were produced overseas using crude oil that Australian refineries would be unable to process (HoRSCE 2013, p. 20).
  - Nonetheless, some refineries made capital expenditure in order to process imported crudes (AIP 2011).
- A change in the mix of demand, with greater growth in demand for diesel fuel over gasoline; given that Australian refineries focus on producing gasoline (HoRSCE 2013, p. 15).
- There was no incentive for domestic refiners to expand capacity, as doing so would not enable them to achieve economies of scale (HoRSCE 2013, p. 18), like those of larger refineries in the region.

The greatest VA per unit of refined output comes from refining domestically-sourced crude, which Australian refineries were designed to process. Fuel refined from imported crude involves less value adding, as more inputs are required to process the different feedstock type. Blending of imported refined fuel requires the least amount of value adding by domestic refiners, as the fuel is already refined and may only require small amounts of blending to meet Australian fuel requirements. A greater share of imports, therefore, results in a greater share of lower value adding activity.

Figure 4.6 shows the physical volume of output for domestic refining, as well as imports and domestic consumption of refined fuels. A proportion of these imports is also counted as part of domestic refining as a result of the domestic blending process. The data show the rise in imports and domestic consumption, with domestic refining falling slightly over cycle 4 (even including the blended imports).

Figure 4.6 **Production, consumption and imports of refined fuels[a]**
Megalitres

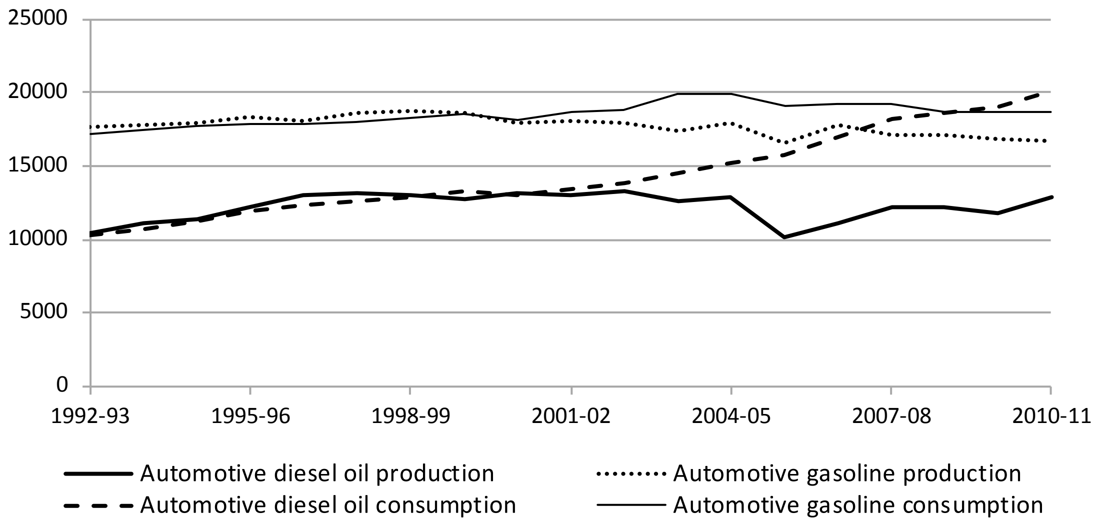


a Some domestically produced refined fuel is exported, so the sum of domestic production and imports is greater than domestic consumption. Also, blending of some imported refined fuel is counted as domestic refined production.

Data source: BREE (2012a).

The sudden rise in imports at the beginning of cycle 4 has much to do with the changing mix of demand, particularly a greater demand for diesel fuel, and, to a lesser extent, aviation fuel. This growth in demand for diesel occurred due to strong economic growth, an increase in the sales of vehicles fitted with diesel engines (ABS 2008b), and the intensive use of diesel by the mining industry (AIP 2013). Figure 4.7 illustrates the growth in diesel consumption relative to gasoline.

Figure 4.7 **Australian production and consumption of diesel and gasoline**
Megalitres



Data source: BREE (2012a).

While output volume has remained steady, VA has fallen as the intermediate inputs used in the production of petroleum have increased. Relatively speaking, more refined fuel rather than crude inputs are being used to supply domestic consumption. As a result, the amount of value-adding per unit of output falls, as there is less refining to be done.

Mismeasurement of cleaner fuels

A significant change in the operating environment for petroleum refining was the introduction of the Commonwealth Government's *Cleaner Fuels* program — a policy designed to tighten fuel standards to reduce harmful environmental pollutants.[4]

The resultant environmental outcomes are not completely taken account of in the volume of output data.[5] Not including improvements in fuel quality in the measured output data may mean that the VA growth in Petroleum refining is underestimated.[6]

4 The program necessitated a greater volume of investment to adapt Australia's existing refineries to comply with the new fuel standards. This is discussed in greater detail in the capital section.

5 While the ABS data makes adjustments to deflators in order to account for changes in fuel quality such as energy content, they do not adjust for improvements in environmental quality (ABS 2006a).

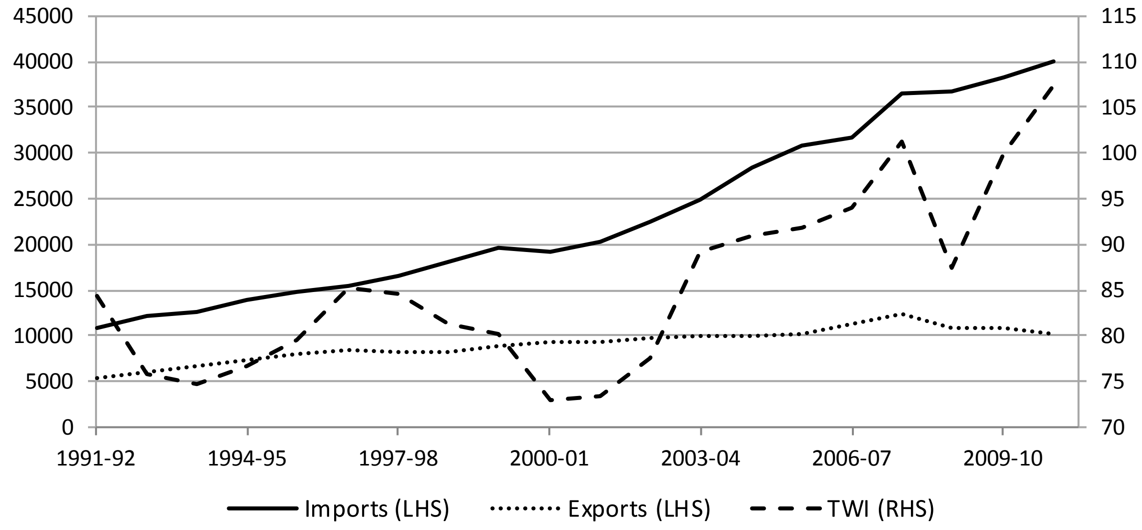
6 The regulatory impact statement for the *Cleaner Fuels* program estimated that the policy change would yield total benefits over the 2000 to 2019 period of around $3.4 billion as a result of the 'avoided health costs' (Environment Australia 2001).

Increased import competition in other parts of the subsector

Australia has long been a net importer of PCCR manufactured goods but, in recent years, the growth in the volume of imports has accelerated relative to export growth (figure 4.8). Much of this import growth is in petroleum-related products, but other parts of PCCR have also experienced strong import growth. One factor that is likely to have driven the relative growth rates of imports and exports is the appreciation of the Australian dollar relative to the currencies of Australia's trading partners from the early 2000s onwards. All else equal, a higher dollar is likely to lead to stronger growth in imports relative to exports, which is observed in PCCR as well as in the rest of Manufacturing.

Figure 4.8 **PCCR imports, exports[a] and the exchange rate[b]**

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



[a] Due to ANZSIC classification changes, there is a break in the trade data between 2005-06 and 2006-07. [b] TWI (trade weighted index) is the multilateral exchange rate $A against trade-weighted average of trading partner currencies.

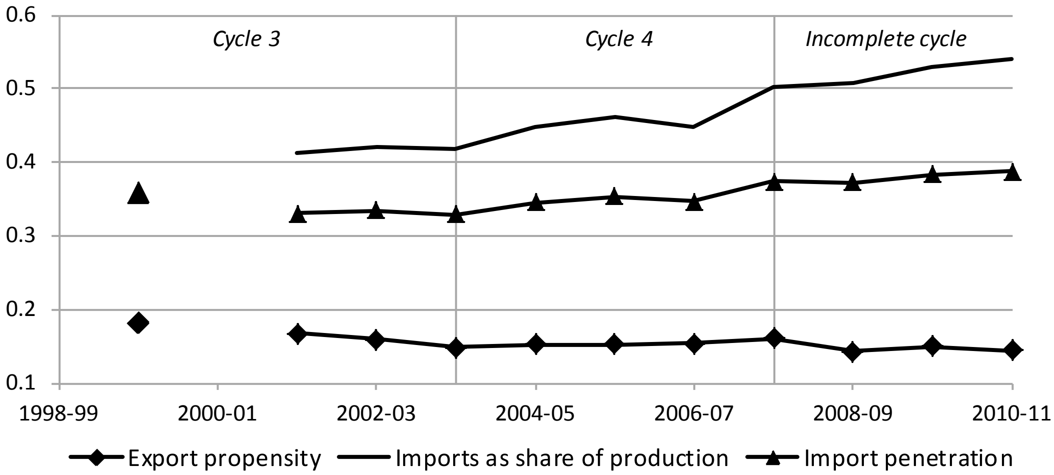
Data sources: Authors' estimates based on ABS (*International Trade in Goods and Services, Australia,* various issues, Cat. no. 5368.0); and ABS (*International Trade Price Indexes,* various issues, Cat. no. 6457.0).

The imports of petroleum products have already been discussed above. It is not the case that all PCCR imports are competing with domestic production (box. 4.3). The remainder of this section examines the import trends in the rest of the PCCR subsector — Chemicals and Polymers.

Box 4.3 **Growth of imports in PCCR products**

Over cycle 4, there was growth in import penetration in PCCR, while export propensity was relatively flat (see figure).

Import penetration and export propensity in PCCR[a]



[a] Import penetration is the value of imports as a share of the domestic market for PCCR goods (which in turn is defined as the total sales and service income of domestic PCCR manufacturing, plus the value of imports, less the value of exports). Export propensity is the value of PCCR exports as a share of PCCR manufacturing sales and service income. 1999-00 is from PC (2003) and may not be directly comparable because of changes to the scope of the survey from which sales and service income is derived.

Data sources: PC (2003); authors' estimates based on ABS *(International Trade in Goods and Services, Australia, September 2012,* Cat. no. 5368.0*)*; and ABS *(Australian Industry*, various issues*,* Cat. no. 8155.0).

Imports may out-compete domestically manufactured products and potentially lead to the exit of some firms from the industry or a reduction in their output. This has been the case for some of the additional imports of PCCR goods over cycle 4. For example, there appears to have been a greater volume of imported finished plastic products and tyres and reduced domestic production of these products.

But in other cases, the imports may not be directly competing with domestic PCCR products. For example:

- there were greater imports of fertiliser over cycle 4 to cope with demand that could not be satisfied by domestic producers in the short term, because of limited production capacity
- there were greater imports of organic chemicals over cycle 4, some of which were used as intermediate inputs by the domestic pharmaceutical manufacturing industry as it expanded its production capacity.

Import competition can provide incentives for firms to improve their efficiency and in the long run is likely to lead to improvements in industry productivity. More generally, trade helps support higher living standards by ensuring that an economy plays to its comparative strengths (box 2.2). However, in the short run, the effect on *measured* productivity may be negative. For example, when firms reduce output this can lead to underutilised capacity, which depresses *measured* productivity.

Faster import growth of chemicals and polymers

Imports of most categories of chemical and polymer products grew faster in cycle 4 than cycle 3. The largest growth was in organic chemicals, fertilisers and plastics in non-primary forms (table 4.3). The largest decline in the rate of import growth occurred in medicinal products (which was also the largest share of total chemical and polymer imports).

Table 4.3 **Import trends in chemical and polymer products[a]**

	Growth in cycle 3[b]	*Growth in cycle 4*[b]	*Difference*	*Real value of imports in 2003-04*
	% py	% py	% pts	2009-10 $m
Organic chemicals	-2.5	7.0	9.5	2 988
Plastics in non-primary forms	3.4	10.6	7.2	1 030
Fertilizers (excluding crude)	-2.6	4.0	6.5	990
Plastics in primary forms	1.1	3.5	2.4	1 769
Inorganic chemicals	5.2	7.2	2.0	842
Dyeing & colouring materials	8.5	10.0	1.6	440
Chemical materials & prods nes.	3.7	3.2	-0.5	1 907
Essential oils etc.	8.6	8.0	-0.7	1 263
Medicinal products	16.2	9.6	-6.6	5 460
Total chemicals and polymers	**5.8**	**7.5**	**1.7**	**16 589**

[a] Based on the Standard International Trade Classification (SITC). Does not include rubber products. Parts do not sum to total due to rounding. More detail is provided in appendix F. [b] Average annual growth rates.

Sources: Authors estimates' based on ABS (*International Merchandise Imports, January 2012,* Cat. no. 5439.0); and ABS (*International Trade Price Indexes*, *March 2013,* Cat. no. 6457.0).

Imported organic chemicals in cycle 4 appear to be, in part, imports of intermediate inputs used in the domestic production of other PCCR products, such as herbicides and pharmaceuticals. Accordingly, the import growth may not be an indicator of import competition leading to slowing VA in PCCR, but instead may be the result of additional demand for intermediate inputs by those parts of PCCR with VA growth.

The growth in imports of plastics in non-primary form comprises many subgroups, including fittings and packaging-related materials. The growth in fittings appears related to the strong growth in construction activity in cycle 4. Both types of imports were in direct competition with Australian manufacturers, which may explain part of the slowdown in PCCR VA growth observed over cycle 4.

Growth in fertiliser imports is explained by strong demand for fertiliser products toward the end of cycle 4, as the drought ended and as farmers attempted to purchase in advance to avoid predicted price rises in the near future (ACCC 2008).

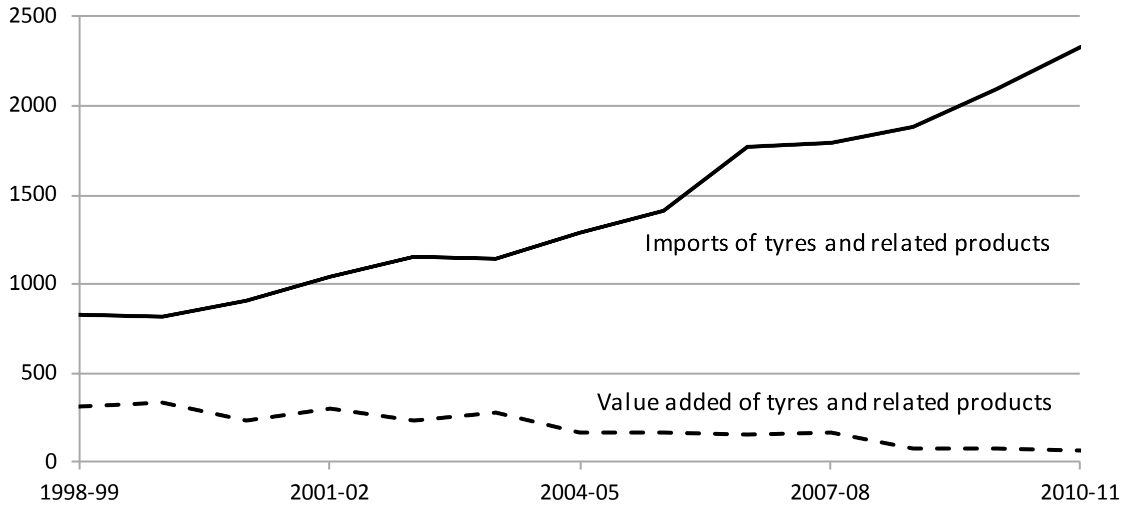
These imports are less likely to have had an effect on Australian manufacturing of fertilisers (in the short run), as the domestic manufacturers were unable to supply the increased demand during 2007-08 (ACCC 2008).

The effect of import competition on tyre manufacturing

Strong import competition contributed to the decline of domestic tyre production and ultimately the cessation of tyre manufacturing shortly after the end of cycle 4. Tyre manufacturing had the strongest rate of decline in nominal VA of any of the classes in the Polymers and rubber subdivision — shrinking from 3.6 per cent of PCCR VA at the beginning of cycle 3 to around 1 per cent by the end of cycle 4. In 2002, during cycle 3, the domestic industry faced pressure from tyres imported from overseas as part of a tyre glut (South Pacific Tyres 2002). It was also noted that the industry was too small to achieve the same economies of scale that overseas manufacturers had achieved (Australian Tyre Manufacturers' Association 2002). In 2005, tariffs on imports of tyres were reduced from 15 per cent to 5 per cent, which further added to the competitive pressure from imports. In concert with a higher dollar, the rate of import growth accelerated while domestic production declined (figure 4.9).

Figure 4.9 **VA and imports of tyres and related products[a]**

$m



[a] Current prices. There is a break in VA series between 2005-06 and 2006-07 due to ANZSIC concordance issues. Imports are on an SITC basis (code 625).

Data sources: ABS (*Australian Industry,* various issues, Cat. no 8155.0); ABS (*Australian Manufacturing,* various issues, Cat. no. 8221.0); and ABS (*International Merchandise Imports, January 2012*, Cat. no. 5439.0).

In mid-2008, the South Pacific Tyres plant at Somerton closed, followed by the Bridgestone plant in Adelaide in 2010. The latter closure marked the end of Australian tyre manufacturing (Global Business Reports 2012). The tyre-related manufacturing activities still undertaken in Australia are associated with the re-treading and repair of tyres rather than the manufacture new of tyres.

Some parts of PCCR had an increase in VA growth

While VA in PCCR has declined in aggregate, not every industry class within the subsector has experienced a decline. Growth in Pharmaceuticals and some construction-related materials within PCCR may have partially offset the VA slowdown elsewhere in the subsector.

Increased production of pharmaceuticals

Growth in Pharmaceuticals[7] provided about a quarter of the VA for the Chemicals subdivision in 2007-08. Real VA in Pharmaceuticals is estimated to have shrunk by 2.3 per cent a year over cycle 3, before growing by 6.0 per cent a year in the next cycle.[8] These growth patterns are the opposite of those observed for PCCR in aggregate, indicating that Pharmaceuticals partially offset the decline in VA in other parts of the subsector.

The VA rise in Pharmaceutical manufacturing during cycle 4 seems to have been driven by the production of a greater volume of lower-VA products.[9] A review of the various pharmaceutical incentive schemes in place over cycles 3 and 4[10] found that:

> The industry has become increasingly characterised by lower value packaging activities at the expense of more highly valued manufacturing formulation activities. (Pharmaceuticals Industry Strategy Group 2008, p. 15)

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7 ANZSIC06 class 1841 ‘Human pharmaceutical and medicinal product manufacturing’.

8 Based on authors’ estimates using current price value added data from ABS Cat. nos 8155.0 and 8221.0, which are in turn deflated using the output price deflator for pharmaceuticals from ABS Cat. no. 6247.0.

9 This is consistent with the observed increase in imports, discussed above.

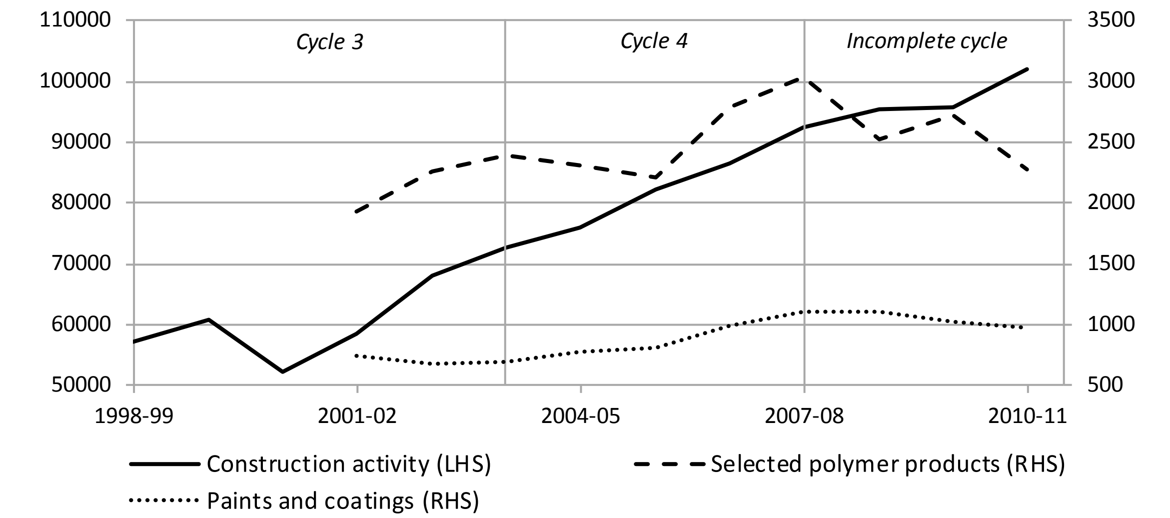
10 There were two government programs. The *Pharmaceutical Industry Investment Program* ran over the period from 1 July 1999 to 30 June 2004 (largely covering the third cycle), while the *Pharmaceuticals Partnership Program* ran over the period from 1 July 2004 to 30 June 2009 (covering all of the fourth and some of the incomplete cycle). The *Pharmaceutical Industry Investment Program* put in place incentives to encourage more value adding and R&D, while the *Pharmaceuticals Partnership Program* was more R&D orientated. See appendix C of Pharmaceuticals Industry Strategy Group (2008).

At the same time, there was strong growth in pharmaceutical expenditure by consumers in Australia — around 6.7 per cent a year in cycle 4.[11] Pharmaceuticals manufacturing is, therefore, likely to have expanded the volume of production sufficiently to offset the lower VA per unit and thus had positive VA growth in total.

Growth in construction activity and its effect on PCCR

Rapid growth in construction activity between 2000-01 and 2008-09 led to additional demand for construction materials produced by the PCCR subsector. Paints and some plastic products, in particular, appear to have benefited from the construction boom (figure 4.10).

Figure 4.10 **Construction boom and VA of selected PCCR products[a]**
2009-10 $m



[a] Selected polymer products include ANZSIC06 1912 ('Rigid and Semi-Rigid Polymer Product Manufacturing') and 1919 ('Other Polymer Product Manufacturing'). Paints and coatings are ANZSIC06 1916. Deflated using producer price indexes for output for ANZSIC06 series 1912 and 1916 (producer price indexes not available pre 2001-02).

Data sources: Authors' estimates based on ABS (*Australian Industry,* various issues, Cat. no 8155.0); ABS (*Australian Manufacturing*, various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); and ABS (*Producer Price Indexes*, various issues, Cat. no. 6427.0); ABS (*Australian System of National Accounts, 2009-10,* Cat. no. 5204.0).

[11] Authors' estimates of Pharmaceutical Benefits Scheme payments and other pharmaceutical expenses paid by consumers based on data from AIHW (2012).

The greater use of plastics stems from an increasing use of plastic fittings, pipes and water tanks, while paints and coatings have benefited from new construction and an increasing 'DIY market' over the period.[12] Indeed, growth in demand also saw an increase in the volume of imports (discussed above) for both plastics and paint, although the trend was more pronounced for the former than the latter.

Capital

The acceleration in capital services growth between cycles 3 and 4, without a proportionate increase in measured VA, played a major role in the decline in PCCR MFP. Two specific elements are behind most of the growth in investment during these cycles — investment associated with new capital equipment to reduce harmful pollutant levels in refined fuel, and a string of new ammonia and ammonium nitrate projects to meet demand for fertilisers and explosives. It is estimated that investment associated with these projects accounts for around 85 per cent of the *growth* in investment between cycles 3 and 4 for PCCR.

Investment by asset and industry subdivision

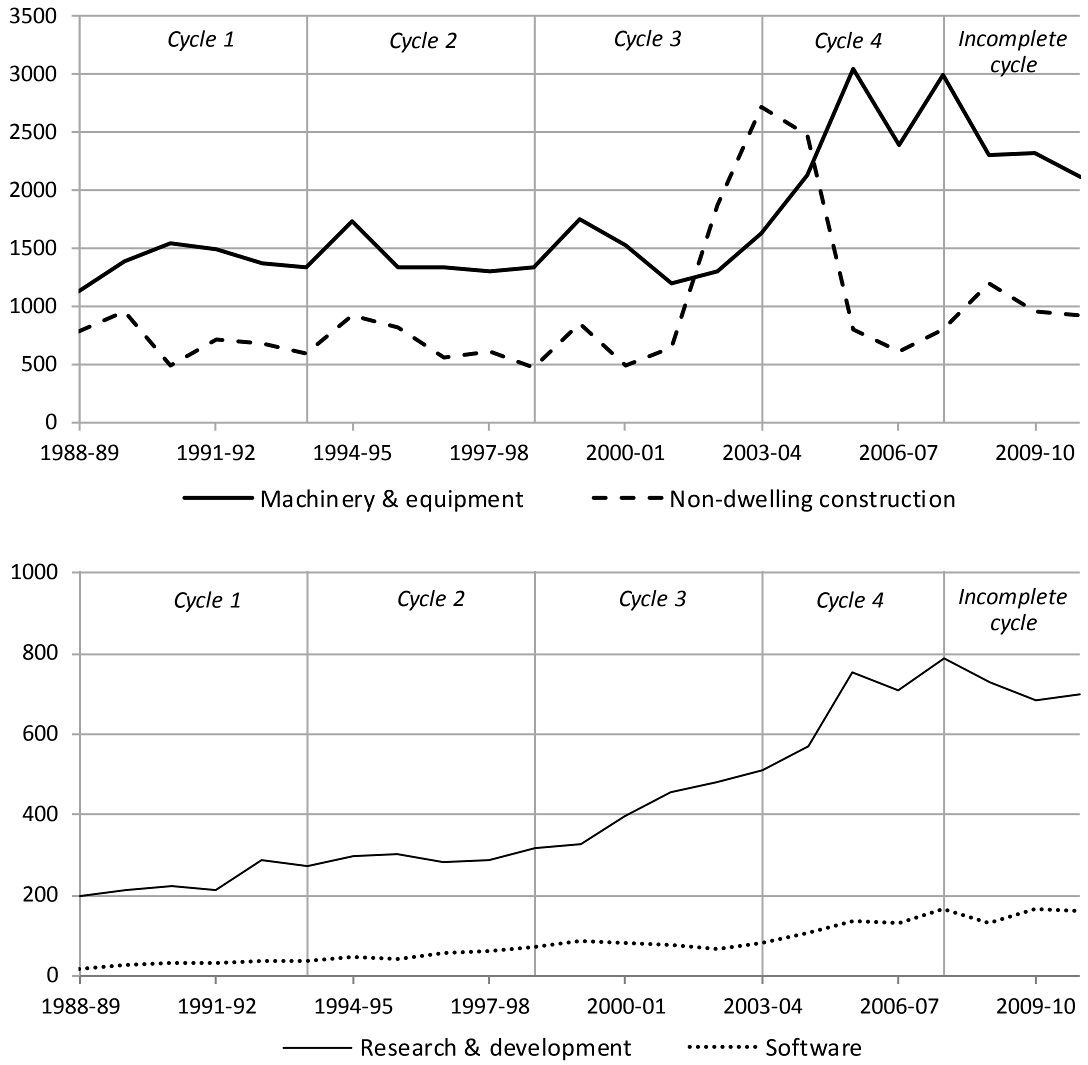
Growth in capital services in PCCR almost doubled between cycles 3 and 4. Figure 4.11 shows the real value of investment by asset type — namely machinery and equipment (M&E), non-dwelling construction (NDC), research & development (R&D) and software. M&E is generally the largest component of investment in PCCR, followed by NDC.

Investment in both M&E and NDC was fairly stable in PCCR until near the end of cycle 3, after which there was a pronounced acceleration. Investment in NDC peaked in 2003-04 and returned to around historical levels in 2005-06, while investment in M&E continued to rise until 2005-06.

[12] For example, a major producer of paints (Dulux) noted that 'Growth was driven primarily by increased renovation activity' (Orica 2007); and the number of households that sourced water from water tanks rose from 16.9 per cent in 1998 to 26.4 per cent in 2010 (ABS 2010b).

Figure 4.11 **PCCR gross fixed capital formation by asset type**[a]

2009-10 $m



[a] The estimation of capital services for each subsector of Manufacturing (as discussed in chapter 3), involved apportioning Manufacturing investment (gross fixed capital formation from the ABS National Accounts) across the different subsectors. This allowed for the construction of a time series for PCCR investment in different capital asset types (see appendix A for details).

Data sources: Authors' estimates based on ABS (*Australian System of National Accounts, 2010-11,* Cat. no. 5204.0); and ABS (unpublished Survey of New Capital Expenditure data).

Both R&D and software investment grew at fairly constant rates until the early 2000s, before the rate of investment in both asset types accelerated. Investment in R&D and software has plateaued or decreased since 2007-08. While these asset types also contributed to the increase in the growth of capital services in PCCR between cycles 3 and 4, their magnitude is much smaller than that of M&E and NDC.[13]

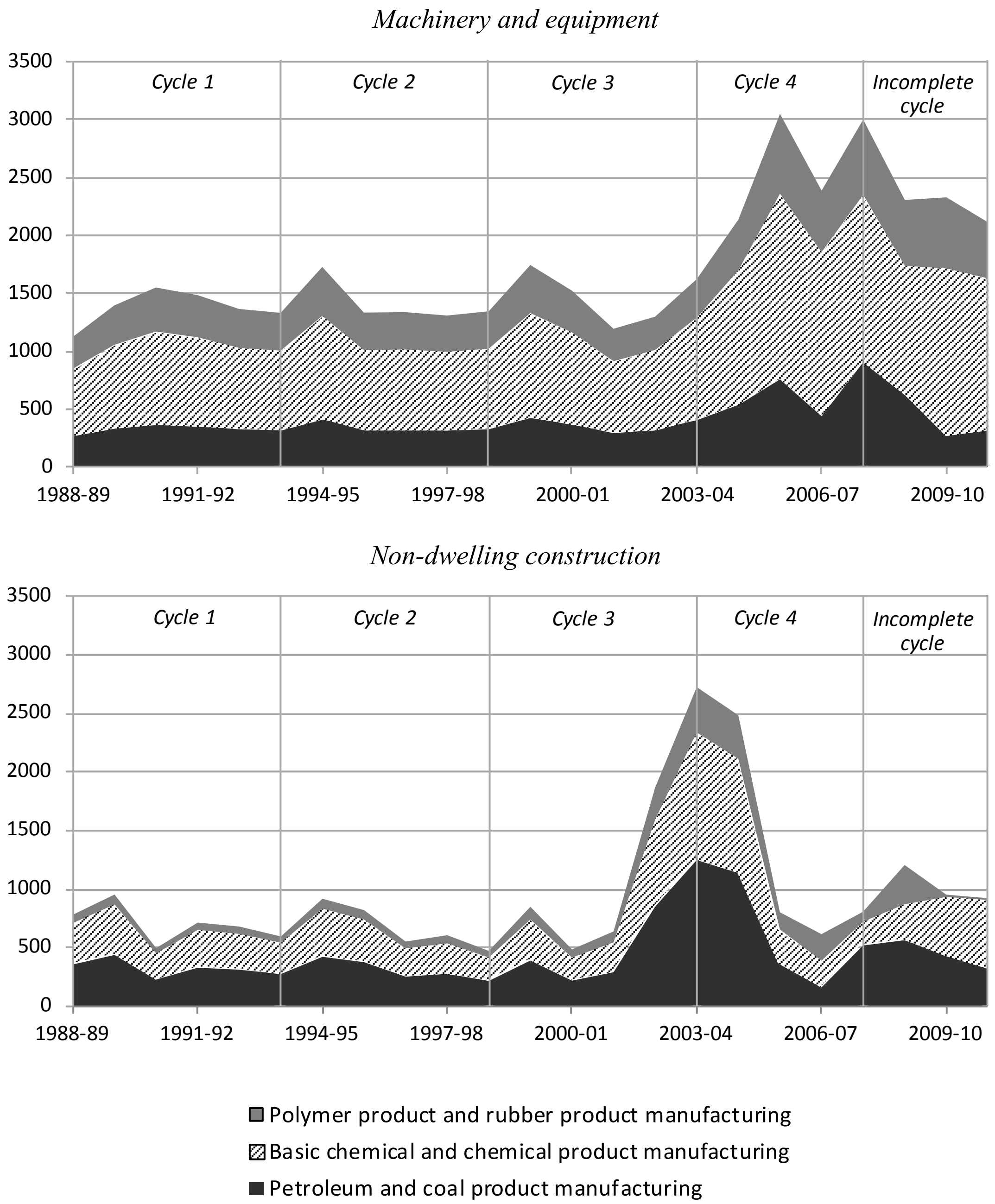
Subdivision level data reveal which parts of PCCR drove the strong growth in investment, and ultimately capital services, for the subsector. Figure 4.12 shows that Chemicals accounted for around half (47 per cent) of the growth in M&E and NDC between cycles, while Petroleum accounted for about a third (32 per cent).

There are different drivers and changes in the operating environment responsible for the investment growth in Petroleum and coal product manufacturing and Basic chemical and chemical product manufacturing.

13 The stronger period of investment between 2003-04 and 2007-08 had the effect of reducing the average age of capital within PCCR by about a year (from 5.6 years to 4.6 years). It is surprising that age of the capital stock itself starts from such a low base. The assumptions embodied in the derivation of capital services and net capital stock at the subsector level use the age profiles as determined by the ABS (detailed in ABS 2012c). This assumes that the maximum lifespans for different types of capital in Manufacturing are 38 years for non-dwelling construction, 14.4 years for machinery and equipment, 11 years for R&D and between 4 and 8 years for software. This paper assumes that the same lifespans are applied to each Manufacturing subsector (appendix A). In the case of the older petroleum refineries (which were originally built between 1922 and 1965), most of the capital embodied is assumed to be already depreciated (notwithstanding capitalised maintenance), which may explain why the average ages observed are so low.

Figure 4.12 **PCCR gross fixed capital formation by subdivision and asset type**[a]

2009-10 $m



[a] Breakdowns are available only for these capital types over the cycles of interest.

Data sources: Authors' estimates based on ABS (*Australian System of National Accounts, 2010-11,* Cat. no. 5204.0); and ABS (unpublished Survey of New Capital Expenditure data).

Investment to meet new emission standards in Petroleum refining

As discussed above, the introduction of the Commonwealth Government's *Cleaner Fuels* program in 2000 mandated reductions in emissions of pollutants with progressive milestones from 2002 onwards. It was anticipated at the time of the introduction of the program that significant investment would be required at Australian refineries in order to comply with these changes in fuel standards (Environment Australia 2001).

The Australian Institute of Petroleum indicated that more than 3 billion dollars was invested in order to meet the new standards over the last decade (AIP 2011). A large proportion of this investment occurred between 2005 and 2008 (AIP 2011), a period which coincided with the strong growth in investment over cycle 4. Such an investment would account for around 14 per cent of total GFCF in PCCR over the cycle (or approximately 59 per cent of GFCF growth between cycles).

This investment was aimed at improving fuel quality, but the benefit associated with the *Cleaner Fuels* program (less pollution) is not counted as an output from Petroleum refining. As this then represents greater investment without additional measured output, the investment leads to measured productivity being understated for petroleum refining.

The rising fuel standards may have also led to periods of underutilised capacity, which could have detracted from measured productivity. There has been an increase in the incidence and severity of unexpected refinery shutdowns since 2004 — around the beginning of cycle 4. It has been suggested that a greater reliance on imported feedstock from overseas and the work undertaken on refineries required to meet the new fuel standards were contributing factors to these shutdowns.

> The major change in supply security from refineries since 2004 is that the impact of unexpected refinery maintenance and shutdowns is more severe than earlier periods, due to the increased level of interdependence of refinery operating units to meet higher Australian fuel specifications. (ACIL Tasman 2008, p. XV)

Investment to expand capacity in some parts of Chemicals

While there has been strong growth in investment in the Chemicals subdivision over cycle 4, this growth has not been uniform across the different parts of the subdivision.

Ammonia and ammonium nitrate

There was particularly strong investment during cycle 4 in order to expand supply of ammonia and ammonium nitrate in response to increased demand from the mining and agricultural sectors.[14] However, many of the projects associated with this investment had substantial lags between when investment was made and when additional output was produced. Such 'capital lags' can reduce measured productivity, particularly when there is an acceleration in the rate of investment, as there was in this case.

Some of the significant investments made during the period include:

- Expansion of the Yarwun (Qld) ammonium nitrate plant, operated by Orica, during 2006 to increase capacity by 300 000 tonnes per year at a cost of around $110 million (Orica 2004).
- Expansion of the Kwinana (WA) ammonium nitrate plant, operated by Wesfarmers/CSBP, during 2006 and 2007 to increase capacity to 470 000 tonnes per year at a cost of $200 million (Wesfarmers 2005).
- Construction of the Moranbah (Qld) ammonium nitrate plant, commenced in 2006 with a proposed output of 330 000 tonnes per year. However, construction on the plant was put on hold in 2007 with $305 million already spent on the project (Trounson 2006; Grant-Taylor 2010).
- Construction of the Burrup (WA) ammonia plant, then operated by Burrup Holdings, commenced in late 2003 and it came on stream in the first half of 2006 with a capacity of 760 000 tonnes per year at a cost of $800 million (ABARE 2003, 2006a; ACCC 2011).

These substantial investments, the majority of which occurred during cycle 4, go some way to explaining the greater capital investment in PCCR over this period. They account for around 7 per cent of total PCCR GFCF during cycle 4 (and approximately 28 per cent of the growth in PCCR GFCF between 2003-04 to 2007-08). For the Yarwun, Kwinana and Burrup projects above, it appears that there would also have been some output from these investments during cycle 4, which would explain the observed trend in increasing nominal sales and service income within Chemicals (appendix F). By contrast, the suspension of the Moranbah project suggests that there was significant investment without any return (in terms of output) over cycle 4.

[14] Ammonia and ammonium nitrate are key inputs to fertilisers and explosives.

There is some evidence to suggest that there was increased output growth in fertilisers and explosives over the incomplete cycle (ABS 2012d), at least part of which represents a return on the substantial investments in ammonia and ammonium nitrate projects during cycle 4 (Wesfarmers 2008).

Pharmaceuticals

Investment in tangible assets appears to have declined (in real terms) over cycle 4 in Pharmaceutical manufacturing (Medicines Australia 2009). At the same time, R&D in Pharmaceuticals manufacturing continued to grow (Medicines Australia 2012), but only partially offsetting the decline in investment in tangible capital. The overall decline in investment by Pharmaceutical manufacturing, however, was not sufficient to offset the additional investments in ammonia and ammonia nitrate listed above.

Labour

Around 90 per cent of the fall in PCCR manufacturing MFP between the last two complete productivity cycles was driven by a decline in VA and an increase in capital inputs. Only 10 per cent of the fall in MFP was driven by an increased rate of growth of labour inputs. Hours worked had declined over cycle 3 and remained virtually constant over cycle 4. Table 4.4 shows the average annual rates of growth in hours worked for the PCCR subsector and its subdivisions.

Table 4.4 **Growth in hours worked for PCCR subdivisions**
Average annual growth rate (per cent)

	Cycle 3: 1998-99 to 2003-04	*Cycle 4: 2003-04 to 2007-08*	*Incomplete cycle: 2007-08 to 2010-11*
Petroleum and coal product mfg	3.8	1.1	2.7
Basic chemical and chemical product mfg	-1.5	-0.7	-0.6
Polymer product and rubber product mfg	-1.4	0.5	-11.8
PCCR	**-1.1**	**0.0**	**-5.3**

Source: Authors' estimates based ABS (unpublished Labour Force Survey data).

The data indicate that the rate of hours worked growth fell between cycles in Petroleum (from 3.8 to 1.1 per cent a year); rose in Chemicals, but was still negative in absolute terms (from -1.5 to -0.7 per cent a year); and became positive in Polymer products (-1.4 to 0.5 per cent a year). The turnaround in hours worked growth in Polymer products was the main driver of the growth in PCCR hours worked between the productivity cycles, more than offsetting the decline observed in Petroleum. There are, however, insufficient data available to identify the specific parts of Polymers that had hours worked growth from cycle 3 to cycle 4 (appendix F).

4.4 Drawing together the implications for productivity

The decline in PCCR's MFP growth rate, from positive in cycle 3 to negative in cycle 4, was driven by:

- a decline in VA growth (accounting for around 50 per cent of the MFP decline)
- strong growth in capital services (around 40 per cent of the MFP decline)
- a marginal rise in hours worked (around 10 per cent).

There appears to be strong evidence that the decline in VA growth (between the productivity cycles) was driven mainly by developments in the Petroleum and Polymer subdivisions.

- In the case of Petroleum, declining domestic feedstock and the availability of refined fuel from overseas refineries led to the importation of a greater volume of refined product, which in turn reduced domestic VA.
- Within Polymers, finished plastic products and tyre manufacturing faced strong import competition and, in the case of tyres, domestic manufacturing has virtually ceased.

The accelerated growth in capital services is a product of strong investment, over cycle 4, in the Petroleum and Chemicals subdivisions.

- The investment in petroleum refining was associated with upgrading refineries to meet new environmental standards relating to fuels. These refining investments appear as additional inputs but the environmental benefits are not completely included as part of the VA measure. This depresses *measured* productivity.
- In the case of ammonia and ammonium nitrate in the Chemicals subdivision, there were significant and large investments associated with increasing capacity in response to heightened demand, but additional output was not fully realised until the period after cycle 4. This represents a growth in inputs with little commensurate growth in outputs, and so detracts from *measured* productivity.

Hours worked declined in cycle 3 and was flat in cycle 4, meaning that there was positive growth in hours worked between the cycles. This growth made a relatively small contribution to the decline in PCCR MFP. However, data limitations make it difficult to reliably determine which parts of PCCR experienced growth or declines in hours worked and why.

It is likely that each of the subdivisions within the PCCR subsector experienced input growth in excess of output growth — each contributing to the PCCR MFP decline in cycle 4 compared with cycle 3. This is not to say that every industry *class* within each of the PCCR subdivisions experienced a productivity decline. Both Pharmaceuticals and Paint manufacturing appear to have increased their output over cycle 4 without increasing their inputs. But given their small size (relative to the rest of PCCR), this was not enough to offset the decline in productivity experienced in other parts of the subsector.

Over the period since the end of cycle 4, MFP growth in PCCR has remained negative on average, but is declining at a slower rate (-1.1 per cent a year). VA for the subsector has fallen at a faster rate (notwithstanding increases in some parts of PCCR). But there has also been some offsetting decline in combined inputs — with a steep decline in hours worked and slower capital services growth.

5 Productivity in Food, beverage and tobacco products

Multifactor productivity (MFP) growth in the Food, beverage and tobacco products (FBT) subsector[1] declined significantly between the last two complete productivity cycles — making the second largest negative contribution of any subsector to the MFP decline in Manufacturing (Petroleum, coal, chemical and rubber products making the largest). The decline in FBT MFP was driven by a slowdown in value added (VA) growth while there was a strong rebound in hours worked and continued growth in capital services. This chapter outlines the scope and size of FBT before examining factors likely to have influenced these changes in its VA, inputs and MFP growth.

5.1 FBT subsector scope and structure

FBT is the largest Manufacturing subsector — in 2009-10 it accounted for 22 per cent of VA and 25 per cent of those employed in Manufacturing. FBT manufacturing includes processing of agricultural products but also more transformed products such as bakery and confectionery products. As well as providing finished goods for final consumption, it also provides intermediate inputs to other parts of the economy, such as retail food services and restaurants.

The FBT subsector includes two industry subdivisions under the ABS *Australian and New Zealand Standard Industrial Classification 2006* (ANZSIC06) — Food product manufacturing ('Food'), and Beverage and tobacco product manufacturing ('BT'). Food is the largest subdivision — 71 per cent of FBT's VA and 87 per cent of FBT's employment in 2009-10.

There is a diverse range of products found within each subdivision. Food manufacturing includes nine ANZSIC groups, being the manufacture of meat and meat products, processed seafood, dairy products, processed fruit and vegetables, oils and fat, grain mill and cereal products, bakery products, sugar and confectionery products, and other food products (such as potato crisps, frozen

[1] Tobacco products manufacturing is not discussed in this chapter — separate data for this group are limited, but it is included in totals.

meals, and pet food). BT includes two ANZSIC groups, being the manufacture of beverages (soft drinks, wine, beer, and spirits) and tobacco products. There have been some shifts in classification over time for the data presented, which can affect comparability (box 5.1).

Box 5.1 **Industry classification for FBT**

The FBT subsector consists of the following ABS *Australian and New Zealand Standard Industrial Classification* subdivisions and groups.

ANZSIC subdivisions and groups within FBT subsector

Subdivision	*Group*
11 Food product manufacturing	
	111 Meat and meat product manufacturing
	112 Seafood processing
	113 Dairy product manufacturing
	114 Fruit and vegetable processing
	115 Oil and fat manufacturing
	116 Grain mill and cereal product manufacturing
	117 Bakery product manufacturing
	118 Sugar and confectionery manufacturing
	119 Other food product manufacturing
12 Beverage and tobacco product manufacturing	
	121 Beverage manufacturing
	122 Cigarette and tobacco product manufacturing

Source: ABS (*Australian and New Zealand Standard Industrial Classification, 2006,* Cat. no. 1292.0).

The shift from the 1993 edition of ANZSIC (ANZSIC93) to the 2006 edition (ANZSIC06) affects the extent to which data for FBT manufacturing can be compared over time. There were numerous shifts into FBT from outside Manufacturing and between industry groups within FBT — but the most significant change was moving non-factory baking (for example, hot bread shops) from Retail trade to FBT manufacturing. Non-factory baking is a large share of total Bakery — 46 per cent of VA and 60 per cent of employment in 2009-10.

The year in which the ABS introduced ANZSIC06 differed across surveys. Only for some surveys did the ABS backcast data to increase comparability over time (that is, convert earlier ANZSIC data into ANZSIC06).

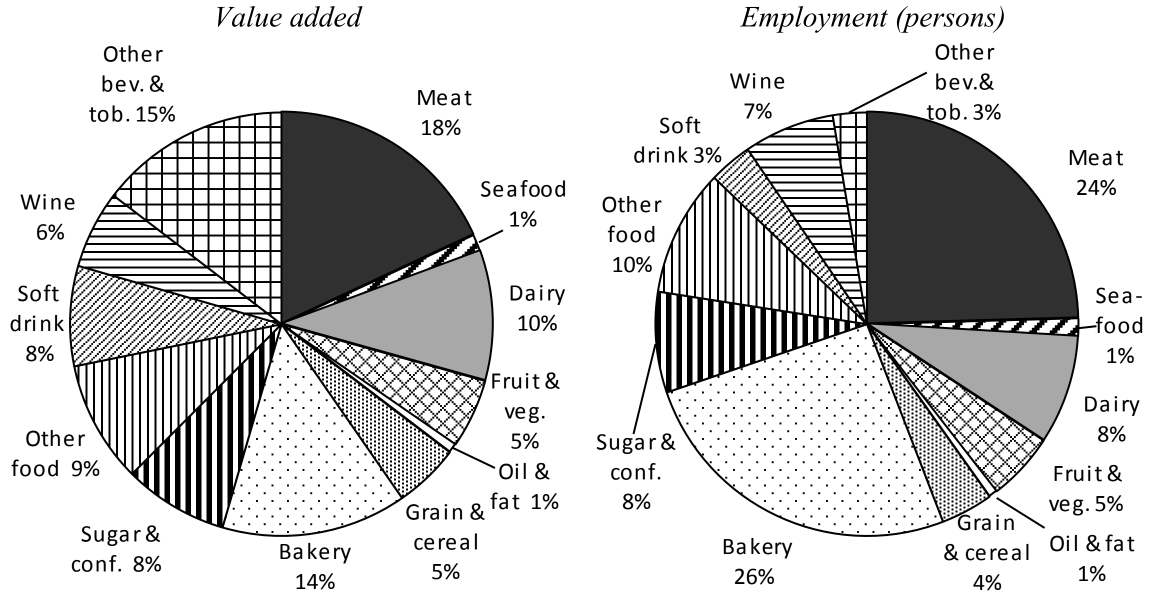
- Where possible, backcast data are used. However, it should be borne in mind that backcast data may not be as accurate as data collected on an ANZSIC06 basis.
- Where backcast data are not available, it has been necessary to refer to unadjusted data. Breaks in series are identified and their implications noted.

Further details are provided in appendix G.

In 2009-10, the largest contributor to Food VA was Meat and meat products, followed by Bakery products (figure 5.1, left panel). Within BT, Soft drink and Wine were of similar size, but more than half of total BT was Other beverages and tobacco (including beer, spirits and tobacco for which data were not separately available).

Differences in the labour intensity of production across types of FBT manufacturing lead to a different picture for employment shares (figure 5.1, right panel). In 2009-10, Bakery was the largest employer, followed by Meat and meat products. Within BT, Wine was the largest employer, followed by Soft drink. Other beverages and tobacco had a considerably lower share of employment than of VA.

Figure 5.1 **Composition of FBT value added and employment, 2009-10[a]**



[a] Industries are ANZSIC06 groups, except for Other beverages and tobacco that includes ANZSIC06 classes of Beer, Spirits and Tobacco products, for which data are not separately available (appendix G).

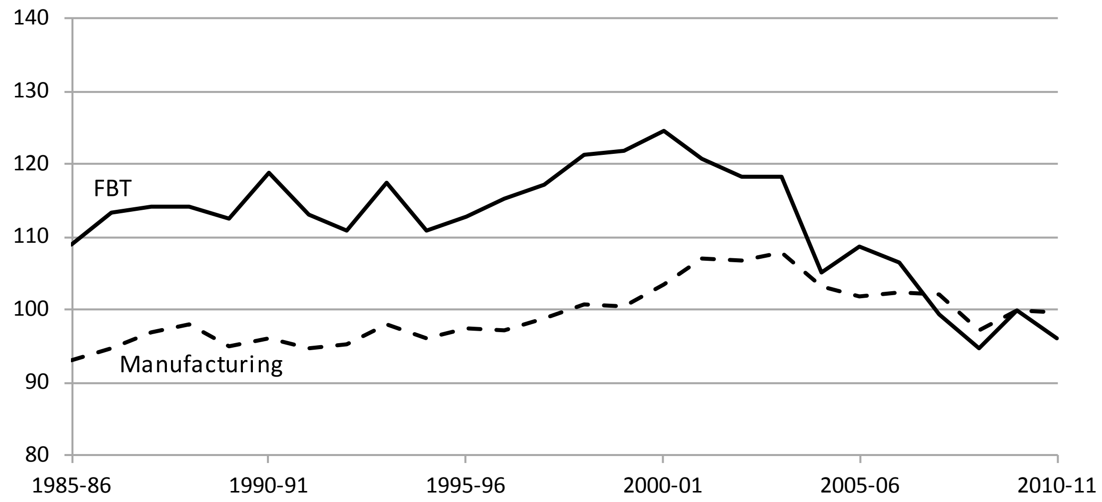
Data source: ABS (*Experimental Estimates for the Manufacturing Industry, 2009-10*, Cat. no. 8159.0).

5.2 FBT's MFP growth and its proximate causes

Between 1985-86 and 2010-11, FBT's average MFP growth was -0.5 per cent a year. But there are distinct changes in the MFP trend over this period — MFP was fairly flat to the mid-1990s, grew more strongly from the mid-1990s to early 2000s, then declined considerably over the 2000s (figure 5.2). FBT had a fairly similar MFP trend to Manufacturing in total up to 2000-01, but since then has declined much faster.

Figure 5.2 **FBT and Manufacturing MFP**

Index 2009-10 = 100



Data sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002).

For the purposes of identifying the contributions of a subsector to MFP for Manufacturing as a whole, the cycles for Manufacturing in aggregate are used.[2] Figure 5.3 shows that FBT's average MFP growth was low over each cycle, but the strongly negative growth rate in cycle 4 was exceptional.

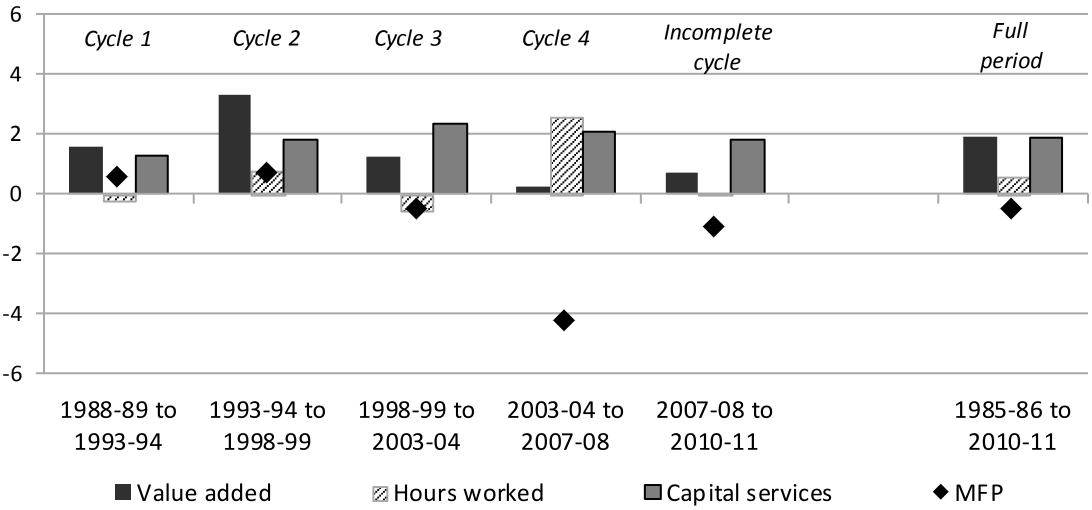
Over cycles 1 to 3, FBT MFP growth was (on average) just above or just below zero, because combined input growth was fairly evenly matched with VA growth. However, the proximate causes (changes in the volumes of VA, capital and labour) differed. Capital growth was positive and relatively strong in each cycle. Although hours worked growth was quite variable, it was lower than capital services growth in each of these cycles — which implies that FBT manufacturing became more capital intensive. VA growth was positive in all three cycles, but strongest in cycle 2.

Cycle 4 (2003-04 to 2007-08) was very different. VA growth was close to zero and there was a very strong increase in hours worked growth along with continued capital growth. Without an increase in VA in proportion to the increase in combined inputs, this produced a large decline in FBT MFP and explains FBT's major contribution to the decline in MFP for Manufacturing in total. Also, in cycle 4, hours worked growth exceeded capital services growth — which marked a departure from the longer-term trend of increasing capital intensity of production.

2 The pattern of MFP growth over FBT-specific cycles, in terms of increase or decrease from cycle to cycle from the mid-1990s, is similar in direction to that over the cycles for Manufacturing in total (appendix C). As a result, FBT-specific cycles are not shown here.

There was some improvement in VA growth in the incomplete cycle, but the absence of any further growth in hours worked was the key factor behind the slowdown in the MFP decline. Capital services growth was again greater than hours worked growth — implying a return to the longer-term trend of increasing capital intensity of production. (However, as noted in chapter 2, some care is needed in the interpretation of the incomplete cycle since it may have been influenced by temporary factors, including the global financial crisis.)

Figure 5.3 **Growth in FBT MFP and its proximate causes[a] by cycle**
Average annual growth rate (per cent)

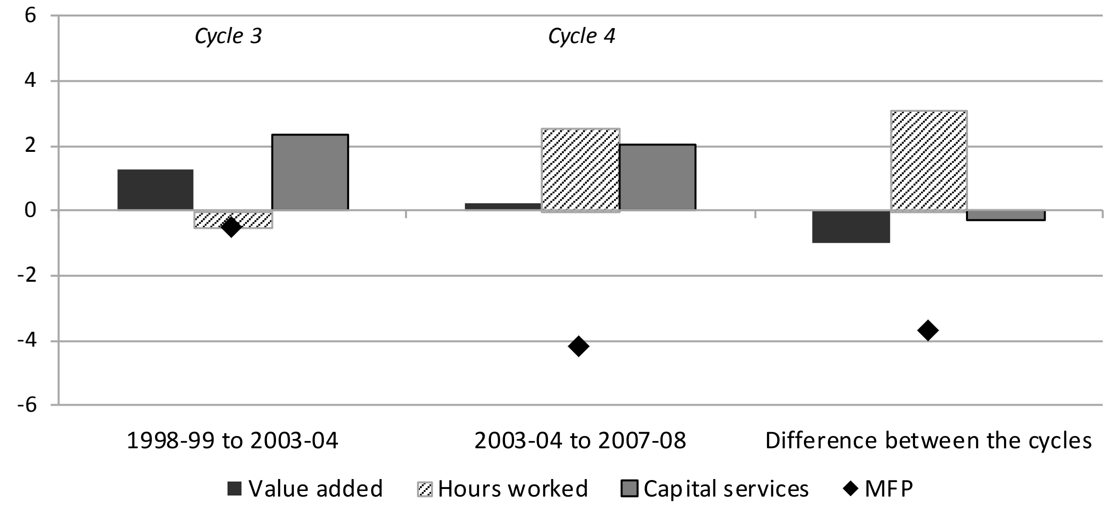


[a] Capital services and hours worked weighted by income shares.

Data source: Authors' estimates.

Focusing on the considerable decline in MFP growth *between* cycles 3 and 4 (that is, growth in cycle 4 less growth in cycle 3), it was the reduction in VA and the increase in the hours worked that were most significant (figure 5.4). At face value, the concurrent slowdown in VA growth and increase in the rate of hours worked growth (and continued capital growth) is a puzzle. The departure from the pattern of increasing capital intensity of production is also unusual. But as noted, FBT is made up of a wide range of activities which are subject to different pressures and which respond to these pressures in different ways and at different speeds. Changes in the composition of output may lead to shifts in the mix of inputs and change in the rate at which production capacity is utilised as output of some products grows and others contract. These factors can affect measured MFP.

Figure 5.4 **Growth in FBT MFP and its components[a] in cycles 3 and 4**
Average annual growth rate (per cent)



[a] Capital services and hours worked weighted by income shares.

Data source: Authors' estimates.

The remainder of this chapter looks at changes between cycles 3 and 4 in VA and inputs at a more disaggregated level. Influences on FBT's VA and input use are examined in section 5.3. Section 5.4 provides a closer look at two specific parts of FBT — Wine and Bakery product manufacturing. Section 5.5 draws together the implications for FBT's productivity.

5.3 Influences on FBT's MFP growth

Changing demand for Australian FBT products

Despite the diversity of FBT manufacturing, there are some broad influences on demand for its output. Shifts in consumer preferences have affected the demand for particular FBT products and the appreciation of the Australian dollar has reduced the competitiveness of domestic FBT products.

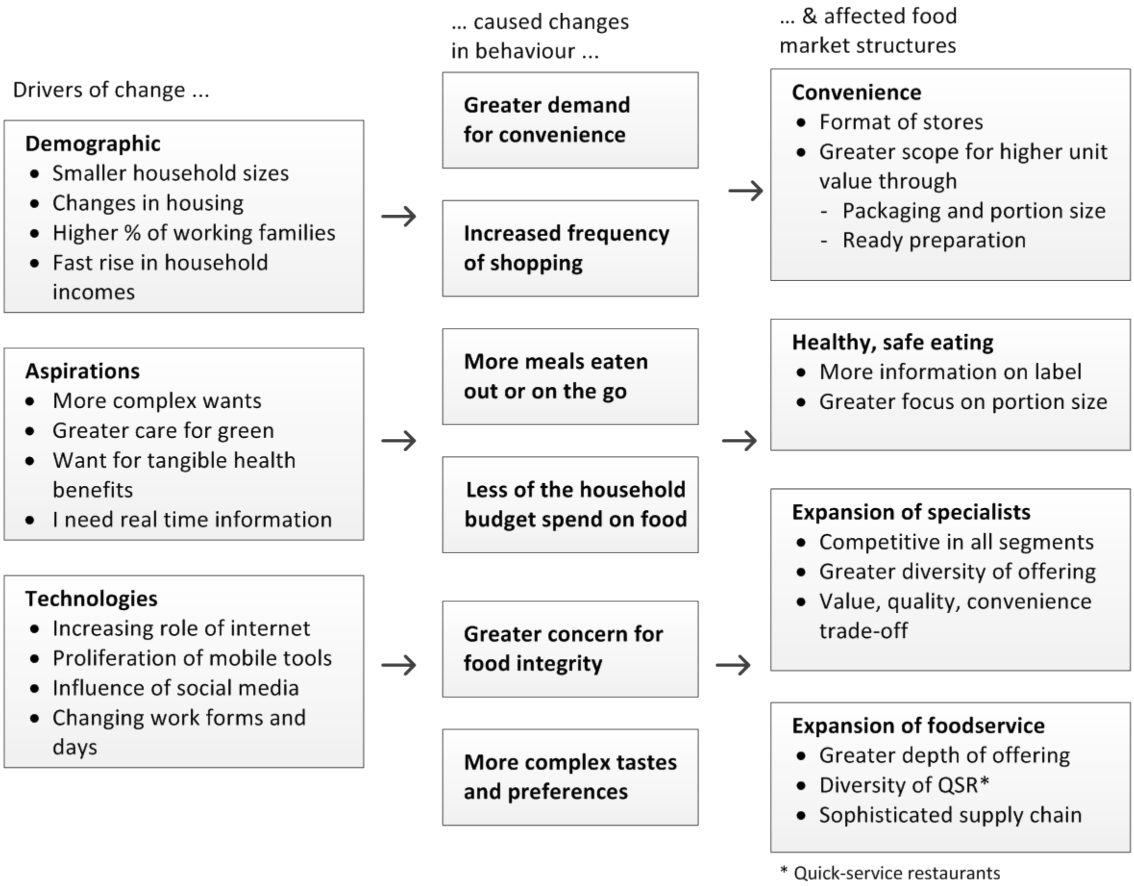
Consumers preferences for health benefits, convenience, quality and value

In high-income countries, the potential for growth in domestic demand for food tends to be limited by low rates of growth in both population and per person consumption. Per person consumption tends to have relatively low responsiveness to income changes in developed countries (Short, Chester and Berry 2006). And average Australian population growth has been relatively stable over the last two complete productivity cycles (around 1.5 per cent a year).

However, changes in tastes (in some cases linked to higher incomes) can influence demand for particular foods and beverages and are likely to have reduced demand for some FBT products and increased demand for others. Box 5.2 provides a summary of some of the broad influences on food markets over the last decade.

Box 5.2 **Broad trends affecting food markets**

The Department of Agriculture, Fisheries and Forestry has identified a number of major trends over the past decade affecting how consumers shop and eat that have created significant but steady change in the food industry environment. These trends affect manufacturers, food service providers and retailers (as summarised in this figure from Spencer and Kneebone 2012, p. 13).



Business Monitor International (2009) noted that recent trends influencing Australia's food-processing sector are similar to those elsewhere in the developed world.

> Consumers are driven by their demands for convenience, growing health awareness and the continued desire to trade up to premium and added-value food products. (p. 27)

Of the range of factors identified by Spencer and Kneebone (2007, 2012) as affecting demand for food in general, those with the most direct implications for the product mix of FBT manufacturing are:

- increased demand for convenience or 'lifestyle compatible' products
  - reduced meal preparation time — with a movement towards ready-prepared components and full meals
  - eating 'on the go' — with a movement towards snacking products and portion size products
- increased consciousness of wellness/healthy eating
  - an increase in healthy eating options per product category
  - increased focus on portion size products
- more complex tastes and preferences reflected in greater diversity of products and producers
  - quality/premium/indulgence products
  - specialised products
  - value products (including private label products).

The net effect of these preference changes on overall demand for food and beverage products, and for particular product groups, is complex. For example, there are potential tradeoffs between preferences for healthy eating, convenience and premium/indulgence products.

The complexities of these changes, and differences in their timing across product groups, make them difficult to identify from the available statistics. However, anecdotal evidence suggests, for example, there has been strong growth in sales of private label products (box 5.3) and chilled ready meals (Kitney 2013). And a greater proportion of space in supermarkets has been allocated to fresh foods and convenience foods (Australian Food and Grocery Council 2011a, p. 16).

Box 5.3 **Private label products**

Private labels are brands owned by and produced on behalf of the retailer. The market share of private labels varies considerably by product, with higher shares for commoditised products where there is less scope for differentiation and branding.

- IBISWorld (2012) points to high market shares of private label products in butter, sugar, bread, milk and canned fruit.
- The Australian Food and Grocery Council (2011a, p. 18) reports private label shares (for various years between 2007 and 2009) of around: 45-55 per cent for sugar, milk and cream; 30-40 per cent for cheese and bread; 15-20 per cent for smallgoods, snack foods, canned fish and sugar confectionery; and 5-10 per cent for yoghurt, ice cream and biscuits.
- Richardson (2012) reports a higher impact of private label and retailer influence on the wine industry than the beer industry, which is much more concentrated and has higher levels of brand loyalty. IBISWorld (2011) reports that private label wine accounted for about 8 per cent of sales in 2010.

While present in the Australian market for some time, changes in consumer attitudes and retailer strategies have led to an increase in private label growth in recent years. Statistics on private label market shares in Australia vary (and generally include all supermarket sales, not just those of FBT manufactured products), but there is general agreement that the share has increased and is likely to grow further.

- The Australian Food and Grocery Council (2011a, p. 17) reports a steady increase in the private label share of total supermarket sales from about 15 to 25 per cent between 2003 and 2010, with further growth anticipated based on global trends. This accelerated growth was attributed to: unprecedented focus on affordability by consumers, cost pressures of manufacturing placing pressure on margins of branded manufacturers, high level of retail market concentration, improved private label product quality, enhanced retailer capabilities and increased sophistication of private label programs.
- IBISWorld (2012) reports private label spending as a share of total supermarket sales in 2007-08 at 13.5 per cent and 25.2 per cent in 2012-13, with anticipated growth to 33 per cent in 2017-18. There were particularly large increases in private label market share in butter, bread and canned fruit between 2002-03 and 2012-13.

While private label growth appears to have increased over cycle 4, it may have been a larger influence still during the incomplete cycle. Some analysts suggest that the global financial crisis prompted more consumers to shift to private label products (see, for example, NZTE 2012).

Market shares have also increased for 'health conscious' products and premium products. For example:

- Consumer demand for more expensive, imported and domestically produced premium and craft beer brands has increased. Premium beers only accounted for approximately 8 per cent of the total packaged beer market in 2002 (Robins 2002) but were reported to have increased in market share to almost 20 per cent in 2009 (Canaider 2009). Craft beers also grew from close to zero a decade ago to make up about 2 to 2.5 per cent of total current beer manufacturing (Bainbridge 2013).

- Sivasailam (2010) reported that confectionery producers, in recent times, have responded to changes in consumer preferences in developed markets for luxury or premium brands, as well as catering to more health conscious consumers. This has been seen in the growth in dark, organic and naturally produced chocolate, as well as sugar-free confectionery.

It is likely that these changes in consumer preferences have affected not only the range of products produced but also the nature of the production process in some cases. For example, 'boutique' production, such as artisan bakery products and craft beer, occurs on a smaller scale than large factory production.

FBT net exports declined as the Australian dollar appreciated

The impact of the high Australian dollar has been identified by FBT manufacturers, together with domestic cost pressures and retailer strategies, as dampening their ability to compete both domestically and internationally (for example, Senate Select Committee on Australia's Food Processing Sector 2012; Food Processing Industry Strategy Group 2012; Australian Food and Grocery Council 2011a).

As noted in chapter 2, the competitiveness of domestically produced goods will be affected by a range of factors including input costs relative to those of foreign competitors and the exchange rate. Imports and exports may also change as a result of constraints on domestic production. For example, imports may increase to meet domestic demand when domestic production is constrained because of reduced input availability during drought; or when current domestic capacity is insufficient to meet a steep, unanticipated rise in demand. Some goods are not produced in Australia and so will not directly compete with domestic production.

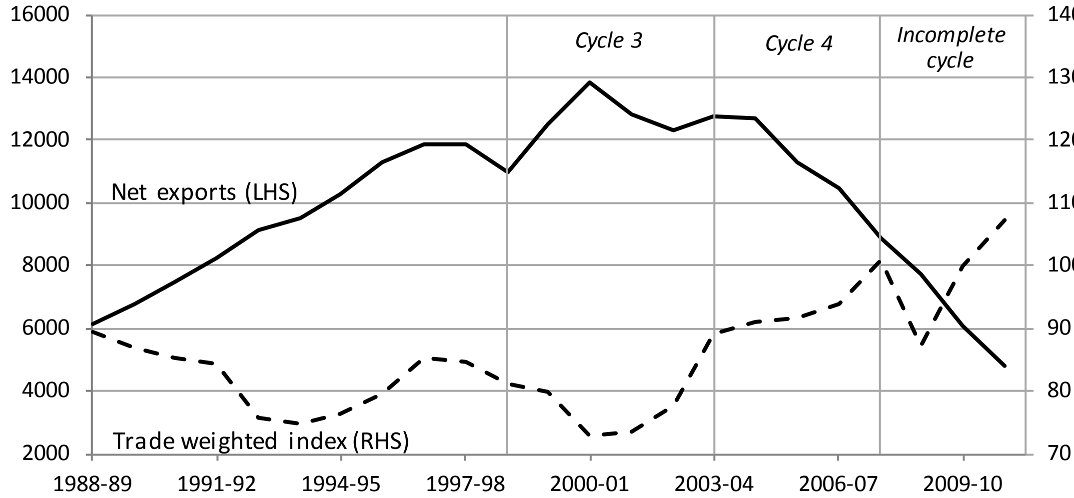
The appreciation of the dollar makes exports relatively expensive on world markets and imports relatively cheap on the domestic market. Consumers benefit from relatively cheap imported final goods. A stronger Australian dollar may also provide benefits to some FBT manufacturers through relatively cheap imported inputs (raw materials, services and capital equipment). The Australian Food and Grocery Council (2011a) acknowledged that a stronger dollar makes globally sourced commodities relatively cheap for Australian manufacturers. However, the Food Processing Industry Strategy Group (2012) suggested that for many food and beverage processors, these cost savings from imports are likely to only partially offset the impact of the high exchange rate on demand.

Import competition can provide incentives for firms to improve their efficiency and in the long run is likely to lead to improvements in industry productivity. More generally, trade helps support higher living standards by ensuring that an economy plays to its comparative strengths (box 2.2). However, in the short run, the effect on *measured* productivity may be negative. For example, when firms reduce output this can lead to underutilised capacity, which depresses *measured* productivity.

While Australia remains a net exporter of FBT manufactures, since the mid-2000s there has been a reasonably rapid decline in the extent to which exports exceed imports as the Australian dollar has appreciated and remained high (figure 5.5).

Figure 5.5 **FBT net exports[a] and the exchange rate[b]**

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



[a] Net exports is real exports less real imports. Due to ANZSIC classification changes, there is a break in series between 2005-06 and 2006-07. [b] The 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).

This deterioration in the net trade position was due both to a strong increase in import volumes and some decrease in export volumes. And in value terms, the share of domestic FBT production exported declined while imports as a share of domestic FBT sales increased (box 5.4). The extent to which different parts of FBT manufacturing are affected by these trends varies, which affects the composition of domestic output.

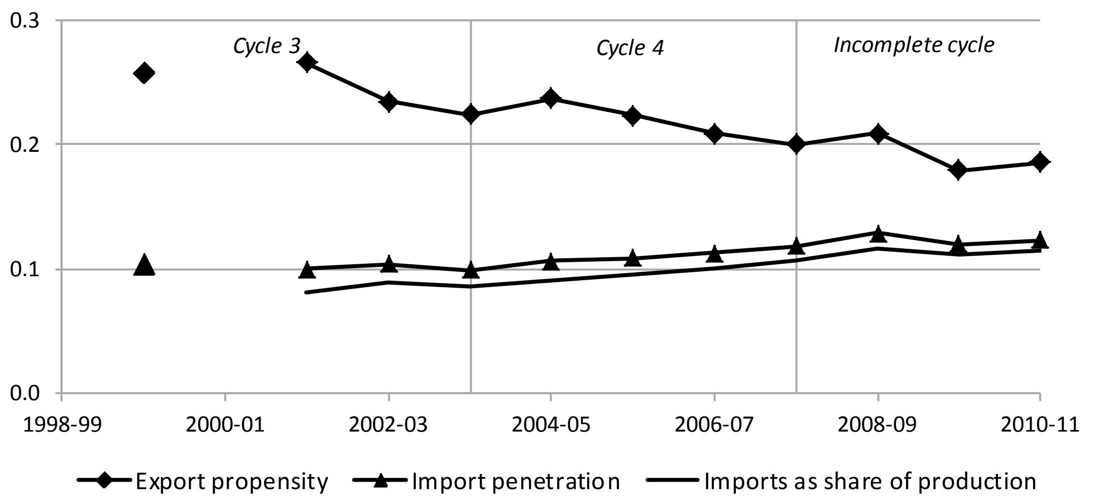
Box 5.4 **Export propensity and import penetration in FBT**

FBT manufacturing in aggregate is less trade exposed than some other parts of Manufacturing (such as Petroleum, coal, chemical and rubber products) — although this varies across different parts of FBT.

Most of total domestic demand for FBT products is supplied from domestic production rather than imports, and most of FBT output is destined for the domestic market rather than export. For example, in 2010-11, export propensity for FBT in total was around 19 per cent and import penetration was around 12 per cent. But import penetration has increased and export propensity has decreased, particularly over cycle 4 (see figure).

It should be noted that these measures are in value, not volume, terms thus also reflect price movements. And the mix of goods produced domestically could vary significantly from the mix of goods that are imported or exported. Not all FBT imports compete directly with domestic production (for example, some may be products not produced in Australia). Some may be inputs into other domestic FBT production, although ABS (2013a) estimates of imports of food and beverages classified as 'mainly for industry' or 'mainly for household consumption' show that most of the increase in imports has been in final consumption goods rather than intermediate inputs (appendix G).

Import penetration and export propensity in FBT[a]



[a] Import penetration is the value of imports as a share of the domestic market for FBT goods (which in turn is total sales and service income of domestic FBT manufacturing, plus the value of imports, less the value of exports). Export propensity is the value of FBT exports as a share of FBT manufacturing sales and service income. 1999-00 is from PC (2003) and may not be directly comparable because of changes to the scope of the survey from which sales and service income is derived.

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

Possible implications for measured productivity

In principle, there are two main ways in which the changes in demand (as a result of consumer preferences and the appreciation of the dollar) might reduce measured MFP.

- Changes in the composition of output can affect the measure of *aggregate* FBT MFP to the extent that different types of FBT manufacturing have different MFP levels. If the shift is into types of production with lower levels of productivity (that is, more input intensive per unit of output), this can reduce aggregate productivity.
- As noted above, during the process of adjusting production levels, producers reducing output may underutilise inputs (and possibly have to write off capital) but these inputs remain 'on the books' for productivity statistics. As other producers increase their output they employ additional inputs. Overall, this can result in input growth in excess of output growth, depressing measured aggregate productivity.

The diversity of the output produced, and of the inputs employed, by FBT manufacturers means that the nature and/or timing of change in the composition and volume of output can vary. The following sections use available data to examine the changes in VA, labour, and capital across the range of FBT manufacturing groups.

Slowdown in value added growth and change in its composition

Real VA[3] growth for FBT in aggregate was almost nil over cycle 4 (0.2 per cent a year), compared with cycle 3 (1.2 per cent a year), based on ABS National Accounts estimates (figure 5.6, left panel). But this conceals differences within FBT.

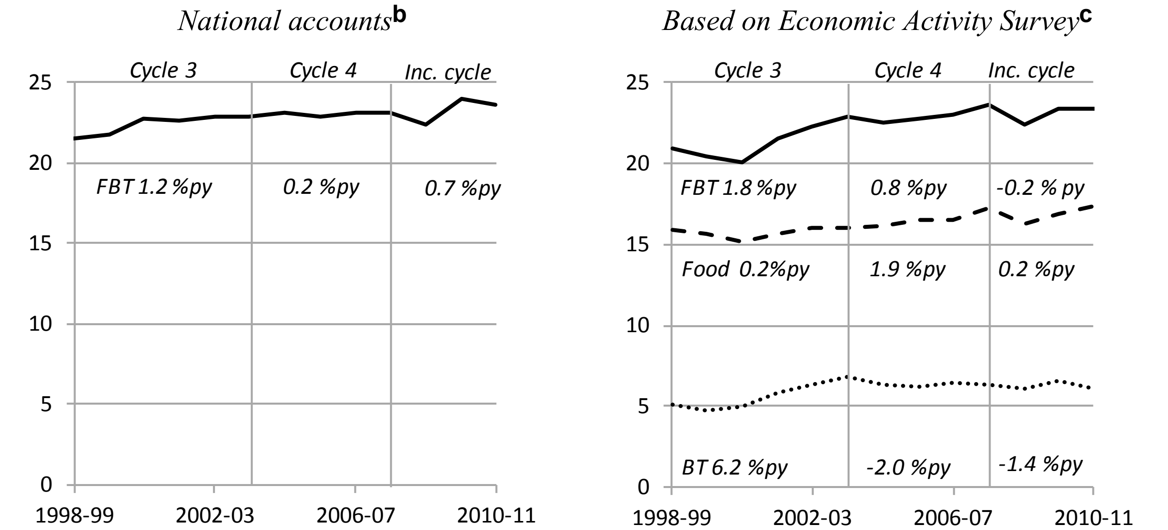
It appears that change in the Beverages and tobacco products (BT) subdivision was the main driver of FBT's real VA growth in cycle 3 and its slowdown in cycle 4 (figure 5.6, right panel). BT's real VA growth was 6.2 per cent a year over cycle 3, but fell to -2.0 per cent a year over cycle 4. This pattern was reversed in Food — with little growth (0.2 per cent a year) over cycle 3, but growth of 1.9 per cent a year over cycle 4. However, it should be noted that these subdivision estimates are

3 VA is gross output less intermediate inputs used in producing that output. Intermediate inputs are the inputs used by the business other than capital and labour — for example, energy, raw materials and services. Real VA (the volume of VA) refers to VA with the effect of price changes removed.

only indicative, since they are based on a different data source to the National Accounts aggregate for FBT and are subject to data limitations.[4]

Figure 5.6 **FBT real VA**[a]

2009-10 $bn and average annual growth rate (per cent)



[a] The charts in left and right panel are from different data sources and there are some differences in trend. Disaggregated data are not available from the ABS National Accounts. See appendix G for details. [b] Chain volume measure. [c] Nominal data adjusted for breaks in series in 2000-01 and 2006-07 and deflated using the producer price index for output. To the extent the output and intermediate input prices have grown at different rates, this derived VA series will differ from a double deflated series (such as FBT real VA from the National Accounts). This affects the BT series more than that for Food (appendix G).

Data sources: Authors' estimates based on ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0); ABS (*Producer Price Indexes, June 2012,* Cat. no. 6427.0); and ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0).

Reliable estimates of real VA at a disaggregated level below Food and BT are not available, but nominal VA data for ANZSIC groups provide some further indication of the areas of a slowdown in growth within those two subdivisions (figure 5.7).[5] In broad terms:

- Seafood, Oil and fat, and Wine had absolute declines in nominal VA in cycle 4, after growing in cycle 3. (Given the large contribution of Wine to the slowdown in nominal VA growth, it is examined in more detail in 5.4.)

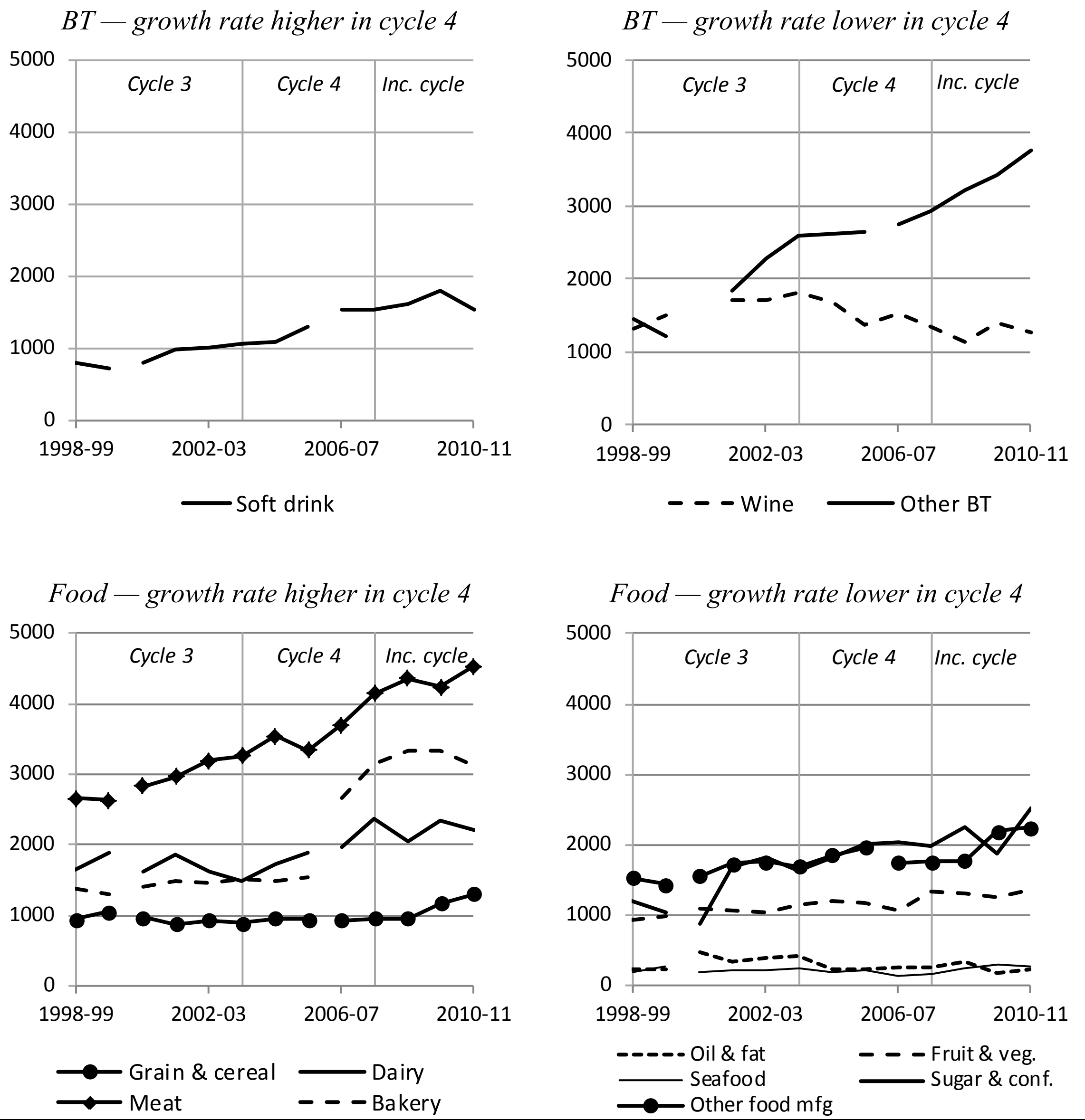
[4] These estimates of real VA in Food and BT are based on nominal VA from the ABS *Economic Activity Survey,* which is affected by issues of comparability over time. The limited availability of appropriate deflators also affects the quality of the derived *real* VA estimates. See appendix G for details.

[5] Nominal VA is affected by both price and volume changes, so may not be a reliable indicator of volume changes. Breaks in series will also affect comparability of nominal VA over time (appendix G).

- Fruit and vegetable processing, Sugar and confectionery, and Other food manufacturing had slower growth in cycle 4, compared with cycle 3.
- Soft drink, Dairy, Meat, and Grain and cereal had faster growth in cycle 4 than cycle 3. For Bakery, the addition of non-factory baking from 2006-07 distorts the comparison. (Bakery is also examined in more detail in section 5.4.)

Figure 5.7 **FBT nominal VA[a] by ANZSIC group**

$m



[a] Blanks indicate break in series: shift to management units in survey in 2000-01; shift to ANZSIC06 in 2006-07; and in the case of beverages missing data for wine and other BT in 2000-01. See appendix G for details.

Data sources: ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0).

Changing consumer tastes shifting the composition of domestic FBT value added

As noted above, changes in consumer preferences for particular characteristics — such as health, convenience, quality, value and diversity — can affect the composition of demand for food and beverage products. It is difficult to be precise about the timing and extent to which manufacturers in different parts of FBT are likely to be affected by, and respond to, these preference changes. There is the potential for positive and negative effects from changing consumer preferences on different parts of FBT manufacturing.

- Preferences for quality, convenience and 'lifestyle-compatible' products may result in an increase in value adding. The Australian Food and Grocery Council (2011b, p. 47) noted that prepared meals that are sold at supermarkets or specialist food retailers generally have higher levels of processing. This can include meal kits, which have the components of a meal assembled and prepared for cooking, and ready to eat meals that are pre-cooked.
- If changing consumer preferences led to some shift in demand from processed food products to fresh produce (such as unprocessed fruit and vegetables), then, in statistical classification terms, this would appear as a decrease in demand for Manufacturing output and an increase in demand for the output of the Agriculture sector.
- The effect of consumer preference shifts on Australian FBT manufacturers will also depend on the relative competitiveness of Australian producers and international producers. (Changes in detailed exports and imports are discussed in the next subsection.)

Figure 5.8 shows that there has been some shift in the composition of nominal VA[6] between FBT groups over cycles 3 and 4. Between 2003-04 and 2007-08, in particular:

- Soft drink, Bakery, Dairy and Meat have increased in share
- Seafood, Oil and fat, Grain and cereal,[7] Fruit and vegetable processing, Sugar and confectionery, Other food, Other BT (including Beer) and Wine have declined in share.

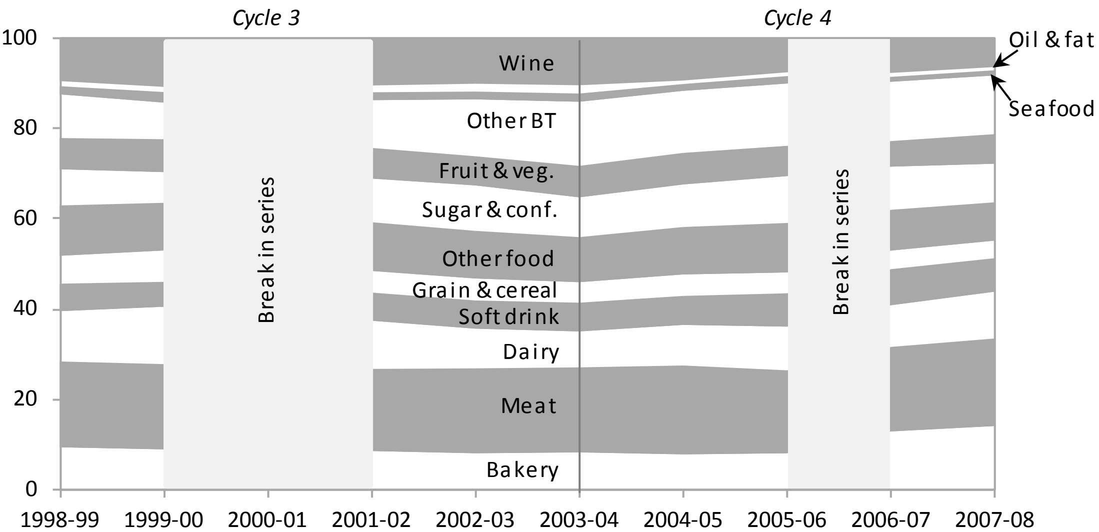
6 The composition of nominal VA is affected by change in relative prices and volume. Also, non-factory bakery is included only from 2006-07 causing a jump in the shares for Bakery. Although comparable data for non-factory bakery are not available prior to this, other sources suggest relatively strong growth in non-factory bakery compared with factory bakery (box 5.10). Therefore the share for Bakery in total is likely to have increased over cycle 4.

7 While Grain and cereal had an increase in its growth rate between cycles (figure 5.7), its share declined because of its relatively low growth rate over cycle 4.

However, it is difficult to link these changes in composition with shifts in consumer preferences. The extent to which consumer preferences have changed between cycles 3 and 4 is unclear, and many of the changes between products will occur within the ANZSIC groups/classes for which data are available, rather than between them.

Figure 5.8 **Composition of nominal VA in FBT by ANZSIC group**[a]

Percentage shares of total FBT



a Shaded blocks indicate break in series: shift to management units in survey in 2000-01; missing data for 2000-01 for Wine and Other BT, and shift to ANZSIC06 in 2006-07 (which particularly affects Bakery).

Data sources: ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0).

A further complicating factor is that it is difficult for measures of real output to fully reflect changes in the quality of FBT products. Real VA growth for FBT in aggregate may be understated if improvements in quality (including convenience) have increased over time and are not fully reflected in VA measurement (box 5.5).

Box 5.5 **Issues in measuring change in the quality of output**

For the purpose of measuring productivity, improvements to the quality of outputs or inputs should ideally be converted into quantity changes, before MFP is estimated. Unmeasured improvements to the quality of outputs would cause an understatement of the volume of output and therefore measured MFP would understate genuine improvements in productive efficiency.

Output volumes are 'backed out' from production valued at market prices. The ABS formulates price indexes for groups of products to do this — and it aims to take account of changes in the quality of products so that the price indexes reflect price inflation rather than payment for improved quality. This requires that products are distinguished from other similar products of lower quality. However, there are some practical limitations to this process. For example, for new products there may be a lag before they can be included in the price index; and with frequent changes in the quality of products it is almost impossible to adequately adjust for all quality changes (see ABS 2006a for further details).

If the rate of quality change is fairly constant over time this measurement issue may not be a major influence on MFP trends, but if the pattern of quality change is variable it may be more important.

Tradeoff between productivity and profitability is difficult to establish with available data

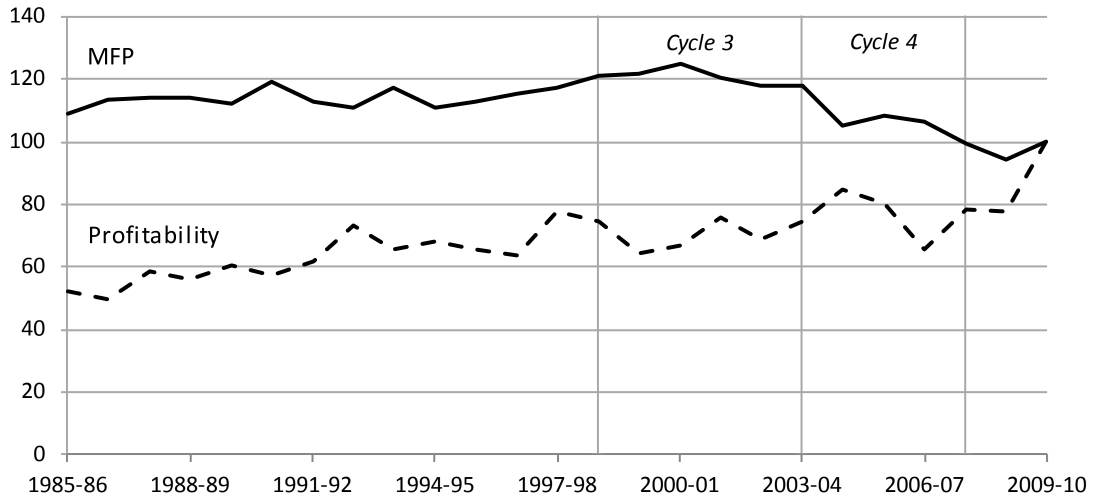
As discussed in chapter 2, an increase in profitability concurrent with a decline in MFP for an industry sector or subsector may indicate that there was some shift in the composition of output towards products with lower measured productivity levels but higher levels of profitability.

For FBT in aggregate, however, there is no consistent relationship between change in productivity and profitability (ratio of profit to capital stock) over the longer term (figure 5.9). And there is also no clear relationship[8] over cycle 4 between productivity and profitability (which is more volatile). These aggregate measures may conceal offsetting effects across different parts of FBT. However, insufficient data are available with which to examine profitability over time for groups within FBT.

8 This is in contrast to Manufacturing in total (figure 2.16), where there is a decline in profitability and productivity over cycle 4.

Figure 5.9 **FBT MFP and profitability**[a]

Index 2009-10 = 100



[a] Profits based on company profits only (does not include unincorporated businesses with fewer than 20 employees), while the capital stock is for all FBT manufacturers. However, the trend is not likely to be materially altered by this exclusion. ABS business count data (*Counts of Australian Businesses, including Entries and Exits, June 2003 to June 2007*, Cat. no. 8165.0) suggest that unincorporated businesses are only around 10-15 per cent of businesses in FBT over cycle 4. And an alternative measure of profit from ABS (Cat. no. 5676.0) which includes imputed profits for unincorporated businesses — gross operating surplus — shows a similar trend to company profits.

Data sources: Authors' estimates; ABS (*Business Indicators, Australia, June 2011,* Cat. no. 5676.0).

Declining net exports in FBT products and lower VA growth

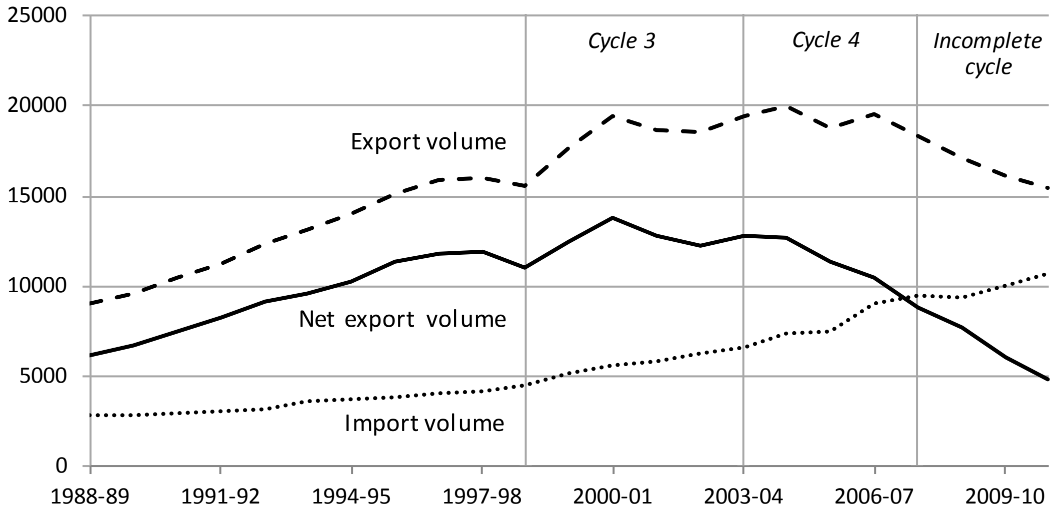
The decline in net exports of FBT products (as noted in figure 5.5) was the result of both a decline in exports and an increase in imports (figure 5.10). Over cycle 4, export volumes fell by an average of 1.4 per cent a year, while import volumes grew at 9.4 per cent a year. (This compares with positive export growth of 4.6 per cent a year and slower import growth of 7.9 per cent a year over cycle 3). These changes contributed to the slowdown in VA growth over cycle 4. In the incomplete cycle, which included the global financial crisis, exports continued to contract and imports continued to grow (albeit at a slower rate), but average VA growth increased.

These trends are consistent with the OECD reporting a decline in Australia's revealed comparative advantage[9] in FBT manufacturing over the 2000s, particularly from 2005 to 2008 (OECD.Stat 2013).

9 A measure based on domestic VA embodied in gross exports.

Figure 5.10 **FBT imports and exports**[a]

2009-10 $m



[a] Due to ANZSIC classification changes, there is a break in series between 2005-06 and 2006-07.

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).

Within FBT manufacturing, trade performance varied considerably. The largest declines in net exports (in nominal terms[10]) were in beverages, processed seafood, processed fruit and vegetables and other food (which includes sugar and confectionery, and other food not elsewhere classified) (figure 5.11). These are FBT groups identified as having lower VA growth over cycle 4 compared with cycle 3. In most of these cases it was higher imports rather than lower exports that contributed more to the decline in net exports — only in Seafood was there a large decline in exports. By contrast, net exports increased in Meat (which had increases in exports in excess of the increase in imports). This FBT group had higher VA growth over cycle 4 compared with cycle 3.

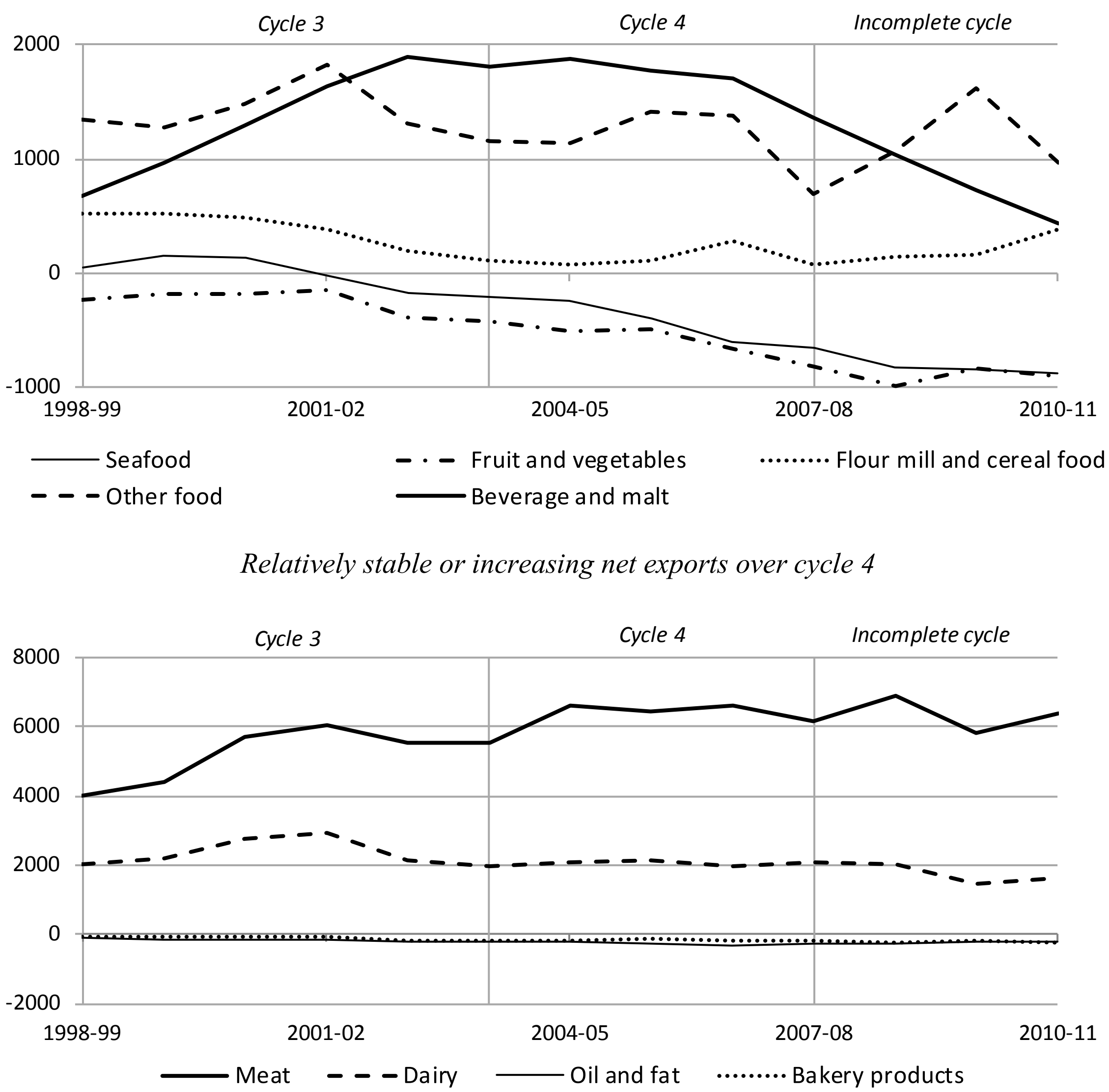
[10] Real export/import data are not available for all ANZSIC groups. Nominal exports and imports are only indicative of changes in volume as they are also affected by changes in prices.

Figure 5.11 **Net exports by FBT product group**[a]

$m

Declining net exports over cycle 4

Relatively stable or increasing net exports over cycle 4



[a] Nominal exports less nominal imports. Trade classification used here differs from ANZSIC classification used elsewhere in chapter. Exports are classified according to the Australian Harmonised Export Classification and imports are classified according the Harmonised Tariff Item Statistical Code (see DAFF 2005a, p. 35 for details).

Data sources: Authors' estimates based on DAFF (2002, 2008, 2013).

To the extent that changes in trade differ across particular FBT product groups, the overall decrease in net exports will affect the composition of domestic FBT production. It may also affect capacity utilisation (this is discussed later in the chapter in the section on capital).

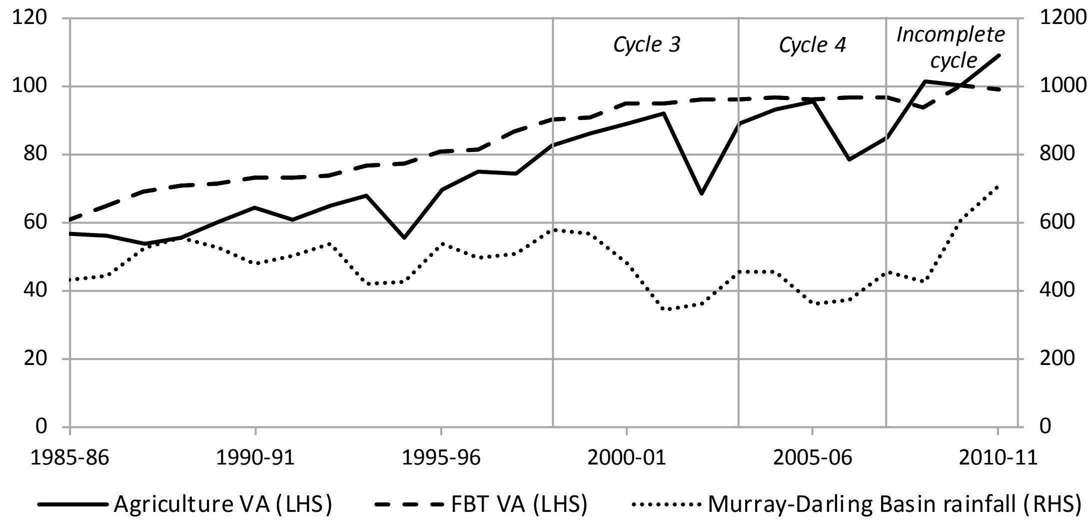
Value added in FBT manufacturing in aggregate did not fall in severe droughts

Given the role of agricultural produce as an input into FBT manufacturing,[11] there is the potential for drought to affect the output of FBT manufacturers. There was a severe drought year in both cycle 3 (2002-03) and cycle 4 (2006-07). Agriculture VA dipped in these years but VA for FBT *in aggregate* did not (figure 5.12). However, the period of slow VA growth in FBT did coincide with an extended period of below average rainfall from 2001-02 to 2008-09, suggesting some link with agricultural performance.

The parts of FBT closely associated with the processing of current agricultural output are the most likely to be affected by drought. For example, the 2006 drought affected wine production including in 2007-08 (this is discussed further in section 5.4).

Figure 5.12 **Value added in FBT and Agriculture,[a] and rainfall**

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



[a] Chain volume measures.

Data sources: ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0); Bureau of Meteorology (2013).

[11] Appendix G shows the input-output linkage between Agriculture and FBT as a whole.

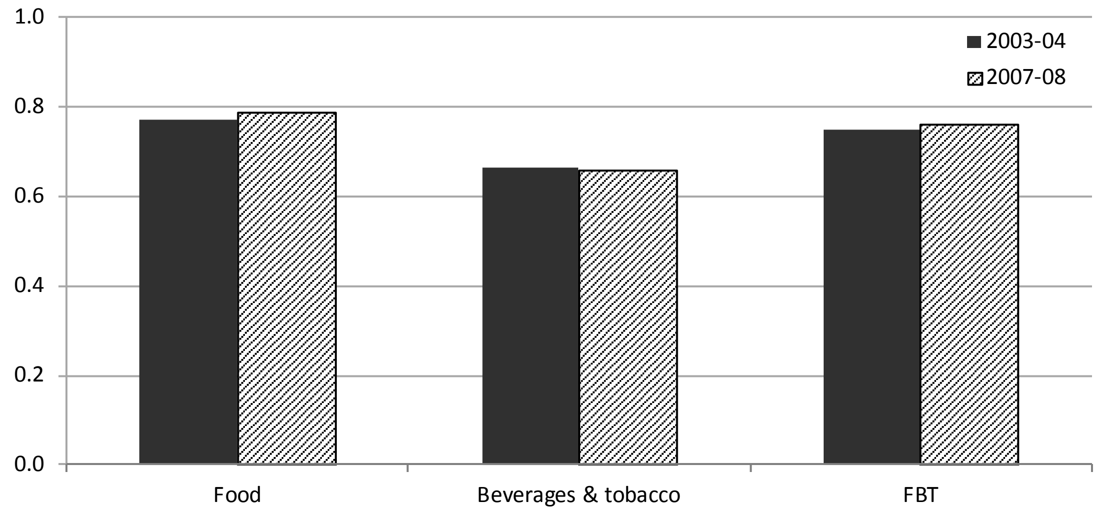
Limited information on change in intermediate inputs

VA can also be reduced if there is an increase in the volume of intermediate inputs used to produce a unit of output.[12] Anecdotal evidence suggests that over the longer term there have been some changes in the nature of products and requirements from retailers and regulators that may have increased the ratio of intermediate inputs to output for some FBT manufacturers, such as:

- increased packaging due to smaller product or portion sizes and retailer requests for 'straight to shelf' packaging to reduce labour costs in stocking shelves (Food Processing Industry Strategy Group 2012, p. 83)
- increased commercial quality audits and regulatory food safety audits, with some duplication of coverage (Senate Select Committee on Australia's Food Processing Sector 2012; Food Processing Industry Strategy Group 2012, p. 106).

However, the influence of these factors in cycle 4 compared with cycle 3 is not known. Insufficient data are available with which to examine change in the ratio of intermediate input to output in *volume* terms. ABS data suggest that over cycle 4 the ratio of intermediate inputs to sales in *value* terms has not changed significantly for FBT manufacturing in aggregate, or for the Food and BT subdivisions within it (figure 5.13). (In value terms, the ratio will also be influenced by changes in the relative price of inputs and outputs.)

Figure 5.13 **Ratio of intermediate inputs[a] to sales and service income[b]**



[a] Intermediate inputs includes purchases of goods, materials and services. [b] Data not readily available for 1998-99. 2003-04 estimates based on ANZSIC93 and 2007-08 based on ANZSIC06.

Data sources: Authors' estimates based on ABS (*Manufacturing Industry, Australia, 2005-06*, Cat. no. 8221.0); and ABS (*Australian Industry, 2007-08,* Cat. no. 8155.0).

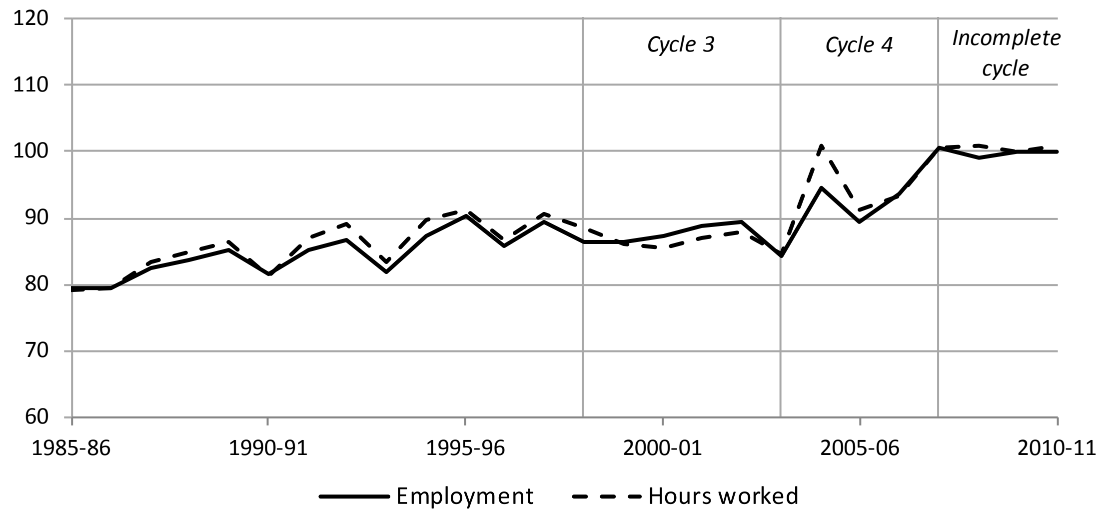
[12] The volume of value added is the volume of gross output less the volume of intermediate inputs such as energy, raw materials and services.

Hours worked

The main proximate cause of the decline in FBT MFP growth between the last two complete productivity cycles was the turnaround in hours worked — from a fall in hours over cycle 3 to significant growth over cycle 4.[13]

Hours worked (and numbers employed) in FBT were relatively stable over cycle 3, compared with the increasing trend up to the mid-1990s (figure 5.14). However, there was a decline in 2003-04 (which is the final year of cycle 3 and the first year of cycle 4). There was some volatility in hours worked and employment during cycle 4, but both were considerably higher in 2007-08 than 2003-04.[14] Labour input remained relatively stable at this higher level in the incomplete cycle.

Figure 5.14 **FBT employment and hours worked**[a]
Index 2009-10 = 100



[a] Hours worked annualised and adjusted for public holidays and changes in survey methodology (appendix A). Unadjusted employment numbers.

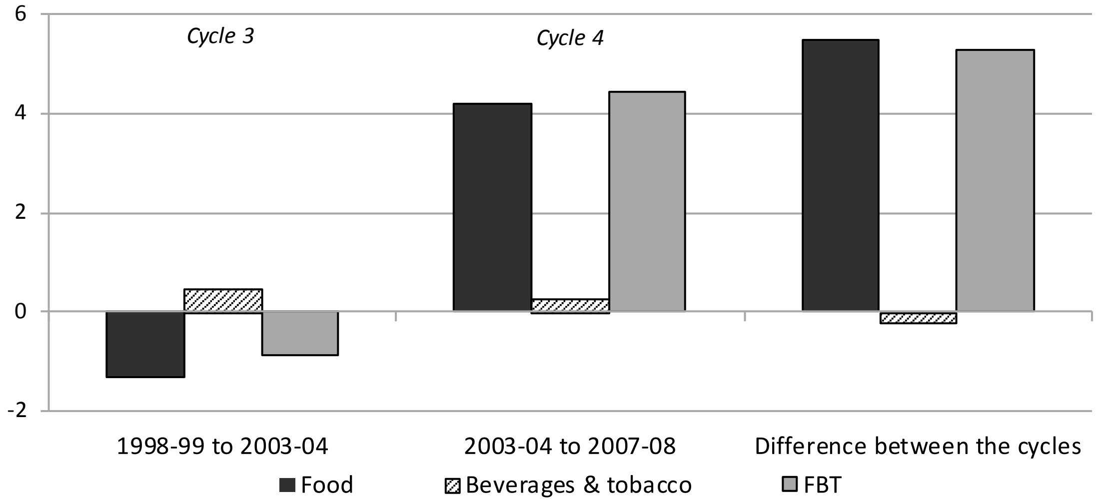
Data source: Authors' estimates based on ABS (unpublished Labour Force Survey data).

[13] The hours worked measure used in the MFP estimates in this paper are based on ABS *Labour Force Survey* data on an ANZSIC06 basis. Comparability between employment estimates from the *Labour Force Survey* and the ABS *Economic Activity Survey* is discussed in appendix G. The trend is broadly similar in both surveys, with faster growth in cycle 4 than cycle 3. However, the *Economic Activity Survey* data suggest a smaller increase between cycles.

[14] While there may be some volatility in employment in FBT manufacturing around drought years (DAFF 2005b, 2007), ABS *Labour Force Survey* data at lower levels of disaggregation can also be subject to 'noise' from year to year.

Figure 5.15 **Contributions of FBT subdivisions to average annual growth in total hours worked in the FBT subsector**

Percentage points



Data source: Authors' estimates based on ABS (unpublished Labour Force Survey data).

FBT hours worked were dominated by Food manufacturing rather than Beverage and tobacco manufacturing. And in both cycles 3 and 4, the change was almost solely due to the Food manufacturing subdivision (figure 5.15).

Explanations put forward for the decline in labour usage in FBT during cycle 3 include:

- rationalisation of production in some parts of FBT (including Meat and Bakery) and the rising Australian dollar between late 2001 and early 2003 (Smith and Jahan 2003)
- decrease in underemployed labour due to changes in workplace arrangements allowing food processors to better match labour with fluctuating demand (Delforce, Dickson and Hogan 2005)
- the severe and widespread drought in 2003 reducing the primary products available for food processing in 2003-04 (DAFF 2005b; Smith and Jahan 2003).

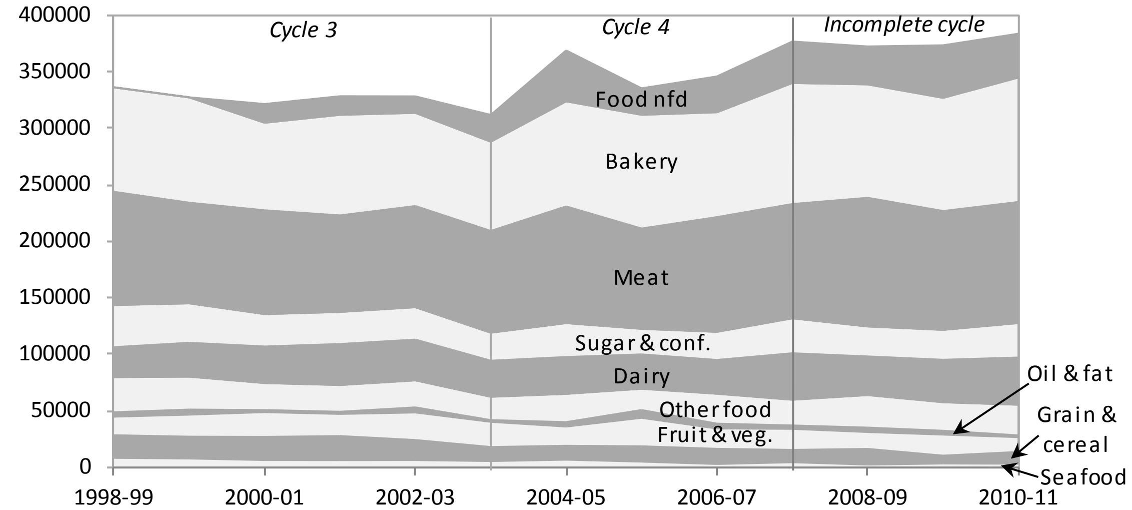
Explanations for the significant increase in FBT hours worked over cycle 4 are less clear. The positive turnaround in hours worked growth in Food manufacturing appears to have been much stronger than the turnaround in real VA growth. And in BT, hours worked continued to grow (albeit at a slower rate), while VA declined. During the process of adjustment of production, there may have been some underutilised labour (or 'labour hoarding') in the parts of FBT with declining VA, particularly if declines were expected to be temporary. Firms may hoard labour in anticipation of an upturn, generally to avoid hiring costs and to retain employees that may be difficult to replace.[15] But change in the composition of output, including in response to consumer preferences, may also have increased the average labour intensity of production.

Largest increases in hours worked in Bakery, Meat, and Sugar and confectionery

Most Food manufacturing groups had a decline in hours worked in cycle 3, followed by a rise in hours worked in cycle 4 (figure 5.16). But the largest turnarounds in hours worked were in Bakery, Meat, and Sugar and confectionery.

Figure 5.16 **Hours worked by Food manufacturing group[a]**

'000 hours



[a] Food nfd (not further defined) includes survey respondents who provided insufficient details to be allocated to an ANZSIC group.

Data source: Authors' estimates based on ABS (unpublished Labour Force Survey data).

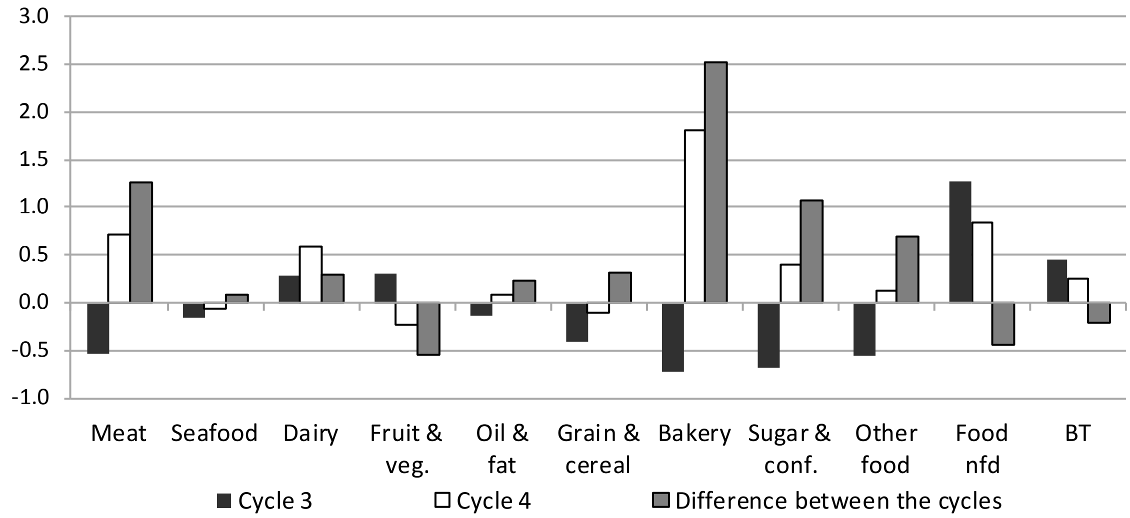
[15] Hours worked does not provide a reliable indicator of labour hoarding — since firms may reduce the number of hours worked by each employee during a downturn. Productivity estimates based on hours worked measures of labour input will be less affected by labour hoarding than estimates based on numbers employed. There are no readily available data to test whether labour hoarding was a significant factor over this period. A decline in average hours worked may provide an indicator of the hoarding of employees at reduced hours per employee. There was a small decrease in average hours worked in FBT over cycle 4, but year-to-year volatility in the data make it difficult to draw firm conclusions. Since cycle 4, average hours worked has stabilised.

Figure 5.17 shows the *contributions* of each of the groups to the increase in growth in aggregate FBT hours worked in cycles 3 and 4 and the change *between* cycles.

- Bakery contributed almost half of the total FBT increase in hours worked growth between cycles,[16] followed by Meat (almost a quarter), and Sugar and confectionery (22 per cent). It was large increases in cycle 4 that led to the particularly large contributions from Bakery and Meat.
  - Within Bakery, it appears to be non-factory baking (for example, hot bread shops) rather than factory baking that led to this growth.[17]
- Seafood, Oil and fat, Grain and cereal, Dairy and Other food made positive contributions of between 2 and 15 per cent of the total FBT increase.
- Fruit and vegetable processing had an offsetting decline in hours worked, as did BT.[18]

Figure 5.17 **Contributions of FBT groups to average annual growth in total hours worked in the FBT subsector[a]**

Percentage points



[a] Food nfd (not further defined) includes survey responses the ABS has been unable to allocate to a specific ANZSIC food group.

Data source: Authors' estimates based on ABS (unpublished Labour Force Survey data).

[16] The large contribution of Bakery is not due to a break in series for ANZSIC06 as the ABS has backcast the *Labour Force Survey* data to make it more consistent over time (appendix G).

[17] Based on more detailed data on employment from the ABS *Economic Activity Survey* (appendix G).

[18] Food not further defined (nfd) also had an offsetting decline. Food nfd is a category for which the ABS have been unable to allocate hours worked to a specific ANZSIC food group (appendix G). While there was considerable growth in this category in both cycle 3 and 4, it was not the source of the increase between cycles 3 and 4.

A move to more labour-intensive products and production processes?

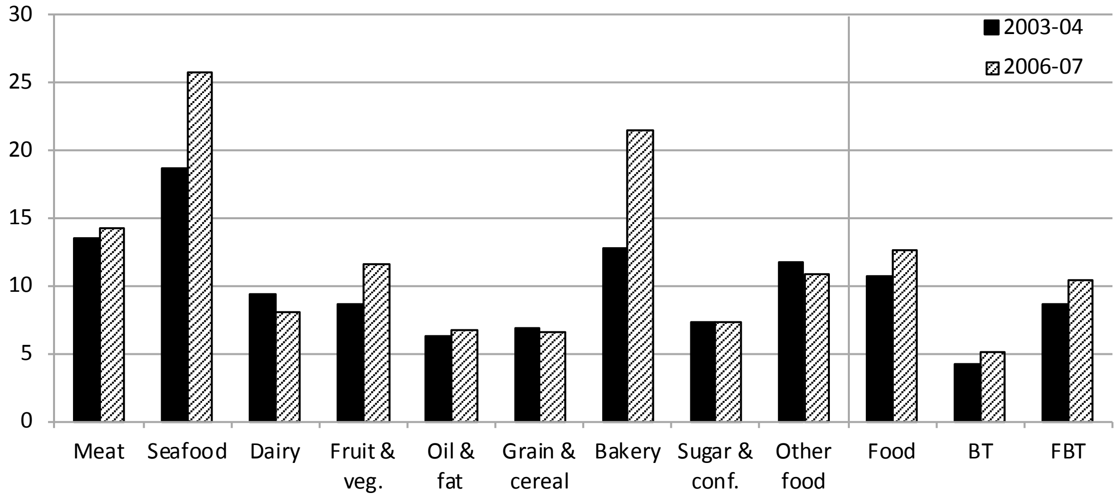
There are some trends in consumer preferences that are consistent with an increase in the labour intensity of FBT production:

- ‘home made’ products or ‘ready to eat’ products that are relatively labour intensive — such as artisan bread, handmade chocolates, and some pre-prepared meals
- ‘boutique’ or niche products made in smaller scale businesses rather than large factories — for example, craft beer and non-factory bakery products. Growth in the number of beer brewers was especially significant in cycle 4, increasing 25 per cent a year from 51 to 126 (Australian Food and Grocery Council 2010).

As noted in the ‘value added’ section, it is difficult to identify the timing and extent of these changes, and data for such finely differentiated products are not available. However, the labour intensity of FBT ANZSIC *groups* can be compared. Figure 5.18 shows that Food is more labour intensive than BT (that is, has a higher number of employees per million dollars of real VA).[19] Therefore the increase in Food manufacturing as a share of FBT VA is consistent with a higher average level of labour intensity for FBT manufacturing as a whole. Furthermore, within Food, there has been an increase in the VA share of some of the more labour-intensive groups (for example, to Meat, Dairy and Bakery away from Oil and fat, and Grain and cereal).

[19] These labour intensity measures should be considered as broad indicators of differences across ANZSIC groups. The real VA estimates used have been derived using producer price indexes for output (see appendix G for a discussion of limitations of this approach). It should also be noted that these estimates are based on VA and employment from the ABS *Economic Activity Survey*, which is subject to limited comparability over time. The *Economic Activity Survey* employment estimates also differ from the *Labour Force Survey* data reported earlier in the chapter and used to estimate MFP for FBT.

Figure 5.18 **Employed persons per $m of real value added in FBT by ANZSIC group**[a]



[a] Real VA in 2009-10 dollars — approximate estimates based on nominal VA deflated by producer price indexes for output (appendix G). Data for employment for 2007-08 are not available from the ABS *Economic Activity Survey*. Data for 2006-07 have not been adjusted for change in industry classification in 2006-07. Bakery includes non-factory baking for 2006-07 but not for 2003-04.

Data sources: Authors' estimates based on ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); and ABS (*Producer Price Indexes, Australia*, *June 2012,* Cat. no. 6427.0).

Compounding these share changes, there has also been some change between 2003-04 and 2006-07 in the labour intensity of some of the ANZSIC groups and this accounts for more than half of the change in overall FBT labour intensity.[20] However, in some cases, this change over time is accentuated by industry classification change. The large increase for Bakery, for example, is due to the addition to this ANZSIC group of non-factory baking which is more labour intensive than factory baking.[21] (The change in the nature of Bakery products and production processes is discussed further in section 5.4.)

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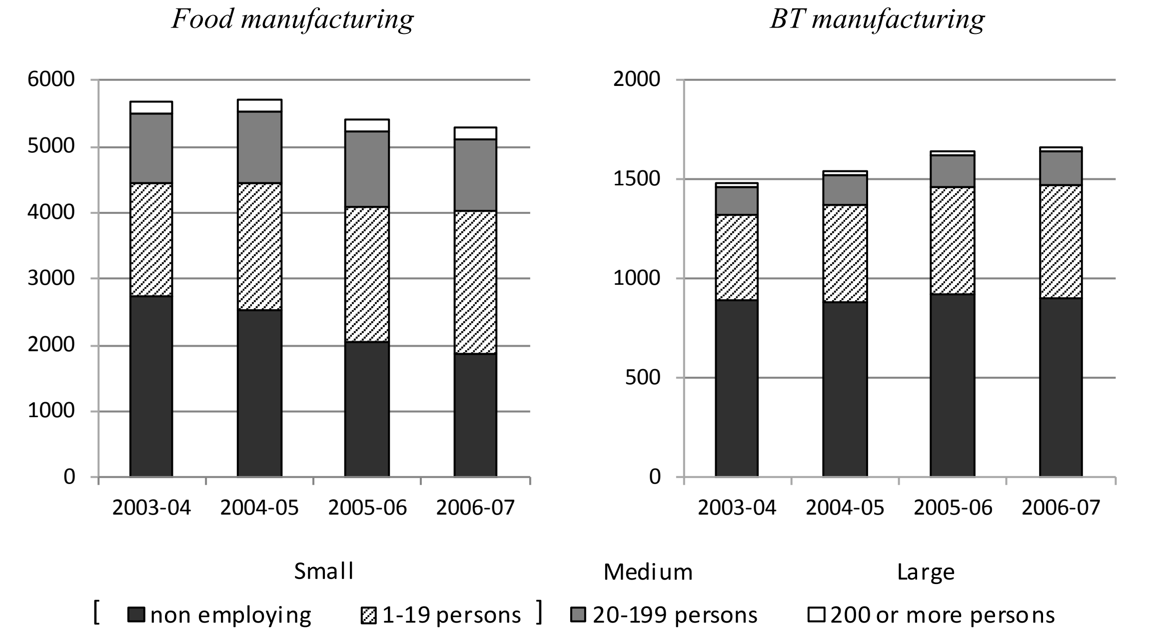
[20] Shift-share analysis (appendix G) suggests that the bulk of the change in average labour intensity was due to changes in the labour intensity of the FBT groups rather than in the relative size of the FBT groups (changes in the VA shares of each group). For those ANZSIC groups with absolute declines in real value added, it is possible that labour 'hoarding' may have contributed to the increase in labour intensity. However, this cannot be determined from available data. Those groups with declines in real value added (such as Seafood processing and Fruit and vegetable processing) made relatively small contributions to the overall increase in labour intensity (table G. 1).

[21] In the ABS *Economic Activity Survey* data, non-factory baking was just added in 2006-07 and not backcast. However, as there has been relatively strong growth in the number of non-factory bakery firms, it is expected that VA per employee for baking in total would still decline over time if the *Economic Activity Survey* series was backcast (appendix G). (The data used to estimate MFP for FBT have been backcast for the inclusion of non-factory baking and other changes in ANZSIC.)

Most FBT businesses employ fewer than 200 persons — and small firms are less able to capture economies of scale. The Prime Minister's Taskforce on Manufacturing (2012) noted that FBT manufacturers were of significantly smaller average scale (by employment) in Australia than in Germany and the United States. However, the number of Australian FBT businesses classified as small (employing fewer than 20 person), medium (20–199 persons) and large (200 or more) remained relatively stable between 2003-04 and 2006-07 (figure 5.19).[22] What has changed is the makeup of the small business category — the number of non-employing businesses has declined and there has been a marked increase in the number of businesses employing 1–19 persons. This change has been more pronounced in Food than in BT.

Figure 5.19 **Shifts in the scale of FBT businesses[a]**
Number of businesses by employment size[b]



[a] On an ANZSIC93 basis (does not include non-factory baking). [b] A non-employing business is one without an active income tax withholding role or which has not remitted income tax withholding for five consecutive quarters. Business counts include only those registered for an Australian Business Number (during the period covered by this figure businesses with a turnover of at least $50 000 per year, or $100 000 in the case of non-profit organisations, were required to register for an Australian Business Number and remit goods and services tax).

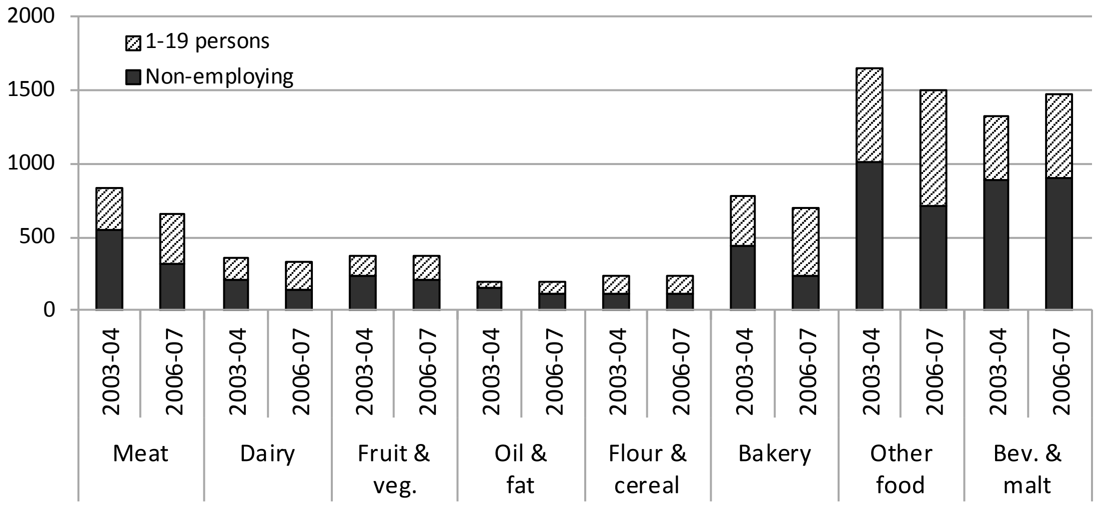
Data source: ABS (*Counts of Australian Businesses, including Entries and Exits, June 2003 to June 2007*, Cat. no. 8165.0).

[22] The number and shares of businesses by turnover size show little change over this period, based on data from ABS (2007).

The Food manufacturing groups that had the largest turnarounds in hours worked growth between cycles 3 and 4 — Meat, Bakery and Sugar and confectionery — also had large shifts from non-employing businesses to businesses employing 1–19 persons (figure 5.20).[23]

Figure 5.20 **Small-scale FBT businesses by ANZSIC group[a]**

Number of businesses by employment size



[a] On an ANZSIC93 basis: Sugar and confectionery is included in Other food manufacturing; and Bakery does not include non-factory baking. Tobacco product manufacturers are not included.

Data source: ABS (*Counts of Australian Businesses, including Entries and Exits, June 2003 to June 2007*, Cat. no. 8165.0).

Measurement error?

The hours worked estimates used in the MFP and labour productivity estimates in this paper are based on the ABS *Labour Force Survey* data that have been backcast by the ABS to account for changes in industry classification over time. It is possible that these estimates are subject to some measurement error.

- Industry misclassification is possible in household surveys, such as the *Labour Force Survey*, as employees' descriptions of their industry of employment may be less precise than those provided by employers.
- Backcasting for change in industry classification is unavoidably based on assumptions and may be subject to imprecision where assumptions do not reflect actual movements.

[23] In figure 5.20, Sugar and confectionery is included in Other food manufacturing and Bakery does not include non-factory baking.

These issues are discussed further in appendix G. However, it should be borne in mind that any measurement error in hours worked growth would need to be very large to reverse the decline in measured MFP in cycle 4 (appendix E).

Capital

Capital services grew at similar rates over cycle 4 (5.1 per cent a year) and cycle 3 (6.0 per cent a year) — so an increase in capital growth was not the proximate cause of the fall in FBT MFP growth *between* these cycles. However, capital growth over cycle 4 in particular warrants closer examination since, *in aggregate*, it produced little growth in the real VA measure. And it does not appear to reflect a substitution of capital for labour inputs (since hours worked growth was even stronger).

Changes in product mix and levels of processing, as discussed above, may have required new types of capital and led to a decline in the utilisation of some of the existing capital stock. There may also have been an adjustment period before some investment (in response to increased competition and input costs) provided benefits in terms of productivity and/or profitability.

Most investment was in machinery and equipment for Food manufacturing

The majority of FBT investment was in machinery and equipment (M&E) — around two-thirds on average in both cycles 3 and 4 (figure 5.21). M&E also accounted for the majority of investment growth, although there was growth in all asset types. Non-dwelling construction (NDC) was relatively volatile, but there was steady growth in software and R&D. R&D intensity also grew — at a faster rate over the last two complete productivity cycles than in the previous decade (figure 5.22).

Food manufacturing accounted for the majority of the investment and the growth in investment in both M&E and NDC (figure 5.23). On average over cycle 3 and 4 this subdivision accounted for around 70 per cent of M&E and 80 per cent of NDC investment.[24]

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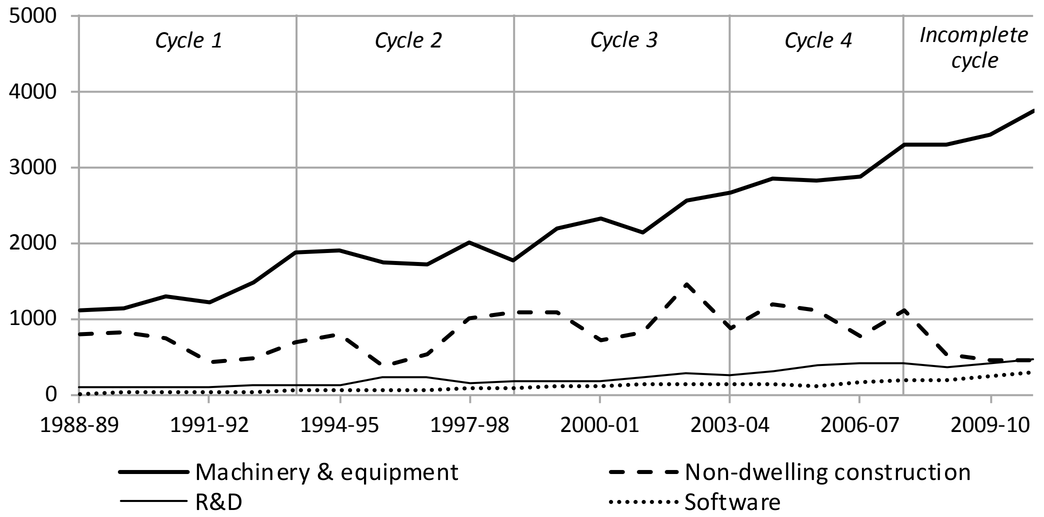
[24] Disaggregated data not available for other assets. Very limited data are available for ANZSIC groups within Food and BT (appendix G).

Figure 5.21 **FBT gross fixed capital formation by asset type**[a]

2009-10 $m

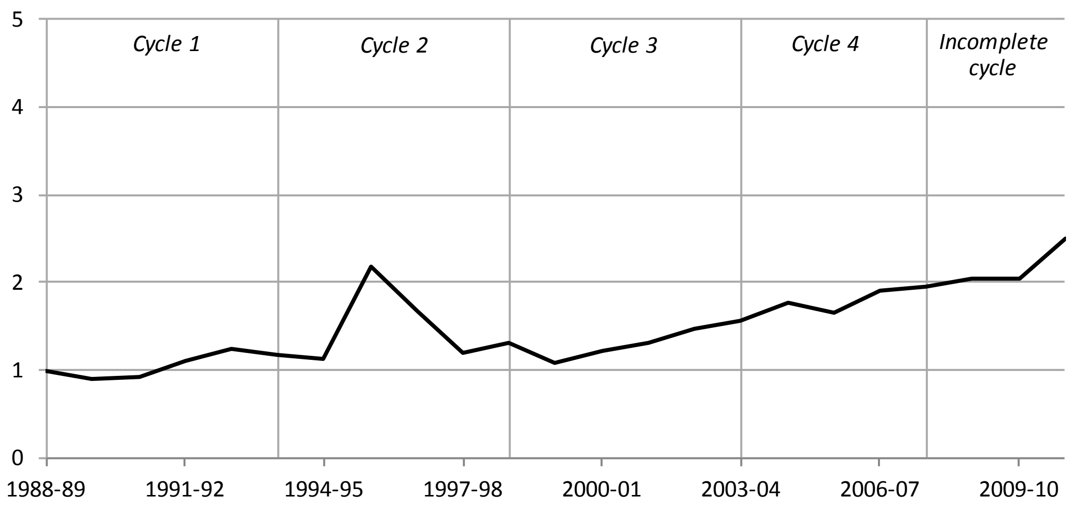


[a] The estimation of capital services for each subsector of Manufacturing (as discussed in chapter 3), involved apportioning Manufacturing investment (gross fixed capital formation from the ABS National Accounts) across the different subsectors. This allowed for the construction of a time series for FBT investment in different capital asset types (see appendix A for details).

Data sources: Authors' estimates based on ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0); and ABS (unpublished Survey of New Capital Expenditure data).

Figure 5.22 **R&D intensity**[a] **for FBT**

Per cent

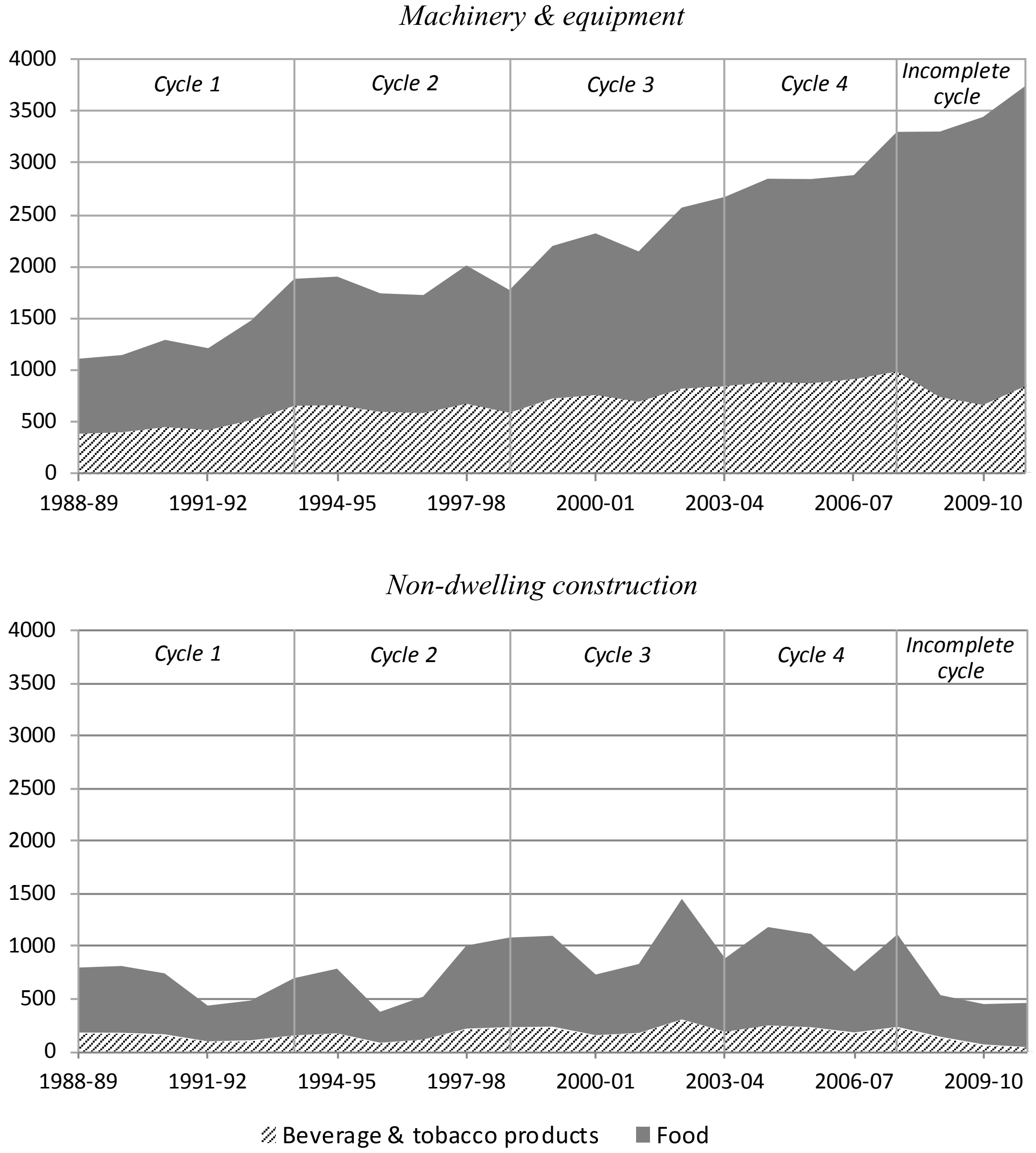


[a] Total R&D expenditure (current and capital expenditure) as a percentage of industry value added.

Data sources: Authors' estimates based on ABS (*Research and Experimental Development, Businesses, Australia*, Cat. no. 8104.0); ABS (*Manufacturing Industry Australia*, various issues, Cat. no. 8221.0); and ABS (*Australian Industry*, various issues, Cat. no. 8155.0).

Figure 5.23 **FBT gross fixed capital formation by subdivision and asset type**[a]

2009-10 $m



Data sources: Authors' estimates based on ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0); and ABS (unpublished Survey of New Capital Expenditure data).

New products and processes require different capital

There has been steady growth in capital in FBT for some time but, more recently, this has been accompanied by low growth in VA in aggregate. Given the diversity of FBT manufacturing activities and limited data on capital at a disaggregated level, a detailed look at FBT investment and its drivers is beyond the scope of this paper. Recent studies of FBT manufacturing (box 5.6) note that competitive pressures have led to some consolidation/rationalisation of existing capital and to investment in improved technology. Shifts in the nature of investment identified include:

- more energy efficient M&E to reduce operating costs
- more automation, including for packaging
- additional equipment needed for higher levels of processing for growing product groups such as 'ready to eat' meals
- more diverse equipment to produce a wider variety of products — including more specialised, smaller and sometimes purpose-built M&E to produce specific niche products. (Scale of production is discussed for Bakery in section 5.4.)

Box 5.6 **Some influences on investment in FBT**

Competitive pressures on FBT have led to investment in improved technology, and also to a rationalisation and offshoring of production.

- The Australian Food and Grocery Council (2011a) noted that, between 2005 and 2010, food and grocery manufacturers had responded to pressures on the industry by rationalising operations through a combination of consolidation and productivity initiatives to cut costs.
- Ambler (2005) found that:

  In 2004-05 there was further rationalisation and increased capital investment in the food manufacturing sector. Many parts of the industry are seeking to lift their competitiveness against increasing competition. Technological capabilities are improving in low-cost competitor countries, and local food retailers, in response to commercial pressures, are benchmarking supplier competitiveness on an increasingly wide geographical basis and changing their sourcing arrangements accordingly. … The commercial success of the Australian food industry lies in its capacity to innovate its practices, processes and products and exploit niche markets through the supply of specialised, high quality, differentiated products. It is likely the move toward private labels will reinforce this trend. (p. 31)

Changing product types have required additional/new equipment.

- The Food Processing Industry Strategy Group (2012) noted that:

  During the 1970s and 1980s there was significant growth in the variety of processed food products; however, the changing nature of this market caused a movement away from standard food machinery products to a diverse market of specialised food machinery (typically smaller machines for specific niche products). … There is great diversity in the food processing sector and the type of machinery used is often highly specialised and sometimes purpose-built. (p. 91)

- The Australian Food and Grocery Council (2011b) noted that:

  Prepared meals that are sold at supermarkets or specialist food retailers generally have higher levels of processing, therefore the demand for food has a positive effect on demand for food machinery. (p. 47)

- New biscuit products have been enabled by improved oven technology and new manufacturing lines (Funnell 2012, p. 58).

(continued on next page)

Box 5.6 **(continued)**

There has been investment in energy efficiency, waste reduction and automation.

- The Food Processing Industry Strategy Group (2012) noted increased investment in energy efficiency and automation.

  Today there is an increasing trend to invest in more energy-efficient machinery and equipment in the food and beverage processing sector to save on operating costs and to ensure the longer-term sustainability of the industry. … IBISWorld estimates major markets for Australian machinery uptake are the meat and seafood processing sectors. These sectors are converting to energy-efficient machinery to reduce operating costs. Upgrades to increase automation have also influenced growth. (p. 91)

  The high cost of labour makes decisions to replace labour with automation easy, despite redundancy costs. … However higher automation means that there is a greater need for trade and engineering skills (restructuring to a higher-paid workforce). The trend toward greater mechanisation of food and beverage processing also potentially diminishes the significance of labour costs in Australia's comparative competitiveness, but perhaps not materially so in the short term. (p. 138)

- Significant capital investment by major confectionery producers has occurred over the last decade to improve the efficiency of their production, including greater automation and higher speed production lines (Sivasailam 2010).
- Some firms are using robotic packaging equipment. One firm in the frozen food industry has installed robotic packing equipment for its pie-packing line; however its introduction involved high conversion costs and supply disruptions (World Packaging News 2011; The Australian 2013). A major biscuit manufacturer is also extending the use of robotics in its biscuit packing (Funnell 2012, p. 58).

The higher exchange rate, which makes imported capital cheaper, may have been a factor in the continued investment by FBT manufacturers.

- Imports are a major source of food processing machinery (Australian Food and Grocery Council 2011b, p. 47).
- Funnell (2012, p. 58) noted that the strong dollar had enabled Campbell Arnott's to get much better returns on predominantly overseas sourced manufacturing equipment and technology.

Possible decline in the utilisation of capital

As well as affecting investment in new capital, changes in consumer preferences and the composition of output may have affected the use of existing capital. In the longer term, producers may respond to reduced levels of demand by rationalising production facilities or exiting the industry altogether. But in the short term, capital may be underutilised when output is reduced. Measures of capital services do not account for declines in utilisation and also may not capture early retirement of capital, so in these circumstances measured productivity will decline.

Rates of capacity utilisation in FBT manufacturing may be low and declining

There are indications that average capacity utilisation in FBT manufacturing is perennially low, although information is very limited (box 5.7). But, in order to contribute to a decline in measured MFP, utilisation rates need to *decrease*. This can occur as a result of change in the composition of production when:

- the parts of FBT that are maintaining or increasing production have relatively low rates of utilisation
- the parts of FBT with absolute declines in production have not made matching reductions in their capital stock, so that their utilisation rate has fallen.

Box 5.7 **Underutilised capacity in FBT**

Available information suggests that there is perennially underutilised capacity in FBT.

- A survey in 1999 reported low capacity utilisation (60 per cent or lower) (AFFA 2000).
- The Food Processing Industry Strategy Group (2012) reported a 2011 PricewaterhouseCoopers survey that found underutilisation of plant and equipment was an issue for FBT manufacturers — with around half of respondents citing market demand preventing greater sales.
- Spencer and Kneebone (2012) identified underutilisation of food processing facilities as a mature risk to the food supply chain.
- Treasury Wine Estates and Accolade Wines entered into reciprocal bottling and packaging contracts in July 2012. Accolade Wines will bottle for Treasury Wine Estates in the United Kingdom and Treasury Wine Estates for Accolade Wines in Australia. Treasury Wine Estates reported that this arrangement will allow them to use spare capacity in their Australian facilities. (Treasury Wine Estates 2012)

Reasons given for low utilisation rates include: seasonality of supply of raw materials, misjudgements about the likely rapidity of growth of domestic and export markets, and the unavailability of ‘off-the-shelf’ smaller sets of plant and equipment (AFFA 2000); and lack of market demand (Food Processing Industry Strategy Group 2012).

No specific measures of FBT utilisation rates over time are available. Anecdotal evidence suggests that:

- A fall in utilisation rates is plausible for those FBT manufacturers experiencing a loss of competitiveness and increased import competition. However, this may have been a larger influence in the incomplete cycle than in cycle 4.
- Capacity utilisation in Wine may have decreased as a result of recent lower production and VA levels (this is discussed in section 5.4).

- In Dairy manufacturing there have been some reductions in the excess processing capacity that existed after the reductions in milk supply following the rationalisation of dairy farming in 2000.

  > As in the farm sector, the milk processing sector is undergoing continuing rationalisation. This has resulted in improved factory capacity, as larger operations have improved their efficiency and economies of scale. The lack of growth in milk production over the past decade has relieved the pressure on Australian dairy companies to continue to invest in increasing processing capacity — at least in the short to medium term. Instead, the challenge has been to remove surplus capacity and to utilise the existing capacity as profitably as possible. (Dairy Australia 2013)

The net effect of change in utilisation rates in different parts of FBT is not known.

Unmeasured retirements of capital?

A complicating factor in the measurement of capital is that some capital that has been retired from production may still remain 'on the books' in the statistics.[25] This may occur, for example, in some cases when machinery and equipment is scrapped early to reduce production capacity. Reductions in the capital stock as a result of factory closures also may not be fully reflected in the measures of capital, while the capital associated with new factories will be measured. Part of the decline in measured productivity may be attributable to this capital that remains on the books but is no longer producing output.

The capital services estimates for FBT manufacturing in this paper assume that capital is not retired before it is fully depreciated and the asset life and age-efficiency assumptions are the same as those used by the ABS for Manufacturing as a whole (appendix A). The above discussion has identified possible changes in the FBT product mix and the associated capital requirements. And there are a number of examples of FBT plants closures and consolidations (box 5.8). However, data are not available to test for an increase in unmeasured retirements of capital in FBT manufacturing during cycle 4.

Lags between when investment is recorded and when it produces output can also depress measured MFP in the short term. However, this is less likely to be a significant issue for FBT than other parts of the economy with very large multi-year investment projects, such as Mining and some parts of Metal products manufacturing (which is discussed in chapter 6).

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[25] Estimates of capital stocks are based on measures of investment and a range of assumptions including asset life (appendix A). For practical reasons the capital stock is not tracked at the level of individual assets or individual factories.

Box 5.8 **Some closures and consolidations in FBT**

A number of closures and consolidation of FBT plants have occurred over the period examined in this study. For example:

- in April 2003, Foster’s Group Limited (2003) announced the closure of its Kent Brewery in NSW by February 2005
- in July 2003, Simplot announced the closure of its pie factory in Kensington after selling its bakery business brands to Patties Bakery (Das 2003)
- in 2004, George Weston Foods closed its Camperdown and Abbotsford manufacturing sites (George Weston Foods 2013)
- in September 2004, Parmalat Australia announced the closure of its soft cheese and butter factory in Warwick, Queensland (Sydney Morning Herald 2004)
- in August 2005, Foster’s Group Limited (2005a) announced its intention to sell its Lower Hunter Valley winery and the smaller of its Coonawarra wineries as soon as practical
- in January 2006, Kraft announced the closure of a biscuit plant in Broadmeadows shifting production to China (Sydney Morning Herald 2006)
- in June 2006, Foster’s Group Limited (2006) announced its intention to sell two Australian wineries, as well as surplus production and packaging facilities in the Upper Hunter Valley, Barossa Valley, and selected facilities at Penfolds Nuriootpa
- in June 2007, Foster’s Group Limited (2007) announced that it would cease beer production at its North Fremantle brewery by the end of September, with production shifting to other Foster’s sites
- in November 2007, Hardy Wine Company announced that from 2008, winemaking and packaging at its Buronga winery would be consolidated to its Berri Estates winery (Constellation Brands Incorporated 2007)
- in April 2008, Campbell Arnott’s announced plans to close its Players biscuit and chocolate factory in Sydney, shifting production of Arnott's branded products to other facilities in Australia (West 2008)
- in August 2008, Constellation Wines Australia (formerly Hardy Wine Company) announced its intention to sell three of 10 production facilities, in addition to the sale of more than 20 vineyard properties; consolidation of bottling operations; portfolio streamlining and rationalization of more than 30 per cent of the company's Australian product lines (Constellation Brands Incorporated 2008)
- in November 2010, McCain Foods closed its vegetable plant in Smithton, Tasmania (McCain Foods Australia/New Zealand 2012)
- in May 2011, Heinz announced that it would close its tomato sauce factory in Girgarre, Victoria and relocate Golden Circle’s beetroot-processing operations in Northgate, Brisbane to New Zealand (Hattersley, Isaacs and Burch 2013)
- in August 2011, Coca-Cola Amatil announced that it would close its Mooroopna fruit and vegetable processing facilities (Hattersley, Isaacs and Burch 2013).

5.4 A closer look at Wine and Bakery manufacturing

A closer examination of two key groups within FBT provides further insight into the interactions between key influences on FBT manufacturers and measured productivity. Wine manufacturing was the largest contributor to the decline in FBT VA between cycles 3 and 4, and Bakery product manufacturing was the largest contributor to the growth in hours worked.

For Wine, declines in output volumes and the amount of value adding per unit of output (in particular more ‘bulk wine’ exporting), and associated underutilised capacity, may have contributed to the decline in FBT MFP. For Bakery product manufacturing, changes in the nature of the output and how it is produced (with growth in non-factory bakeries) may also have contributed to the decline in FBT MFP, particularly through its contribution to growth in hours worked. Bakery product manufacturing has also been affected by measurement issues.

Wine

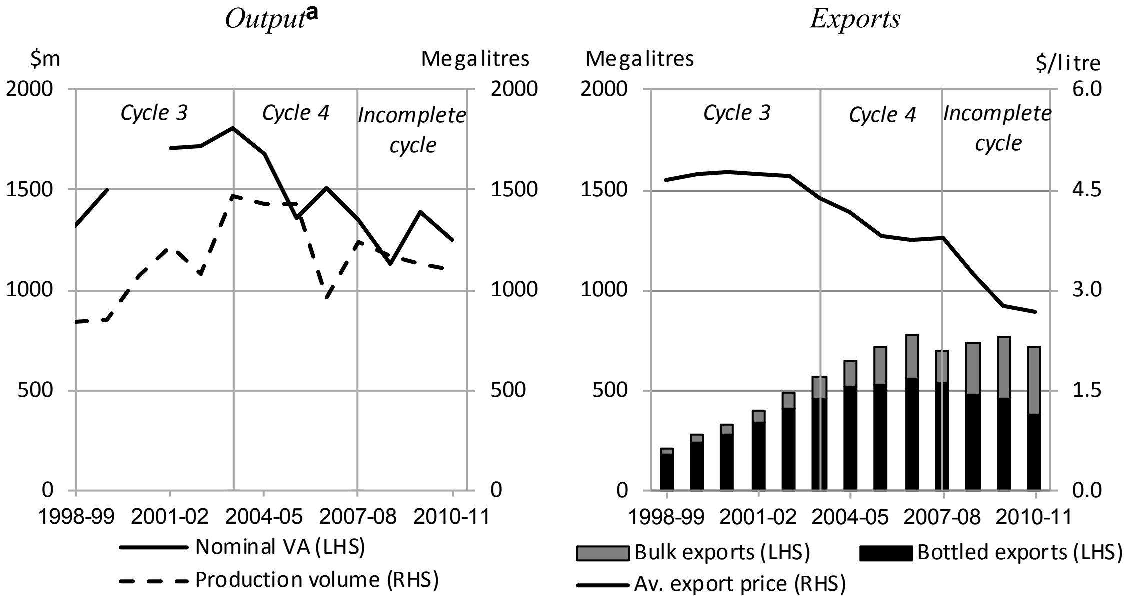
Wine manufacturing is likely to have contributed to the decline in aggregate FBT MFP between the last two complete productivity cycles. Assuming no comparable adjustment in the inputs used in Wine manufacturing, the driver of this decline is likely to have been the significant fall in VA in cycle 4 after strong VA growth during cycle 3. This section provides a summary of the influences on productivity in Wine manufacturing — further details are provided in appendix G.

Declining output and reduced value added

Strong international demand for Australian wine, beginning in the late 1980s, led to a significant expansion in Australian grape growing and wine production capacity. This underpinned the strong production, VA and export growth in the Australian wine industry in cycle 3 (figure 5.24).[26] By the middle of cycle 4, Wine manufacturers faced an excess supply of wine relative to demand (Sheales et al. 2006). These market circumstances contributed to the significant decline in (nominal) VA by the end of the cycle.

[26] The volume of Australian exports reached 584 million litres in 2003-04 (growing from 201 million litres in 1998-99). By 2001-02, exports overtook domestic sales as the largest contributor to total Australian wine disposals.

Figure 5.24 **Wine manufacturing output and exports**



[a] Nominal industry VA ($m), survey break in 2000-01. Production (megalitres), only includes wineries crushing more than 400 tonnes annually.

Data sources: ABS (*Australian Wine and Grape Industry*, various issues, Cat. no. 1329.0); ABS (*Manufacturing Industry, Australia*, various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0); Wine Australia (unpublished data).

Wine production grew by 11.6 per cent a year in cycle 3, contributing to a build-up of inventories. Strong production levels continued throughout cycle 4, despite some consolidation among large winemakers (Kiri-Ganai Research 2006). Record production volumes, averaging around 1441 megalitres, were achieved in the years 2003-04 to 2005-06 as a result of strong vineyard investments between 1998 and 2000 (Sheales et al. 2006). This led to a peak in wine inventories of over 2100 megalitres by 2005-06. The 2006 drought drove production lower by the end of cycle 4, marked by significantly lower production in 2006-07 and 2007-08 compared with the record levels at the start of the productivity cycle. Nevertheless, inventories of Australian wine remained high, at around 154 per cent of total production for the year 2007-08 (ABS 2012e).

Producers responded to changes in market conditions by shifting the composition of wine sales. Excess Australian (and global) wine capacity, greater competition from other 'New World' wine producers and a high Australian dollar, resulted in the concentration of sales around lower price points in many export markets (Bailey 2011). The average export price of Australian wine dropped from $4.40 per litre in 2003-04 to $3.80 in 2007-08 (figure 5.24). This was the result of both discounted sales and the trading of increased volumes of bulk stock (Rabobank 2012).

Bulk wine export volumes as a share of total exports increased from an average of 14.8 per cent in cycle 3 to 22.4 per cent in cycle 4 (figure 5.24) as producers looked to maintain market share and shift surplus stocks in an increasingly competitive global market. The effect of increased bulk wine production was to reduce the amount of value adding per litre of wine in Australia — with bottling and other packaging activity undertaken in the destination-market country. (As figure 5.24 shows, bulk wine exports have become even more significant during the current incomplete cycle.)

This change in the composition of wine sales, along with the effect of the 2006-07 drought, led to industry nominal VA declining from $1808 million to $1347 million (averaging negative 7.1 per cent a year) over cycle 4.

Have inputs contracted in line with value added?

While VA declined, there is no strong evidence that inputs declined at the same pace. For example, employment continued to grow over cycle 4 by 2.1 per cent a year, although this was much slower than the 11.7 per cent a year growth over cycle 3 (ABS 2008c, 2012d). This growth in both cycles is likely to have been driven by strong growth in the number of smaller winemakers, despite some consolidation of larger producers.[27]

There is limited data available about the capital side of production. It is likely that capital investment increased in cycle 3 as industry in the mid-1990s advocated for investment priorities to shift from vineyards to processing and storage capacity to utilise increased grape supplies from the growth in vineyard plantings in the 1990s (Australian Wine Foundation and Winemakers' Federation of Australia 1996). For example, winemaking facilities were processing around 72 per cent more wine grapes by the end of cycle 3 (2003-04) compared with the beginning of the cycle (1998-99) — from 1.1 million to 1.9 million tonnes (ABS 2012e). And record production volumes were achieved in the first three years of cycle 4. By the end of cycle 4, it is likely that some capital was underutilised (assuming most producers retained their production capacity) because output declined late in the cycle and more of the value adding moved overseas. The consolidation among large producers could have had some offsetting effect (depending on the extent to which this involved a reduction in the total capital stock). However, data on change in the capital stock are not available.

[27] According to Winetitles (2013), between 2004-05 and 2007-08 the number of wine producers crushing less than 500 tonnes grew by 21 per cent, while those crushing over 10 000 tonnes declined by 15 per cent. ABS (2012e) show a general consolidation in producer numbers (based on wineries crushing 50 tonnes or more of grapes).

Pace of industry adjustment

The adjustment on the input side to the weaker market conditions might have been slowed by several factors.

- Significant change in market conditions. The excess world supply of wine relative to demand (referred to as 'the wine glut' by some commentators), with which domestic winemakers were faced in the middle of cycle 4, was preceded by a period of rapid expansion with record production levels and strong growth in export volumes. Adjustment to such large changes in market conditions takes time — especially the adjustment of capital.
- Taxation arrangements. According to Henry et al. (2009, p. 438)

  The wine producer rebate [Wine Equalisation Tax rebate] fosters small-scale production and supports some small, otherwise uneconomic wineries. The industry currently reports a widespread grape oversupply and that around half of all wine producers are currently unprofitable. This suggests that resources such as land, water and capital are not being used efficiently. Moreover, the rebate may be acting to prevent an appropriate market response to these circumstances by discouraging mergers within the industry.
- Lifestyle ventures. High income or high net worth urban owners can operate their wine businesses at a loss as they have other sources of income and capital. For example, some hobby or 'sea change' growers can rely on other sources of income (for example, cafe, bed and breakfast accommodation or tourist attractions) (Kiri-Ganai Research 2006).
- Expectations of export growth in new markets. For example, the value of Australian exports to China grew (albeit from a very small base) by 28.2 per cent a year in cycle 3 and 79.9 per cent a year in cycle 4. In 2008-09 China became Australia's fourth biggest wine export market (in value terms) (ABS 2012e).

Implications for MFP

While there is insufficient information to estimate MFP in Wine manufacturing, MFP may have declined over cycle 4. There is no clear evidence of a reduction in inputs of sufficient size to offset the decline in real VA and thus maintain productivity levels.

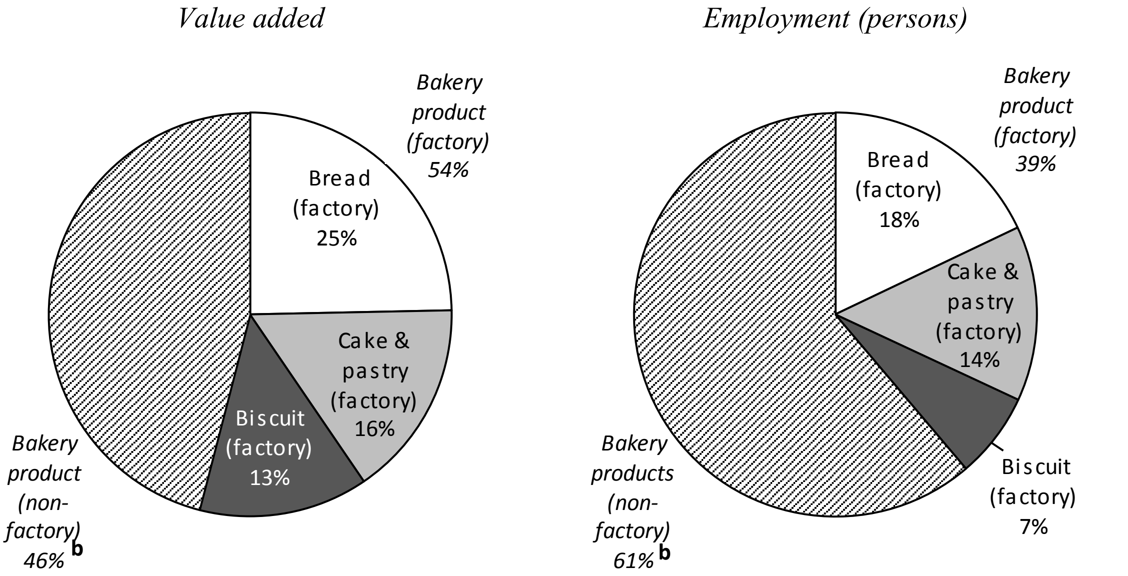
Since then, there are signs that the wine industry has made further adjustments in response to (global) market conditions. A major statement by key Australian winemaking and grape growing bodies noted the need for the industry to address structural oversupply of wine (Winemakers' Federation of Australia et al. 2009). Output and VA have declined further, and there has been a further shift to bulk exports (figure 5.24).

On the input side, there has been some decline in employment at an average rate of 0.7 per cent a year between 2007-08 and 2010-11 (the current incomplete cycle).[28] Further consolidation among larger producers is also occurring, including a deal by the two largest wine producers to consolidate their bottling activities in Australia and overseas (Treasury Wine Estates 2012; Accolade Wines 2012). However, given the lack of capital data for the industry as a whole, it is not known whether the industry has reduced its total inputs in line with VA or if MFP has declined further since cycle 4.

Bakery product manufacturing

Bakery product manufacturing ('Bakery') is made up of factory and non-factory based production. Non-factory bakery accounted for 46 per cent of Bakery nominal VA in 2008-09 (figure 5.25, left panel). Non-factory bakery is relatively labour intensive, with 61 per cent of Bakery employment in 2008-09 compared with 39 per cent for factory bakery (figure 5.25, right panel).

Figure 5.25 **Composition of Bakery product manufacturing[a], 2008-09**
Percentage shares



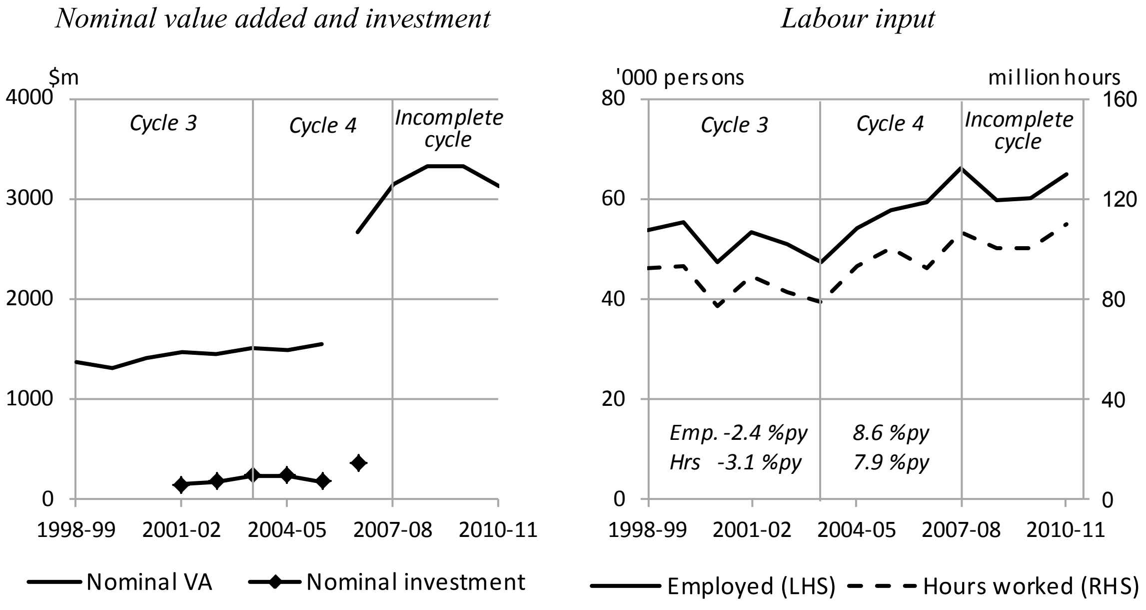
a In-house supermarket bakeries do not appear to be included in ABS statistics for Bakery product manufacturing (appendix G). They are mentioned in this chapter in the context of changes in overall supply of bakery products. **b** The ABS does not disaggregate Bakery product (non-factory) by product type.

Data source: ABS (*Experimental Estimates for the Manufacturing Industry, 2008-09*, Cat. no. 8159.0).

[28] Derived from ABS (*Australian Industry*, Cat. no. 8155.0). Employment for 2007-08 was imputed as the average of the adjoining years, given that no estimate was published by the ABS.

Bakery may have contributed to the decline in aggregate FBT MFP between the last two complete productivity cycles, as strong growth in hours worked does not appear to have been accompanied by a comparable increase in measured VA.

Figure 5.26 **Value added, investment[a] and labour input in Bakery product manufacturing[b]**



[a] Investment is total acquisitions (expenditure on the acquisition of capital including plant, machinery and equipment, buildings, and other assets) and is not net of disposals of assets. [b] Break in series due to change in ANZSIC, with the addition of non-factory bakery from 2006-07. Data in left panel have not been adjusted for this break in series (or other survey methodology breaks from 2000-01 and 2007-08). Data in right panel have been backcast by ABS for the ANZSIC change. See appendix G for limitations on the comparability of these estimates.

Data sources: Authors' estimates based on ABS (unpublished Labour Force Survey data); ABS (*Manufacturing Industry, Australia*, various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); and ABS (*Australian Industry,* various issues, Cat. no. 8155.0).

Figure 5.26 shows Bakery product manufacturing output and inputs — nominal VA and investment (left panel) and labour inputs (right panel).

- Nominal VA grew slightly over cycle 3. It is not possible to estimate the extent of VA growth over cycle 4 because of change in industry classification, although it is likely to have been stronger in cycle 4 than cycle 3.[29]

[29] VA growth between 2006-07 and 2007-08 alone is greater than the growth over cycle 3. This growth is due mainly to the classes of baking that are comparable with those included in the cycle 3 estimates. Earlier data for non-factory bakery are not available (appendix G).

- Employment and hours worked fell over cycle 3, but grew strongly over cycle 4.
- Investment data are limited but show fairly stable investment, again affected by the change in industry classification.

Labour input growth may have been stronger than VA growth over cycle 4, if there was relatively strong output growth in the more labour-intensive non-factory bakery. And available investment data do not show a fall in investment sufficient to offset the strong rise in hours worked. This suggests that Bakery may have had a decline in MFP and contributed to the decline in FBT's measured MFP between cycles 3 and 4. The following provides a summary of the influences on Bakery and their likely implications for productivity — further details are provided in appendix G.

Changing consumer tastes shifting the composition of Bakery output

Over the longer term, there has been considerable change in the pattern of demand for Bakery products (box 5.9). This shift is the result of change in consumer preferences related to a range of factors — including demand for a wider diversity of products, including artisan products, premium products and international-style specialty products, but also private label products and for products with particular health-related characteristics (such as high fibre).

While it is difficult to establish the extent of such changes over cycle 4 compared with cycle 3, anecdotal evidence suggests some increase in the pace of change in demand for some bakery products. For example, Food Magazine (2008) noted that increasing sophistication of consumers drove greater product development and diversity in bread manufacturing over the 5 years to 2008 than in previous decades.

Box 5.9 **Trends in bakery product purchasing patterns**

There has been considerable change in purchasing patterns for bakery products, affecting total demand and demand for particular products.

Health

Increased focus on foods that offer health benefits (such as high fibre or healthy additives) or meet other dietary requirements (such as gluten free, low salt, low fat or yeast free) has increased the demand for specific bakery products.

- Premium wholemeal and grains bread grew 10-15 per cent over the 5 years to 2010 and there has been a decline in market share of white bread (Wahlquist 2010).
- Health trends have increased demand for low-fat cakes and muffins (DAFF 2003).

But the popularity of low carbohydrate diets may have decreased overall demand for bread. There was a slight decrease in the proportion of the population consuming bread between 2001 and 2008 (AIHW 2011).

Lifestyle/convenience

Changing lifestyles have led to some replacement of sandwich lunches with hot meals eaten out, although with some reversal of this trend since the global financial crisis (National Baking Industry Association 2011).

Increased snacking, and packaging innovation to provide convenience and portability, have allowed the development of VA products with higher margins (Dobie 2012).

There has been growth in lunchbox fillers, such as muffins and bakery treats, and some crossover between biscuits and the confectionery/snack sector (DAFF 2003).

Quality, value, specialties and diversity

A shift to premium products in bread and cakes/pastries led to stronger growth in value (than volume) between 1997-98 and 2000-01. Specialty and gourmet pies, and premium or indulgence biscuits also grew. (DAFF 2003)

Consumers have been prepared to purchase more expensive specialty breads and high quality freshly baked bread, including premium artisan bakery products.

- Demand for a more varied range of bread has been reinforced by the changing ethnic structure of the Australian population, which has had its greatest impact on non-factory bread production (Food Magazine 2008).
- Product diversity is exemplified by the 319 different product lines of one non-factory baking franchise in 2010 (Wahlquist 2010).

But there has also been an increase in the market share in private label products.

- There has been an increase in share of generic or house brand biscuits (DAFF 2003).
- The National Baking Industry Association (2011) reported that private label products were 8 per cent of the total value of baked goods in 2009, and higher shares within the packaged/industrial baked goods sub-category (bread products 22 per cent; pastries 52 per cent; and cakes 35 per cent).

Different products produced in a different way?

Changes in consumer preferences may affect various types of Bakery manufacturers differently. For example, for bread manufacturing, change in consumer preferences may have led to stronger growth in non-factory production and affected factory production.

- The Department of Agriculture, Fisheries and Forestry (2003, p. 52) suggested that smaller bakers and hot bread shops are better positioned to produce a greater variety of bread products; while large bread manufacturers are restricted to producing in larger quantities but can drive development of innovative products through their R&D capabilities.
- Food Magazine (2008) noted that demand for a more varied range of products had its greatest impact on non-factory production, and that small bread makers competed with larger producers by offering more specialised products.
- But large factory bakeries have also introduced a wider range of bread lines including health ranges and international breads (Food Magazine 2008). More recently, Goodman Fielder developed an artisan bread strategy and invested in a new artisan-style bread plant, reducing other product lines and closing three other bakeries (Mitchell 2013).

Change in the composition of output can have implications for productivity. For example, 'hand-crafted' bread from a small-scale artisan bakery will have a different production process to the standard white loaf made in a large-scale automated factory, and productivity levels are likely to be commensurately different. Non-factory production that does not have economies of scale and is more labour intensive is likely to have lower levels of measured productivity, particularly given the challenges of measuring output quality differences. But smaller production runs of a wider variety of products in a factory may also reduce economies of scale. There may also be changes in the type of capital required, which could lead to retirement of capital or changes in utilisation rates. Limited ABS data make it difficult to quantify these changes. Available information about growth in non-factory bakeries and differences in the input intensity between factory and non-factory production are presented below.

Growth in the number of non-factory bakeries

There has been stronger growth in non-factory bakery than factory bakery over the longer term, particularly in bread (box 5.10). And Food Magazine (2008) noted that small bakeries became more competitive with major players in the bread industry in the few years up to 2008.

Box 5.10 **Growth of non-factory bakeries**

There are limited statistics on the growth of non-factory bakeries specifically over cycle 4 (2003-04 to 2007-08). But over the longer term (since the 1990s) there is clear growth in non-factory bakery operations and some evidence of faster growth in some non-factory bread output than in factory bread output.

There has been strong growth in the number of non-factory franchise bakeries since the early 1990s, but most of the growth in store numbers was before cycle 4.

- The number of Bakers Delight bakeries grew from 200 to 600 between 1993 and 2003 (in Australia and New Zealand), reaching 700 in 2013 (with most of the additional 100 stores opened in Canada) (Bakers Delight 2013b). Since the early 1990s, the number of Brumby's Bakeries (in Australia and New Zealand) has grown from 51 to over 300 (Brumby's Bakeries 2013). There were 254 Brumby's stores in Australia in 2003, suggesting that, like Bakers Delight, most of the growth in store numbers took place before 2003 (DAFF 2003, p. 19).

Output of non-factory bread manufacturers grew faster than factory production between 1995 and 2000, and may have grown further in cycle 4.

- Total growth in the volume of bread production over the 5 years to 2000 was 45 per cent in traditional hot bread shops and 10 per cent in franchise hot bread shops, compared with -0.7 per cent in factory bread and -3 per cent in supermarket in-house bakeries. But factory bread still had the largest share of output in 2000 (61 per cent), compared with supermarket bakeries (20 per cent), franchise hot bread shops (14 per cent) and traditional hot bread shops (5 per cent). (DAFF 2003, p. 12)
- Since then, the market share of franchise bakeries appears to have grown further, with the bread market share of Bakers Delight alone at 13.7 per cent in 2010 (Wahlquist 2010) and 12.5 per cent in 2013 (Bakers Delight 2013a).

But there may also have been some shift in market share between different types of non-factory bakeries and, more recently, a return to growth for factory bakeries.

- Perry and Alam (2005, p. 5) noted a marked decrease in the number of small baking operations with the rise of national franchise and in-house supermarket bakeries — with small independent local bakeries all but disappearing. However, they also reported growth in boutique bread baking with new markets in specialty, exotic and health associated breads.
- The National Baking Industry Association (2011) also noted the rise of a small but growing artisan baking sector and suggested a recent turnaround in the output of factory bakeries.

  > Previously, competition between the on-site operations is strong which has forced the prices of their products down, often to the point where the products are cheaper than the packaged equivalent produced by corporate plant bread bakeries. Consequently the onsite operations are gaining market share while the plant bread market share is in steady decline, which has caused the corporate plant bakeries to diversify. However, now with the supermarket's reduction in the price of bread, it is our perception that this trend has been reversed and forced a significant downturn in trade for retail bakeries. (p. 3)

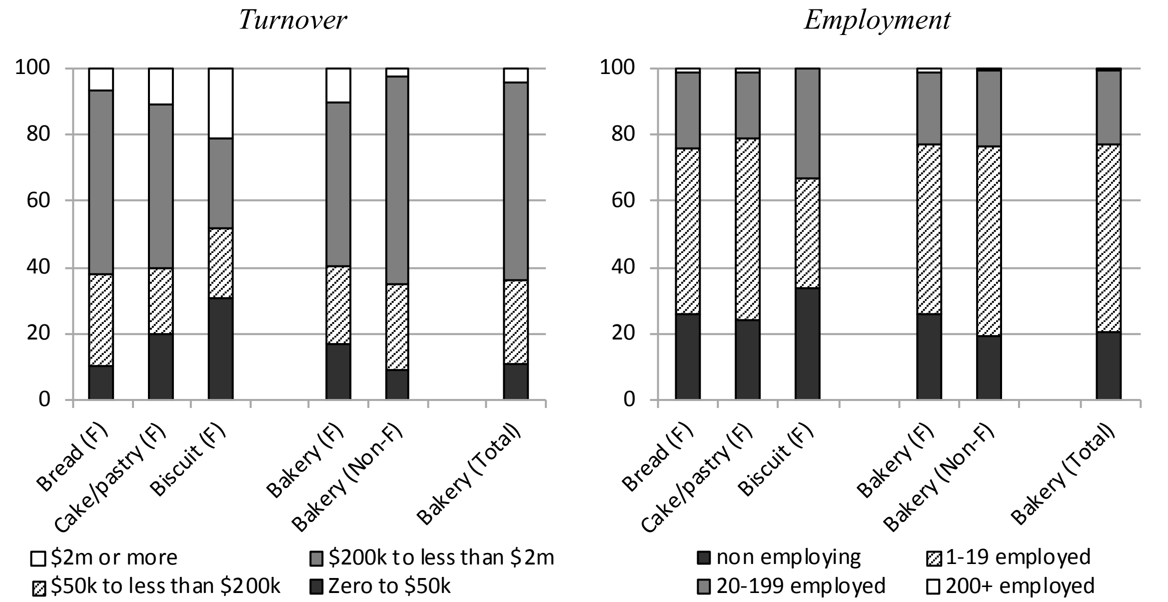
Smaller scale operations?

As expected, non-factory bakery had a lower proportion of businesses in the largest size category (by employment and turnover) than factory bakery in 2006-07 (figure 5.27). But non-factory bakery also had a lower proportion of businesses in the smallest size category.[30]

Business numbers grew by 9 per cent in Bread (factory) manufacturing between 2002-03 and 2005-06, driven by a 10 per cent growth in the number of small and medium size businesses (employing fewer than 200 people). (There was a decline in the number of large businesses from nine to six.)[31]

Figure 5.27 **Bakery product manufacturing[a] businesses by size, 2006-07**

Percentage shares



[a] Bakery product manufacturing, Bakery (Total), includes Factory (F) and Non-factory (Non-F).

Data source: ABS (*Counts of Australian Businesses, including Entries and Exits, June 2007 to June 2009*, Cat. no. 8165.0).

Non-factory bakery uses smaller scale equipment than factory bakery. There are two types of bakery equipment — retail bakery equipment (servicing the independent and franchise sector) and industrial bakery, larger, automated equipment (servicing larger independents and corporate plant bakeries) (DAFF 2003, p. 34).

30 Given the wide ranges for the size categories, there could be considerable differences in actual average size.

31 Authors' estimates based on ABS (2007).

Non-factory bakery is more labour intensive than all three groups within factory bakery. Table 5.1 shows employment per million dollars of nominal VA in 2006-07.

Table 5.1 **Labour intensity of Bakery product manufacturing, 2006-07**

ANZSIC06 group/class	*Employed per $m of VA*[a]	*Share of VA*	*Share of employed*
	persons	share	share
117 Bakery product manufacturing	**24.3**	**1.00**	**1.00**
1171 Bread manufacturing (factory)	16.2	0.27	0.18
1172 Cake and pastry manufacturing (factory)	23.5	0.14	0.14
1173 Biscuit manufacturing (factory)	11.1	0.16	0.07
1174 Bakery product manufacturing (non-factory)	35.1	0.42	0.60

[a] Nominal value added.

Source: Authors' estimates based on ABS (*Manufacturing Industry, Australia, 2006-07*, Cat. no. 8221.0).

The higher labour intensity of non-factory bakery is related to scale but also to other differences in production processes. For example, 'hand-crafted' artisan bread has a relatively labour-intensive production process. Other types of non-factory bakery using instant doughs and pre-mixes from flour millers are likely to be less labour intensive than artisan bread, but still more so than factory bakery. Unlike factory bakeries, all non-factory bakeries will also require labour for the retailing component of their operations.[32]

Lower labour intensity of factory bakery is due to both larger scale and automation.

> In the typical large-scale bakery or factory, there is now little manual labour directly involved in production. … The introduction of new technology and the adoption of greater automation are inevitably reducing the role of labour in the production process. This is especially true in factory baking where, in the last decade, high speed production lines have dramatically increased throughput, allowing manufacturers to significantly raise production without requiring corresponding increases in employment. (Food Magazine 2008, pp. 18–9)

Employment appears to have been growing faster in non-factory bakery than factory bakery. From 1997-98 to 2001-02 factory bakery employment remained fairly flat before declining in 2001-02 (with rationalisation of bread manufacturing), while employment in retail bakeries increased at around 1 per cent a year (DAFF 2003, p. 8). Comparable statistics are not available for cycle 4. However, the strong growth in hours worked for Bakery in total (as measured in ABS *Labour Force*

32 Non-factory bakery may also have a higher proportion of part-time employment. This may have contributed to the higher growth of employment than hours worked for Bakery over cycle 4 (figure 5.26).

Survey, shown in figure 5.26) is more likely to be due to non-factory bakery than factory bakery (given the relatively low labour intensity of the latter).[33]

Lower productivity but higher profitability in non-factory bakery?

The change in the composition of Bakery may represent a shift into products with lower measured productivity levels but higher levels of profitability. There is some evidence that non-factory bakery is relatively profitable. In 2006-07 the profit margin was higher in non-factory bakery (9.7 per cent) than in each of the factory bakery groups — Biscuit (9.6 per cent); Bread (7.5 per cent); and Cake and pastry (-1.2 per cent).[34]

However, a complicating factor (as discussed for FBT in general in box 5.5) is that it is difficult to accurately capture changes in product quality. This may mean that any shift in the composition of Bakery output towards higher quality products may not be adequately captured in the measure of real VA growth that is available for FBT as a whole. This may have led to an overstatement of the decline in FBT MFP.

Implications for MFP

While there is insufficient information to estimate MFP in Bakery, it may have declined over cycle 4. Shifts in the composition of bakery output and the growth of non-factory bakery production are consistent with lower levels of measured MFP arising from fewer economies of scale and increased labour intensity in production. This is notwithstanding other changes in Bakery that may have had some offsetting positive effects on MFP (such as increased automation in large factory bakeries and efficiencies in some non-factory baking from the use of pre-mixes). It is also possible that Bakery manufacturing contributed to the *measured* decline in MFP in FBT between cycles 3 and 4 because of measurement challenges related to output quality improvements and changes in industry classification. However, again, insufficient data are available to test these hypotheses.

Since cycle 4, VA and hours worked in Bakery have been relatively stable (with no continuation of the strong hours worked growth recorded in cycle 4). However, given the lack of data on capital, the change in Bakery MFP is not known.

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[33] Growth in total hours worked in Bakery over cycle 4 (compared with cycle 3) may also have been affected by the change in industry classification — it was necessary for the ABS to backcast the *Labour Force Survey* data into ANZSIC06 using assumptions (appendix G).

[34] Ratio of operating profit before tax to income from sale of goods, services, and rent, leasing and hiring from ABS (2008c).

5.5 Drawing together the implications for productivity

MFP in FBT declined significantly between the last two complete productivity cycles and was the second largest contributor to Manufacturing MFP decline (Petroleum, coal, chemical and rubber products being the largest).

The key proximate causes of the large decline in the rate of MFP growth in FBT over cycle 4 compared with cycle 3 were a slowdown in VA growth at the same time as strong growth in hours worked. There was consistent capital services growth in each cycle (although the average rate of capacity utilisation may have declined in cycle 4).

The slowdown in real VA growth was most noticeable in BT manufacturing — which grew over cycle 3 but declined in absolute terms over cycle 4. The increased rate of hours worked growth occurred mainly in Food manufacturing — which had a fall in hours worked in cycle 3 and a very large increase in cycle 4.

Both BT and Food contributed to the decline in FBT MFP in aggregate by having input growth in excess of real VA growth, but for different reasons.

- In BT it was due to *decline* in real VA that does not appear to have been accompanied by a similar decline in inputs. Wine was a major contributor to this.
- In Food it was due to an *increase* in real VA that was accompanied by an even greater increase in inputs. Bakery was a major contributor to this.

A range of influences on FBT have been identified that may explain the changes in the proximate causes of MFP.

- The composition of the output produced by Australian FBT manufacturers appears to have changed as a result of change in consumer product preferences related to health considerations, quality, value, diversity and convenience.
- There was decreased export demand and increased import competition resulting from the appreciation of the Australian dollar and other influences on the competitiveness of Australian products.
- There was reduced availability of some agricultural inputs due to drought (for example, grapes in the case of Wine).

These influences are consistent with:

- an increase in the production of more input-intensive products and/or a decrease in the average scale of production (for example, towards pre-prepared meals and 'boutique' or niche products).
- an increase in underutilised capacity.

Such changes are consistent with a reduction in the average level of MFP. However, it is not clear whether the influences identified and the extent of change, particularly in consumer preferences, were of sufficient magnitude to explain all of the observed fall in measured MFP. There are limited data available to test this. For example, many of the changes in consumer preferences are likely to have taken place at a level of disaggregation for which data are not available. And in some cases there are no data available for the relevant measures, such as capacity utilisation.

It is also possible that the decline in *measured* MFP in FBT was overstated because of other measurement challenges.

- Output quality improvements are difficult to measure, so real VA growth may have been understated.
- Changes in industry classification and survey limitations may mean that labour input growth was overstated.

Notwithstanding these measurement issues, it appears that the steep decline in MFP in FBT manufacturing over cycle 4 was exceptional. In the period since, hours worked has not grown further and the rate of VA growth has increased. Capital services growth has slowed. While MFP growth was still negative on average between 2007-08 and 2010-11, it was at a rate more typical of the long term.

6 Productivity in Metal products

Multifactor productivity (MFP) growth in the Metal products (MP) subsector of Manufacturing declined between cycle 3 (1998-99 to 2003-04) and cycle 4 (2003-04 to 2007-08) — with the subsector making the third largest negative contribution of any subsector to the MFP decline in total Manufacturing. The MFP decline in MP occurred despite very strong growth in output over cycle 4, because the growth in inputs was even larger.

This chapter examines the structure and characteristics of the MP subsector before detailing its pattern of MFP growth and the factors that are likely to have influenced it.

6.1 Metal products subsector structure and characteristics

MP consists of two *Australian and New Zealand Standard Industrial Classification* (ANZSIC06) subdivisions (table 6.1): Primary metal product manufacturing ('Primary metals') and Fabricated metal product manufacturing ('Fabricated metals').

Table 6.1 **Activities within the Metal products subsector**

Subdivision	*Primary activities*
Primary metal product manufacturing	Includes the manufacturing of iron and steel (including casting and production of pipes and tubes), alumina refining and aluminium smelting, and smelting of other non-ferrous metals (such as copper, gold, zinc, lead, silver). Also includes casting of metals, aluminium rolling, drawing and extruding, and other manufactured products (such as wires, rods, plates, sheets and foil).
Fabricated metal product manufacturing	Includes iron and steel forging, structural metal products (including structural steel and architectural aluminium products), metal container manufacturing, sheet metal products, metal coatings, and other fabricated manufactures (such as cutlery, livestock yarding equipment, mattress supports and ammunition).

Source: ABS (*Australian and New Zealand Standard Industrial Classification, 2006,* Cat. no. 1292.0).

The output from Primary metals is mostly exported (for example, refined metal and alumina) or used as inputs to Fabricated metals. Output from Fabricated metals is mainly used in construction and final consumption goods.

MP is a sizable share of total Manufacturing — 23 per cent of value added, 17 per cent of hours worked and 32 per cent of investment (gross fixed capital formation) in 2007-08. During cycle 4, MP's share of investment rose particularly quickly, which had productivity implications that are discussed later in the chapter.

Relative sizes of the Metal products subdivisions

In 2007-08 (the end of cycle 4), Primary metals was the larger of the two subdivisions in terms of value added, hours worked and investment (table 6.2). However, there is some volatility in the shares of outputs and inputs over time.[1]

The mix of activities within the MP subdivisions is quite diverse. In Primary metals, the majority of value added comes from Basic non-ferrous metal manufacturing, of which Alumina production and Aluminium smelting are the largest components. Basic ferrous metal manufacturing — primarily the manufacture of steel — also makes up a significant share of Primary metals output.

In Fabricated metals, Structural metal product manufacturing — a product group that is mainly used in construction — makes up the largest proportion of value added. In turn, the largest parts of Structural metal product manufacturing are Structural steel fabricating and Architectural aluminium product manufacturing. Other fabricated metal product manufacturing also contributes a large proportion of value added in Fabricated metals.

[1] During cycle 4, the share of hours worked and investment growth comprised by Primary metals rose quickly. And since 2007-08, Primary metals has had a smaller share of value added than Fabricated metals, since value added in Primary metals has declined. More details are provided in appendix H.

Table 6.2 **Composition of Metal products subsector, 2007-08**[a]

Percentage shares of MP

ANZSIC06 subdivision/group/class[b]	*Value added*	*Hours worked*	*Investment*[c]
21 Primary metal product manufacturing	**61.3**	**52.9**	**76.7**
211 Basic ferrous metal manufacturing	17.6		
212 Basic ferrous metal product manufacturing	5.3		
213 Basic non-ferrous metal manufacturing	36.5		
2131 Alumina production	*16.9*		
2132 Aluminium smelting	*8.4*		
2133 Copper, silver, lead and zinc smelting and refining	*2.3*		
2139 Other basic non-ferrous metal manufacturing	*8.9*		
214 Basic non-ferrous metal product manufacturing	1.9		
22 Fabricated metal product manufacturing	**38.7**	**47.1**	**23.3**
221 Iron and steel forging	0.8		
222 Structural metal product manufacturing	19.5		
2221 Structural steel fabricating	*8.8*		
2222 Prefabricated metal building manufacturing	*2.1*		
2223 Architectural aluminium product manufacturing	*5.1*		
2224 Metal roof and guttering mfg (except aluminium)	*0.6*		
2229 Other structural metal product manufacturing	*2.9*		
223 Metal container manufacturing	3.5		
224 Sheet metal product mfg[d]	2.9		
229 Other fabricated metal product manufacturing	12.0		

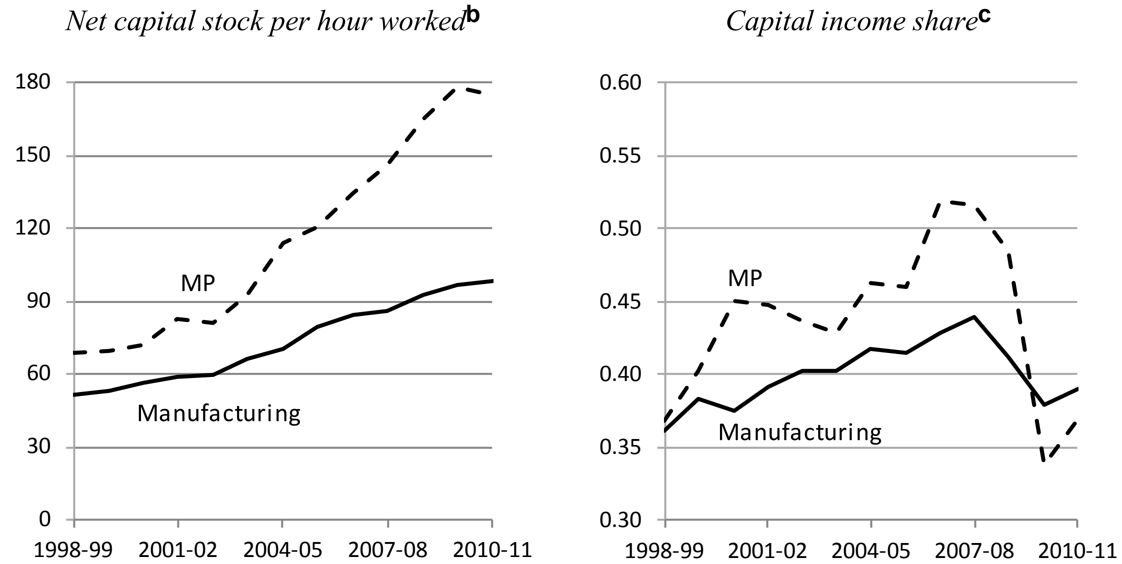
[a] 2007-08 shares are presented because they are more representative of cycle 4, especially due to dramatic changes in prices in the following year. See figure H.1. [b] Detailed disaggregation not available for hours worked and investment. [c] Private new capital expenditure. [d] Except metal structural and container products.

Sources: ABS (*Experimental Estimates for the Manufacturing Industry, 2006-07 and 2007-08*, Cat. no. 8159.0); ABS (unpublished Labour Force Survey data); ABS (*Private New Capital Expenditure and Expected Expenditure, Australia, June 2011*, Cat. no. 5625.0).

High capital intensity

MP is a more capital intensive activity than Manufacturing on average. MP had a higher share of its income from value added paid to capital than Manufacturing until the global financial crisis (GFC). And the extent to which MP's net capital stock per hour worked exceeds that of Manufacturing has risen over time (figure 6.1). Explaining this strong growth in capital intensity is key to understanding this subsector's productivity performance and is discussed in detail later in the chapter.

Figure 6.1 **Measures of capital intensity for Metal products[a]**



[a] Aggregate Manufacturing series presented here are those derived by the authors (appendix A). [b] 2009-10 dollars. [c] On a value added basis and includes some taxes attributable to capital (appendix A).

Data sources: Authors' estimates based on ABS (*Australian Industry,* various issues, Cat. no 8155.0); ABS (*Australian Manufacturing,* various issues, Cat. no. 8221.0); ABS (*Australian System of National Accounts, 2010-11,* Cat. no. 5204.0); and ABS (unpublished Labour Force Survey data).

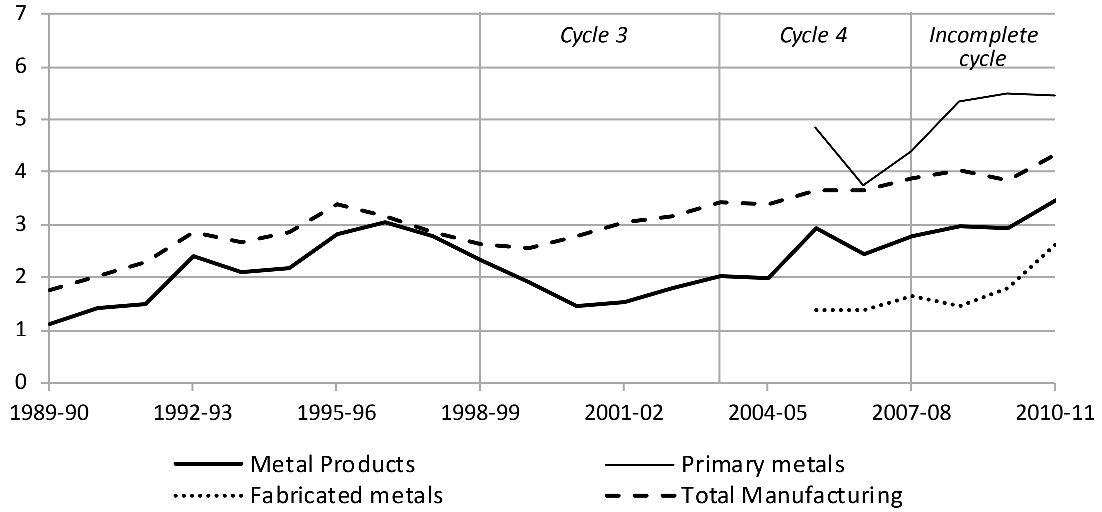
Growth in R&D intensity

The R&D intensity of the subsector has been rising since 2000-01, although it remains lower than for Manufacturing as a whole. Within the subsector, the R&D intensity of Primary metals is higher than that of Fabricated metals (figure 6.2).

The R&D intensity of MP has been rising since the beginning of cycle 4, which suggests that changes in R&D activity are not behind the decline in MFP in MP over cycle 4.

Figure 6.2 **R&D intensity[a] for Metal products**

Per cent



[a] Total R&D expenditure (current and capital expenditure) as a percentage of industry value added.

Data sources: Authors' estimates based on ABS (*Research and Experimental Development, Businesses, Australia, 2010-11*, various issues, Cat. no. 8104.0); ABS (*Australian Manufacturing*, various issues, Cat. no. 8221.0); and ABS (*Australian Industry,* various issues, Cat. no. 8155.0).

6.2 Operating environment for Metal products

Demand for both primary and fabricated metal products has increased over the last two productivity cycles. Increased global demand for base metals led to higher commodity prices, which in turn influenced production and investment decisions in Primary metals. A boom in construction activity in Australia boosted demand for Fabricated metals, and indirectly for some Primary metals.

Primary metal products received higher prices

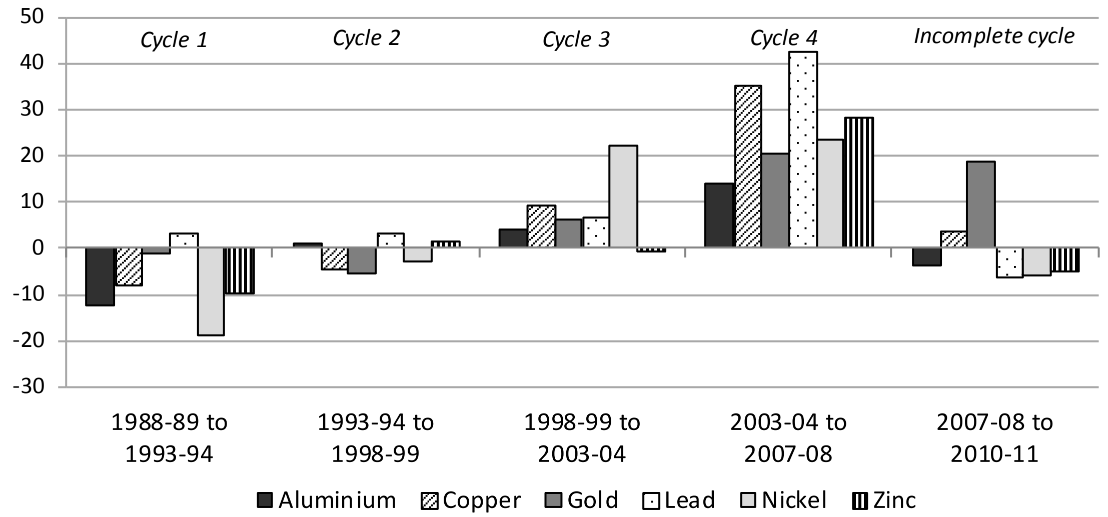
Basic non-ferrous metals

There was strong growth in non-ferrous metal prices during the last two productivity cycles, particularly in cycle 4 (figure 6.3). This growth in prices was driven by strong demand from Asia over the period (Syed, Grafton and Kalirajan 2013; Australian Government 2012). The sustained prices encouraged investment by the producers of these metals, which explains much of the investment growth observed in the subsector as a whole.

The change in aluminium prices is particularly relevant as Australia is the world's leading producer of bauxite ore and second largest producer of alumina (AAC 2010).

Figure 6.3 **Changes in selected non-ferrous metal prices by cycle[a]**

Average annual growth rate (per cent)



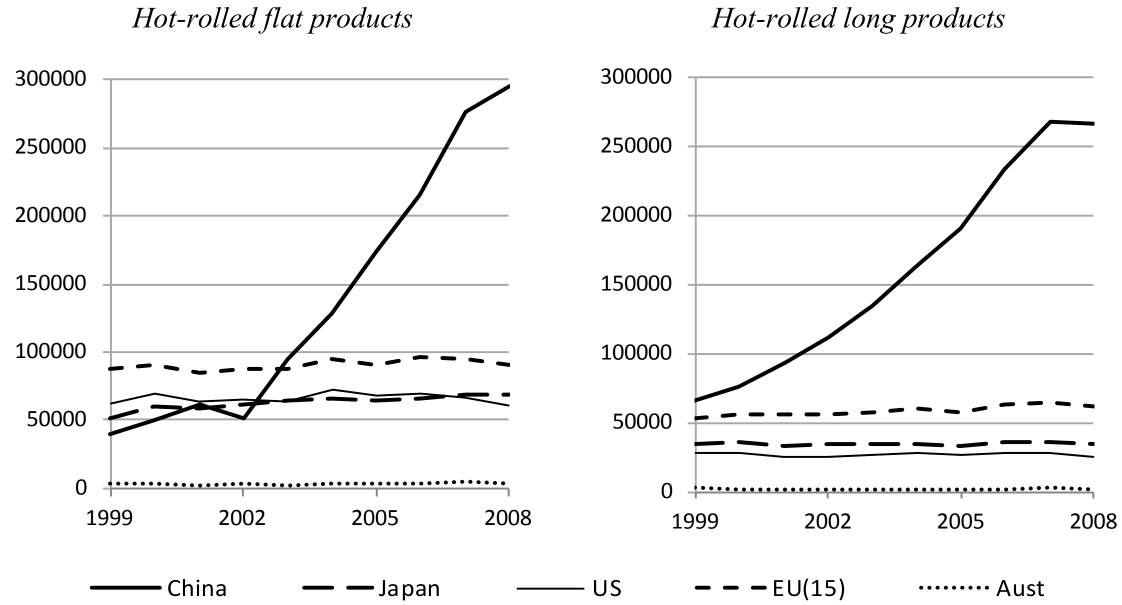
[a] London Metals Exchange spot-market nominal prices.

Data source: BREE (2011).

Basic ferrous metals

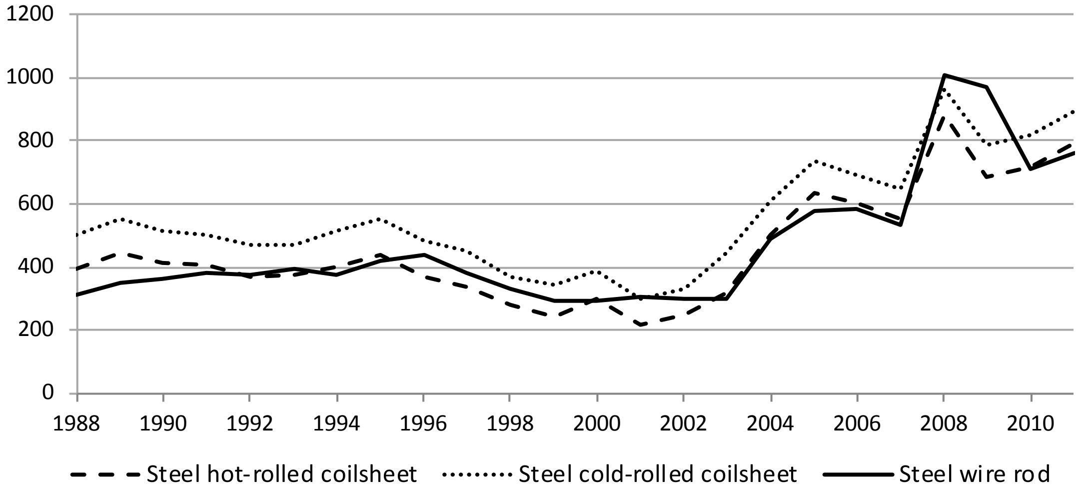
A major shift in the operating environment for Australian manufacturers of ferrous metals (iron and steel) is the strong growth of steel output from China in recent years. During the 2000s, growth in Chinese steel production was close to 20 per cent a year, with China becoming a net exporter of steel in 2006 (Holloway, Roberts and Rush 2010). China not only increased its share of global steel production, but also changed its mix of steel production towards higher value flat products used in Manufacturing (Holloway, Roberts and Rush 2010). As shown in figure 6.4, China has recently become the largest producer of these steel products by a wide margin. Despite this increase in world supply, steel prices rose steadily through the 2000s (figure 6.5).

Figure 6.4 **Country/region share of world steel production[a]**
'000 tonnes



[a] For selected steel products (hot rolled flat and hot rolled long only).
Data source: World Steel Association (2011).

Figure 6.5 **Steel prices[a]**
US$/mt

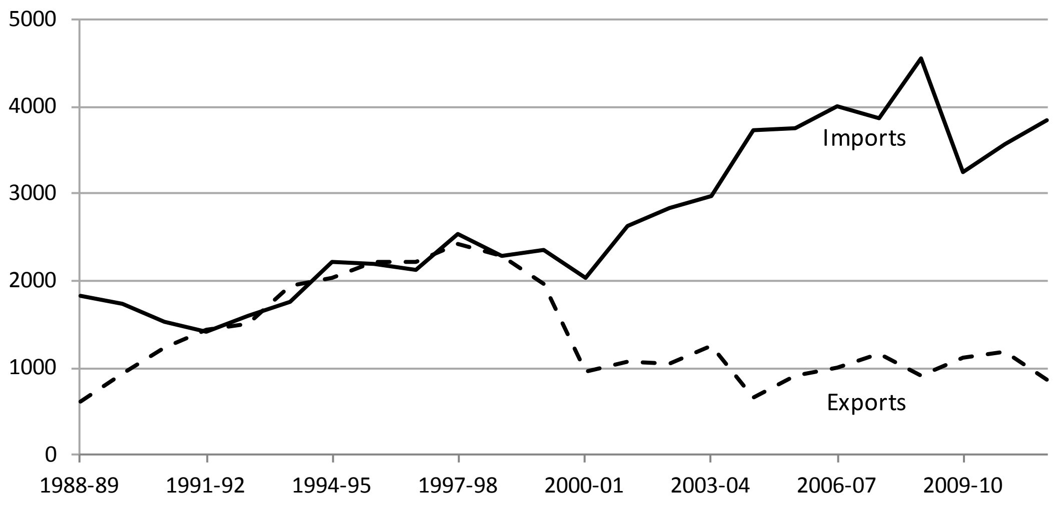


[a] Current prices.
Data source: World Bank (2013).

Responses to greater imports of steel

The domestic producers of steel faced a higher price for both inputs and outputs, as well as greater competition in domestic and overseas markets. Responses of the major steelmakers in Australia have varied. For example, BlueScope Steel responded to the increased competition in the domestic market by becoming more focused on exports of higher value products (BlueScope Steel 2006). In contrast, Arrium (previously OneSteel) responded through diversification — altering its steel production process to use lower-quality iron ore and export the higher-quality iron ore from its mines (Onesteel 2005). Figure 6.6 shows the movements in trade in iron and steel.[2]

Figure 6.6 **Australian trade in Iron and Steel[a]**
2009-10 $m



[a] Based on Standard International Trade Classification (SITC) division 67: Iron and Steel.

Data sources: Authors' estimates based on ABS (*International Merchandise Exports, February 2013*, Cat. no. 5432); ABS (*International Merchandise Imports, February 2013,* Cat. no. 5439.0); and ABS (*International Trade Price Indexes, March 2013,* Cat. no. 6457.0).

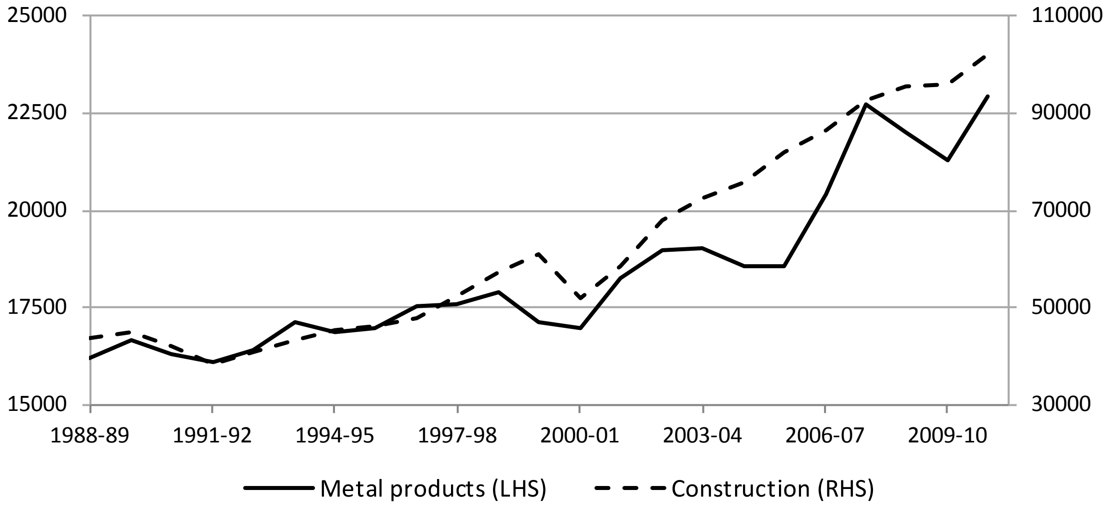
2 Trade in all metal products is discussed in greater detail in appendix H.

Changing use of Metal products: from Manufacturing to Construction and Mining

Strong growth in construction activity in Australia over cycles 3 and 4 meant that there was additional demand for construction materials (figure 6.7).

Figure 6.7 **Real value added of Metal products and Construction**

2009-10 $m (chain volume measure)



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

Increased non-residential building and engineering construction led to increased demand for steel products over cycle 4. The resources boom also helped encourage greater urban infrastructure development and residential construction in mining regions (BlueScope Steel 2006). The commissioning of new mining and petroleum projects has presented opportunities for steel and fabricated metals producers, although the scope of these opportunities may have been more limited since the end of cycle 4.[3]

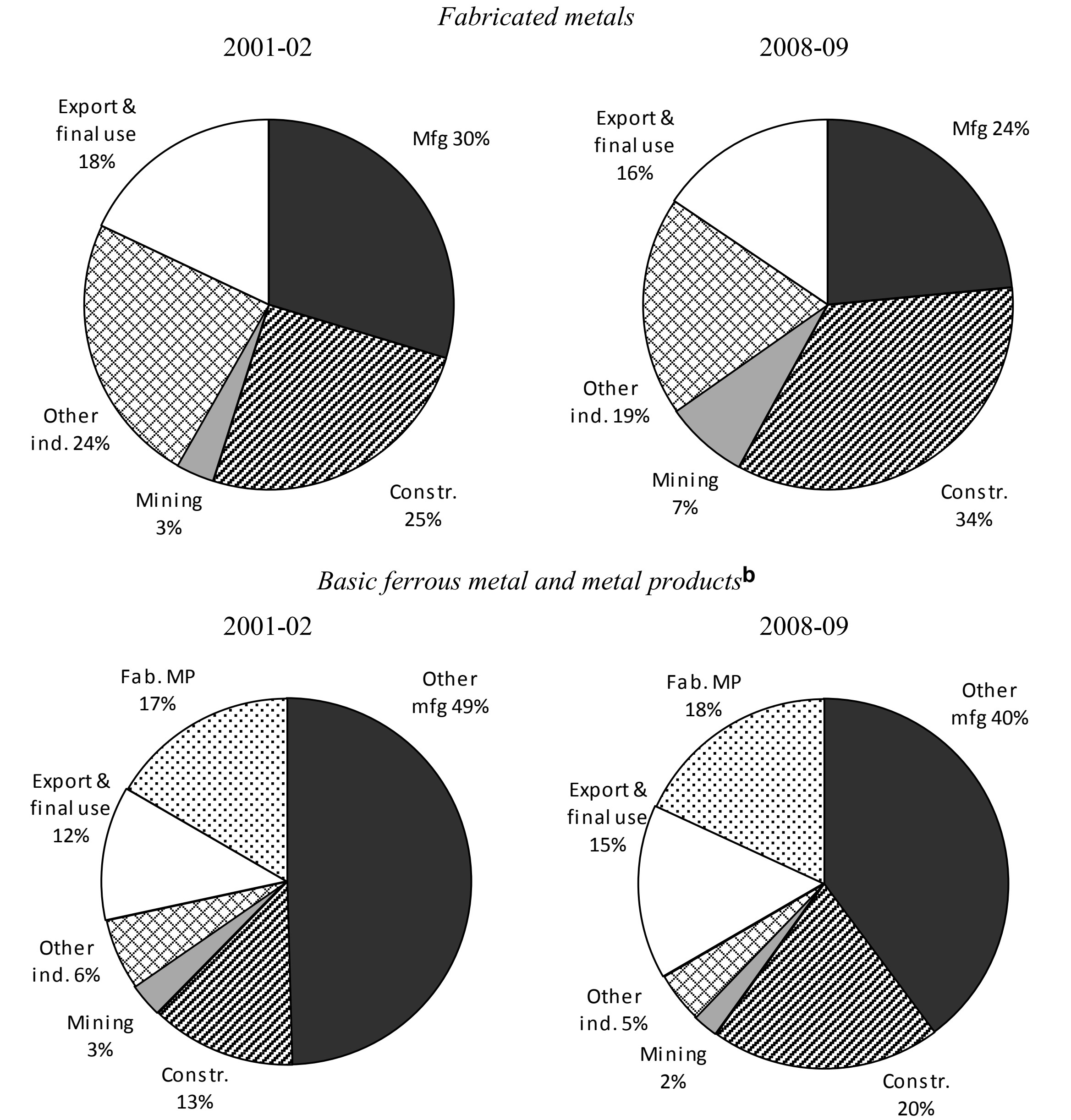
The proportion of MP output going as inputs to the Construction and Mining industries increased accordingly over the 2000s — particularly fabricated metal products and 'basic ferrous metal and metal products' (figure 6.8).[4]

3 The steel industry has raised concerns that Australian suppliers are increasingly overlooked when it comes to supplying major mining and construction projects (McDonald 2009). Other research indicates that Metal products continues to supply a significant proportion to the mining industry and that changes in source of supply reflect the changing composition of mining projects (especially in regards to constructing new liquefied natural gas capacity) (Connolly and Orsmond 2011).

4 Proportions based on input-output tables are in nominal terms. Accordingly, changes in shares could reflect changes in volume and/or price.

Figure 6.8 **Changing use of the output of Metal products**[a]

Share of nominal output



[a] Total supply is the sum of all final uses (including export) and total industry use. Based on the input-output table with direct allocation of imports. More input-output data are presented in appendix H. [b] Includes ANZSIC06 groups 211 and 212 for 2008-09 and ANZSIC93 group 271 for 2001-02. Other manufacturing includes all manufacturing uses other than that of Fabricated metals.

Data source: Authors' estimates based on ABS (*Australian National Accounts: Input-Output Tables,* various issues, Cat. no. 5209.0.55.001, table 5).

Between 2000-01 and 2008-09:

- the proportion of fabricated metal products output used as inputs by Manufacturing fell from 30 to 24 per cent, while the proportions used in Mining and Construction rose (from 3 to 7 per cent, and 25 to 34 per cent, respectively)

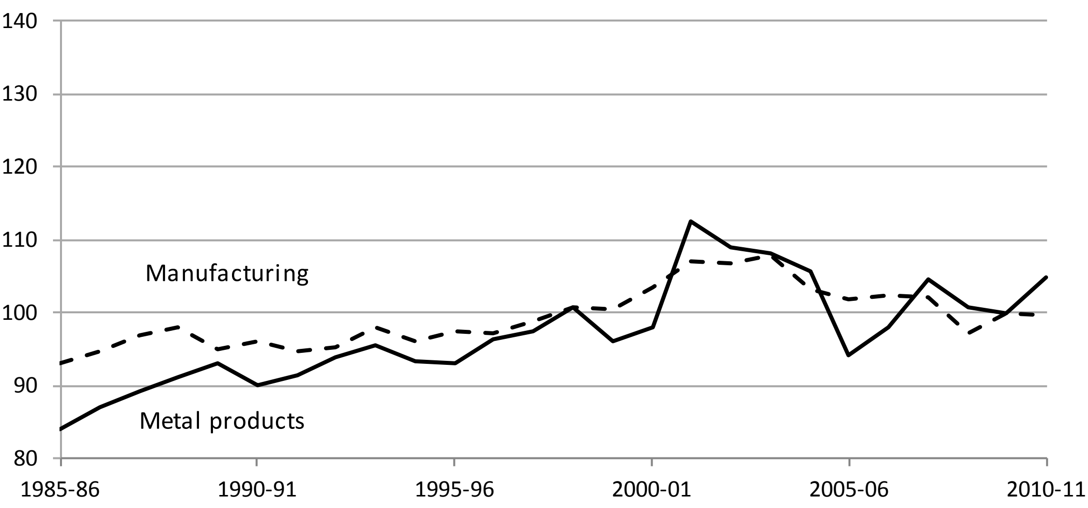
- the proportion of basic ferrous metal and metal products output used as inputs by Manufacturing (other than Fabricated metals manufacturing) fell from 49 per cent to 40 per cent, while the proportion used by Construction rose from 13 to 20 per cent.

Over the period of cycles 3 and 4, the value of Fabricated metals and Basic ferrous metals and products supplied to the Construction sector rose much more quickly than the value of products supplied to Manufacturing. BlueScope Steel (2006) posited that local steel-intensive manufacturing, such as in white goods, hardware, appliances and food packing, was contracting. They noted a drop in the volume of sales to downstream manufacturers between 1997-98 and 2005-06. In particular, drying up of downstream users in Manufacturing and import competition had led to plant closures in tin plate steel and electrical steel (BlueScope Steel 2006).

6.3 MFP growth and its proximate causes in Metal products

MP's average MFP growth was 2 per cent a year between 1985-86 and 2010-11. MFP in MP generally had an upward trend up to the early 2000s, before declining considerably to the mid-2000s, after which it picked up again (figure 6.9). This trend was fairly similar to that for Manufacturing in total, except for the drop in 2005-06.

Figure 6.9 **MFP in Metal products and Manufacturing**
Index 2009-10 = 100

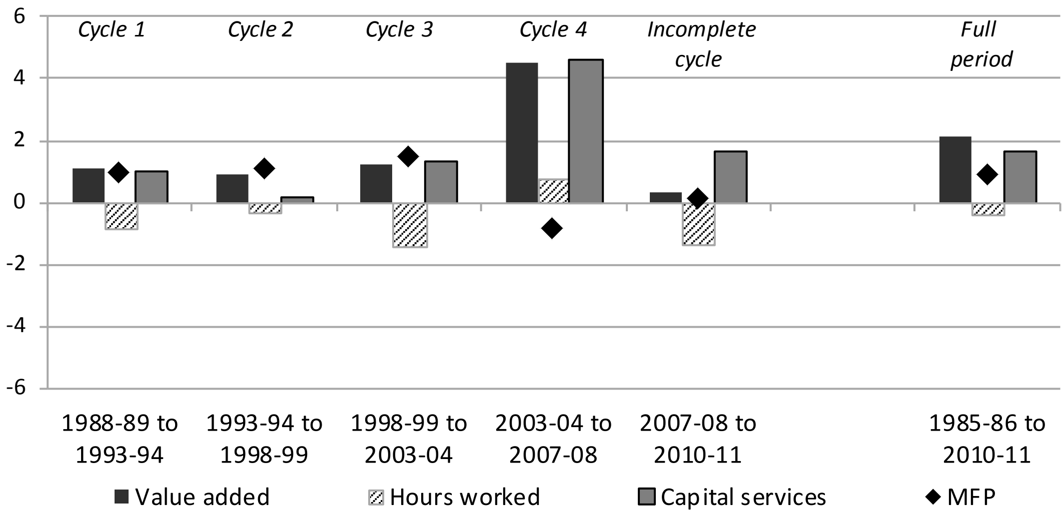


Data sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

For the purposes of identifying the contributions of a subsector to MFP for Manufacturing as a whole, the cycles for Manufacturing in aggregate are used.[5] Figure 6.10 presents MFP growth and growth in its proximate causes — the volumes of value added, hours worked and capital services — over the productivity cycles since 1988-89. MP's average MFP growth was positive and fairly stable in the first three cycles — with value added growth exceeding combined growth in capital and labour. The negative MFP growth in cycle 4 (2003-04 to 2007-08) was exceptional. Despite very strong growth in value added, this was exceeded by even stronger growth in combined inputs, particularly capital.

Figure 6.10 **MFP growth and its proximate causes[a] in Metal products by cycle**

Average annual growth rate (per cent)



[a] Capital services and hours worked weighted by income shares.

Data source: Authors' estimates.

Growth of capital services has been consistently positive (up to 1 per cent a year for the first three cycles), but it was particularly strong in cycle 4 (up to 4.6 per cent a year). At the same time, hours worked generally declined — except in cycle 4, where they increased, but not to the same extent as capital services and value added. The growth of capital services relative to hours worked implies an increase in the capital-labour ratio, suggesting that MP has become more capital-intensive (as shown in figure 6.1).

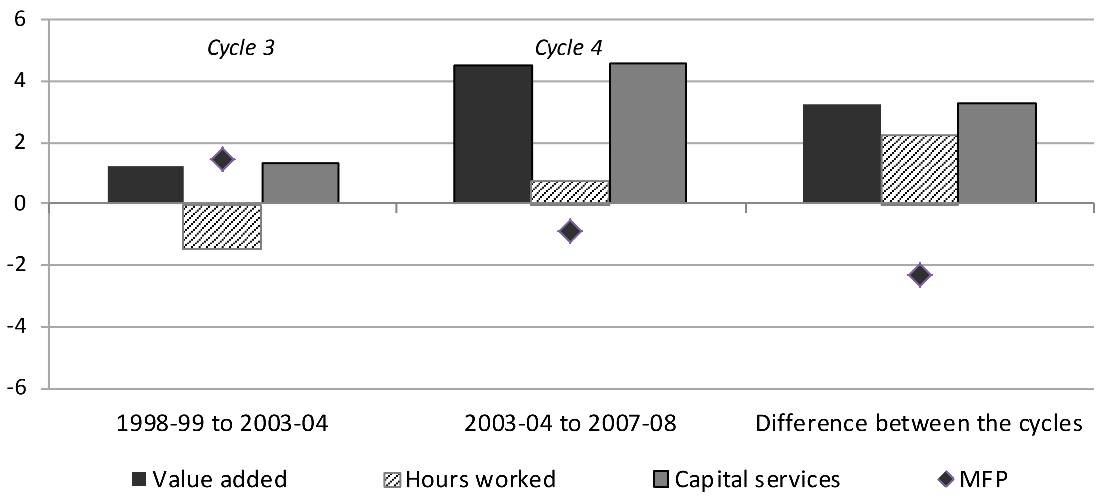
5 The cycles for MP do not exactly match those of Manufacturing (appendix C), but the change in timing does not detract from the overall finding that MP has had a significant decline in MFP over the mid- to late-2000s and contributed to the overall decline in Manufacturing MFP. As a result, MP-specific cycles are not shown here.

There has been some improvement in MFP growth in the incomplete cycle. Input growth slowed by more than value added growth — with a return to reductions in hours worked and a more typical rate of capital services growth. (However, as noted in chapter 2, some care is needed in the interpretation of the incomplete cycle since it may be influenced by temporary factors, including the global financial crisis.)

As discussed in chapter 3, the principal focus of this paper is on explaining the decline in Manufacturing MFP growth between cycles 3 and 4 when MP made a large contribution to this decline. Figure 6.11 highlights the extent of the decline in MP's MFP growth — with the large increase in value added growth being offset by an even larger increase in input growth, particularly capital services. The remainder of the chapter discusses influences that might underlie these large changes in MP between cycles 3 and 4.

Figure 6.11 **MFP growth and its proximate causes[a] in Metal products, cycles 3 and 4**

Average annual growth rate (per cent)



[a] Capital services and hours worked weighted by income shares.

Data source: Authors' estimates.

6.4 Influences on MFP growth in Metal products

Fabricated metals appears to have been driving MP value added growth and the bulk of the hours worked growth, while Primary metals appears to have been largely responsible for the rapid growth in capital services.

Strong value added growth in Fabricated metals

Real value added growth for the MP subsector as a whole was 4.5 per cent a year over cycle 4 — 3.2 percentage points higher than the previous cycle (figure 6.11). Data for real value added in each of the subdivisions (Primary metals and Fabricated metals) are not available. However, other indicators suggest that Fabricated metals, rather than Primary metals, was the source of value added growth in the MP subsector.[6]

One available measure of output volumes (*real* 'sales and service income') shows an increase for Fabricated metals over cycle 4 and a decline for Primary metals (figure 6.12).[7] *Nominal* sales and service income of Primary metals rose as prices for the subdivision's output increased in response to greater demand for those products.[8] However, *real* sales and service income (which nets out this price change) indicates that the volume of Primary metals output fell. Fabricated metals, which had real sales growth, was more likely to have contributed to the strong value added growth in MP over cycle 4.

The remainder of this subsection examines more disaggregated data from alternative sources to help identify possible drivers of output in each MP subdivision.

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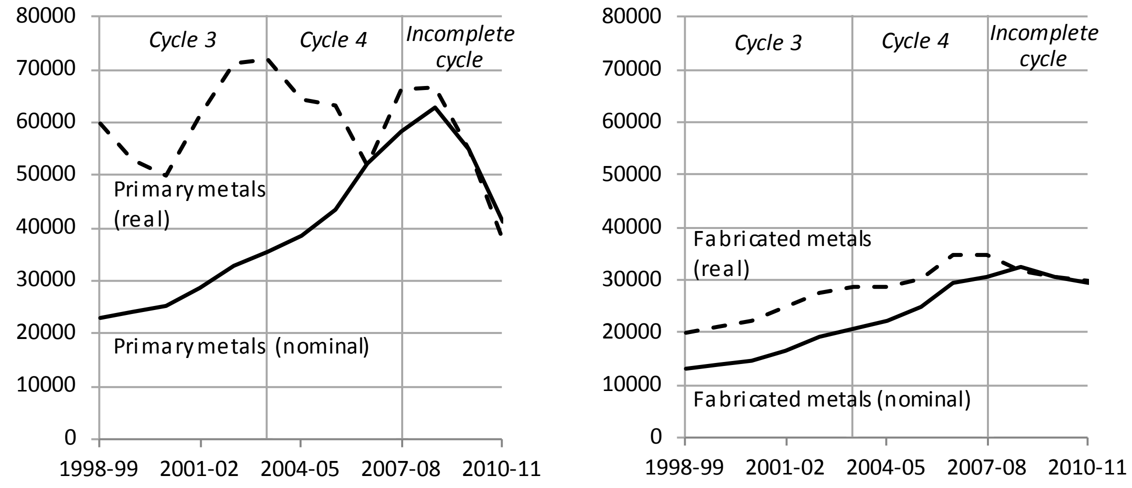
6 Value added is gross output less intermediate inputs used in producing that output. Intermediate inputs are the inputs used by the business other than capital and labour — for example, energy, raw materials and services. The volume of value added refers to value added with the effect of price changes removed.

In the case of MP, there is little evidence to suggest a change in the proportion of intermediate inputs being used, thus changes in value added are being primarily driven by changes in gross output.

7 Comparability of data for MP from the National Accounts and from other ABS surveys is discussed in appendix H.

8 This is borne out by an examination of the implicit price deflators for Primary metals based on the sales and service income, as well as the producer price indexes of output for the subdivision. Specifically, growth in the output producer price index for Primary metals was 1.6 and 13.5 per cent a year for cycles 3 and 4, respectively — an acceleration of 11.9 percentage points. The implicit price deflator for sales and service income for Primary metals grew at a rate of 5.3 and 15.6 per cent a year for cycles 3 and 4, respectively — an acceleration of 10.3 percentage points. See appendix H for further details.

Figure 6.12 **Sales[a] in Metal products subdivisions**
Nominal ($m) and real (chain volume measure 2009-10 $m)



[a] Sales and service income.

Data source: ABS (*Business Indicators*, *September 2012,* Cat. no. 5676.0).

Primary metal products

Output data published by the Bureau of Resource and Energy Economics (BREE) confirms that the physical volume of output of most primary metal products did not grow faster in cycle 4 than cycle 3 (table 6.3).[9]

Volumes for most primary metal products declined during cycle 4 with a total decline of -0.2 per cent a year, which was 2.8 percentage points lower than the cycle 3 growth rate of 2.6 per cent a year. Product-specific factors were at play in explaining many of the declines in output volumes. For example, refined gold output fell in line with declining mine output. Iron and steel output dropped due to the closure of the Boodarie iron briquette plant (BHP Billiton 2005; ABARE 2004b, p. 447).

9 The value of production (inferred from BREE data) captures, on average, around 70 per cent of the sales and service income in Primary metals (from ABS Cat. no. 8155.0) for the years 2000-01 to 2010-11.

Table 6.3 **Estimated growth in output volumes of primary metal products**

	Cycle 3: 1998-99 to 2003-04		*Cycle 4: 2003-04 to 2007-08*		*Difference between the cycles*	
	Change in volume[a]	*Contribution to total*[b]	*Change in volume*[a]	*Contribution to total*[b]	*Change in volume*[a]	*Contribution to total*[b]
	% py	% pts	% py	% pts	% py	% pts
Alumina	3.3	0.6	3.8	0.7	0.5	0.1
Tin	-1.5	0.0	-16.6	0.0	-15.1	-0.0
Silver	8.6	0.1	-0.6	0.0	-9.1	-0.1
Lead	1.8	0.0	-5.4	-0.1	-7.2	-0.1
Aluminium	2.2	0.4	1.1	0.2	-1.0	-0.2
Gold	-1.1	-0.3	-2.1	-0.5	-1.1	-0.2
Zinc	6.6	0.2	0.4	0.0	-6.2	-0.2
Copper	8.4	0.5	-0.7	-0.1	-9.1	-0.5
Iron and steel[c]	2.0	0.4	-3.6	-0.4	-5.6	-0.8
Nickel[d]	9.8	0.8	-0.5	-0.1	-10.4	-0.9
Total		**2.6**		**-0.2**		**-2.8**

[a] Production volumes — average annual growth rates. [b] Size times growth. Estimated relative contributions to growth of all of the BREE-listed metal products commodities. Contribution based on value weights, calculated from export price or London Metal Exchange price. [c] Consists of manufactured ferrous products. [d] Nickel is the sum of class I and II products.

Source: Authors' estimates based on BREE (2012b).

The primary metal products that experienced positive growth in cycle 4 were alumina (3.8 per cent a year), aluminium (1.1 per cent a year) and zinc (0.4 per cent a year). Of these, only alumina output grew at a rate faster than in cycle 3.

Growth in the volume of output of alumina, aluminium and zinc does not seem to be sufficient to explain the strong growth in value added for the MP subsector as a whole.

Fabricated metals

Practically all of the value added growth in Fabricated metals seems to have occurred in construction-related products, which tallies well with the changes in the operating environment.

While there are some difficulties in calculating real value added (box 6.1), there is strong evidence to indicate that those parts of the subdivision associated with construction — particularly structural steel manufacturing — were responsible for the bulk of nominal value added growth in MP, between cycles 3 and 4.

Box 6.1 **Difficulties in measuring value added in Fabricated metals**

Value added data are available only in nominal terms for ANZSIC groups within the MP subsector. Because changes in nominal value added reflect both price and volume changes, at best they provide a broad indication of the relative growth the volume of value added in different parts of Fabricated metals manufacturing. There is no source of data analogous to that used for Primary metal manufacturing to look at physical volumes of production.

ANZSIC changes

There are also several differences in the definition of Fabricated metal products manufacturing between the 1993 and 2006 editions of ANZSIC. This makes it difficult to construct a long enough time series to fully describe movement within the subdivision over cycles 3 and 4. The main problem is that parts of several ANZSIC93 classes were divided up into a greater number of overlapping ANZSIC06 classes and some activities were moved from the MP manufacturing subsector to other parts of Manufacturing (for example, Machinery and equipment manufacturing and Other manufacturing) or to Construction.

There are, however, a handful of classes that concord exactly from ANZSIC93 to ANZSIC06 (by ANZSIC06 code):

- 2221 *Structural steel fabricating* (23 per cent of Fabricated metals value added in 2007-08)
- 2229 *Other structural metal product manufacturing* (13 per cent)
- 2291 *Spring and wire product manufacturing* (7 per cent)
- 2292 *Nut, bolt, screw and rivet manufacturing* (4 per cent)
- 2293 *Metal coating and finishing* (2 per cent)

In addition, there is another category that concords closely, based on the descriptions given in both editions of the relevant ANZSIC manual:

- 2223 *Architectural aluminium product manufacturing* (8 per cent)

Thus, it is possible to examine movements in the above series (which comprise around 57 per cent of the subdivision value added, and almost three-quarters of the growth, in cycle 4) as well as an amalgamated group of all other fabricated metal products activities that comprise the remainder of the subdivision.

Sources: ABS (*Australian and New Zealand Standard Industrial Classification, 2006,* Cat. no. 1292.0); authors estimates' based on ABS (*Experimental Estimates for the Manufacturing Industry, 2006-07 and 2007-08,* Cat. no. 8159.0).

Table 6.4 details the growth in selected industry classes within the Fabricated metals subdivision, together with a 'catch-all' category for the part of the subdivision that cannot be easily tracked over time due to industry classification changes.

Table 6.4 **Estimated contributions to growth in nominal value added of Fabricated metals**

		Cycle 3: 1998-99 to 2003-04		*Cycle 4: 2003-04 to 2007-08*		*Difference between the cycles*	
		Change	*Share of growth*	*Change*	*Share of growth*	*Change*	*Share of growth*
		$m	%	$m	%	$m	%
2221	Structural steel fabricating	-142	-8.3	1 151	40.5	1 293	115.1
2223	Architectural aluminium product mfg	270	15.7	356	12.5	86	7.6
2229	Other structural metal product mfg	128	7.4	279	9.8	152	13.5
2291	Spring and wire product mfg	4	0.2	20	0.7	16	1.4
2292	Nut, bolt, screw and rivet mfg	62	3.6	32	1.1	-30	-2.6
2293	Metal coating and finishing	112	6.5	284	10.0	172	15.3
Selected classes[a]		*434*	*25.2*	*2 122*	*74.6*	*1 688*	*150.3*
All other fabricated metal prod.[b]		*1 286*	*74.8*	*721*	*25.4*	*-565*	*-50.3*
22 Fabricated metals		**1 720**	**100.0**	**2 843**	**100.0**	**1 123**	**100.0**

[a] Includes ANZSIC classes listed above. [b] See box 6.1 for definition.

Sources: Authors' estimates based on ABS (*Australian Manufacturing*, various issues, Cat. no, 8221.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0); and ABS *(Experimental Estimates for the Manufacturing Industry,* various issues, Cat. no. 8159.0).

Much of the growth over cycle 3 was contributed by this catch-all category, but the classes responsible for growth in cycle 4 are more easily identified. Nearly three-quarters of the growth in cycle 4 in the nominal value added of Fabricated metals was in 'Structural steel fabricating' (over 40 per cent), 'Architectural aluminium product manufacturing' (12.5 per cent), 'Metal coating and finishing' (10 per cent) and 'Other structural metal product manufacturing' (9.8 per cent).

Structural steel products, therefore, more than accounts for the total increase in nominal value added growth in Fabricated metals *between* cycles 3 and 4. This was partially offset by a decline in the value added of the other Fabricated metals category. Metal coating and finishing and Other structural metal product manufacturing also registered strong growth between the cycles.

Summary of value added trends

While data are limited at more disaggregated levels within MP manufacturing, all the available evidence indicates that the majority of growth observed between cycles 3 and 4 occurred in structural steel products. Much of that growth appears related to activities associated with construction — which suggests that the construction 'boom' in the lead-up to the global financial crisis may have benefited Fabricated metals and explains the growth in nominal value added for the subdivision over the period (appendix H).

Capital

Much of the decline in MFP for MP between the last two complete productivity cycles was driven by the strong capital services growth of the subsector. There was a rapid rise in capital investment by MP in cycle 4, during which the subsector contributed about 40 per cent of the capital services growth in Manufacturing as a whole.

Capital services growth in MP was driven by the strong investment in Primary metals, particularly in projects designed to increase the capacity (and in some cases efficiency) of alumina refining. There were also some smaller investments made in nickel refining and copper smelting. Investments were also made in Fabricated metal production, but on a much smaller scale.

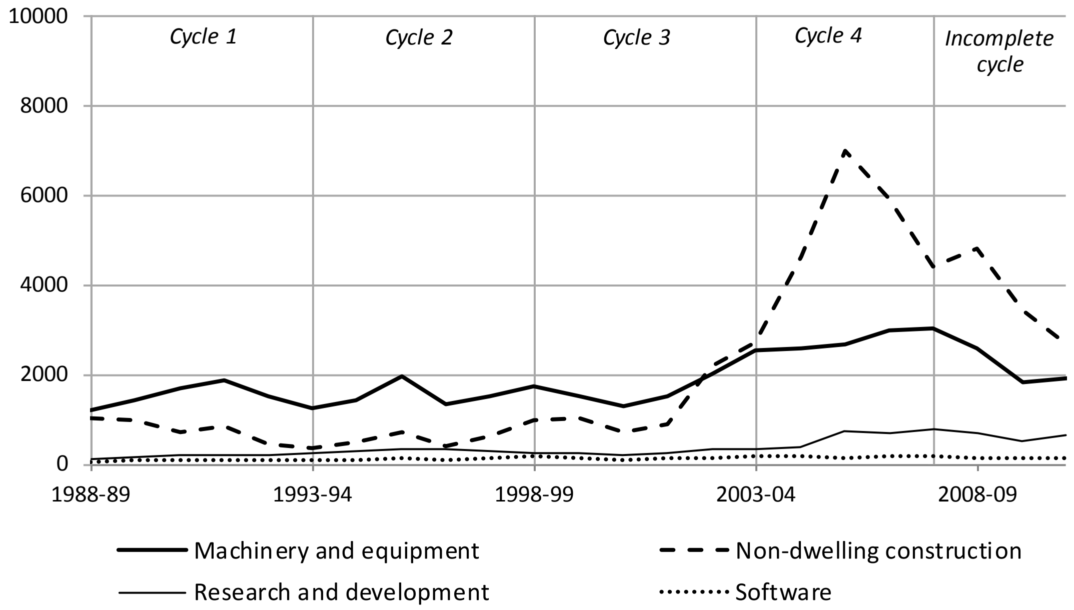
Investment by asset and industry

Growth in capital services for MP more than quadrupled in cycle 4 relative to cycle 3. A starting point for examining the reasons for the increase in capital services is to look at the type of investment undertaken.

Figure 6.13 shows the real value of MP investment by asset type — namely machinery and equipment, non-dwelling construction, research & development and software. Machinery and equipment and non-dwelling construction were the largest components of investment, with very strong growth in non-dwelling construction in cycle 4. While the level of R&D investment is much smaller, it also grew substantially over cycle 4 in MP, although there has now been some decline over the incomplete cycle.

Figure 6.13 **Metal products gross fixed capital formation by asset type**[a]

2009-10 $m



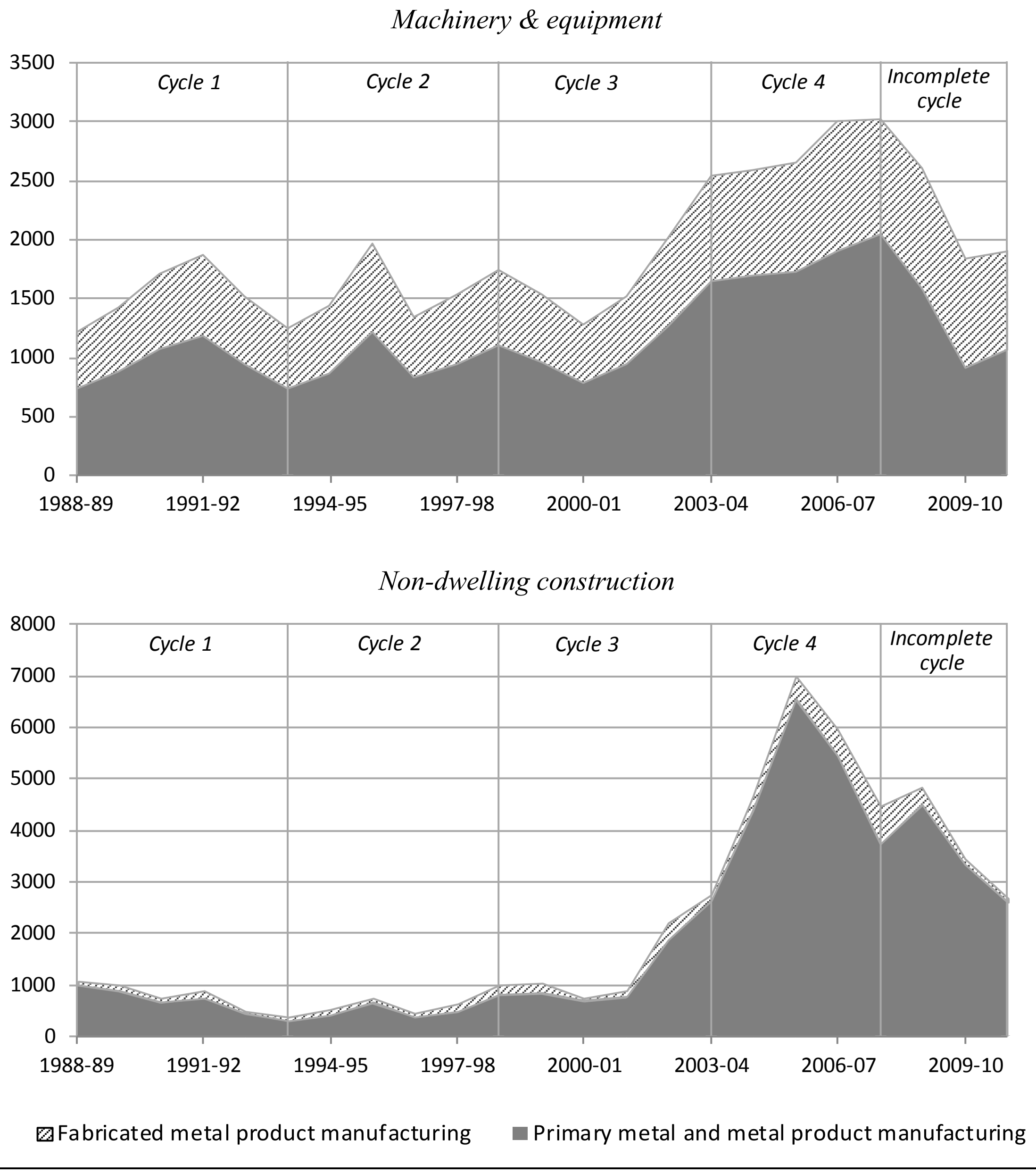
[a] The estimation of capital services for each subsector of Manufacturing (as discussed in chapter 3), involved apportioning Manufacturing investment (gross fixed capital formation from the ABS National Accounts) across the different subsectors. This allowed for the construction of a time series for MP investment in different capital asset types (see appendix A for details).

Data sources: Authors' estimates based on ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0); ABS (unpublished Survey of New Capital Expenditure data); and ABS (*Research and Experimental Development, Businesses, Australia,* various issues, Cat. no. 8104.0).

Nearly all of the growth in MP investment over cycle 4 was driven by Primary metals (figure 6.14).

Figure 6.14 **Metal products gross fixed capital formation by subdivision and asset type**

2009-10 $m



Data sources: Authors' estimates based on ABS (*Australian System of National Accounts, 2010-11,* Cat. no. 5204.0); and ABS (unpublished Survey of New Capital Expenditure data).

Primary metals

As discussed in section 6.2, capital expenditure to expand production capacity in mining and in metals processing is likely to be in response to rising commodity prices throughout cycles 3 and 4. Most of the investment in MP between the last two complete productivity cycles occurred in Primary metals and, of that, most occurred in expanding alumina production capacity.

Table 6.5 shows the growth in net capital expenditure between 2001-02 and 2006-07 by selected groups and classes in Primary metals.[10] It indicates that Primary metals contributed around 88 per cent of the growth in net capital expenditure for MP as a whole (or 11.3 percentage points of the 12.8 per cent a year). Of this, most occurred in alumina refining (8.5 percentage points) and other non-ferrous metal manufacturing (3.2 percentage points).

Table 6.5 **Breakdown of net capital expenditure of Metal products subsector[a]**
2001-02 to 2006-07

	Change	*Growth rate*	*Contribution to growth*
	$m	% py	% pts
Total Metal product manufacturing	**1 909**	**12.8**	**12.8**
Primary metal product manufacturing	**1 681**	**13.9**	**11.3**
Iron & steel	229	8.2	1.5
Basic non-ferrous metal	1 330	14.9	8.9
Alumina production	*1 265*	*51.7*	*8.5*
Aluminium smelting	*-407*	*-15.1*	*-2.7*
Other non-ferrous[b]	*472*	*16.3*	*3.2*
Basic non-ferrous metal products	122	36.3	0.8
Aluminium drawing, rolling and extruding	*123*	*49.5*	*0.8*
Fabricated metal product manufacturing[c]	**228**	**8.2**	**1.5**

[a] Current prices. Data for 2006-07 are based on ANZSIC06 adjusted to match ANZSIC93. There are minor concordance issues with 'Aluminium smelting' and with 'Non-ferrous basic metal products' in 2006-07. The concordance issues for Fabricated metals are significant (box 6.1). [b] For 'Other non-ferrous', average annual growth is for 2001-02 to 2004-05. Other non-ferrous' is a catch-all category which includes classes 2723 Copper, silver, lead and zinc smelting, refining and 2729 Basic non-ferrous metal manufacturing nec. [c] Fabricated metals includes 274 Structural Metal Product Manufacturing, 276 Sheet Metal Product Manufacturing and 275 Fabricated Metal Product Manufacturing in 2001-02.

Source: Authors' estimates based on ABS (*Manufacturing Industry, Australia*, various issues, Cat. no. 8221.0).

[10] Net capital expenditure is another measure of investment, which differs from 'gross fixed capital formation' and 'private new capital expenditure'. Net capital expenditure is used here because it is the only measure of investment available below the subdivision level of disaggregation. However, these data were only published for the 2001-02 to 2006-07 period.

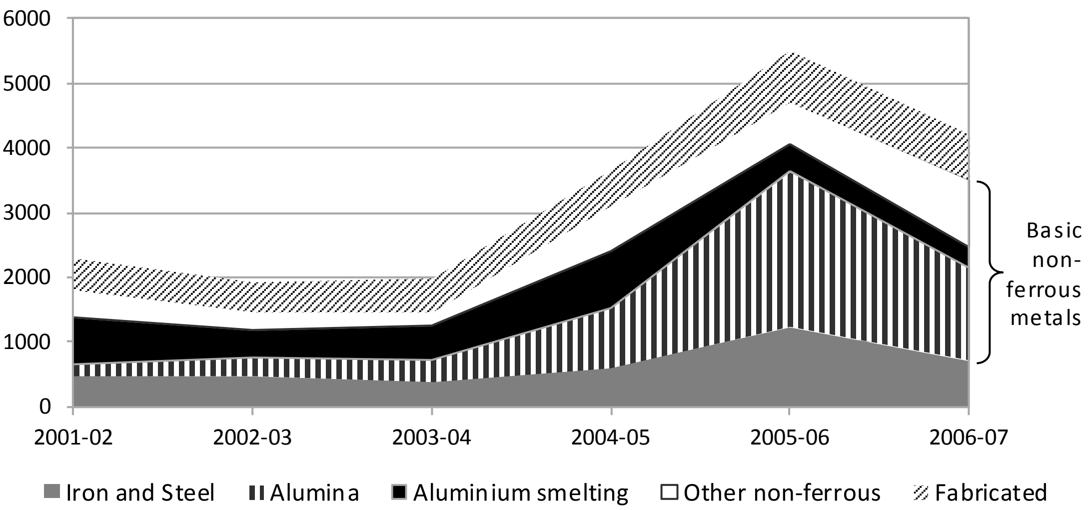
Around 70 per cent of the growth in investment in MP between cycles 3 and 4 can be attributed to new metal processing investments. Most of these projects were alumina-related (around 80 per cent of the capital expenditure identified in the ABARE 'minerals and energy major development projects' list),[11] while steel (8 per cent) and nickel (5.6 per cent) were also important.

The rest of this section examines these specific investments and the likely motivations behind the investment in the alumina, aluminium and other primary metal product industries.

Alumina investment to expand capacity

Alumina projects drove most of the capital expenditure in Basic non-ferrous metals, particularly in cycle 4. While there were several aluminium brownfields projects that took place during the last two complete productivity cycles, they were far exceeded in value by alumina projects in cycle 4, some of which were worth multibillions of dollars. Alumina significantly increased its share of net capital expenditure by MP, while aluminium smelting reduced its share in the period for which class data are available (figure 6.15).

Figure 6.15 **Net capital expenditure of Metal products subsector[a]**
$m



[a] Current prices. Data for 2006-07 are based on ANZSIC06 adjusted to match ANZSIC93. 'Other non-ferrous metals' which includes the classes '2723 copper, silver, lead and zinc smelting and refining' and '2729 Basic non-ferrous metal mfg nec', also include group '273 Non-ferrous basic metal product manufacturing'.

Data source: ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0).

[11] The list details many mineral processing investments that fall under Primary metal product manufacturing and includes data regarding expected completion dates and value of capital expenditure (Gleeson et al. 2008).

These investments were aimed at expanding production capacity in response to expectations that commodity prices would remain high. ABARE (2004a, pp. 126–7) forecast strong growth in alumina output associated with these new investments to meet greater overseas demand for alumina to meet aluminium smelting requirements.

Other data also indicate that Australia's refining capacity increased significantly over the 2000s: from 13 Mt in 2000 to 20 Mt in 2010 (Prosser 2013, pers. comm., 8 October). Indeed, in 2005 the Australian Aluminium Council noted:

> While both alumina and aluminium production levels in 2005 remained similar to 2004 results, alumina capacity is currently being increased through both debottlenecking of existing plant and the construction of additional capacity. Further production growth is anticipated as recent developments ramp up to full capacity. (AAC 2005, p. 2)

The Australian Aluminium Council (2006, 2007) also indicated that there was likely to be growth in production of alumina (and aluminium) as expansion projects began to utilise their additional capacity. However, there may have been some underutilised capacity within the industry over cycle 4 (and to an even greater extent following the GFC). While there was an increase in the production of alumina over cycle 4 (table 6.3), growth in output volumes fell short of expectations. For example, alumina output generally fell short of ABARE forecasts over the 2005-06 to 2009-10 period.

As well as increasing capacity, investment may also have been aimed at improving cost-competitiveness by taking advantage of lower cost energy sources, such as natural gas. While the technical process of alumina refining has largely remained unchanged in the past twenty years, there have been changes in energy sources used. There has been a shift towards adopting cogeneration as a more efficient and less greenhouse gas-intensive source of energy (AAC 2004). Investment undertaken during cycle 4 and the current incomplete productivity cycle included the construction of co-generation facilities (box 6.2).

Box 6.2 **Cogeneration**

Cogeneration is a process of generating electricity while using or recovering the waste heat in addition to the primary power source. Alumina production requires steam, and cogeneration uses waste heat from the production of electricity to generate high-pressure steam more efficiently. Investment in cogeneration is driven by cost-reduction and is dependent on alumina refineries being able to secure a supply of energy source, usually gas.

Alcoa Pinjarra Alumina Refinery upgrade ($440 million, commissioned April 2006)

- This project involved an efficiency upgrade to the refinery as well as installation of two cogeneration plants, bringing total capacity to 4.2 mt per year. The cogeneration facilities are not owned by Alcoa, but by Alinta. They run on natural gas and provide electricity and high-pressure steam for the refinery, while also supplying electricity to the grid. The steam produced by cogeneration replaces the 240 tonnes per hour of steam that was previously generated by the refinery's own boilers, which is just less than half of the refinery's steam requirements (Power-technology.com 2012).

Rio Tinto Alcan Yarwun 2 ($2.5 billion, completed 2012)

- The Yarwun 2 project involved installing a new cogeneration plant run on coal seam gas, which was commissioned in August 2011. The cogeneration plant makes Yarwun self-sufficient in electricity and steam requirements, and also provides surplus power to the grid (Sizer 2011).

The effect of a move to cogeneration on *measured* productivity in MP manufacturing is complex and will depend on the relative efficiency of the electricity production and ownership of the cogeneration facilities. For example, such a shift could raise value added as intermediate inputs in the form of purchased electricity are reduced, but it would also involve additional capital investment, hours worked and other intermediate inputs.

Given the sudden and pronounced increase in investment, particularly in alumina refining over cycle 4, this raises the question of whether the poor productivity performance in the MP subsector was partly driven by a lag between when this new investment was recorded and when output associated with the investment came on stream (a 'capital lag'). For example, some of the alumina investment projects took several years to complete and there was also a process of ramping up production following expansions (AAC 2006).

Analysis of possible capital lags (box 6.3) tends to indicate that, even after allowing for lag between investment in cycle 4 and new capacity becoming available for production in the incomplete cycle, output growth has been relatively low. This suggests that, in the incomplete cycle, some of the new capacity within the MP subsector may have been underutilised, but could be employed if the operating environment improved.

Box 6.3 **Testing for capital lags**

MFP is calculated on the basis that investment is immediately productive, but this may not be the case for projects that take a long time to complete. This introduces a lag between the measured increase in capital inputs and any associated increase in output. The length of time between investment and output is called a 'capital-lag'.

One technique to gauge the magnitude of the effect that capital-lags could have on measured MFP is to lag capital expenditure in order to better reflect capital inputs coming on-stream and any growth in output that may ensue. Lagging capital is most likely to produce the greatest effect on MFP growth in periods where there is a surge in capital inputs, and may smooth out MFP fluctuation in the short run. It is expected to have little effect on MFP in the long run.

On average, the time between investment and completion in MP is between two and three years. The effect, then, of lagging capital inputs is very apparent in the 2003-04 to 2007-08 productivity cycle — the period of strong capital inputs growth. Allowing for a two-year lag of capital services (so that they are matched with output produced two years after capital installation), annual average MFP growth in cycle 4 improves by 0.6 of a percentage point but is still negative (-0.3 per cent) and MFP growth in the next (incomplete) cycle becomes negative. With a three-year lag, MFP improves by 1.8 percentage points and actually becomes positive (1.0 per cent) in cycle 4, but the MFP in the incomplete cycle becomes even more negative.

Effect of two- and three-year capital lags on Metal products MFP

	Average annual MFP growth			*Effect of the lag on MFP*[a]	
Cycle	*no lags*	*2 year lag*	*3 year lag*	*2 year lag*	*3 year lag*
	%	%	%	% pts	% pts
Cycle 1: 1988-89 to 1993-94	1.0	0.3	0.2	-0.7	-0.8
Cycle 2: 1993-94 to 1998-99	1.1	1.3	0.8	0.2	-0.3
Cycle 3: 1998-99 to 2003-04	1.4	2.3	2.5	0.9	1.1
Cycle 4: 2003-04 to 2007-08	-0.9	-0.3	1.0	0.6	1.8
2007-08 to 2010-11[b]	0.1	-1.7	-2.4	-1.8	-2.5

[a] Relative to the case with no lags. [b] Incomplete cycle.

Source: Authors' estimates.

In effect, as output growth has been relatively low during the incomplete cycle despite the increased capacity, allowing for capital lags has only 'pushed out' the period of the poor productivity performance to a later period. While these investments in alumina refining have been completed, output has remained roughly equal to the level reached at the end of cycle 4. For example, the production of alumina in 2011 was 19.6 Mt, while total capacity is quoted as 21.95Mt (AAC 2012), which suggests there is underutilised capacity. (A further discussion on capital lags for MP is provided in appendix H.)

Aluminium investment

While there has been an increase in the level of alumina investment over cycles 3 and 4, there has been a decline in the amount of investment in aluminium. Nonetheless, there were a few projects that were completed over cycle 4.

- In 2006, Hydro Aluminium completed two upgrades worth a total of $130 million at the Kurri Kurri facility (ABARE 2006b).
- In 2006, the Boyne Island Smelter completed a $56 million project to increase capacity (ABARE 2006b).
- In 2007, Tomago Aluminium also completed upgrades worth $200 million to expand capacity and improve energy efficiency (Tomago Aluminium 2013).

Collectively, these investments amounted to $386 million during cycle 4, which would have contributed to the growth in capital services in MP observed over the period. However, aluminium investments above account for only a small proportion of investment over cycle 4 compared with alumina investment (table 6.5).

Other non-ferrous metals investment in response to higher prices

There have been other investments in Basic non-ferrous metals manufacturing, particularly nickel and copper metal manufacturing.

Investment in nickel refining appears to be driven by a single large investment of $731 million, associated with the Yabulu nickel refinery upgrade, in order to process ore from the new mine at Ravensthorpe (Gleeson et al. 2008). The motivation behind this upgrade was the particularly strong increase in prices for nickel driven by increased demand from China, particularly for use in stainless steel (Oututec 2005).[12]

[12] It is worth noting that during the incomplete cycle, the price of nickel fell and the Ravensthorpe nickel mine was mothballed. The Yabulu refinery was sold, but continued to produce refined nickel from other sources. In 2013, it was refining nickel at record levels.

Xstrata also invested over cycle 4 to expand its copper smelter at Mt Isa and upgrade its refinery in Townsville — an investment of $100 million which was completed in 2007. The purpose of the expansion was to increase the smelter's capacity by about 16 per cent to 280 kilotons per year (ABARE 2005, p. 137).[13]

Collectively these account for around $830 million of investment, much of which occurred over cycle 4. While not as large as the investments in alumina (table 6.5), these other non-ferrous metal investments still made a significant contribution to the growth in capital services observed in MP.

Basic ferrous metals investment in response to changing conditions

There have been two investment projects of particular note with respect to steelmaking over cycle 4.

One project was undertaken by Arrium (formerly OneSteel), which has a relatively vertically integrated chain of production to make steel, ranging from iron ore mines to steelworks. It responded to the higher iron ore prices by investing in measures to allow a lower grade of ore (magnetite) to be used so that it could export its supply of higher grade ore (hematite). This 'project Magnet' was completed in 2007 and cost $395 million. In addition to changing the type of ore used, it also extended the life of the steelworks from 2020 to 2027, since the surrounding Middleback mines had limited hematite reserves (OneSteel 2005).

The other project was the 'HIsmelt' plant commissioned by Rio Tinto in 2005 at a cost of $400 million. This plant was considered a breakthrough in smelting technology, as a means of directly smelting iron ore into high grade molten iron for use in steel products. It was designed to process high phosphorous iron ore and to use non-coking coals, thus reducing environmental impact (Goodman 2007). However, after the GFC, the smelter ceased production and in 2011 the plant was dismantled and relocated to India (Rio Tinto 2011).

[13] This project was also adversely affected by plummeting prices after the GFC. In the face of competition from Chinese refineries, Xstrata decided to dismantle both the Mt Isa smelter and Townsville refinery by 2016, but to continue to acquire and invest in copper mining. Investment measures are typically adjusted to take account of disposals of assets in order to derive capital services inputs, but in the case where the write-off of an asset occurs below that of its previous value (that is, the replacement value at the time the investment was made), then there is some scope for part of the capital asset to remain in the capital services measure.

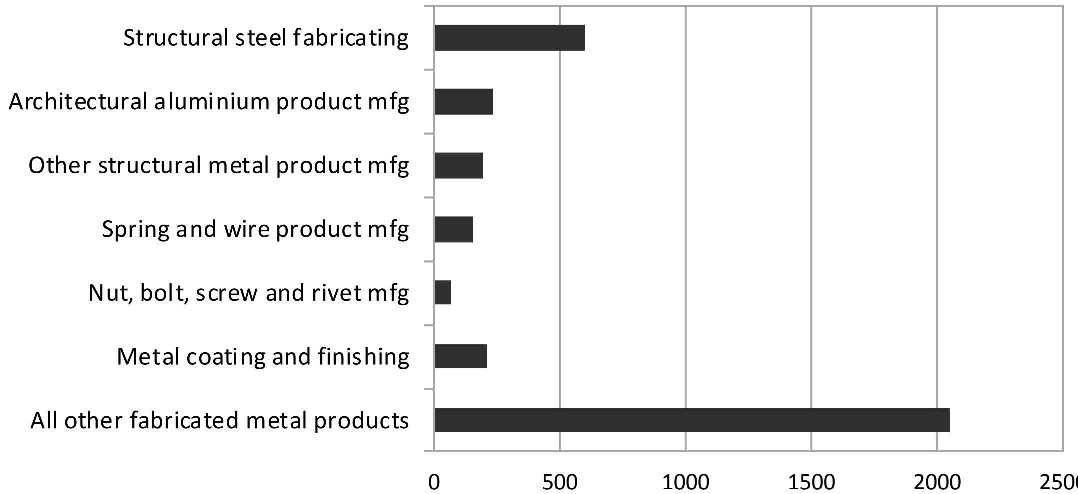
Fabricated metals

Fabricated metals made a significantly smaller contribution to the capital services growth in MP than Primary metals, but still had increasing investment over cycle 4.

Figure 6.16 shows net capital expenditure by selected Fabricated metals product groups, as well the remainder of the subdivision. The data indicate that the strongest growth in net capital investment occurred in those categories that cannot be separately identified, but there was also noticeable investment growth in Structural steel product manufacturing and Metal and coatings manufacturing. There is some evidence to indicate that some investment in the fabricated sector was associated with expansion and automation of the steel industry (McDonald 2009).[14]

Figure 6.16 **Net capital expenditure of Fabricated metals subdivision[a]**

Sum of net capital expenditure 2001-02 to 2006-07, $m (current prices)



a There exists a break series between 2005-06 and 2006-07 due to changes in ANZSIC. Those industry classes shown have been concorded between classifications, but some are unable to be concorded — these are grouped together in the 'all other fabricated metal products' (which should not be confused with ANZSIC06 group 229 or ANZSIC06 class 2299). See box 6.1 for more details regarding Fabricated metals concordance.

Data source: Authors' estimates based on ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0).

Investments in Fabricated metals may have been made in association with the construction boom and in anticipation of additional future demand for construction materials. In addition, there is also evidence to suggest that investment was

[14] Information from the Australian Steel Institute, presented in a consultancy report to the then Steel Industry Innovation Council, indicates that the scale of investment in automation and expansion of capacity between 2006 and 2008 was in the order of $400 million (Howard Partners 2012). The report noted that 'These investments preceded the GFC in 2009 and many businesses were subjected to significant financial pressure, with many going out of business over the last two years as demand has failed to recover.' (Howard Partners 2012, p. 53).

designed to allow the manufacturing of different sorts of construction goods. Examples of innovation for steel in residential construction goods cited by BlueScope Steel (2006) include blue resin for coated steel and complete roofing, truss and guttering systems. The construction boom also coincided with a push by the fabricated metals industry to incorporate a 'design and construct' trend (as had occurred in the United Kingdom) (The Warren Centre 2007). This involves providing more tailored products to meet changing downstream demand.

Labour

There was growth in hours worked in MP over cycle 4, after a decline over cycle 3 (table 6.6). It is difficult to establish definitively which of the subdivisions within MP contributed to this growth in hours worked. One source of disaggregated data suggests that employment in Fabricated metals grew over cycle 4. This is consistent with value added growth in Fabricated metals — particularly those parts related to construction. (For a comparison of the alternative data sources see appendix H.)

Table 6.6 **Metal products hours worked**
Average annual growth rate (per cent)

	Growth
Cycle 3: 1998-99 to 2003-04	-2.6
Cycle 4: 2003-04 to 2007-08	1.5
Incomplete cycle: 2007-08 to 2010-11	-2.7

Sources: Authors' estimates based on ABS (unpublished Labour Force Survey data).

6.5 Drawing together the implications for productivity

Metal product manufacturing made the third largest contribution to the slowdown in MFP growth within Manufacturing between productivity cycles 3 and 4. This negative growth in the subsector's MFP was driven by very strong growth in inputs, which outpaced particularly strong growth in outputs. However, growth in inputs and outputs were very different across the two subdivisions within the subsector. The strong value added growth observed in the subsector appears to have been driven by growth in Fabricated metals, motivated by stronger demand from the domestic construction and mining sectors. There was also some value added growth in parts of Primary metals — primarily in alumina refining.

Growth in capital inputs accounted for around 63 per cent of the growth in combined inputs between cycles 3 and 4, with practically all of the investment growth taking place in Primary metals. This investment — the bulk of which was in alumina refining — was associated with building new metal refining assets and upgrading existing ones. This expansion was in response to the higher commodity prices observed over 2003-04 to 2007-08 and in anticipation of strong demand in the future.

Growth in hours worked between the cycles accounted for the remaining 37 per cent of growth in total inputs, with Fabricated metals likely to have contributed most of this growth. This rise in the number of hours worked during cycle 4 was significant as it reversed a trend of declining hours worked for the subsector, which had reduced hours worked in every cycle since 1988-89.

Fabricated metals appears likely to have experienced positive MFP growth over cycle 4 — a result of having the bulk of the output growth over the period, although it also had most of the labour input growth.

In contrast, Primary metals is likely to have contributed nearly all the decline in MFP, due to extraordinary growth in capital inputs without any evidence of growth in the real volume of output for the subdivision in total. There may be an element of 'capital-lag' to this result, although the length of such a lag may be longer than expected, as falling demand in the incomplete cycle means that the investment in capital is yet to be fully utilised.

In summary, Primary and Fabricated metals appear to have been pulling MFP in the MP subsector in different directions between cycles 3 and 4, with Primary metals playing the main role in the decline and Fabricated metals offsetting the scale of the decline to some extent.

It appears likely that the decline in MFP in MP over cycle 4 was exceptional. Average MFP growth in MP was just above zero in the incomplete cycle (0.1 per cent a year). While value added growth fell to 0.3 per cent a year, combined input growth was also very low. Hours worked fell, almost offsetting growth in capital services, which has slowed relative to the exceptional growth of cycle 4.

A Growth accounting framework and data sources

A.1 Growth accounting framework

The growth accounting framework, is an accounting exercise that breaks down output growth into input growth and attributes the residual to technical change. It examines *growth* in output rather than the *level* of output.

In the ABS official estimates of multifactor productivity (MFP) growth for Australia, output is measured as gross value added (gross output less intermediate inputs). In this case, the growth accounting framework says that value added growth is equal to a weighted average of capital growth and labour growth plus a residual not explained by growth in combined inputs. The residual is commonly referred to as MFP growth.[1] Although MFP growth is sometimes interpreted as a measure of technical progress, 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.

Growth accounting is based on a number of important assumptions:

- constant returns to scale in the underlying production function
- output markets are competitive
- inputs markets are competitive (that is, factor inputs are paid their marginal products)
- inputs are fully divisible
- inputs are fully utilised
- the economy is in equilibrium.

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1 Growth accounting can also be done in terms of labour productivity growth (growth in output per hour worked) rather than output growth, in which case labour productivity growth is equal to capital income share weighted growth in the capital-labour ratio (capital deepening) plus MFP growth.

The following sections discuss the methodology and data sources used to estimate the variables required to calculate MFP growth at the subsector level.

A.2 Industry classification

MFP estimates for Manufacturing in aggregate are available from 1985-86 to 2010-11 in ABS *Experimental Estimates of Industry Multifactor Productivity, 2010-11* (Cat. no. 5260.0.55.002). These estimates are the industry division of Manufacturing as defined in the 2006 edition of the *Australian and New Zealand Standard Industrial Classification* (ANZSIC06) (ABS 2006b).

The main disaggregation of Manufacturing used in this paper is based on the eight Manufacturing subsectors reported in the annual ABS National Accounts publication (Cat. no. 5204.0). Table A.1 shows the relationship between these eight subsectors and the Manufacturing subdivisions in the ANZSIC06. These subdivisions include a wide range of activities (box A.1).

Table A.1 **Manufacturing subsectors and ANZSIC06 Manufacturing subdivisions**

Manufacturing subsectors (ANZSIC06 National Accounts groupings)	*ANZSIC06 Manufacturing subdivisions*
Food, beverage & tobacco products (FBT)	11 Food product manufacturing
	12 Beverage & tobacco product manufacturing
Textile, clothing & other manufacturing (TCO)	13 Textile, leather, clothing & footwear mfg
	25 Furniture & other manufacturing
Wood & paper products (WP)	14 Wood product manufacturing
	15 Pulp, paper & converted paper product mfg
Printing & recorded media (PRM)	16 Printing (incl. reproduction of recorded media)
Petroleum, coal, chemical & rubber products (PCCR)	17 Petroleum & coal product manufacturing
	18 Basic chemical & chemical product mfg
	19 Polymer product & rubber product mfg
Non-metallic mineral products (NM)	20 Non-metallic mineral product manufacturing
Metal products (MP)	21 Primary metal & metal product manufacturing
	22 Fabricated metal product manufacturing
Machinery & equipment (ME)	23 Transport equipment manufacturing
	24 Machinery & equipment manufacturing

Box A.1 ANZSIC06 Manufacturing subdivisions and groups

11 Food product mfg	
111 Meat & meat product mfg	112 Seafood processing
113 Dairy product mfg	114 Fruit & vegetable processing
115 Oil & fat mfg	116 Grain mill & cereal product mfg
117 Bakery product mfg	118 Sugar & confectionery mfg
119 Other food product mfg	
12 Beverage & tobacco product mfg	
121 Beverage mfg	122 Cigarette & tobacco product mfg
13 Textile, leather, clothing & footwear mfg	
131 Textile mfg	132 Leather tanning, fur dressing & leather
133 Textile product mfg	134 Knitted product mfg
135 Clothing & footwear mfg	
14 Wood product mfg	
141 Log sawmilling & timber dressing	149 Other wood product mfg
15 Pulp, paper & converted paper product mfg	
151 Pulp, paper & paperboard mfg	152 Converted paper product mfg
16 Printing (including the reproduction of recorded media)	
161 Printing & printing support services	162 Reproduction of recorded media
17 Petroleum & coal product mfg	
170 Petroleum & coal product mfg	
18 Basic chemical & chemical product mfg	
181 Basic chemical mfg	182 Basic polymer mfg
183 Fertiliser & pesticide mfg	184 Pharmaceutical & medicinal product mfg
185 Cleaning compound & toiletry prep'n mfg	189 Other basic chemical product mfg
19 Polymer product & rubber product mfg	
191 Polymer product mfg	192 Natural rubber product mfg
20 Non-metallic mineral product mfg	
201 Glass & glass product mfg	202 Ceramic product mfg
203 Cement, lime, plaster & concrete Prod.	209 Other non-metallic mineral prod. mfg
21 Primary metal & metal product mfg	
211 Basic ferrous metal mfg	212 Basic ferrous metal product mfg
213 Basic non-ferrous metal mfg	214 Basic non-ferrous metal product mfg
22 Fabricated metal product mfg	
221 Iron & steel forging	222 Structural metal product mfg
223 Metal container mfg	224 Sheet metal product mfg
229 Other fabricated metal product mfg	
23 Transport equipment mfg	
231 Motor vehicle & motor vehicle part mfg	239 Other transport equipment mfg
24 Machinery & equipment mfg	
241 Professional & scientific equipment mfg	242 Computer & electronic equipment mfg
243 Electrical equipment mfg	244 Domestic appliance mfg
245 Pump, compressor, heating & ventilation	246 Specialised machinery & equipment mfg
249 Other machinery & equipment mfg	
25 Furniture & other Mfg	
251 Furniture mfg	259 Other mfg

Source: ABS (*Australian and New Zealand Standard Industrial Classification 2006,* Cat. no. 1292.0).

To construct a time series from 1985-86 to 2010-11 for some of the variables required to estimate subsector MFP, it was necessary to use some data collected under the previous industry classifications. Subsector data based on ANZSIC06 were backcast to earlier years using the growth rate in data under the 1993 edition of the *Australian and New Zealand Standard Industrial Classification* (ANZSIC93) and *Australian Standard Industrial Classification* (ASIC). In a broad sense, the Manufacturing subdivisions under previous industry classifications correspond fairly closely to the eight subsectors under ANZSIC06. Table A.2 provides the broad correspondence between the two industry classifications that was used. Precise concordances were not possible due to limited availability of data.

Table A.2 **ANZSIC93 correspondence to ANZSIC06 Manufacturing subsectors**[a]

ANZSIC06-based subsectors	*Main corresponding ANZSIC93 subdivision(s)*[a]	*Main corresponding ASIC subdivision(s)*
Food, beverage & tobacco products (FBT)	21 Food, beverage & tobacco mfg	21 Food, beverages & tobacco
Textile, clothing & other manufacturing (TCO)	22 Textile, clothing, footwear & leather mfg 29 Other manufacturing	23 Textiles 24 Clothing & footwear 34 Miscellaneous mfg
Wood & paper products (WP)	23 Wood & paper product mfg	25 Wood, wood products & furniture
Printing & recorded media (PRM)	24 Printing, publishing & recorded media[b]	26 Paper, paper products, printing & publishing[c]
Petroleum, coal, chemical & rubber products (PCCR)	25 Petroleum, coal, chemical & associated product mfg	27 Chemical, petroleum & coal products
Non-metallic mineral products (NM)	26 Non-metallic mineral product mfg	28 Non-metallic mineral products
Metal products (MP)	27 Metal product mfg	29 Basic metal products 31 Fabricated metal products
Machinery & equipment (ME)	28 Machinery & equipment mfg	32 Transport equipment 33 Other machinery & equip't

[a] Although this correspondence is assumed to provide a reasonable basis for ascertaining broad industry trends, there are a number of individual activities that moved between sectors with the introduction of ANZSIC06. Details of these moves are presented in ABS (Cat. no. 1292.0). [b] 'Publishing' was moved from the Manufacturing division under ANZSIC93 to the Information, media and telecommunications division under ANZSIC06. [c] Paper products was moved to Wood and paper under ANZSIC93/06.

Sources: Authors' estimates based on ABS (*Australian and New Zealand Standard Industrial Classification 2006,* Cat. no. 1292.0); ABS (*Concordance Between the Australian Standard Industrial Classification (ASIC) and the Australian and New Zealand Standard Industrial Classification (ANZSIC), 1993,* Cat. no. 1292.0.15.004).

A.3 Value added

For the measurement of MFP, output *volume* measures are required. The ABS uses gross value added (gross output less intermediate inputs) as the output measure for its aggregate Manufacturing MFP estimates. This is also the measure used for the disaggregated estimates in this study.

The ABS uses gross value added chain volume measures (GVA CVMs) from the National Accounts (ABS Cat. no. 5204.0) in its estimates of MFP for Manufacturing in total. The ABS National Accounts also include GVA CVMs for Manufacturing divided into eight subsectors (based on ANZSIC06) from 1985-86 to 2010-11. GVA CVMs are not available for all 15 ANZSIC06 Manufacturing subdivisions. This limited the level of disaggregation that was possible in this study.

From 1995-96, the annual ABS chain volume measures of GVA at the industry level have been derived using the double deflation method, that is as the difference between volume estimates of output and intermediate input (see ABS 2000a, para. 10.30 for further details). Prior to 1995-96, it was assumed that the volume measure of gross value added grew at the same rate as the volume measure of output (that is, the output indicator method). This method is based on the underlying assumption that in volume terms the ratio of intermediate input to output is stable. This was carried out at as detailed a level as practicable and the volume indexes were weighted together using the current price estimate of GVA, so as to ameliorate the effects of departures from this assumption (ABS 2000a, para. 10.32).[2]

A.4 Hours worked

The labour input measure used by the ABS in its aggregate Manufacturing MFP estimates is an index of annual hours worked, based on data from the ABS *Labour Force Survey*. Hours worked indexes for each of the eight subsectors were derived from this aggregate Manufacturing series, using information (from the same survey) about the distribution of hours worked across Manufacturing subsectors.[3]

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2 The ABS deflates output for petroleum production using a combination of price deflators and additional data regarding physical volumes of production. Quality adjustments are made to the deflator, which reflect certain characteristics of fuel (such as the volume of ethanol), but does not reflect any changes in environmental standards.

3 Comparability of employment data from the ABS *Labour Force Survey* and the ABS *Economic Activity Survey* is discussed for FBT in appendix G and for MP in appendix H. Connolly et al. (2013) found that the difference between employment numbers in the *Labour Force Survey* and *Economic Activity Survey* for Manufacturing as a whole were relatively small compared with most ANZSIC industry divisions (on average between 2007-08 to 2011-12).

The ABS publishes an hours worked index for the Manufacturing division in *Experimental Estimates of Industry Multifactor Productivity, 2010-11* (Cat. no. 5260.0.55.002). This index is based on data from the ABS *Labour Force Survey* that has been annualised and adjusted for changes in survey methodology to improve consistency over time.

- The *Labour Force Survey* collects hours worked data in reference weeks, not every week of the year. The ABS annualises hours worked by making adjustments for events such public and school holidays. For details of this ABS method see ABS (2006c) and Baker and von Sanden (2006).
- Changes in survey methodology include the *Labour Force Survey* questionnaire redesign in 2000-01 (ABS 2000b).

The hours worked level series underlying this aggregate Manufacturing index is unpublished but was provided by the ABS. This total number of hours worked in Manufacturing was allocated across subsectors using ratios of each subsector's hours worked to Manufacturing's total hours worked from the quarterly *Labour Force Survey*.[4] This is the same method the ABS applies to allocate its estimate of total economy hours worked to industry divisions (ABS 2006c). The resulting subsector series differ from simple aggregations of the published *Labour Force Survey* data.[5]

The quarterly *Labour Force Survey* data were available from November 1984 for all 15 Manufacturing subdivisions on an ANZSIC06 basis. (Data back to 1994 were available from Cat. no. 6291.0.55.003, August 2011[6]; data prior to 1994 were obtained as a special data request). The subdivisions were aggregated into the eight subsectors being used in this study (as listed in table A.1).

4 Estimates of hours worked for selected ANZSIC subdivisions and groups are also presented in this paper. These estimates were derived using the same method.

5 In the *Labour Force Survey*, where there is insufficient detail collected from the survey respondent to allocate to an ANZSIC subdivision within Manufacturing, a Manufacturing 'not further defined' (nfd) code is used. Since 2000, there has been some growth in allocations to this nfd category as a result of changes to coding practices (ABS 1999, 2003, 2005). The subsector estimates in this paper assume that this Manufacturing nfd is distributed across subsectors in proportion to *Labour Force Survey* responses that were able to be allocated to specific subdivisions.

6 This is the last issue released prior to the construction of the ABS Manufacturing hours worked index used underlying the MFP estimates in the 2010-11 issue of ABS *Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002.

A.5 Capital services

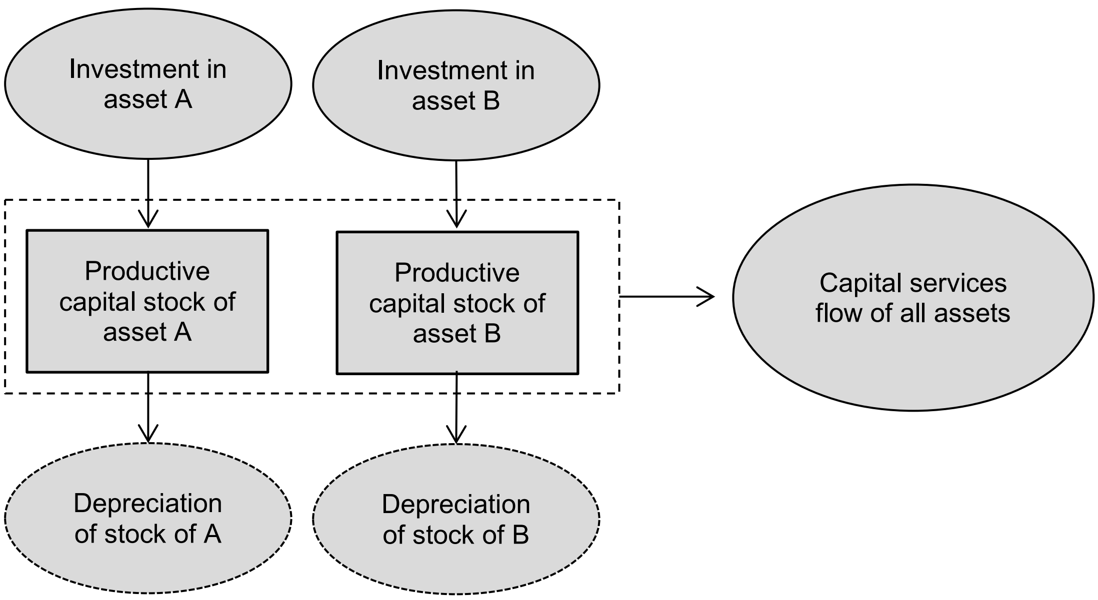
Summary

Capital services is a flow measure of capital inputs, which is used by the ABS and in this paper to calculate MFP. For any asset, capital services represents the amount of service provided in a given period — in this case, annual data are used. The capital services provided in a period by an asset is assumed by the ABS to be proportional to the value of the productive capital stock.

Productive capital stock, in turn, is calculated through the use of a perpetual inventory method (PIM). This involves compiling a rolling inventory of capital stocks, with investment in new assets each year added to stocks, retired assets deducted, and the value of remaining assets adjusted according to ageing. A variety of assumptions, such as how long it takes different capital types to fully depreciate, and the manner in which they do so is required, along with investment data.

A single capital services measure for an industry or subsector is then calculated by weighting the growth in the productive capital stocks of different assets by using their relative volumes and rental prices. Figure A.1 shows a stylised representation of the stocks and flows that affect capital services.

Figure A.1 **A stylised representation of capital services**[a]

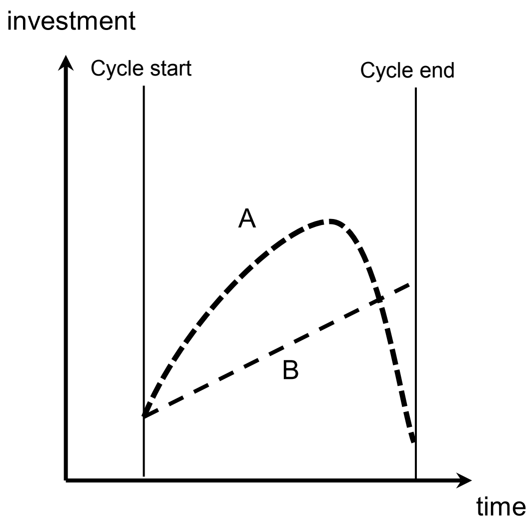


a This figure shows the flows (circles) and stocks (squares) at a particular point in time. Investment adds to the productive capital stock, while depreciation subtracts. The amount of productive capital stock then defines the flow of capital services for that point in time. Here, only two asset types are presented; in practice there can be any number of asset types.

Capital input growth cannot be calculated as the average annual growth in investment between start and end points of productivity cycles. This is because the investments that occur within a cycle will affect the productive capital stock and the growth of capital services by the end of the cycle. This is discussed in greater detail in box A.2.

Box A.2 **Investment over cycles**

Investment in each year adds to productive capital stock, and thus affects the growth rate of capital services. It is not possible to simply examine investment at the beginning and end of the cycle and conclude the effect on capital services. Capital services growth over a cycle is affected by the existing stock and investment in each year of the cycle. A simple example of this is presented in the figure below.



The figure to the left shows two investment profiles (A and B) over a productivity cycle.

The average annual growth rate between the start- and end-points is negative for A, but positive for B. However, between the cycle start- and end-points, there is much greater investment by A relative to B (the area under each curve).

Broadly speaking, capital services growth under 'A' would be stronger than under 'B' over the productivity cycle, even though the average annual growth rates between the start- and end-points would suggest otherwise.

The initial capital stock and age of that capital stock should also be considered when interpreting the impact of investment on capital services.

The ABS estimates a capital services index for Manufacturing in aggregate, but not for the subsectors within Manufacturing. For this study, capital services indexes for the subsectors were estimated using a broadly similar methodology to that used by the ABS for Manufacturing as a whole, in order to be as consistent as possible.

However, due to data limitations, there are some important differences in the approach taken to estimating capital services for the subsectors. One difference is that fewer asset types were included in the subsector estimates than are used by the ABS for Manufacturing in aggregate (table A.3). The ABS includes twelve different asset types in its Manufacturing division-level estimates, but in the subsector estimates only the four asset types were able to be included (one of which aggregates six 'machinery and equipment' asset types considered separately by the ABS).

Table A.3 **Comparison of asset types included in capital services**

For ABS Manufacturing estimates	*For subsector estimates*
Computer software	Computer software
Research & development	Research & development
Inventories - Non-farm	*(unavailable)*
Land	*(unavailable)*
Machinery & equipment - Computers Machinery & equipment - Electrical & Electronic Equipment Machinery & equipment - Industrial Machinery & Equipment Machinery & equipment - Other Plant & Equipment Machinery & equipment - Other Transport Equipment Machinery & equipment - Road Vehicles	Machinery & equipment (jointly)[a]
Non-dwelling construction	Non-dwelling construction
Ownership transfer costs	*(unavailable)*

[a] All machinery and equipment types are aggregated together into a single asset type as the data are unavailable to split the aggregate to the subsector level.

Sources: ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002); ABS (*Australian System of National Accounts: Concepts, Sources and Methods, 2000*, Cat. no. 5216.0).

Another difference is the source of data. Gross fixed capital formation (GFCF), the measure of capital investment from the National Accounts used to derive productive capital stock (and, in turn, capital services), are not available at the subsector level. Instead, alternative data sources were used to calculate subsector shares of investment that were then applied to apportion GFCF for Manufacturing in aggregate across the different subsectors (table A.4). For investment in 'non-dwelling construction', 'machinery and equipment' and software, subsector data on private new capital expenditure (PNCE) was used to apportion Manufacturing GFCF for these asset types across subsectors. Business expenditure on research and development (R&D) by subsector was used to apportion Manufacturing R&D GFCF across subsectors.

Table A.4 Apportionment of Manufacturing gross fixed capital formation to subsectors

Manufacturing division-level GFCF asset[a]	*Data used to apportion to Manufacturing subsectors*
Non-dwelling construction	The 'buildings' asset type from Private New Capital Expenditure (from ABS 5625.0)[b] and PC(2003)
Machinery & equipment	The 'plant, machinery and equipment' asset type from Private New Capital Expenditure (from ABS 5625.0)[b] and PC (2003)
Research & development	Current business expenditure from Research and Experimental Development, Businesses, Australia (from ABS 8104.0) and Shanks and Zheng (2006)
Computer software	As for machinery & equipment, above[c]

[a] These are the broad asset categories detailed in the ABS National Accounts (ABS Cat. no. 5204.0). [b] Includes unpublished data sourced from the ABS that disaggregates expenditure by asset type. [c] There is no data on expenditure on computer software and an imputation based on machinery and equipment was used instead. This is discussed in greater detail later in this section.

This provided the investment series for each Manufacturing subsector, which, in addition to information on the prices of capital types and other parameters, allowed the derivation of capital services at this lower level of aggregation.

The aggregate of the subsector capital services indexes in this paper does not exactly match that published by the ABS for Manufacturing in total (figure A.2). This is because of the different asset types considered and assumptions made regarding the investment series where subsector data were unavailable.

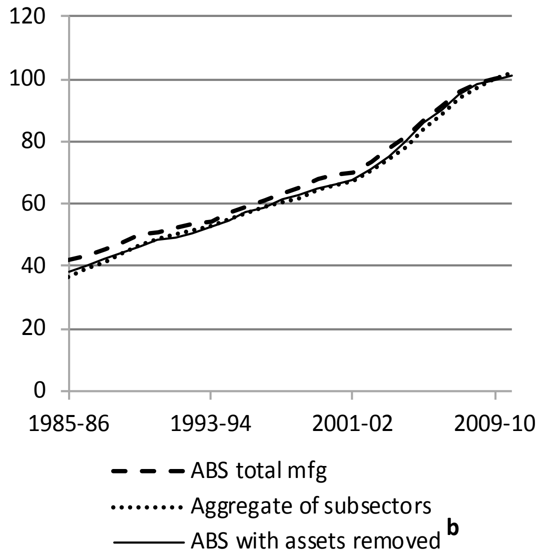
Figure A.2 shows the discrepancy between the aggregate of the capital services series in this paper and that published by the ABS for Manufacturing in total. The question raised by these differences is how much of the discrepancy is being driven by the difference in asset coverage as opposed to errors in the PIM?

While the additional asset types used by the ABS cannot be included in the subsector estimates of capital services, it is possible to remove those assets from the ABS series for Manufacturing in total to derive another series that is more comparable. Growth in this series is shown in the last column of figure A.2 and is, generally speaking, more consistent with the aggregate of the subsector estimates in this paper. There are still large differences over the incomplete cycle.

In short, much of the discrepancy between the published ABS series and that derived in this paper can be attributed to the different asset coverage. The remainder of this section details the derivation of capital services more formally, including the data sources used, and the differences between the published ABS series and estimates presented in this paper.

Figure A.2 **Capital services discrepancy**

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



Cycle	*ABS total mfg*	*Aggregate of subsectors*	*ABS with assets removed*[b]
	% py	% py	% py
1988-89 to 1993-94	2.8	3.7	3.5
1993-94 to 1998-99	3.7	3.2	3.6
1998-99 to 2003-04	3.4	3.7	3.7
2003-04 to 2007-08	5.6	6.0	6.1
2007-08 to 2010-11[a]	1.8	2.9	2.1
Full period			
1985-86 to 2010-11	3.6	4.2	3.9

[a] Incomplete productivity cycle. [b] Refers to ABS series without those assets for which data were unavailable at the subsector level.

Data sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.001).

Method and data

Calculating capital services

According to the ABS

> Capital services reflect the amount of 'service' each asset provides during a period. For each asset, the services provided in a period are directly proportional to the asset's productive capital value in the period. As an asset ages and its efficiency declines so does the productive capital value and the services the asset provides. In equilibrium, the value of capital services is equal to the gross returns (or rentals) to owners of capital. … The relationship between the capital services provided by an asset and the asset's productive value is fixed over the asset's life. However, this relationship varies from asset to asset and it depends on an asset's expected life, the discount rate, and the rate of decline in the asset's efficiency. (ABS 2012c, p. 360)

Growth in capital services is taken as the rate of growth in the productive capital stock for each asset type, weighted by the product of the rental price and productive capital stock as a share of total returns to capital; averaged over the period.

$$KS_{it} = \prod_j \left(\frac{PKS_{ijt}}{PKS_{ij(t-1)}}\right)^{w_{ijt}} \quad \text{(A1)}$$

$$\text{where } w_{ijt} = \left(\frac{\frac{R_{ijt}PKS_{ijt}}{\sum_{ij} R_{ijt}PKS_{ijt}} + \frac{R_{ij(t-1)}PKS_{ij(t-1)}}{\sum_{ij} R_{ij(t-1)}PKS_{ij(t-1)}}}{2} \right) \quad \text{(A2)}$$

Where KS denotes capital services flow over the period, PKS denotes the real productive capital stock, R the rental price, and i, j and t denote industry, asset and time, respectively.

In this paper, the 'industry' subscript denotes the eight subsectors described in section A.2. That is, capital services were calculated on the basis of the rate of change in the productive capital stock over time for each subsector-asset, weighted by the rental prices for those subsector-assets.

The assets included in this paper are 'machinery and equipment', 'non-dwelling construction', 'research and development' and 'computer software'. As noted above, this is fewer asset types than considered by the ABS and includes an aggregation of the machinery and equipment types (table A.3).

Calculating productive capital stock

Method

The ABS calculates productive capital stocks for each asset through the use of a perpetual inventory model:

> The perpetual inventory model (PIM) involves the compilation of a 'rolling' inventory of capital stocks; in any particular period, investment in capital assets is added to stocks, and retired assets are deducted. To apply the PIM, the following are generally required:
>
> - gross fixed capital formation (GFCF) for the period for which the capital stock estimate is required and for periods prior to that period equal to the maximum life of the asset;
> - price indexes for the entire timespan of GFCF;
> - the average length of asset lives, i.e. average of the length of time they are used in production;
> - the age-efficiency function of assets (used to derive productive capital stock estimates);
> - the extent to which assets are retired before, on or after the average asset life for that asset – the retirement distribution. Alternatively, retirements can be expressed as a survival function; and
> - the age-price function of assets (used to derive net capital stock estimates and estimates of consumption of fixed capital). (ABS 2012c, p. 360)

The real investment series, derived from GFCF and its associated price indexes, was used to calculate the productive capital stock via the PIM. The formula used to calculate productive capital stock is:

$$PKS_{ij}^{t} = \sum_{\tau=0}^{T} h_{ij}^{\tau} F_{ij}^{\tau} \left(\frac{I_{ij}^{t-\tau}}{p_{ij}^{t-\tau,0}} \right) \tag{A3}$$

Where PKS_{ij}^{t} denotes productive capital stock for industry *i* at time *t*; h_{ij}^{τ} is the age efficiency function discussed above; F_{ij}^{τ} is the retirement function discussed above[7]; $I_{ij}^{t-\tau}$ nominal investment; and $p_{ij}^{t-\tau,0}$ a price deflator for investment.

This ABS method was followed in broad terms for the subsector estimates presented in this paper. However, there have been some modifications due to data limitations.

Data and parameters

Nominal investment

The ABS does not estimate GFCF by asset for subsectors on a National Accounts basis.[8] In order to be consistent with the ABS estimates for capital services for Manufacturing in total, Manufacturing GFCF was apportioned across subsectors using subsector shares of investment from alternative sources (as described below).

Non-dwelling construction and machinery and equipment

For non-dwelling construction and machinery and equipment, data for PNCE were used to derive subsector shares. Unpublished quarterly PNCE data from the ABS *Survey of New Capital Expenditure* (Cat. no. 5625.0) were obtained from the ABS by Manufacturing ANZSIC06 subdivision for these two asset types over the period 1987-88 to 2010-11. These data were backcast to 1974-75 using index data regarding PNCE for non-dwelling construction and machinery and equipment from PC (2003).

The levels of GFCF and PNCE for Manufacturing in aggregate are considerably different (figure A.3). While GFCF is the measure used for national accounting purposes (including the calculation of industry-level MFP estimates), there are no

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[7] While the ABS include a retirement function in its calculation of productive capital stocks, this paper does not use such a function. This is discussed in greater detail following table A.6.

[8] A measure of gross fixed capital formation is published in *Australian Industry* (ABS Cat. no. 8155.0), but this is not consistent with the National Accounts measure that is used by the ABS for productivity estimates, nor is it separated by asset type.

GFCF data consistent at a subsector level. PNCE data, however, provide information regarding the share of total Manufacturing investment undertaken by each subsector.

Figure A.3 **Current price investment measures[a] for Manufacturing**

$m

a PNCE only includes expenditure on Machinery and equipment and Non-dwelling construction asset types, and so GFCF for those asset types is presented here for comparison.

Data sources: ABS (unpublished Survey of New Capital Expenditure data); ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0).

GFCF and PNCE can differ for a number of reasons.

- GFCF is a measure that takes into account the purchase and disposal of second-hand assets, whereas PNCE does not.
- The survey used to determine GFCF for non-dwelling construction differs from that used for 'Buildings' in PNCE.
- GFCF is calculated in aggregate as part of the ABS supply-use framework and then apportioned to industry divisions. PNCE is surveyed at the subdivision level for manufacturing, and then summed to get an aggregate industry division measure.

The approach taken in this paper, following consultation with the ABS, was to use the quarterly PNCE data to apportion the financial-year GFCF data for the Manufacturing division across the subsectors by asset type. This approach allows measures of capital services to be estimated that are broadly consistent with those of the ABS.[9] (The effect on the capital services measure of using PNCE data instead is discussed in box A.3.)

Box A.3 **Effect of using an alternative capital measure**

The PNCE data available at the subdivision level were used to apportion GFCF data from the division level to each of the Manufacturing subsectors. GFCF was used as it is the investment measure used by the ABS for their aggregate and division-level productivity estimates.

An alternative approach would be to use the PNCE data itself to derive capital services for Manufacturing productivity analysis at the subdivision level. The growth rates in each capital services measure (authors' estimates based on PNCE-based, GFCF-based and the ABS published capital services index) are presented. Over the last two productivity cycles, the main period of interest of this paper, the GFCF-based measures match those of the ABS much more closely.

Average annual growth in Manufacturing capital services measures by cycle

	Cycle 1	*Cycle 2*	*Cycle 3*	*Cycle 4*	*Difference between cycles 3 and 4*
	% py	*% py*	*% py*	*% py*	*% pts*
GFCF-based[a]	3.7	3.2	3.7	6.0	2.4
PNCE-based[a]	3.1	3.7	2.1	3.3	1.3
ABS published	2.8	3.7	3.4	5.6	2.2

[a] Authors' estimates. Compares the growth in capital services indexes whether NDC and PME capital asset types are estimated using GFCF-apportioned data or PNCE-level data.

Sources: Authors estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11*, Cat. no. 5260.0.55.002).

The main effect of using a PNCE measure was that capital services growth was much slower over the last two productivity cycles, relative to the GFCF-based and ABS measures. (This should be expected, given that the PNCE data records slower growth in key asset types for Manufacturing, as seen in figure A.3, above.)

9 Consistent in that the same investment series are used, but not the case that all the same assets are available. Specifically, the estimates here are based on a single measure of investment for machinery and equipment, where the ABS disaggregates machinery and equipment into six different types. The data to do such a split at the subsector level were unavailable.

Financial-year totals were constructed from the quarterly PNCE data. Some missing observations (due to ABS confidentiality requirements) had to be imputed. A summary of the missing observations by subdivision-asset pair is shown in table A.5. Around 7 per cent of observations are missing by asset type, but less than 1 per cent of observations were missing for total capital expenditure. All of the missing observations occur after the September quarter 2006.

Table A.5 **Missing PNCE data by Manufacturing subdivision and asset type, 1987-88 to 2010-11**

Quarters not published[a]

ANZSIC06 subdivision	*Equipment*	*Buildings*	*Total of equipment and buildings*
Food product mfg	0	0	0
Beverage & tobacco product mfg	0	0	0
Textile, leather, clothing & footwear mfg	15	15	3
Wood product mfg	10	9	1
Pulp, paper & converted paper product mfg	16	16	0
Printing (incl. reproduction of recorded media)	11	11	2
Petroleum & coal product mfg	19	18	2
Basic chemical & chemical product mfg	0	0	0
Polymer product & rubber product mfg	9	9	0
Non-metallic mineral product mfg	2	2	0
Primary metal & metal product mfg	0	0	0
Fabricated metal product mfg	3	3	0
Transport equipment mfg	1	1	0
Machinery & equipment mfg	3	2	1
Furniture & other mfg	14	14	6
Total[b]	**103**	**100**	**15**

[a] Not published is defined by the ABS as 'not available for publication but included in totals where applicable, unless otherwise stated'. [b] The total number of observations is 1470 (98 quarters by 15 industry subdivisions).

Source: ABS (unpublished Survey of New Capital Expenditure data).

Where data were available for one of the two asset types and for the total of both asset types, the missing value was imputed as the difference between the total and the value of the investment in the asset for which there were data. In many cases, however, there were total values but missing observations for both asset types. The imputation method in that case is discussed in box A.4.

Box A.4 **Imputing missing observations in private new capital expenditure data**

The following process was followed in order to clean the PNCE data received by the ABS. In any quarter for a particular asset in a particular subdivision if there were data available it was kept 'as is'. Where data were missing:

1. If there was a missing value, the most recent, previous available value for the asset-subdivision in question was used to derive a ratio of the total of subdivision asset expenditure in that previously available quarter. This ratio was then applied to the total value for the quarter where there was the missing data in order to impute a value. This solved for the majority of missing values.

   For example: There was missing data for equipment capital expenditure in the September 2006 quarter for Textiles, leather, clothing and footwear. In the previous quarter, there was expenditure of $47 million. Total capital expenditure for Textiles, leather, clothing and footwear for the June 2006 quarter was $50 million, meaning that equipment manufacturing comprised 94 per cent of total capital expenditure. The data indicate that there was $37 million in total capital expenditure for Textiles, leather, clothing and footwear in the September 2006 quarter. Applying the same ratio of 94 per cent to this number imputes equipment capital expenditure for September 2006 as $34.7 million.

2. If data were missing both for an asset and total within a subdivision, then the total could often be recovered by consulting the published PNCE data, which had fewer missing observations than that received from the data request from the ABS.* With the totals, step 2 could then be carried out to impute missing values for asset-subsector pairs.

3. For the remaining missing observations, the total of multiple missing values was derived as the difference between the published total PNCE for Manufacturing (which includes the value of the missing data in aggregate) and the sum of the reported values by asset type. This total for missing values was then split across industry subdivisions using the proportions from the most recent previous data.

   For example: There was missing data for total capital expenditure in the June 2007 quarter for both Petroleum and Other manufacturing. The total capital expenditure for this quarter as published was $2901 million, while the sum of the asset data is $2792 million — a difference of $109 million. Petroleum accounted for 82 per cent of Petroleum and Other manufacturing PNCE in the March quarter of 2007, and it was this proportion that was applied to the $109 million for Petroleum in the June quarter of 2007.

This process imputed all the missing values.

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* The discrepancy between the missing observations for total subdivision PNCE in the published and purchased data arises as the ABS has a stricter policy on quality surrounding purchased data.

The complete PNCE data series was used to calculate the subsector shares of total Manufacturing investment for non-dwelling construction and for machinery and equipment. These shares were then applied to the relevant GFCF asset type in order to generate GFCF by subsector for the purposes of the PIM.

R&D capital

As with the tangible asset types above, there is no subsector-level disaggregation of R&D GFCF. A similar process to that used for apportioning total Manufacturing GFCF for non-dwelling construction and machinery and equipment was used. Current[10] business expenditure on R&D (BERD) is used to derive the subsector shares. Two sources of data were used:

1. Current BERD from ABS (*Survey of Research and Experimental Development*, Cat. no. 8104.0) from 1992-93 to 2010-11.
2. *Total* BERD (including both current and capitalised) from Shanks and Zheng (2006), from 1968-69 to 2002-03. The overlap over the period between 1992-93 and 2002-03 with the data source above was used to determine the proportion of total BERD that is current BERD.

Data were concorded into ANZSIC06 where necessary (box A.5).

Software capital investment

There is no readily available data source for software investment at the Manufacturing subsector level of disaggregation. Total Manufacturing software GFCF was simply apportioned in the same ratio of each subsector's share of total machinery and equipment investment. Because the lifespan assumed by the ABS for computer software varies depending on whether the software is 'purchased' or developed 'in-house', another imputation has to be made regarding what proportion of computer software is 'purchased' relative to 'developed in-house'. Due to a lack of data, the developed in-house proportion for a subdivision was taken to be the same as the proportion of total investment made up by R&D (on the grounds that R&D intensive industries are more likely to develop their own software).[11]

[10] 'Current' in this context does not refer to current price expenditure, but rather expenditure on R&D that is *not* capitalised. Capitalised BERD is already accounted for in GFCF in the relevant, tangible asset type.

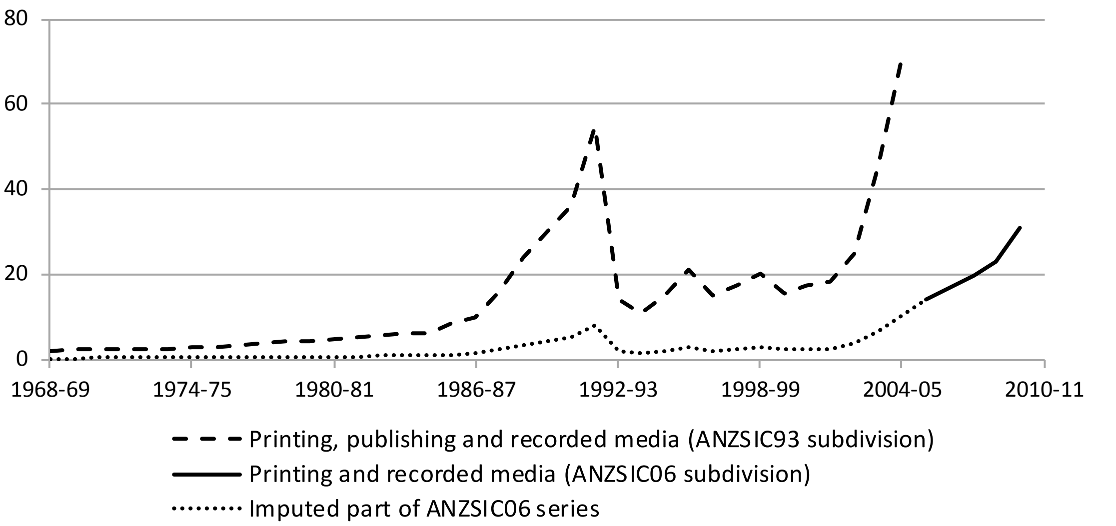
[11] This is a very rough imputation. However, computer software, relative to the other categories of investment is very small, comprising at most 2 per cent of total manufacturing investment.

Box A.5 **ANZSIC concordance issues related to business expenditure on R&D**

Business expenditure on R&D (BERD) is not published on an ANZSIC06 basis prior to 2005-06, but there is an overlap between ANZSIC93 and ANZSIC06 BERD data for the years 2005-06 and 2006-07. An inspection of this data indicates that there are large differences in the BERD between the ANZSIC93 divisions Printing, publishing and recorded media, Textile, clothing, footwear and leather manufacturing, and Other manufacturing with their ANZSIC06 subdivision counterparts. (See table A.2 for concordances.)

These differences make it unfeasible to simply 'splice' the historical ANZSIC93 to the post-2005-06 ANZSIC06 data without making an adjustment for the change in classifications. The proportion that publishing (ANZSIC93 group 242) makes of the ANZSIC93 Printing, publishing and recorded media subdivision in the overlap years was removed back through the series to make the BERD data consistent with the ANZSIC06 subdivision for Printing and recorded media (see figure).

BERD in Printing and recorded media
$m (current prices)



A similar method was used to adjust for changes in Textile, clothing, footwear and leather manufacturing, and Other manufacturing.

Sources: Authors' estimates based on ABS (*Research and Experimental Development, Businesses, Australia*, various issues, Cat. no. 8104.0); and Shanks and Zheng (2006).

Deflation of current price capital series

The nominal investment series, as estimated above, are deflated using implicit price deflators supplied by the ABS.[12] A specific deflator for each asset type (non-dwelling construction, machinery and equipment, R&D, and computer software) was applied across all Manufacturing subsectors. No subsector-specific price deflators are available.

PIM assumptions

The real investment series discussed above were used in the PIM to generate productive capital stocks for each asset in each subsector. The PIM uses the following parameters (table A.6). The same assumptions were used for each of the subsectors — data were not available to derive subsector specific parameters.

One key difference between the ABS PIM and the PIM used in this paper relates to the use of a retirement function. The ABS includes such a function, which allows for some proportion of assets to be retired before and after the mean asset lives listed above. The subsector estimates in this paper do not use a retirement function on the grounds that the additional complexity is not warranted given that previous studies found that it did not significantly change the results (Gretton and Fisher 1997).

[12] In practice, these deflators are the same as the ones implied by comparing current price GFCF and CVM GFCF from the National Accounts.

Table A.6 **PIM parameters used by the ABS and in this paper**

Parameter	*Used by ABS for Manufacturing in aggregate*	*Used in this paper for each of the subsectors*
Mean asset life		
Non-dwelling construction	38 years	38 years
Machinery & equipment	14.4 years[a]	14.4 years
Research & development	11 years	11 years
Software	4-8 years[b]	4-8 years
Age efficiency profile[c]		
Non-dwelling construction	0.75	0.75
Machinery & equipment	0.50	0.50
Research & development	0.50[d]	0.50
Software	0.50	0.50
Retirement function	Yes (Winfrey distribution)	No retirement function
Real discount rate[e]	4 per cent	4 per cent

a The weighted average of the mean asset life for machinery and equipment was published in the earlier edition of concepts, sources and methods. In practice, the ABS uses a different asset life for a larger number of machinery and equipment assets, while the productive capital stock measures derived here use this weighted average for a single machinery and equipment asset class. **b** The mean asset life for software depends on when the investment was made, and whether it was made on in-house software or purchased software. The parameters used in the paper match those of the ABS exactly in this regard. **c** The ABS uses a hyperbolic age efficiency profile, where efficiency is defined as [(M – t)/(M – bt)], where M is the mean asset life, t is the age of the asset at a particular point in time and b is efficiency reduction parameter detailed in the table. **d** This value is not published, but was determined via correspondence with the ABS. **e** The net present value of future capital services can be calculated by discounting the capital services flow using this discount rate, chosen by the ABS. This allows the construction of net capital stocks, the difference of which between consecutive years is equal to the depreciation.

Source: ABS (*Australian System of National Accounts: Concepts, Sources and Methods,* Cat. no. 5216.0, 2000 and 2012 editions).

Initial capital stocks

The PIM also requires an initial stock of capital for each asset and an assumption about the average age of that stock. The PIM constructed for this paper starts in 1973-74 and used the following assumptions regarding initial capital stocks and their ages:

- For non-dwelling construction and machinery and equipment, the net capital stock values available from PC (2003) were used. The average age of these two assets is chosen to be 14 and 7 years, respectively, based on ABS assumptions from ABS (2000a).
- For R&D, data from Shanks and Zheng (2006) was used as the capital stock for R&D. The starting stock of R&D is assumed to be 0 years old.

- For computer software, the total constant price value of capital stock is known for 1973-74, but there is no information about its disaggregation. The total, was therefore apportioned by the distribution of software investment in the following year (1974-75). A further distribution was then needed to apportion computer software investment between 'in-house' and 'purchased'. The in-house investment was assumed to be the same proportion of total computer software investment as R&D investment comprises of total investment within an industry. The starting stock of software capital is assumed to be 0 years old.

Net capital stock and depreciation

The PIM allows the calculation of productive capital stock for each period of time. The productive capital stock can then be discounted over the remaining productive life for different vintages of assets to derive net capital stock — which is the net present value of future capital services from the productive capital stock. This is detailed by the ABS:

> The age-efficiency function describes the decline in the flow of capital services of an asset as it ages. Using the discount rate, the net present value of future capital services can be readily calculated. For instance, when multiplied by a suitable scalar, the first value of the age-price function represents the present discounted value of the capital services provided by an asset over its entire life. The second value of the age-price function represents the present discounted value of the capital services provided by an asset from the end of its first year until the end of its life. The third value represents the present discounted value of the capital services provided by an asset from the end of its second year until the end of its life, and so on. … When the net present values of the different assets are aggregated for a particular period, they form the net capital stock for that period. (ABS 2012c, p. 363)

A discount rate is, therefore, needed to derive net capital stock — the ABS uses 4 per cent, and this parameter was adopted in this paper for all assets and subsectors as well.

The change in net present value for each vintage of asset between periods defines economic depreciation. This depreciation, taken as a share of net capital stock for a given period defines the depreciation rate. Depreciation rates are needed as part of the calculation of the rental prices.

Calculating rental prices

Productive capital stocks for different asset types are not simply added together to derive capital services, but are instead weighted according to the relative rental price and relative volumes of productive capital stock of each asset (see equation A2). The methodology used by the ABS to calculate rental prices is followed as closely as possible. For a subsector i with asset type j in time t, the rental price is given as:

$$R_{ijt} = T_{ijt}p_{ijt}\left(i_{it} + d_{ijt} - \dot{g_{ijt}}\right) + p_{ijt}x_{it} \qquad \text{(A4)}$$

Where R denotes the rental price, T an income tax parameter, p the price of the asset, i the nominal internal rate of return of the asset, d the rate of deprecation, g the change in price of the asset and x the indirect tax parameter. Effectively, the rental price represents the replacement cost of capital in that it embodies the value of the asset (its internal rate of return and cost to cover depreciation, less any increase in the value of the asset).

The components of the rental price equation are sourced from a variety of sources.

- The income tax parameter (T) were sourced from unpublished ABS data and is the same across each Manufacturing subsector.
- The indirect tax parameter (x) was calculated from ABS data (specifically, other taxes less subsidies as a share of current price net capital stock) and is the same across each Manufacturing subsector.
- The price deflator data (p) were sourced from ABS National Accounts data and unpublished data — it is the same across each Manufacturing subsector.
- Depreciation (d) was calculated in the process of determining productive capital stock from the PIM (discussed previously) — accordingly, it is different across each Manufacturing subsector.

In practice, equation A4 is solved 'endogenously' for the rate of return i by assuming that capital income is equal to the rental price R multiplied by the productive capital stock:

$$i_{it} = \frac{\sum_j R_{ijt}K_{ijt} - \sum_j K_{ijt}\left(T_{ijt}p_{ijt}\left(d_{ijt} - \dot{g_{ijt}}\right) + p_{ijt}x_{it}\right)}{\sum_j K_{ijt}T_{ijt}p_{ijt}} \qquad \text{(A5)}$$

'Gross operating surplus', the income that accrues to capital (discussed below) was used to calculate the internal rate of return, and, by extension, rental prices.

In the calculation of rental prices, the ABS applies two restrictions and this process was also used in this paper:

- the internal rate of return i may not be lower than the Consumer Price Index plus 4 percentage points
- rental prices are strictly positive (and are given a value of 0.001 where the estimated value of equation A4 is non-positive).

These rental price weights were then used (as per equation A2) to create a weighted Tornqvist index of capital services for each subsector, as well as for Manufacturing as a whole, as detailed above.

A.6 Income shares

Subsector factor income shares are required to combine the growth rates of capital services and hours worked. Subsector capital income levels are also required for the calculation of capital services (as discussed in section A.5).

To estimate factor income shares, data are required for labour income (including labour-related net taxes on production), capital income (including capital-related net taxes on production) and value added at basic prices.

At the aggregate level, the ABS uses factor incomes from the National Accounts in estimating Manufacturing MFP growth. However, subsector level factor incomes are not available from that source. Therefore, labour income and value added data at the subsector level were compiled from ABS surveys covering Manufacturing.[13] Capital income was derived as the difference between these two series. The factor income levels were then expressed as shares of value added.

Over the period from 1984-85, Manufacturing was included in three separate surveys. To compile a time series, data were taken from the following surveys:

- 2006-07 to 2010-11 from *Australian Industry* (ABS Cat. no. 8155.0).
- 1987-88 to 2005-06 from *Manufacturing Industry, Australia* (ABS Cat. no. 8221.0) — this is a census of Manufacturing so was used in preference to 8155.0 in the latter years when both surveys were published.
- 1984-85 and 1986-87 from *Enterprise Statistics, Australia* (ABS Cat. no. 8103.0) — no survey was conducted in 1985-86.[14]

[13] In this paper, these are collectively referred to as the ABS *Economic Activity Survey* (which is the name of the current ABS survey which underlies the data in Cat. no. 8155.0).

[14] For 1985-86 labour and capital income levels were assumed to be the average of 1984-85 and 1986-87 levels.

Labour income

The measure of labour income required includes 'on costs' such as superannuation, payroll tax and fringe benefits tax. While wages and salaries is available from each of the surveys listed above, the reporting of 'on costs' varies.

Data for wages and salaries and different types of 'on costs' were available from 1997-98. Prior to this, wages and salaries data were scaled up using an 'on costs' percentage based on the data from 1997-98. The 1997-98 percentage was adjusted to reflect changes over time in fringe benefits tax and the superannuation guarantee. Fringe benefits tax was not introduced until 1986 and was excluded prior to that. The percentage for superannuation was adjusted each year according to Australian Taxation Office information (ATO 2011) and the *Superannuation Guarantee (Administration) Act 1992*, as listed in the table A.7.

Table A.7 **Superannuation assumptions used in income shares**

Year	*Proportion of wages and salaries*
1984-85 (assume half workforce covered at 3 per cent)	0.015
1985-86 (assume linear growth to 1989-90)	0.016
1986-87 (assume linear growth to 1989-90)	0.017
1987-88 (assume linear growth to 1989-90)	0.018
1988-89 (assume linear growth to 1989-90)	0.019
1989-90 (assume 2/3 workforce covered at 3 per cent)	0.02
1990-91 (assume 2/3 workforce covered at 3 per cent)	0.02
1991-92 (assume 2/3 workforce covered at 3 per cent)	0.02
1992-93 (Superannuation Guarantee Administration Act)	0.03
1993-94 (Superannuation Guarantee Administration Act)	0.03
1994-95 (Superannuation Guarantee Administration Act)	0.04
1995-96 (Superannuation Guarantee Administration Act)	0.05
1996-97 (Superannuation Guarantee Administration Act)	0.06

Sources: ATO (2011); *Superannuation Guarantee (Administration) Act 1992.*

The explanatory notes to the surveys also indicate that the inclusion of 'in kind' wages has changed over time. However, no data appear to be available to enable an adjustment for this.

Value added

The definition of value added reported in the ABS industry surveys varies from that used by ABS National Accounts and changes over time.

From 1997-98 to 2010-11 a measure of value added (broadly in line with that used by ABS National Accounts) was published in Cat. nos 8221.0 and 8155.0. Prior to

1997-98, value added (as measured in this way) was not available. From 1996-97 back to 1989-90, value added was imputed based on related data, as follows:

- Turnover was reported in Cat. no. 8221.0 from 1989-90 to 1997-98. The turnover growth rate was applied to 1997-98 estimate of value added to backcast value added to 1989-90.[15]

Data prior to 1989-90 was either not reported for value added or reported for a different definition of value added.

- For 1984-85 and 1986-87 ABS published 'adjusted value added'. A number of intermediate expenses, including land tax and payroll tax, were deducted by the ABS in estimating this measure. For consistency of the time series being used in this paper, land tax and payroll tax (for which data were also separately available) were added back to 'adjusted value added'. This provided a measure closer to the National Accounts definition of value added.
- For 1987-88 and 1988-89 no value added measure was published. Growth in turnover was applied to adjusted value added for 1986-87 to impute adjusted value added for 1987-88 and 1988-89.

An additional difference in the definition of value added for Petroleum refining prior to 1989-90 is also noted by the ABS (1993, p. 74).

> Prior to this census, most commodities produced in the petroleum refining industry (ASIC Class 2770) were manufactured on commission for non-manufacturing businesses from materials owned and supplied by those businesses. In these cases, manufacturing turnover reflected only the value of commission earned by the manufacturing establishments involved (not the gross value of the commodities produced). Due to a change in accounting practices, a number of businesses have changed to reporting gross value of production. This change has significantly affected the comparability of turnover and value added statistics between 1989-90 and previous years for Industry Subdivision 27.

In the absence of an overlapping year of data for the two definitions of value added, value added for 1988-89 was derived by assuming that the ratio of labour income to value added was the same in 1988-89 as in 1989-90. Value added for 1984-85 to 1987-88 was then backcast using the growth rate in the unadjusted value added series as derived using the method applied to all other subsectors.

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15 ABS (Cat. no. 8221.0, 1997-98 issue) notes a change in definition of turnover to include intellectual property royalties from then on. However, the increase due to this change in definition was listed as 0 per cent for most subsectors and a maximum of 0.3 per cent for one subsector. This effect was considered too small to make the complexities of further adjustment worthwhile.

Other breaks in series

In addition to the various changes outlined above, there are some other breaks in series that affect both variables. These breaks, and whether it was possible to adjust for them, is discussed below.

Industry classification

The data compiled were in ASIC from 1984-85 to 1988-89, ANZSIC93 from 1989-90 to 2003-04, ANZSIC06 from 2004-05 to 2009-10.[16] Data were available for 1989-90 in ASIC and ANZSIC93 and for 2004-05 in ANZSIC93 and ANZSIC06.

For each subsector, the closest corresponding subsector on the previous classification was identified. For each subsector (and total Manufacturing) the ratio of the data under each classification for 1989-90 and 2004-05 was used to crudely 'concord' the data into the new classification. (This process was applied twice to convert the ASIC data into ANZSIC06). These ratios were calculated for labour income and for value added (table A.8).

It is acknowledged that this approach based on a single year of 'overlapping' data may yield less accurate results the further back in time it is applied (to the extent that the composition of the subsector has changed over time).

One way of assessing the likely accuracy of the backcast series derived using these factors is to look at the change in the composition of the subsectors (at the class level) over time. This was done for the subsectors with the adjustment factors that deviated most from one (Printing and recorded media, and Textile, clothing and other manufacturing). In both cases, the classes within the ANZSIC93 subdivision that mapped most closely to the corresponding ANZSIC06 subsector were a fairly stable share (in aggregate) of the ANZSIC93 subdivision total over time.

[16] Estimates for 2004-05 and 2005-06 were converted from ANZSIC93 to ANZSIC06 by the ABS.

Table A.8 **Conversion factors: ASIC/ANZSIC93 and ANZSIC93/06**

Subdivision[b]	*Turnover/value added factor*[a]	*Labour costs factor*
ASIC to ANZSIC93 (1989-90)	*Turnover factor*	
ASIC 21 Food, beverage & tobacco to ANZSIC93 21 Food, beverage & tobacco	1.01	1.00
ASIC 23+24 Textiles, Clothing & footwear to ANZSIC93 22 Textiles, clothing, footwear & leather mfg	1.07	1.06
ASIC 25 Wood, wood products & furniture to ANZSIC93 23 Wood & paper product mfg	1.15	0.95
ASIC 26 Paper, printing & publishing to ANZSIC93 24 Printing, publishing & recorded media	**0.76**	**0.81**
ASIC 27 Chemical, petroleum & coal products to ANZSIC 25 Petroleum, coal, chemical & assoc'd product mfg	**1.29**	**1.66**
ASIC 28 Non-metallic mineral products to ANZSIC93 26 Non-metallic mineral product mfg	1.03	1.03
ASIC 29+31 Basic metal products, Fabricated metal products to ANZSIC93 27 Metal product mfg	0.99	0.99
ASIC 32+33 Transport equip, Other machinery & equipment to ANZSIC93 28 Machinery & equipment mfg	1.01	1.01
ASIC 34 Misc mfg to ANZSIC93 29 Other mfg	**0.69**	**0.83**
Total Manufacturing	1.01	1.02
ANZSIC93 to ANZSIC06 (2004-05)	*Value added factor*	
ANZSIC93 21 Food, beverages & tobacco to ANZSIC06 11+12 Food product mfg; Beverage & tobacco mfg	1.01	1.06
ANZSIC93 22 Textiles, clothing, footwear & leather mfg to ANZSIC06 13 Textile, leather, clothing & footwear mfg	0.94	1.01
ANZSIC93 23 Wood & paper product mfg to ANZSIC06 14+15 Wood prod. mfg; Pulp, paper & conv. paper mfg	1.08	1.13
ANZSIC93 24 Printing, publishing & recorded media to ANZSIC06 16 Printing (including recorded media)	**0.37**	**0.44**
ANZSIC93 25 Petroleum, coal, chemical & assoc'd product mfg to ANZSIC06 17+18+19 Petroleum & coal prod. mfg; Basic chemical & chemical prod. mfg; Polymer product & rubber prod. mfg	0.98	1.01
ANZSIC93 26 Non-metallic mineral product mfg to ANZSIC06 20 Non-metallic mineral product mfg	0.92	0.97
ANZSIC93 27 Metal product mfg to ANZSIC06 21+22 Primary metal & metal prod. mfg; Fabricated metal product mfg	1.00	0.97
ANZSIC93 28 Machinery & equipment mfg to ANZSIC06 23+24 Transport equip. mfg; Machinery & equip. mfg	0.92	0.95
ANZSIC93 29 Other mfg to ANZSIC06 25 Furniture & other mfg	**0.53**	**0.60**
Total Manufacturing	0.90	0.93

[a] Turnover used where overlapping value added data not available. [b] Some movements in classification were between Textiles, clothing and footwear and Other manufacturing. 'Textile, clothing and other manufacturing' is a single subsector in this study, so adjustment factors were calculated for this aggregate — ASIC to ANZSIC93 0.89 turnover; 0.96 labour costs; ANZSIC93 to ANZSIC06 0.70 value added; 0.77 labour costs.

Sources: Authors' estimates based on ABS (*Australian Industry*, various issues, Cat. no. 8155.0); ABS (*Manufacturing Industry Australia*, various issues, Cat. no. 8221.0); ABS (*Enterprise Statistics, Australia*, various issues, Cat. no. 8103.0).

Changes in survey

Move from Cat. no. 8103.0 to 8221.0 and Cat. no. 8221.0 to 8155.0

Data were available from Cat. no. 8221.0 for most of the time series, but the ABS income shares for Manufacturing from Cat. no. 5260.0.55.002 appeared to be more closely aligned to the Cat. no. 8155.0 series. The compiled data from Cat. no. 8221.0 were scaled to match the coverage of Cat. no. 8155.0 using a ratio calculated from data from both surveys for 2006-07 (table A.9). The Cat. no. 8155.0 data used were those reported in 2009-10 issue, which included revisions to data back to 2006-07 (largely related to improvements in the sample design and other aspects of survey methodology).

Table A.9 **Conversion factors: Cat. no. 8221.0 to Cat. no. 8155.0**

Subsector[a]	*Value added*	*Labour costs*
Food, beverage & tobacco products	1.02	1.00
Textile, clothing & other manufacturing	1.04	1.00
Wood & paper products	1.02	0.99
Printing & recorded media	1.02	0.95
Petroleum, coal, chemical & rubber products	1.17	0.98
Non-metallic mineral products	1.03	1.00
Metal products	1.04	0.99
Machinery & equipment manufacturing	1.02	1.00
Total Manufacturing	**1.03**	**1.00**

[a] Aggregated to subsectors from ANZSIC06 industry subdivisions.

Sources: Authors' estimates based on ABS (*Manufacturing Industry, Australia, 2006-07*, Cat. no. 8221.0); and ABS (*Australian Industry, 2006-07*, Cat. no. 8155.0).

The 1989-90 issue of Cat. no. 8221.0 refers to a change in the coverage compared with earlier surveys and provides a table of conversion factors (table A.10). It appears that these have already been applied to data from 1987-88 published in later issues of Cat. no. 8221.0. Therefore the conversion factors were applied to 1986-87 and 1984-85 data. The Cat. no. 8221.0 to 8155.0 factors were then applied to this converted data.

Table A.10 **Conversion factors: Cat. no. 8103.0 to Cat. no. 8221.0**

Subsector[a]	*Conversion factor*
Food, beverage & tobacco products	1.01
Textile, clothing & other manufacturing	1.03
Wood & paper products	1.04
Printing & recorded media	1.03
Petroleum, coal, chemical & rubber products	1.02
Non-metallic mineral products	1.02
Metal products	1.02
Machinery & equipment manufacturing	1.02
Total Manufacturing	**1.03**

[a] Aggregated to subsectors from ANZSIC93 industry subdivisions based on value added shares for 1986-87.

Source: Authors' estimates based on ABS (*Manufacturing Industry, Australia, 1989-90*, Cat. no. 8221.0, table 12).

Change in establishment size

Prior to 1987-88, single establishment Manufacturing enterprises with less than four employed were excluded from the survey. Insufficient data were available to adjust the series for this change.

Change from establishments to management units

The 2000-01 issue of Cat. no. 8221.0 notes the change from measuring establishments to measuring management units. The two concepts are defined as follows.

> The establishment is the smallest accounting unit of a business, within a state or territory, controlling its productive activities and maintaining a specified range of detailed data … In general, an establishment covers all operations at a physical location, but may consist of groups of locations provided they are within the same state or territory. The majority of establishments operate at one location only.
>
> The management unit is the highest-level accounting unit within a business, having regard to industry homogeneity, for which accounts are maintained. In nearly all cases, it coincides with the legal entity owning the business … In the case of large diversified businesses, however, there may be more than one management unit, each coinciding with a 'division' or 'line of business'. A division or line of business is recognised where separate and comprehensive accounts are compiled for it. A management unit consists of one or more establishments.

A management unit can therefore be a more aggregated unit — it may include more than one establishment.

The main implication of this change is that some activities will be allocated to a different industry classification on the basis of management units than on the basis of establishments. A management unit is allocated to an industry classification based on its predominate activity, but the data collected for it will cover all its activities. Where a management unit includes activities that are, for example, in different subdivisions of Manufacturing, all activities will be allocated to the subdivision of the predominant activity.

Prior to this change to management units, data had been collected for some years for both establishments and management units. Using this data the ABS provided bridging factors for conversion of data on an establishment basis to a management units basis (table A.11). The ABS appears to have already applied these factors back as far as 1995-96 and included these revised years of data in the 2000-01 issue. These factors were therefore applied to the compiled data from 1994-95 to 1988-89. Prior to 1988-89 the definition of the unit measured appears more similar to the management unit definition so the bridging factors were not applied.

Table A.11 **Bridging factors: establishments to management units**

ANZSIC93 subdivisions	*Value added*	*Wages and salaries*
Food, beverage & tobacco mfg	1.010	1.213
Textiles, clothing, footwear & leather mfg	0.920	0.989
Wood & paper product mfg	1.126	1.091
Printing, publishing & recorded media	1.048	1.011
Petroleum, coal, chemical & assoc'd product mfg	1.007	1.107
Non-metallic mineral product mfg	1.084	1.186
Metal product mfg	1.105	1.040
Machinery & equipment mfg	1.006	1.054
Other manufacturing	1.007	1.003
Total Manufacturing	**1.035**	**1.084**

Source: Authors' estimates based on ABS (*Manufacturing Industry, 2000-01,* Cat. no. 8221.0, appendix 3).

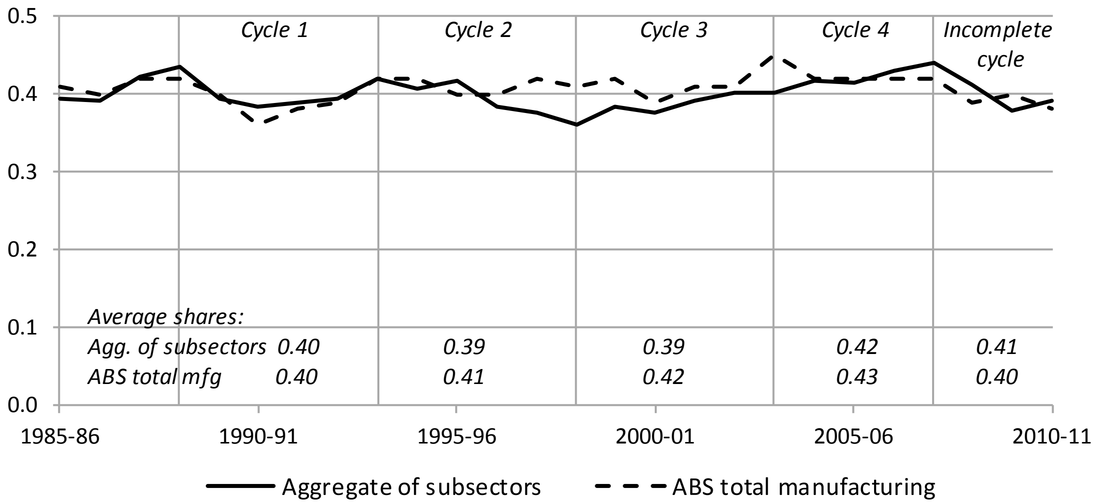
Benchmarking of level estimates

Finally, the series for value added levels for each subsector produced using the above method were benchmarked to the National Accounts estimates of subsector GVA CVM for the base year (2009-10) — the base year effectively being a current price estimate.[17] The earlier year estimates were derived using the growth rate in unadjusted series. The proportion of value added that were capital income and labour income were preserved, with new factor income levels being derived. The income shares were therefore unchanged.

As a result of data limitations, there is a discrepancy between the aggregate of the subsector factor income shares and the ABS income shares for ABS Manufacturing as a whole. Figure A.4 compares the two different series of capital income shares. It is the average cycle shares that are used in the MFP estimates, and the discrepancy between the two series is relatively small. The MFP growth estimates are not significantly affected by this difference.

Figure A.4 **Capital income shares**[a]

Share of value added



[a] Capital income share plus labour income share add to one.

Data sources: Authors' estimates based on ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002); ABS (*Australian Industry,* various issues, Cat. no. 8155.0); ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Enterprise Statistics, Australia,* various issues, Cat. no. 8103.0); and ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0).

[17] Time series of current price value added by subsector are not available from the National Accounts.

A.7 Multifactor productivity

MFP growth is calculated as the difference in the rate of output growth less the rate of input growth. Output is measured by growth in gross value added in this paper. Inputs are measured as a Tornqvist index calculated using the average relative factor income shares to weight growth in hours worked and capital services.

$$A_t = \frac{V_t}{I_t}$$

where A_t represents MFP, V_t represents real output and I_t the Tornqvist index of factor inputs:

$$\frac{I_t}{I_{t-1}} = \left(\frac{K_t}{K_{t-1}}\right)^{W_{kt}} \left(\frac{L_t}{L_{t-1}}\right)^{W_{lt}}$$

where K_t represents capital services, L_t represents hours worked, and the W_{kt} and W_{lt} represent the average relative income shares of capital and labour over the two periods, respectively:

$$W_{kt} = \frac{S_{kt} + S_{k(t-1)}}{2}; W_{lt} = \frac{S_{lt} + S_{l(t-1)}}{2}$$

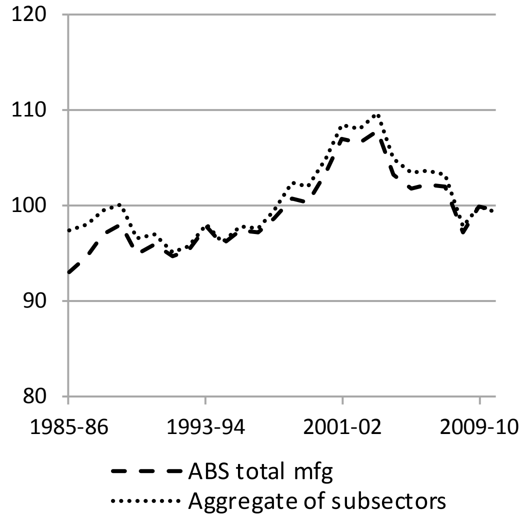
This then implies that growth in MFP is equal to growth in outputs less the income-weighted shares of capital and labour inputs:

$$ln\ \frac{A_t}{A_{t-1}} = ln\ \frac{V_t}{V_{t-1}} - W_{kt}\left(ln\ \frac{K_t}{K_{t-1}}\right) - W_{lt}\left(ln\ \frac{L_t}{L_{t-1}}\right)$$

As noted in sections A.5 and A.6, data limitations have resulted in some discrepancies between the aggregate of the subsector estimates and the ABS estimates for capital services and factor income shares for Manufacturing as a whole. The resulting difference in the MFP indexes is shown in figure A.5.

Figure A.5 **MFP discrepancy**

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



Cycle	*ABS total mfg*	*Aggregate of subsectors*	*ABS with assets removed*[b]
	% py	% py	% py
1988-89 to 1993-94	0.0	-0.4	-0.3
1993-94 to 1998-99	0.6	0.9	0.6
1998-99 to 2003-04	1.3	1.4	1.2
2003-04 to 2007-08	-1.4	-1.5	-1.7
2007-08 to 2010-11[a]	-0.8	-1.3	-0.9
Full period			
1985-86 to 2010-11	0.3	0.1	0.1

[a] Incomplete productivity cycle. [b] Refers to ABS series without those assets for which data are unavailable at the subsector level.

Data sources: Authors' estimates; ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

As discussed in section A.5, while the additional asset types used by the ABS cannot be included in the subsector estimates of capital services (and therefore MFP), it is possible to remove those assets from the ABS series for Manufacturing as a whole to derive another MFP series that is more comparable. Growth in this MFP series is shown in the last column of figure A.5 and is, generally speaking, more consistent with the aggregate of the subsector MFP estimates in this paper. There is still a large difference over the incomplete cycle.

In short, much of the discrepancy between the published ABS MFP series and that derived in this paper can be attributed to the different asset coverage. Further testing of the sensitivity of the subsector MFP estimates is included in appendix E.

B Manufacturing's input-output linkages

This appendix provides further background on the linkages between Manufacturing and other sectors of the economy discussed in chapter 2.

B.1 Using the input-output tables

The ABS publishes input-output (IO) tables as part of the National Accounts (Cat. no. 5209.0.55.001), which can be used to identify up- and downstream relationships between Manufacturing and other sectors, as well as between different Manufacturing subsectors. IO tables break down the value of the total production of ANZSIC-based industry groups[1] into primary inputs and intermediate inputs. The rows in the tables show the value in basic prices of output from each industry or product group being absorbed as intermediate inputs to other industries, as well as the final uses of that industry or product group. The columns show the value of intermediate inputs absorbed by each industry, as well as its primary inputs and the value of its total Australian production.

Analysis of the IO tables in this appendix is based on industry-to-industry tables, rather than product group-to-industry tables, unless otherwise indicated. That is, the cells report the flow of products from supply industries (in the row-headings) to the use industries (in the column-headings). In an industry-to-industry table, the cell entries include not only those products that are mainly produced by, or primary to, the row-heading industry, but also its secondary products, that is, those products that are mainly produced by other industries. Where secondary products make up a significant proportion of the output of an industry, typical IO analysis needs to be interpreted with particular caution. This problem appears not to be substantial in the case of Manufacturing as only a relatively minor proportion of products produced by the industry are not primary to Manufacturing.

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1 The ABS *Australian and New Zealand Standard Industrial Classification* (ABS 2006b).

The ABS also includes data on imported intermediate goods in the IO tables. The IO tables have either a direct or indirect allocation of imports. Where imports are allocated directly, all the rows which show the intermediate inputs to use industries report the value of domestically produced intermediate inputs only. Where imports are allocated indirectly, each row showing the supply of intermediate inputs to industries comprises the total value of imported and domestically produced intermediate inputs.

Tables with direct allocation of imports give a better indication of how changing supply-use flows affect domestic manufacturers and are therefore useful for studying the reliance of Australian Manufacturing on domestic downstream users. Tables with indirect allocation of imports give a better indication of the technological input structure of an industry, since they show the value of all the intermediate inputs used, regardless of their origin. These are useful for informing how manufacturers may have changed their input structure over time. Unless otherwise indicated, the IO tables used in the analysis in this appendix directly allocate imports (that is, the intermediate flows refer to domestic products only).

The IO tables present static data, based on prices in that reference year only. Stemming from this, the main limitation for observing changing industry-flow relationships over time using the IO tables is that any change in the value of intermediate inputs flowing from a supply to a use industry between any two years captures both price and volume effects. Unless appropriate deflators are used to adjust for price effects, the price and volume effects cannot be separated. Where an input is subject to high price volatility, and use industries are price-takers, the difficulty of interpreting a change in the value of the intermediate use of that input is exacerbated: a price rise (or fall) in an input would change the value of the intermediate flow of that input to a use industry, even where the input structure of the use industry remains unchanged.

The analysis in this appendix is based on reference years 1994-95, 2001-02 and 2008-09 (which is the latest year for which IO data are available). IO tables are based on the edition of ANZSIC current at the time of compilation. To the extent possible, the information presented in this appendix has been adjusted for concordance issues between the 1993 edition (ANZSIC93) and 2006 edition (ANZSIC06). (Box B.1 outlines the major changes to Printing and recorded media. Insufficient data were available to adjust for other changes.)

Box B.1 **Concordance issues for Printing and recorded media**

The 2008-09 tables are based on ANZSIC06, whereas the tables from the previous years are based on ANZSIC93. Comparisons of IO tables across these years are based on ANZSIC06. For the 1994-95 and the 2001-02 IO tables, the Input-Output Industry Groups (IOIG) 2401 ‘Printing and services to printing’ and 2402 ‘Publishing, recorded media’ were classified as subdivision 24 Printing, publishing and recorded media and were considered part of Division C Manufacturing in ANZSIC93. These activities have since been reclassified in ANZSIC06 so that they are now mapped to new IOIGs which fall under C Manufacturing, J Information media and telecommunications and N Administrative and support services. However, the mapping from the former IOIGs (IOIG 2005) to the new IOIGs (IOIG 2009) is partial rather than complete (see ABS 2012 for details).

In order to have the earlier IO tables concord with 2008-09, 2401 (IOIG 2005) ‘Printing and services to printing’ is considered to be part of Manufacturing and in this appendix, is compared directly to 1601 (IOIG 2009) ‘Printing (including the reproduction of recorded media)’ (PRM) in the 2008-09 IO tables. But as well as including activities which match PRM, the old 2401 (IOIG 2005) also includes 1502 ‘Paper stationery and other converted paper product manufacturing’ (which belongs to 15 ‘Pulp, paper and converted paper product manufacturing’) as well as activities which are now reclassified outside of Manufacturing into 5401 ‘Publishing (except internet and music publishing) and 7201 ‘Building cleaning, pest control, administrative and other support services’. Because these activities are not separated out, the inclusion of the old 1601 (IOIG 2009) in PRM would overstate input and output flows to and from this subdivision.

On the other hand, 2402 (IOIG 2005) ‘Publishing; recorded media and publishing’ from the earlier tables is, in this appendix, treated as part of Services rather than as Manufacturing because activities in this industry group have mainly been reclassified to division J Information media and telecommunications in ANZSIC 2006.[1] This, however, would have the effect of understating the input and output flows from PRM because parts of 1601 (IOIG 2009) ‘Printing (including the reproduction of recorded media)’ were actually formerly included in the old 2402 (IOIG 2005).[2] Manufacturing activity (as defined in ANZSIC06) that dropped out would include newspaper printing (which would fall under 1611 Printing) and the Reproduction of recorded media (1620).

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[1] These include 5401 Publishing (except internet and music publishing); 5501 Motion picture and sound recording and 5701 Internet publishing and broadcasting and services providers, websearch portals and data processing services

[2] The ANZSIC93 classes which were in 2402 Publishing; recorded media and publishing included: 2421 Newspaper printing or publishing; 2422 Other periodical publishing; 2423 Book and other publishing and 2430 Recorded media manufacturing and publishing. 2430 Recorded media manufacturing and publishing corresponds to these ANZSIC06 classes: 1620 Reproduction of recorded media (which is part of Manufacturing) and partially to 5420 Software publishing and 5521 Music publishing (which are outside of Manufacturing). 2421 Newspaper printing or publishing corresponds partially to these ANZSIC06 classes: 1611 Printing (which is part of Manufacturing) and 5411 Newspaper publishing.

B.2 Manufacturing linkages to other sectors

Manufacturing largely occupies a central position along the supply chain and therefore has a high level of linkages, not only within itself, but also with other sectors of the Australian economy. It is a large downstream user of output from Manufacturing itself, as well as from Agriculture and Mining and a large upstream supplier to Construction and Transport.

Table B.1 shows the IO linkages between Agriculture, Mining, Manufacturing and a selection of service sectors for 2008-09, the latest year for which IO tables have been released by the ABS. This table shows the direct requirement coefficients which are the value of the flows from the supply industry (the row heading), expressed as a percentage of the value of total output produced by the use industry (the column heading). The column for Manufacturing shows the contributions of intermediate inputs from the supply industries to the value of Manufacturing output. Every $100 of Manufacturing output produced required, on average, $55.50 of intermediate inputs ($7.20 from Agriculture, $8.30 from Mining, $19.50 from Manufacturing and the rest from services). Since these data are based on a direct allocation of imports table from the ABS, the intermediate flows between industry refers only to domestic products.

Table B.1 **Input-output linkages between sectors,[a] 2008-09**

Per cent

		TO						
		Ag.	*Mining*	*Mfg*	*EGWWS*[b]	*Constr.*	*Transport*	*Other services*[c]
FROM	Agriculture	18.4	0.1	**7.2**	0.0	0.1	0.2	0.5
	Mining	0.1	9.2	**8.3**	6.8	0.3	0.2	0.2
	Manufacturing	**8.3**	**5.1**	**19.5**	**3.4**	**14.4**	**9.1**	**4.8**
	EGWWS[b]	1.4	1.2	**1.5**	23.4	1.0	1.1	0.7
	Construction	2.1	3.5	**0.8**	4.5	25.9	2.2	2.3
	Transport	4.4	2.3	**4.6**	1.2	2.1	7.9	2.7
	Other services	15.8	11.8	**13.6**	11.0	20.8	26.9	27.5
	Total domestic intermediates	*50.4*	*33.2*	***55.5***	*50.2*	*64.6*	*47.5*	*38.7*
	Value added	41.9	62.8	**27.7**	45.6	30.2	44.9	56.8
	Imports[d]	7.1	4.0	**16.2**	3.8	4.9	6.8	3.9
	Total[e]	100	100	**100**	100	100	100	100

[a] Based on direct allocation of imports so that the percentages intermediate inputs refer only to domestically produced inputs. [b] Electricity, gas, water and waste services. [c] Includes non-market sector industries. [d] Imports refer to imported intermediate goods used by column (use) industry and can be products from any industry. [e] Includes taxes less subsidies on products.

Source: ABS (*Australian National Accounts: Input-Output Tables, 2008-09*, Cat. no. 5209.0.55.001, Table 5).

Changes in the coefficients give a broad indication of the changing relationships between Australian manufacturers and their users and suppliers. Table B.1 shows the coefficients at the divisional level and table B.2 shows the coefficients for the subsectors of Manufacturing. Petroleum, coal, chemical and rubber products (PCCR) provides a relatively large share of intermediate inputs to Agriculture and Mining as well as to the Manufacturing subsectors. Of all the Manufacturing subsectors, Metal products (MP) provides the largest share of intermediate inputs used by total Manufacturing. Every $100 of Manufacturing output requires $9.20 of intermediate inputs from MP. Machinery and equipment manufacturing (ME) and Textile, clothing and other manufacturing (TCO) have a high reliance on inputs from MP.

Suppliers to Manufacturing

A Commission Research Paper in 2003 identified that in the mid-1990s, Manufacturing was a significant user of inputs from the primary industries (Agriculture and Mining), with the resource processing parts of Manufacturing having more linkage with resources than the elaborately transformed manufactures (PC 2003). Since then, the linkages between Manufacturing and the primary industries have strengthened, likely as a result of the mining boom.

While in 1994-95, intermediate inputs from Mining contributed $5.10 per every $100 of Manufacturing output, by 2008-09, it contributed $8.30 (ABS 2012a). Aside from the intra-industry flows within Agriculture and Mining, Manufacturing is the most significant user of inputs from these industries (table B.1).

In the 2003 Research Paper, the Commission also noted that the outsourcing of non-core service activities (such as accountancy, cleaning, transport and data-processing) by firms in Manufacturing had contributed to the decline in the sector's share of gross domestic product. Intermediate inputs from the services sector had been making a significantly higher contribution to Manufacturing in the mid-1990s than in the early 1980s, suggesting that activities that were previously performed by manufacturers themselves were increasingly being supplied from the services sector. The coefficient representing the flow of services into Manufacturing has since stabilised, suggesting that the outsourcing trend may have plateaued. As shown in table B.1, the services industries contributed $20.50 to every $100 of Manufacturing output. This is similar to 1994-95: the IO tables for that year show that the services contribution was $19.80.

Table B.2 **Input-output linkages of Manufacturing subsectors,[a] 2008-09**

Per cent

		TO											
		Agric.	***Mining***	*FBT*	*TCO*	*WP*	*PRM*	*PCCR*	*NM*	*MP*	*ME*	***Total Mfg***	***Services***
FROM	**Agriculture**	18.4	0.1	29.5	5.8	8.1	0.1	0.5	0.0	0.0	0.0	7.2	0.4
	Mining	0.1	9.2	0.5	0.1	0.6	0.2	12.1	7.8	20.6	0.1	8.3	0.4
	FBT	2.2	0.2	11.6	2.8	0.2	0.2	0.8	0.2	0.1	0.2	2.9	1.2
	TCO	0.2	0.1	0.2	4.1	0.2	0.4	0.2	0.2	0.2	0.4	0.4	0.2
	WP	0.2	0.1	1.5	2.8	7.3	4.7	0.7	0.6	0.3	0.4	1.3	0.7
	PRM	0.1	0.1	0.2	0.1	0.7	1.8	0.1	0.2	0.1	0.2	0.2	0.5
	PCCR	4.1	2.1	2.1	2.2	3.2	6.6	9.5	2.7	1.1	1.9	3.4	1.3
	NM	0.1	0.1	0.5	0.2	0.2	0.3	0.4	11.7	0.3	0.8	0.9	0.6
	MP	0.4	1.6	0.6	5.9	2.3	0.7	0.8	2.4	21.5	16.0	9.2	1.3
	ME	1.0	0.8	0.3	0.5	0.6	0.7	0.3	0.4	0.3	6.0	1.3	0.9
	Total Mfg	8.3	5.1	17.0	18.7	14.8	15.2	12.8	18.4	23.8	25.9	19.5	6.7
	Services	23.7	18.9	20.4	18.3	30.6	27.1	20.8	26.9	15.0	23.9	20.5	36.6
	Total domestic intermediate inputs	*50.4*	*33.2*	*67.4*	*43.0*	*54.2*	*42.6*	*46.1*	*53.2*	*59.5*	*49.9*	*55.5*	*44.0*
	Value added	41.9	62.8	26.7	40.4	35.5	44.7	23.7	37.4	22.9	30.6	27.7	51.1
	Imports[b]	7.1	4.0	5.3	15.5	9.8	12.3	29.2	8.6	17.4	19.1	16.2	4.3
	Total	100	100	100	100	100	100	100	100	100	100	100	100

FBT is Food, beverage & tobacco products; TCO is Textile, clothing & other manufacturing; WP is Wood & paper products; PRM is Printing & recorded media; PCCR is Petroleum, coal, chemical & rubber products; NM is Non-metallic mineral products; MP is Metal products; ME is Machinery & equipment manufacturing. **a** Based on direct allocation of imports so that the percentages 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) industry and can be products from any industry.

Source: ABS (*Australian National Accounts: Input-Output Tables, 2008-09,* Cat. no. 5209.0.55.001, Table 5).

Users of Manufacturing

Table B.3 shows the change in the relationships between Manufacturing and its users over time. It shows the direct requirement coefficients for Manufacturing, which is the same information in the row for Manufacturing in table B.1, expressed as the contribution of intermediate inputs from Manufacturing for every $100 of output produced by sectors in the economy for three selected years.

Table B.3 **Supply of Manufacturing intermediate inputs to industry sector[a]**

Value of Australian Manufacturing intermediate inputs required for every $100 of industry output, basic prices

	1994-95	*2001-02*	*2008-09*
	$	$	$
Agriculture	12.70	8.30	8.30
Mining	7.20	7.40	5.10
Manufacturing	23.70	20.40	20.50
All services	8.30	7.50	6.70

[a] Adjustments have been made, to the extent practicable, to broadly match IOIGs for 1994-95 based on the ANZSIC 1993 with the IOIGs for 2001-02 and 2008-09 based on ANZSIC 2006. In 1994-95 and 2001-02 IOIG 2402 Publishing; recorded media and publishing is treated as part of 'All services' rather than Manufacturing.

Source: ABS (*Australian National Accounts: Input-Output Tables,* 1994-95, 2001-02 and 2008-09 issues, Cat. no. 5209.0.55.001, Table 5).

As discussed, movements in the coefficients across different years need to be interpreted with care since the IO tables do not distinguish price and volume effects. The falling coefficients could represent a fall in the relative price of manufactured products used as intermediate goods: for example, price rises in intermediate inputs from other supplying industries, or price rises in the goods produced by the use industries may outpace price rises in the intermediate inputs from Manufacturing.

A change in relative price may in itself produce volume changes by signalling firms and final users to seek cheaper substitutes where these are available. Since table B.3 is based on an IO table with direct allocation of imports, all the coefficients show the amount of domestically produced intermediate goods from Manufacturing used to produce $100 of goods in the row industries.

A decline in the coefficients may also be brought about by the use industries changing their own output mix (in response to changing consumer tastes, or to drought conditions, for instance) in favour of those goods or services which require less intermediate inputs from Manufacturing. It should be noted that coefficients from IO tables do not fully capture the effect of these sources of structural change.

Intermediate and final usage of Manufacturing

As well as providing information on the intermediate use of goods from supplying industries, the IO tables also provide information on final demand, which includes final consumption by households and government, private and public gross fixed capital formation, change in inventories, and exports.

Table B.4 **Breakdown of Manufacturing subsector[a] output into industry and final use categories, 2001-02 and 2008-09**

Percentage of total supply

	FBT	*TCO*	*WP*	*PRM*[b]	*PCCR*	*NM*	*MP*	*ME*	*Total Mfg*
2001-02									
Industry use	*32.7*	*34.3*	*83.1*	*86.8*	*66.9*	*96.7*	*57.5*	*46.4*	*53.1*
Final use									
Final consumption	40.1	31.4	7.3	7.7	17.4	1.9	1.5	23.1	20.3
Exports	24.6	20.0	10.9	2.7	13.1	4.0	38.8	17.4	21.5
GFCF[c]	2.6	14.3	-1.4	2.7	2.7	-2.6	2.3	13.2	5.1
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
2008-09									
Industry use	*40.5*	*30.3*	*81.2*	*98.3*	*60.1*	*94.7*	*59.2*	*34.9*	*53.6*
Final use									
Final consumption	36.8	34.3	8.3	0.9	20.3	2.8	0.9	17.6	17.0
Exports	21.8	18.8	9.7	1.7	16.7	2.4	36.2	17.1	21.9
GFCF[c]	0.9	16.6	0.7	-0.9	2.9	0.2	3.7	30.4	7.5
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

[a] For full subsector names see table B.2. [b] There are some concordance issues between Manufacturing subsectors from ANZSIC93 to ANZSIC 06. For 2001-02, Printing includes IOIG 2401 ‘Printing and services to printing’; so as to best concord with ANZSIC06, IOIG 2402 ‘Publishing; recorded media and publishing’ is not considered as Manufacturing and is therefore not included in either ‘Printing’ or in ‘Total Mfg’. [c] In this table, change in inventories is included in GFCF so it can therefore be negative.

Source: ABS (*Australian National Accounts: Input-Output Tables,* 2001-02 and 2008-09 issues, Cat. no. 5209.0.55.001, Table 5).

Manufacturing is an important supplier of goods for intermediate use both within the Manufacturing sector itself and to other sectors. This can be seen in table B.4 which shows a breakdown of intermediate and final demand for Manufacturing. Well over a half of Australia’s Manufacturing output is supplied for domestic intermediate use and while this has remained largely unchanged over the last one and a half decades[2] at an aggregate level, there are disparate trends across the subsectors.

2 This is based on a comparison with 1994-95 IO tables.

The majority of the output of Wood and paper products (WP), PRM and NM goes to downstream intermediate users. These subsectors are therefore particularly affected by cyclical or structural fluctuations in their downstream use industries. WP, MP and NM are particularly reliant on domestic downstream intermediate users in Manufacturing (table B.4). Other subsectors have a higher proportion of their output going to final consumption and exports. While in table B.4 PRM has shown an increase in share of total supply going to intermediate use, the concordance problems associated with the introduction of the ANZSIC06 means that no clear conclusions can be drawn about this subsector.

C MFP growth cycles for Manufacturing subsectors

Using the method outlined in Barnes (2011), multifactor productivity (MFP) growth cycles were identified for all eight subsectors of Manufacturing examined in this paper. It should be noted that the underlying data were not subjected to the tests (outlined in that paper) for suitability for cycle identification method to be applied.

Subsector MFP growth cycles are periods over which it is best to examine growth *within* a subsector over time. These are cycles that start and end at subsector productivity peaks that are less likely to be affected by temporary influences (see Barnes 2011 for further details). This can be useful in identifying factors that may be specific to utilisation rates in a subsector. While these subsector cycles can differ from those for Manufacturing as a whole, it is appropriate to examine subsector growth over cycles *for Manufacturing* when identifying the contribution of subsectors to changes in total Manufacturing productivity performance over those periods.

Table C.1 presents the peaks identified as the start/end years of MFP growth cycles for the Manufacturing subsectors and total Manufacturing. While there is some variation across subsectors, for three of the five peaks for total Manufacturing at least half of the subsectors have coinciding peaks. There are also several peaks for subsectors in years that are adjacent to the peaks for total Manufacturing.

Table C.2 compares average annual MFP growth for each subsector calculated over subsector-specific MFP growth cycles compared with subsector growth calculated over the MFP growth cycle periods for total Manufacturing. The subsector cycles that are underlined are those that coincide with those for Manufacturing in total — Machinery and equipment has three in common with total Manufacturing, while Metal products, Non-metallic mineral products and Printing and recorded media have one each. The remaining three subsectors have no cycles in common with total Manufacturing.

Table C.1 Peaks identified for use in subsector-specific MFP growth cycles[a]

Shaded rows are total Manufacturing peak years

	Subsector[b]								
	FBT	*TCO*	*WP*	*PRM*	*PCCR*	*NM*	*MP*	*ME*	*Peaks per year*
1985-86									**c**
1986-87	✓sw								1
1987-88		✓s			✓				3
1988-89			✓			✓		✓	3
1989-90				✓s2			✓s		1
1990-91	✓	✓s2*			✓				3
1991-92									0
1992-93			✓s						1
1993-94	✓			✓2		✓	✓s	✓	5
1994-95									0
1995-96			✓s		✓2				2
1996-97				✓sw					1
1997-98		✓s							1
1998-99							✓	✓2	2
1999-00									0
2000-01	✓s2								1
2001-02			✓2			✓s	✓		3
2002-03					✓s				1
2003-04	✓	✓2		✓				✓2	4
2004-05			✓s						1
2005-06									0
2006-07	✓					✓			2
2007-08		✓	✓sw	✓			✓		4
2008-09									0
2009-10	✓w					✓sw		✓w2*	3
2010-11									**c**
Number of peaks	7	5	6	5	4	5	5	5	**42**

[a] Revisions by the ABS to its official industry MFP time series, as well as additional years of data, may also lead to revisions to the industry cycles identified and average annual growth rates over these cycles. [b] Subsector labels: FBT is Food, beverage & tobacco products; TCO is Textile, clothing & other manufacturing; WP is Wood & paper products; PRM is Printing & recorded media; PCCR is Petroleum, coal, chemical & rubber products; NM is Non-metallic mineral products; MP is Metal products; and ME is Machinery & equipment manufacturing. [c] Insufficient observations are available to identify peaks in these years. **w** indicates weakly robust. **s** indicates a small deviation. **2** indicates a peak selected from a pair of close together peaks. ***** judgment exercised to select between consecutive sets of close together peaks — largest H11 peak year selected.

Source: Authors' estimates based on methodology in Barnes (2011).

Table C.2 **MFP growth over subsector-specific cycles compared with over total Manufacturing cycles**[a]

Average annual growth rate (per cent)

	Subsector-specific cycles		Total mfg cycles	
Food, beverage & tobacco products (FBT)	1986-87 to 1990-91	1.2	1988-89 to 1993-94	0.6
	1990-91 to 1993-94	-0.4		
	1993-94 to 2000-01	0.9	1993-94 to 1998-99	0.7
	2000-01 to 2003-04	-1.8	1998-99 to 2003-04	-0.5
	2003-04 to 2006-07	-3.4	2003-04 to 2007-08	-4.2
	2006-07 to 2009-10	-2.1		
Textile, clothing, & other mfg (TCO)	1987-88 to 1990-91	-2.1	1988-89 to 1993-94	-2.3
	1990-91 to 1997-98	-0.6	1993-94 to 1998-99	0.5
	1997-98 to 2003-04	1.9	1998-99 to 2003-04	2.5
	2003-04 to 2007-08	-1.6	2003-04 to 2007-08	-1.6
Wood & paper products (WP)	1988-89 to 1992-93	-2.8	1988-89 to 1993-94	-2.5
	1992-93 to 1995-96	-1.2	1993-94 to 1998-99	-1.0
	1995-96 to 2001-02	-0.9	1998-99 to 2003-04	-1.1
	2001-02 to 2004-05	-2.6		
	2004-05 to 2007-08	-2.3	2003-04 to 2007-08	-1.2
Printing & recorded media (PRM)	1989-90 to 1993-94	-1.9	1988-89 to 1993-94	-1.3
	1993-94 to 1996-97	-3.6	1993-94 to 1998-99	-1.8
	1996-97 to 2003-04	4.8	1998-99 to 2003-04	6.4
	2003-04 to 2007-08	-2.8	2003-04 to 2007-08	-2.8
Petroleum, coal, chemical & rubber products (PCCR)	1987-88 to 1990-91	-2.7	1988-89 to 1993-94	-2.6
	1990-91 to 1995-96	-0.3	1993-94 to 1998-99	1.1
	1995-96 to 2002-03	0.5	1998-99 to 2003-04	0.6
			2003-04 to 2007-08	-4.1
Non-metallic mineral products (NM)	1988-89 to 1993-94	-2.5	1988-89 to 1993-94	-2.5
	1993-94 to 2001-02	3.1	1993-94 to 1998-99	0.3
	2001-02 to 2006-07	7.4	1998-99 to 2003-04	6.3
	2006-07 to 2009-10	-1.2	2003-04 to 2007-08	4.9
Metal products (MP)	1989-90 to 1993-94	0.7	1988-89 to 1993-94	1.0
	1993-94 to 1998-99	1.1	1993-94 to 1998-99	1.1
	1998-99 to 2001-02	3.8	1998-99 to 2003-04	1.4
	2001-02 to 2007-08	-1.2	2003-04 to 2007-08	-0.9
Machinery & equipment mfg (ME)	1988-99 to 1993-94	2.0	1988-89 to 1993-94	2.0
	1993-94 to 1998-99	2.5	1993-94 to 1998-99	2.5
	1998-99 to 2003-04	1.6	1998-99 to 2003-04	1.6
	2003-04 to 2009-10	0.5	2003-04 to 2007-08	-0.2

[a] Underlined subsector-specific cycles coincide with Manufacturing cycles.

Source: Authors' estimates.

Figure C.1 illustrates the differences in subsector MFP growth rates when calculated over subsector-specific cycles compared with over total Manufacturing cycles. In general, the pattern of increase/decrease from cycle to cycle is not changed, although the magnitudes vary. The main exception is Petroleum, coal, chemicals and rubber products for which there is a change in the direction of change between the second and third cycles and for which the fourth subsector-specific cycle is yet to be determined. This is discussed further in chapter 4.

Figure C.1 **MFP growth by Manufacturing subsector, over subsector-specific cycles compared with over total Manufacturing cycles**

Average annual growth rate (per cent)

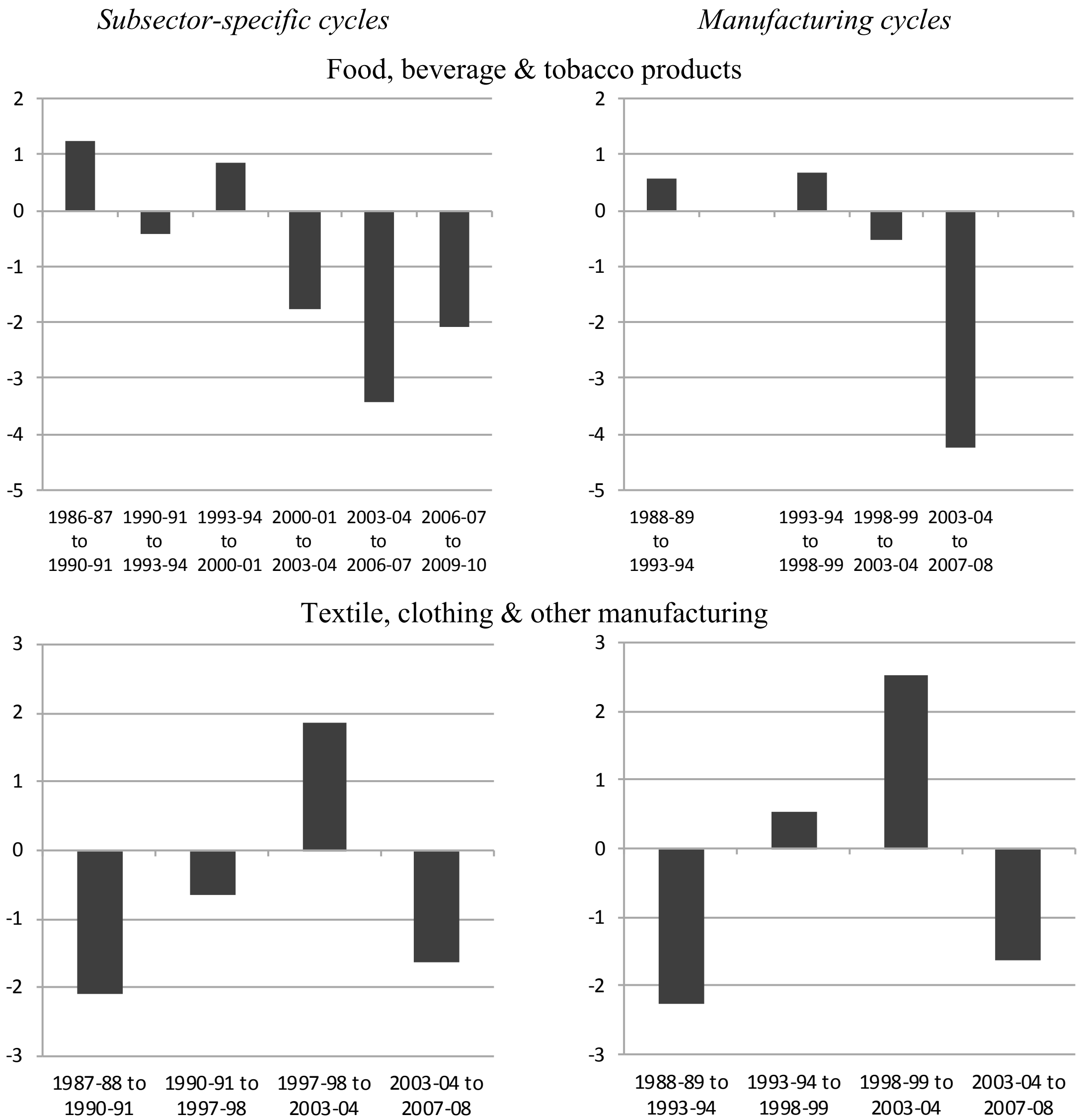

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Figure C.1 **(continued)**

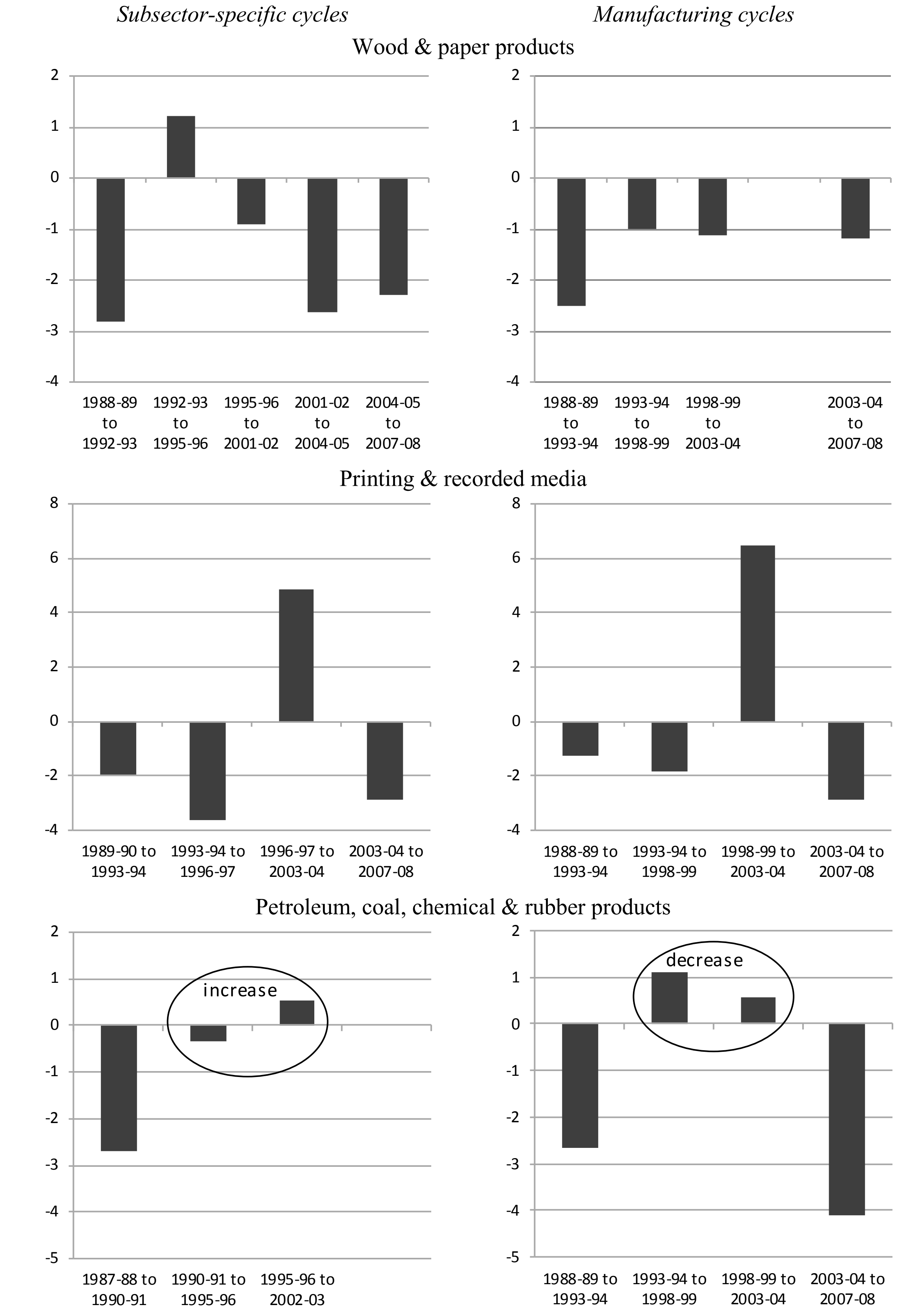

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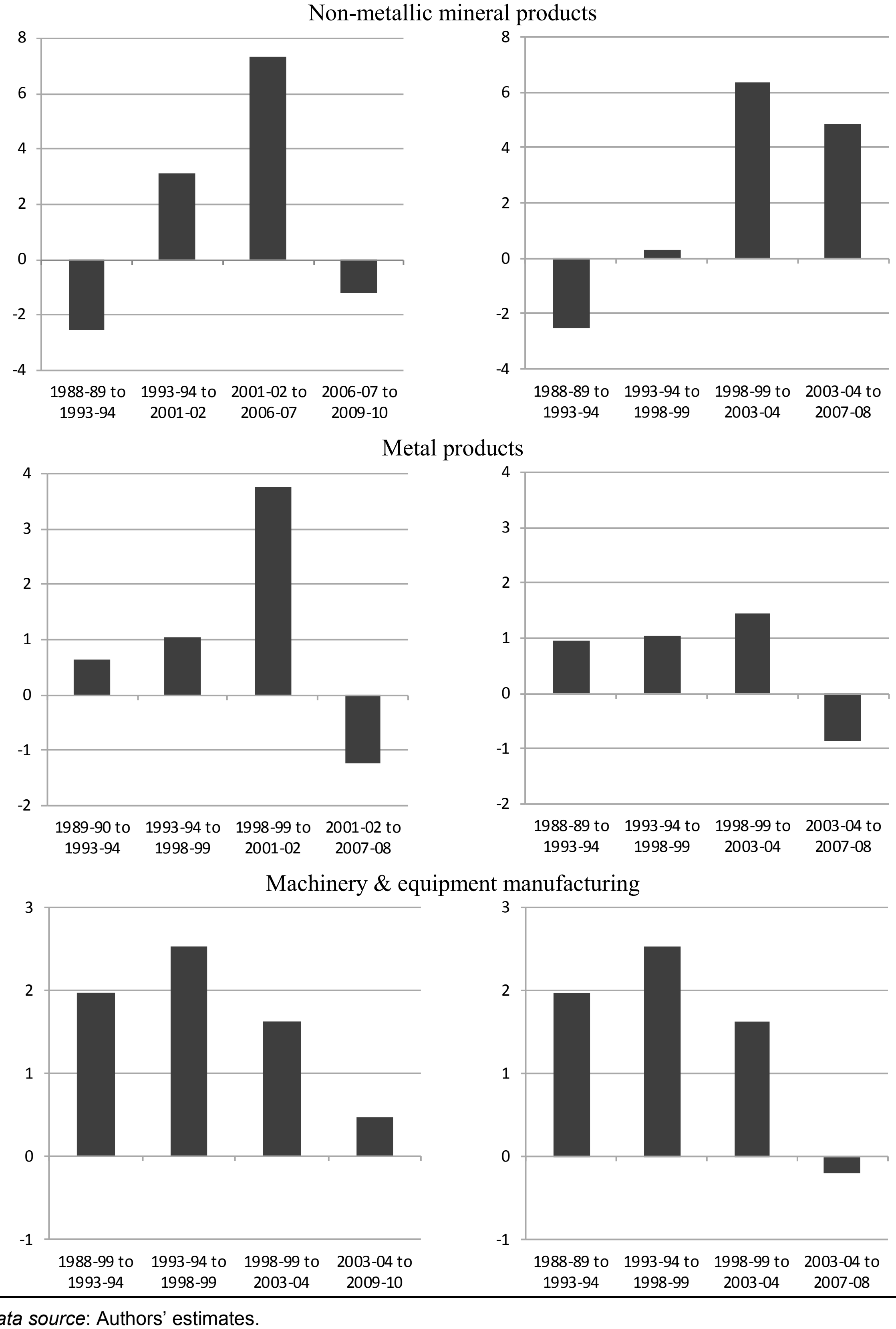
Figure C.1 **(continued)**

Subsector-specific cycles *Manufacturing cycles*



Data source: Authors' estimates.

It is possible that the cycles in some Manufacturing subsectors are related to those in the industry sectors that supply inputs to those Manufacturing subsectors or use the output of those Manufacturing subsectors. For example, Food, beverage and tobacco products uses inputs from Agriculture; Construction uses the output of Non-metallic mineral products and Metal products; and parts of Petroleum, coal, chemical and rubber products and Metal products process the output of Mining.

Table C.3 shows that three peaks for Food, beverage and tobacco products coincide with those for Agriculture and another two peaks are lagged one year from Agriculture peaks.

Table C.3 **Comparison of Food, beverage and tobacco products cycles and Agriculture cycles**[a]

Shaded rows are Agriculture peak years

	Food, beverage & tobacco products	*Agriculture, forestry & fishing*
1985-86[b]		
1986-87	✓sw	
1987-88		
1988-89		
1989-90		
1990-91	✓	✓s
1991-92		
1992-93		
1993-94	✓	✓s
1994-95		
1995-96		
1996-97		✓s2
1997-98		
1998-99		
1999-00		
2000-01	✓s2	✓s2
2001-02		
2002-03		
2003-04	✓	
2004-05		
2005-06		✓
2006-07	✓	
2007-08		
2008-09		✓s
2009-10	✓w	
2010-11[b]		
Number of peaks	7	6

[a] Revisions by the ABS to its official industry MFP time series, as well as additional years of data, may also lead to revisions to the industry cycles identified and average annual growth rates over these cycles. [b] Insufficient observations are available to identify peaks in these years. **w** indicates weakly robust. **s** indicates a small deviation. **2** indicates a peak selected from a pair of close together peaks.

Source: Authors' estimates based on methodology in Barnes (2011).

Table C.4 shows that only one peak for Non-metallic mineral products coincides with those for Construction. Another two peaks for Non-metallic mineral products are in the year before a Construction peak and one is in the year after. Three peaks for Metal products coincide with those for Construction.

Table C.4 Comparison of Non-metallic mineral products, Metal products and Construction cycles[a]

Shaded rows are Construction peak years

	Non-metallic mineral products	*Metal products*	*Construction*
1985-86[b]			
1986-87			
1987-88			✓s
1988-89	✓		
1989-90		✓s	
1990-91			
1991-92			
1992-93			
1993-94	✓	✓s	✓s
1994-95			
1995-96			
1996-97			
1997-98			
1998-99		✓	✓
1999-00			
2000-01			
2001-02	✓s	✓	
2002-03			✓
2003-04			
2004-05			
2005-06			
2006-07	✓		
2007-08		✓	✓s2
2008-09			
2009-10	✓sw		
2010-11[b]			
Number of peaks	5	5	5

a Revisions by the ABS to its official industry MFP time series, as well as additional years of data, may also lead to revisions to the industry cycles identified and average annual growth rates over these cycles. **b** Insufficient observations are available to identify peaks in these years. **w** indicates weakly robust. **s** indicates a small deviation. **2** indicates a peak selected from a pair of close together peaks.

Source: Authors' estimates based on methodology in Barnes (2011).

Table C.5 shows that two peaks for Petroleum, coal, chemical and rubber products coincide with those for Mining and another one is in a year before a Mining peak. For Metal products no peaks coincide with those for Mining, but two peaks are lagged one year from Mining peaks.

Table C.5 **Comparison of Petroleum, coal, chemical and rubber products, Metal products and Mining cycles[a]**

Shaded rows are Mining peak years

	Petroleum, coal, chemical & rubber products	*Metal products*	*Mining*
1985-86[b]			
1986-87			
1987-88	✓		✓s
1988-89			
1989-90		✓s	
1990-91	✓		
1991-92			✓
1992-93			
1993-94		✓s	
1994-95			
1995-96	✓2		✓
1996-97			
1997-98			
1998-99		✓	
1999-00			
2000-01			✓
2001-02		✓	
2002-03	✓s		
2003-04			
2004-05			
2005-06			
2006-07			✓s2
2007-08		✓	
2008-09			
2009-10			✓w
2010-11[b]			
Peaks per industry	4	5	6

[a] Revisions by the ABS to its official industry MFP time series, as well as additional years of data, may also lead to revisions to the industry cycles identified and average annual growth rates over these cycles. [b] Insufficient observations are available to identify peaks in these years. **w** indicates weakly robust. **s** indicates a small deviation. **2** indicates a peak selected from a pair of close together peaks.

Source: Authors' estimates based on methodology in Barnes (2011).

Of these four Manufacturing subsectors, Food, beverage and tobacco products and Metal products appear to have the closest coincidence of subsector-specific cycles with those of the related sector (Agriculture and Construction, respectively).

D Further details about subsector productivity

This appendix provides further details about the *contributions* of the subsectors to Manufacturing multifactor productivity (MFP) growth and its *proximate causes* (changes in value added (VA), labour and capital inputs) in cycle 3 (1998-99 to 2003-04), cycle 4 (2003-04 to 2007-08), and in the current incomplete cycle (2007-08 to 2010-11). (The growth rates over the incomplete cycle that are presented in this appendix should be interpreted with caution because they may be influenced by temporary factors.)

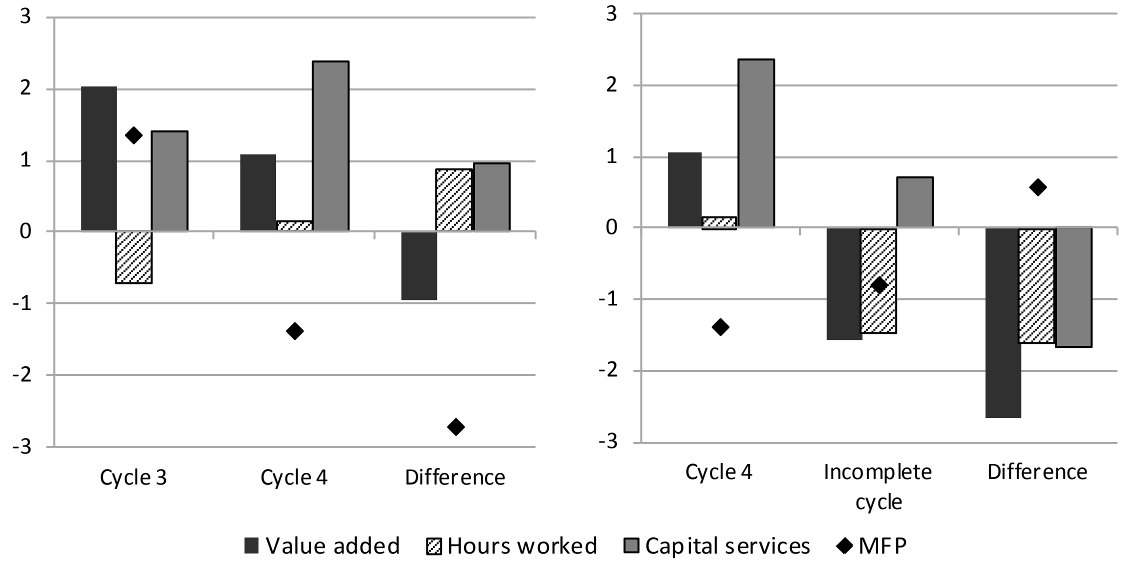
Manufacturing MFP growth went from being positive in cycle 3 to being negative in cycle 4, falling by 2.7 percentage points between the cycles. The decline was driven by a fall in the rate of VA growth and by higher input growth. In cycle 4, capital services growth further increased and there was a transition away from labour shedding in cycle 3, to modest, positive growth in hours worked.

In the incomplete cycle, MFP growth remained negative, although there was some improvement from cycle 4. The decline in VA between cycle 4 and the incomplete cycle was offset by a contraction in labour inputs and lower growth in capital services (figure D.1).

Each of the Manufacturing subsectors makes a different contribution to Manufacturing VA and to its labour and capital inputs. Hence, the subsectors make different contributions to the MFP performance of Manufacturing as a whole (as discussed in chapter 3). The subsectors' contributions to the change in Manufacturing MFP and to its proximate causes between cycle 3 and cycle 4, and cycle 4 and the incomplete cycle are shown below. This is followed by discussion of the proximate causes of the MFP growth specific to each of the subsectors, in the order of the size of their contribution to the Manufacturing MFP decline between cycle 3 and 4.

Figure D.1 **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: ABS (*Experimental Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.0.55.002).

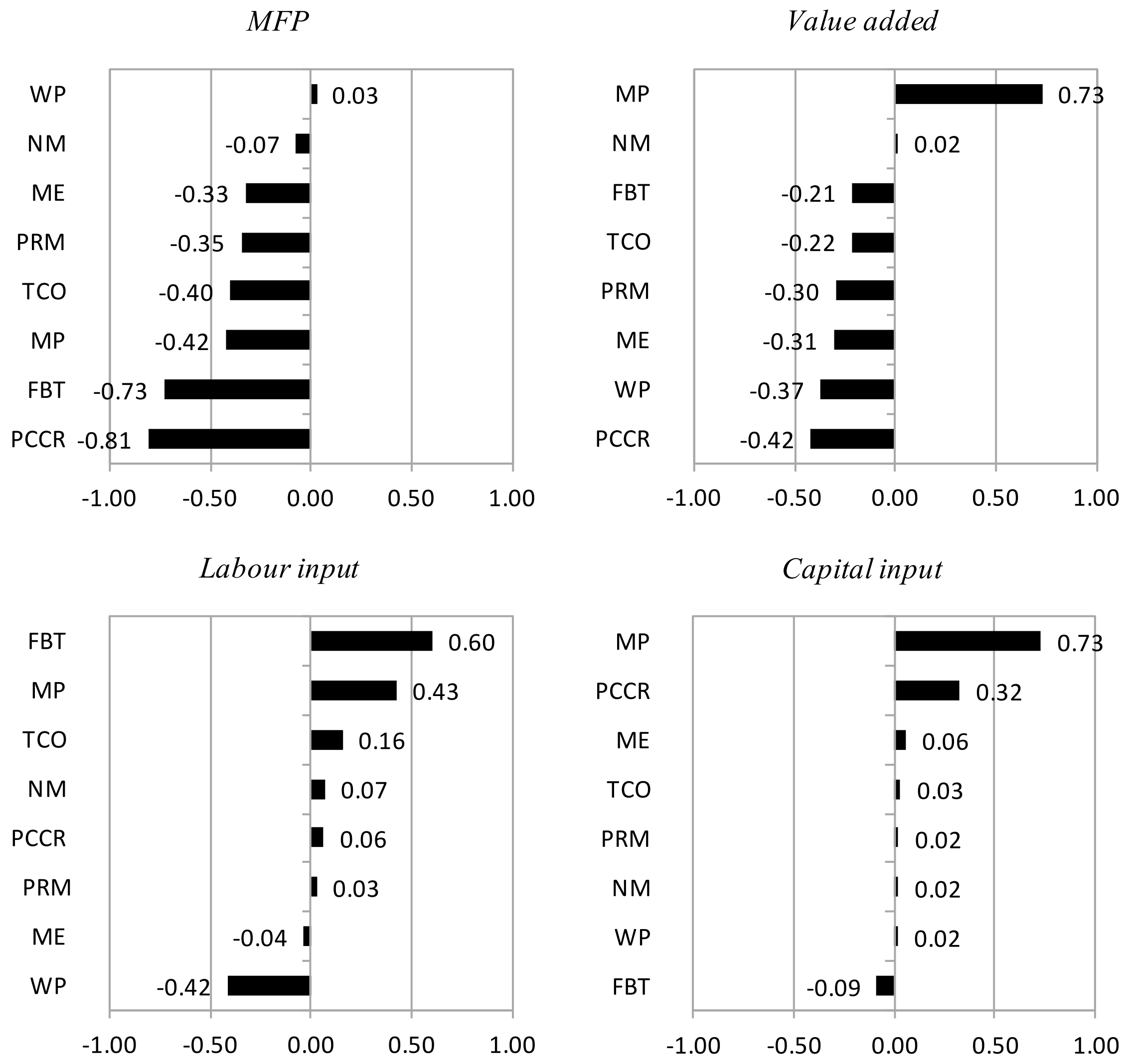
D.1 Subsector contributions to Manufacturing MFP growth

Contributions to decline between cycles 3 and 4

As shown in figure D.2, almost all the subsectors contributed to the decline in MFP growth between the last two complete cycles, with Petroleum, coal, chemical and rubber products (PCCR), Food, beverage and tobacco products (FBT) and Metal products (MP) making the larger negative contributions (as discussed in chapter 3). The MFP decline was due in part to a slowdown in VA growth, to which almost all the subsectors made similar-sized contributions. The exceptions were Non-metallic mineral products (NM), which made very little difference between the cycles, and MP, which made a stand-out positive contribution. The other driver of the MFP decline was the acceleration in Manufacturing inputs growth. This was less evenly spread across subsectors. It was driven largely by FBT and MP (for labour inputs) and by MP and PCCR (for capital inputs).

Figure D.2 **Subsector contributions to total Manufacturing MFP growth and its proximate causes between cycles 3 and 4[a]**

Percentage point change



FBT is Food, beverage and tobacco products; ME is Machinery and equipment manufacturing; MP is Metal products; NM is Non-metallic mineral products; PCCR is Petroleum, coal, chemical and rubber products; PRM is Printing and recorded media; TCO is Textile, clothing and other manufacturing; WP is Wood and paper products. [a] Due to approximation errors, the subsector contributions do not sum to the ABS data shown in figure D.1. See chapter 3 and appendix A for details.

Data source: Authors' estimates.

Within and between effects

The contribution of a subsector to the change in aggregate Manufacturing MFP growth is a combination of changes in its MFP growth and changes in its relative size (that is, changes in the subsector composition of the Manufacturing sector). It is possible to decompose the subsector contributions into these two components — referred to as within and between effects, respectively. (This is also called shift-share analysis.) By looking at the between effects, it is possible to determine the importance of compositional change to the change in aggregate Manufacturing MFP (box D.1). Between cycles 3 and 4, change in the composition of Manufacturing between subsectors made little contribution to the change in Manufacturing MFP, accounting for only 1.4 per cent of the total MFP decline in Manufacturing. Change in the composition of the subsectors will be captured in the within effect.

Box D.1 **Contribution of compositional change to MFP growth**

MFP growth in aggregate Manufacturing can be broken down into growth due to change in the subsector rates of MFP growth and growth due to change in the subsector composition of the Manufacturing sector. This is done by estimating what aggregate Manufacturing MFP growth would have been as a result only of the subsector rates of growth (that is, if there had been no change in the subsector composition of Manufacturing) (the within effect) and comparing it to the actual change in MFP growth. The difference is the compositional (or between) effect.

The table below shows this decomposition for cycles 3 and 4. Comparing the magnitude of the within and between effects, the within effects were generally far more significant than the between effects for each subsector. The exception is TCO in cycle 4, which would have increased Manufacturing MFP (by 0.08 of a percentage point) if its relative size had not declined.

Within and between effects for subsector[a] MFP contributions
Percentage point contributions

	Cycle 3			*Cycle 4*			*Difference between cycles 3 and 4*		
	Total	*Within*	*Between*	*Total*	*Within*	*Between*	*Total*	*Within*	*Between*
FBT	-0.12	-0.14	0.02	-0.85	-0.84	-0.02	-0.73	-0.69	-0.03
TCO	0.38	0.41	-0.03	-0.02	0.08	-0.10	-0.40	-0.33	-0.07
WP	-0.11	-0.08	-0.03	-0.08	-0.12	0.05	0.03	-0.05	0.08
PRM	0.25	0.23	0.02	-0.10	-0.09	-0.01	-0.35	-0.32	-0.03
PCCR	0.08	0.07	0.01	-0.73	-0.71	-0.02	-0.81	-0.78	-0.03
NM	0.31	0.32	-0.01	0.24	0.24	-0.01	-0.07	-0.08	0.01
MP	0.30	0.24	0.07	-0.12	-0.19	0.06	-0.42	-0.42	0.00
ME	0.29	0.31	-0.03	-0.04	-0.05	0.01	-0.33	-0.36	0.03
Sum[b]	**1.38**	**1.37**	**0.01**	**-1.70**	**-1.67**	**-0.03**	**-3.08**	**-3.03**	**-0.04**

[a] For subsector names see figure D.2. [b] Based on the sum of subsector contributions (table 3.4).

Source: Authors' estimates based on methodology from Parham (2012).

The last three columns shows the difference between cycles in the within and between effects. The between column shows that compositional change in Manufacturing contributed only 0.04 of a percentage point to the decline in Manufacturing MFP between cycles (this is just over one per cent of the total MFP decline). This means that growth in the relative size of subsectors with relatively lower MFP growth was only a small contributor to the slowdown in MFP growth in aggregate Manufacturing.

Contributions to the decline between cycle 4 and the incomplete cycle

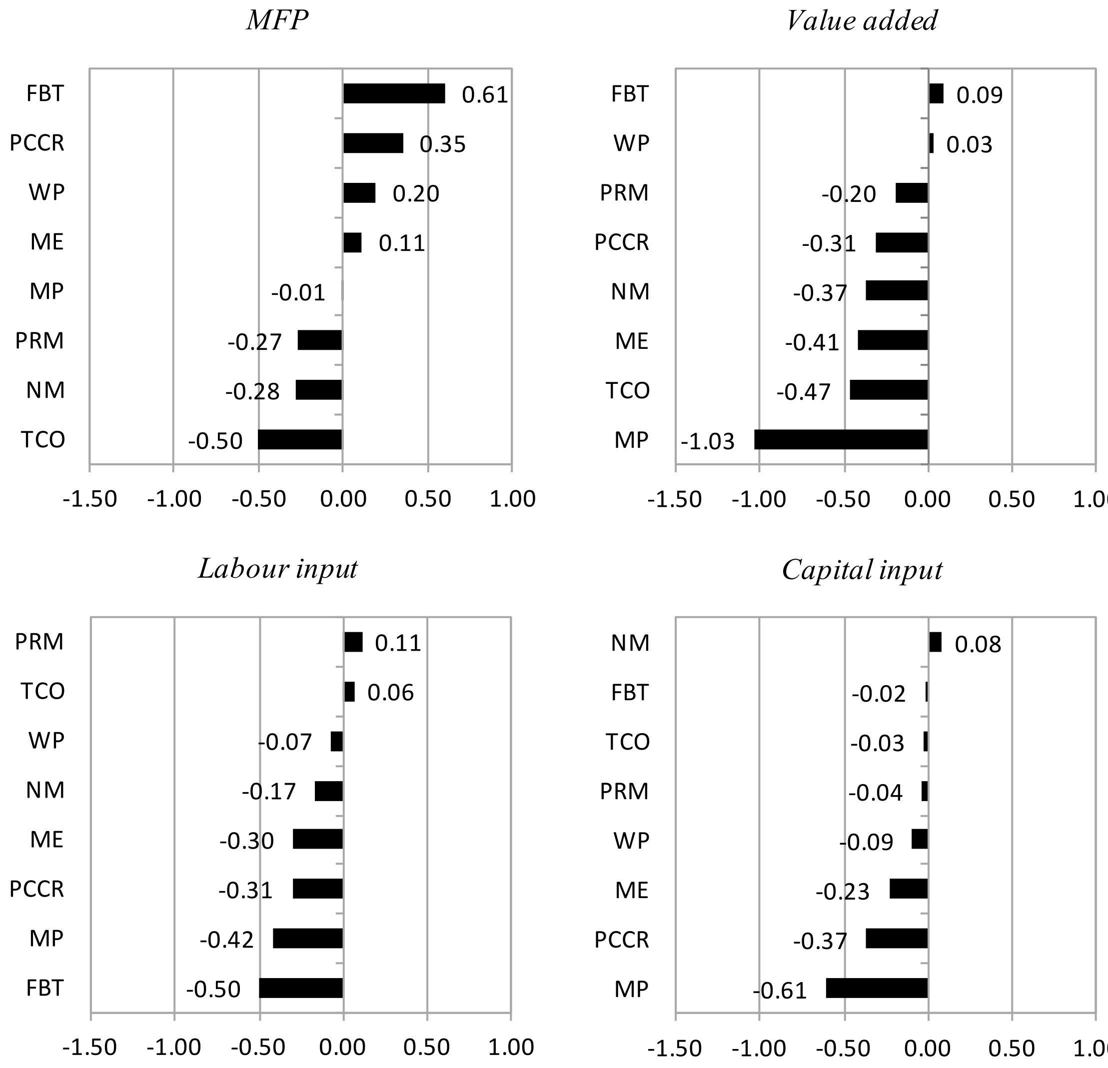
Figure D.3 shows the contribution of the subsectors to the *change* in Manufacturing MFP and in its proximate causes between cycle 4 and the incomplete cycle. Manufacturing experienced a slowing rate of growth in each of the proximate causes: VA, capital and labour. The improvement in Manufacturing MFP was driven by a greater downturn in its capital and labour inputs growth than in its VA growth.

The contribution of the different subsectors to the *change* in MFP growth was mixed. Those subsectors that made positive contributions — FBT, PCCR, Wood and paper products (WP) and Machinery and equipment manufacturing (ME) — were able to offset the negative contributions of the other subsectors — Textile, clothing and other manufacturing (TCO), NM, Printing and recorded media (PRM) and MP.

On the other hand, the subsector contributions to the *change* in the growth in the proximate causes were more uniform in direction, with negative contributions to the change in VA, labour and capital growth being widespread among the subsectors.

- Most subsectors contributed around between 0.2 to 0.5 of a percentage point to the decline in VA growth. MP had a larger contribution of just over 1 percentage point, which accounts for around a third of the VA decline between the cycles.
- There was greater uniformity in the subsectors' contributions to the hours worked decline between the cycles, with each subsector making negative contributions of between -0.1 to -0.5 of a percentage point. PRM and TCO were the exceptions, each making small positive contributions to the change in hours worked.
- The downturn in capital inputs growth was mainly concentrated in ME, PCCR and MP, which together contributed to almost all of the overall decline. The other subsectors combined had less than 0.2 percentage point decline in capital input growth, which is around 10 per cent of the total decline (after netting out the positive contribution of NM).

Figure D.3 **Subsector contributions to total manufacturing MFP growth and its proximate causes between cycle 4 and the incomplete cycle[a]**
Percentage point change



FBT is Food, beverage and tobacco products; ME is Machinery and equipment manufacturing; MP is Metal products; NM is Non-metallic mineral products; PCCR is Petroleum, coal, chemical and rubber products; PRM is Printing and recorded media; TCO is Textile, clothing and other manufacturing; WP is Wood and paper products. [a] Due to approximation errors, the subsector contributions do not sum to the ABS data shown in figure D.1. See chapter 3 and appendix A for details.

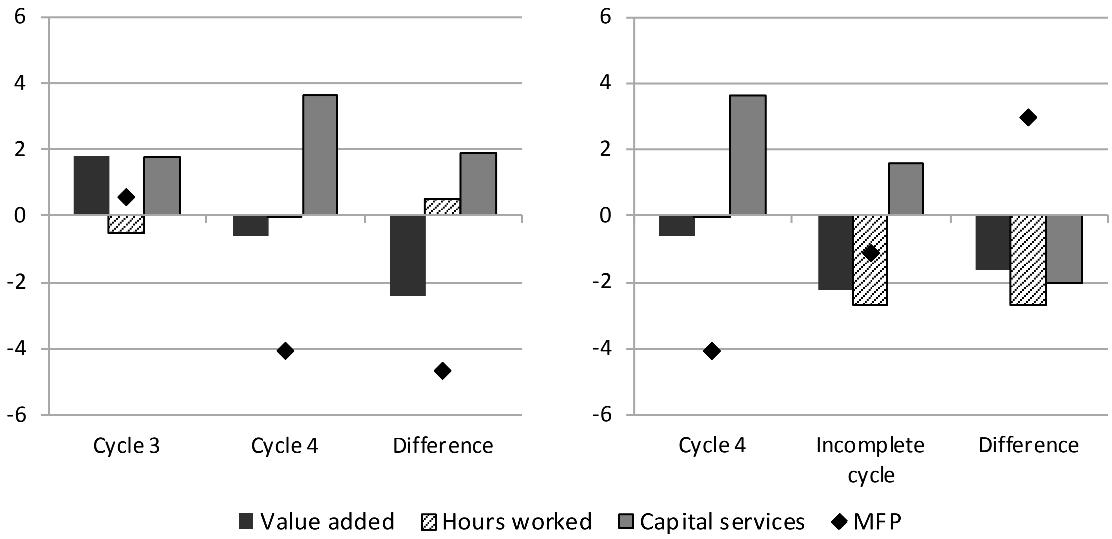
Data source: Authors' estimates.

D.2 Subsector MFP growth and its proximate causes

Petroleum, coal, chemical and rubber products

PCCR had a large decline in MFP between cycles 3 and 4, making the largest contribution to the decline for Manufacturing in total (accounting for around a quarter of the decline). It was also a positive contributor to the improvement in Manufacturing MFP between cycle 4 and the incomplete cycle (figure D.3 above).

Figure D.4 **PCCR MFP growth 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.

Between cycles 3 and 4 (figure D.4), PCCR had a decline in MFP growth to a negative rate. This was associated with:

- a decline in VA growth to a negative rate
- a slowing of labour shedding
- a surge in capital inputs (in cycle 4, PCCR had the second highest capital inputs growth of all the subsectors).

Between cycle 4 and the incomplete cycle there was an improvement in PCCR MFP growth to a less negative rate. This was associated with:

- further decline in VA in PCCR
- intensified labour shedding
- significant slowing in growth in capital inputs.

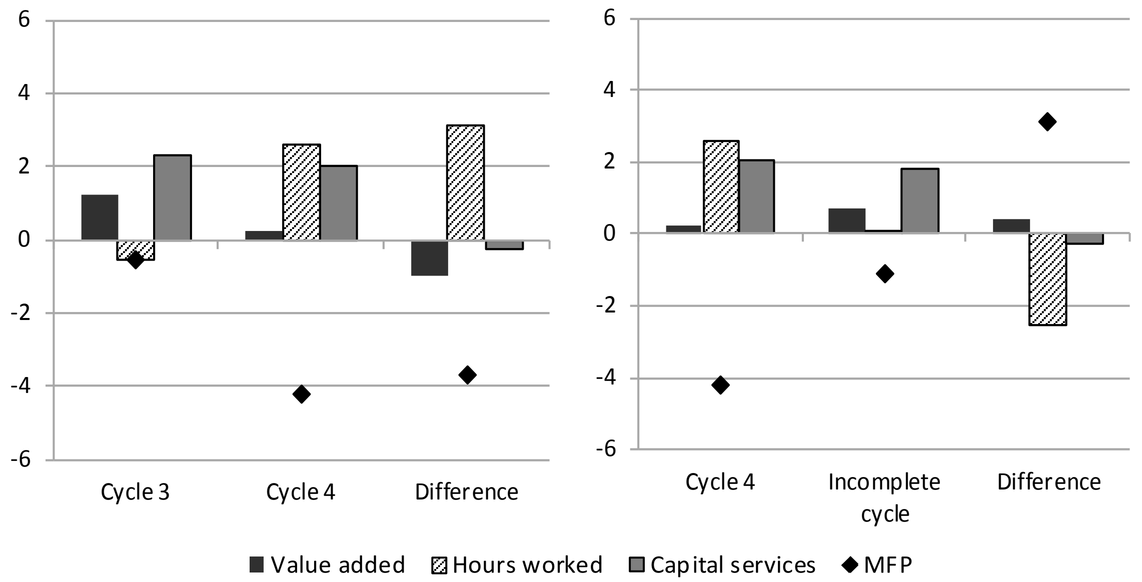
The factors influencing productivity growth in PCCR are discussed in detail in chapter 4.

Food, beverage and tobacco products

FBT made the second largest contribution to the decline in MFP growth for Manufacturing in total between the last two complete productivity cycles. FBT was the largest positive contributor to the improvement in Manufacturing MFP between cycle 4 and the incomplete cycle (with less negative MFP growth in the incomplete cycle).

Figure D.5 **FBT MFP growth 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.

Between cycles 3 and 4, the decline in FBT's MFP growth was driven largely by a surge in hours worked growth with no accompanying surge in VA growth (figure D.5). FBT had:

- positive VA growth in both cycles, but there was a significant fall in its growth between cycles
- a large increase in its hours worked growth between cycles (from labour shedding in cycle 3, to high positive growth in cycle 4)
- a slight fall in capital services growth between cycles.

From the last complete cycle to the current incomplete cycle, FBT's MFP growth became less negative. This was associated with:

- an increase in VA growth
- a decrease in hours worked growth to near zero.
- a slight decrease in capital services growth.

The factors influencing productivity growth in FBT are discussed in detail in chapter 5.

Metal products

MP made the third largest contribution to the MFP decline in Manufacturing between cycles 3 and 4. It did not contribute to the improvement in growth in Manufacturing MFP between cycle 4 and the incomplete cycle.[1]

Between cycle 3 and 4, MP had a decline in MFP growth to a negative rate (figure D.6). Unlike most subsectors, this was associated with a surge in VA growth between the cycles, but an even greater surge in inputs.

- VA growth almost quadrupled.
- There was a transition from cutting hours worked in cycle 3 to having modest hours worked growth in cycle 4.
- Capital growth also surged, almost four times higher in cycle 4 than cycle 3 (MP had the highest capital services growth of all subsectors in cycle 4).

Between cycle 4 and the incomplete cycle MP MFP growth returned to a small positive rate. This was associated with a fall in VA growth but an even larger fall in input growth.

- VA growth fell from a very high positive rate to close to zero.
- Labour inputs growth went from being positive to being negative.
- Capital services input growth fell sharply, but remained positive.

The factors influencing productivity growth in MP are discussed in detail in chapter 6.

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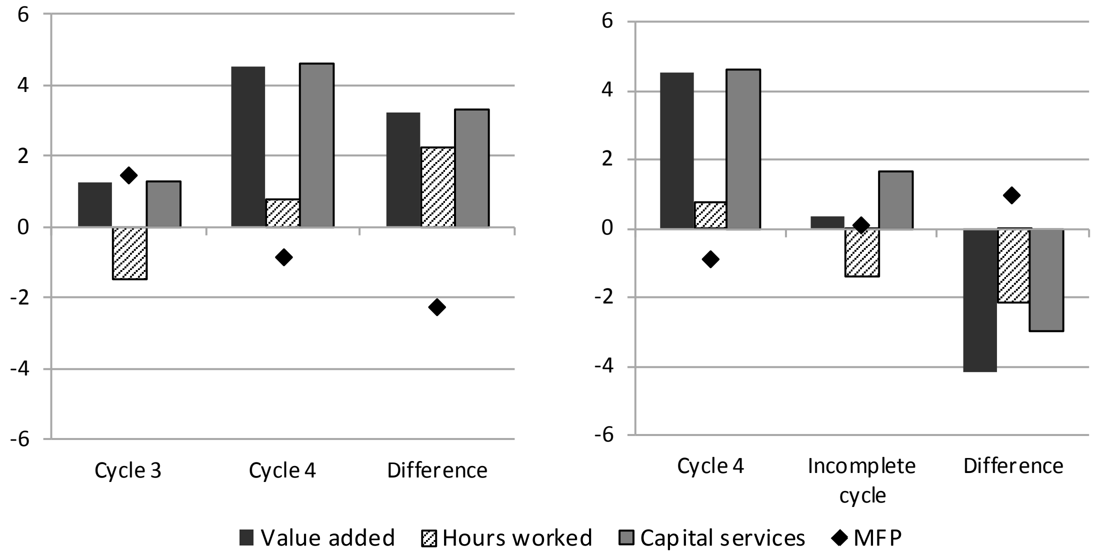
[1] It may seem inconsistent that MP experienced stronger MFP growth in the incomplete cycle, relative to cycle 4, yet did not contribute to the improvement in MFP growth for Manufacturing in total over the same period (figure D.3). This outcome occurs as the weights used to calculate MP's contribution to Manufacturing MFP fell from cycle 4 to the incomplete cycle.

Figure D.6 **MP MFP growth 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.

Textile, clothing and other manufacturing

TCO made a negative contribution to the change in Manufacturing MFP between cycles 3 and 4 that was in the middle of the range. It made the largest negative contribution to the change in MFP between cycle 4 and the incomplete cycle.

TCO had experienced declining VA and labour shedding in the last two complete cycles (figure D.7). Between cycles 3 and 4, MFP growth in TCO went from positive to negative.

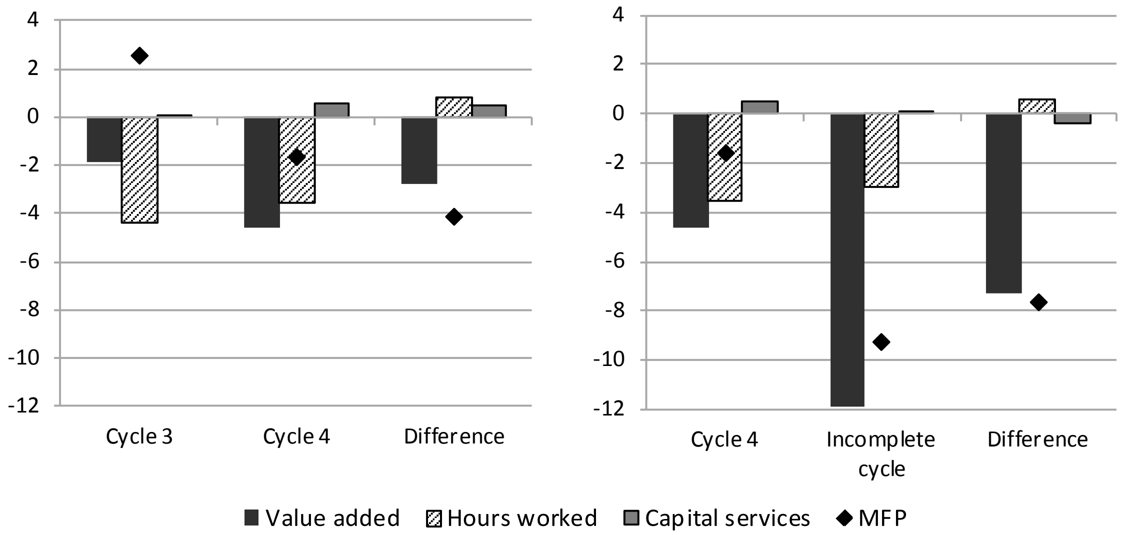
- The rate of its decline in VA more than doubled.
- Labour shedding was substantial in both cycles, but eased slightly between cycles.
- Capital services growth increased slightly.

Between cycle 4 and the current incomplete cycle, TCO experienced very sharp decline in MFP, largely driven by an acceleration of VA decline.

- The decline in VA was much higher than the other subsectors in the incomplete cycle, and it again more than doubled between cycles.
- The rate of labour shedding continued to ease, so that the change in labour input growth was positive.
- Capital services growth fell to near zero.

Figure D.7 **TCO MFP growth 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.

Printing and recorded media

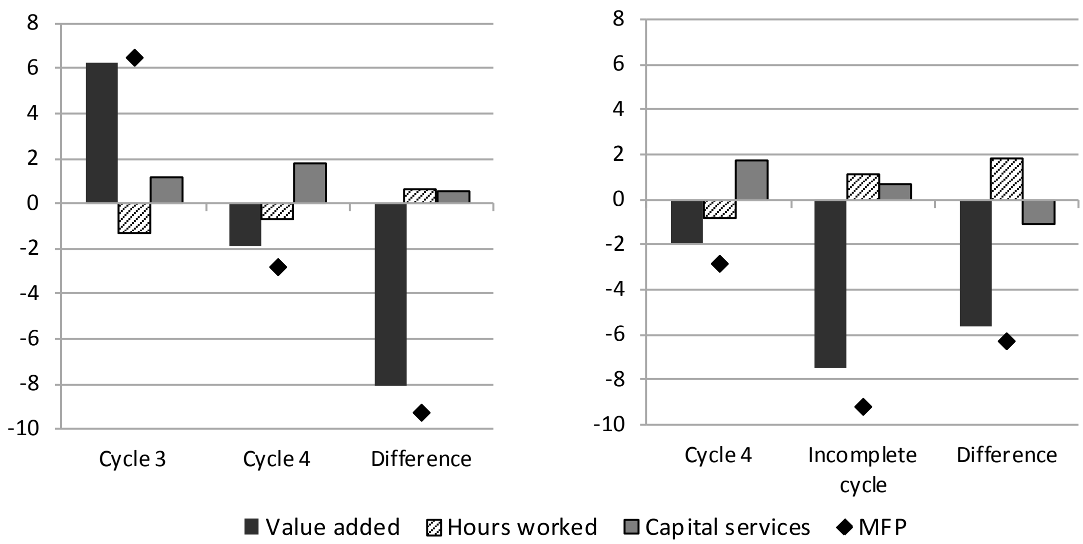
PRM made a moderate contribution to the Manufacturing MFP decline between cycle 3 and 4. Between cycle 4 and the incomplete cycle, it also made a moderate, negative contribution to the change in Manufacturing MFP growth.

Between cycle 3 and 4, PRM experienced a very sharp decline in its MFP growth, going from having the highest MFP growth for all the subsectors in cycle 3, to having negative MFP growth in cycle 4 (figure D.8). This was largely driven by VA decline.

- The subsector's VA growth went from being one of the highest, in cycle 3, to being negative in cycle 4.
- Labour shedding slowed.
- Capital inputs growth increased slightly.

Figure D.8 **PRM MFP growth 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.

Between cycle 4 and the incomplete cycle, there was further decline in MFP growth.

- There was sharp VA decline in the incomplete cycle, with the decline almost quadrupling
- Unlike the other subsectors, PRM went from labour shedding in cycle 4 to hiring more labour in the incomplete cycle
- Capital inputs growth slowed.

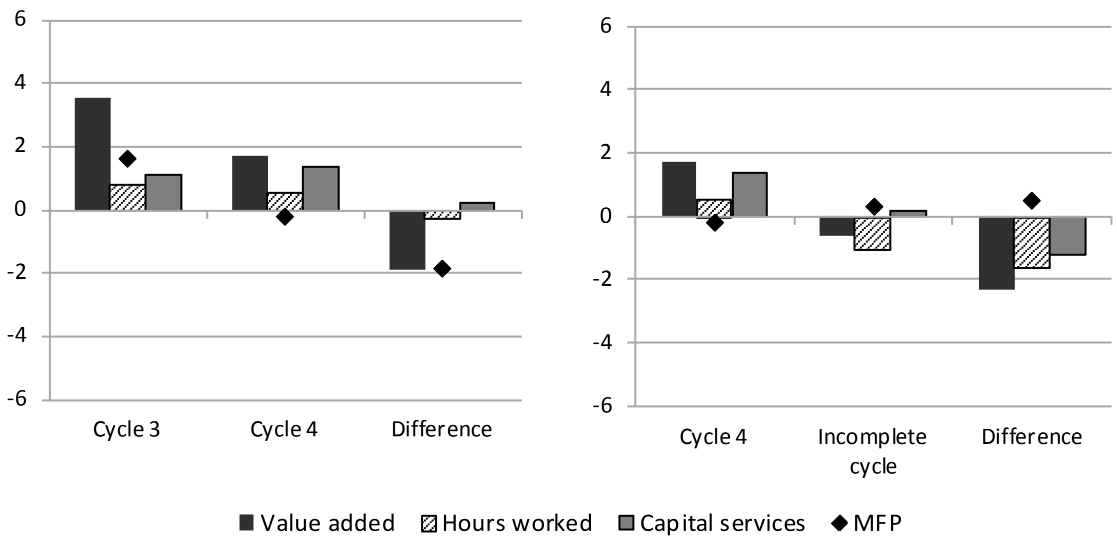
Machinery and equipment manufacturing

ME made a moderate contribution to the MFP decline between cycles 3 and 4, and a small positive contribution to the recovery in MFP growth between cycle 4 and the incomplete cycle.

Between cycle 3 and cycle 4, ME went from having moderate MFP growth to MFP growth just below zero (figure D.9).

- Although ME still had the third highest VA growth in cycle 4, its VA growth rate fell by around half between cycles.
- There was a slight fall in hours worked growth.
- Capital services growth increased slightly.

Figure D.9 **ME MFP growth 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.

Between cycle 4 and the incomplete cycle, MFP recovered slightly because the fall in VA growth was offset by slowing inputs growth.

- VA growth went from being positive to being negative.
- Labour inputs growth also went from positive to negative.
- The capital inputs growth fell to close to zero in the incomplete cycle.

Non-metallic mineral products

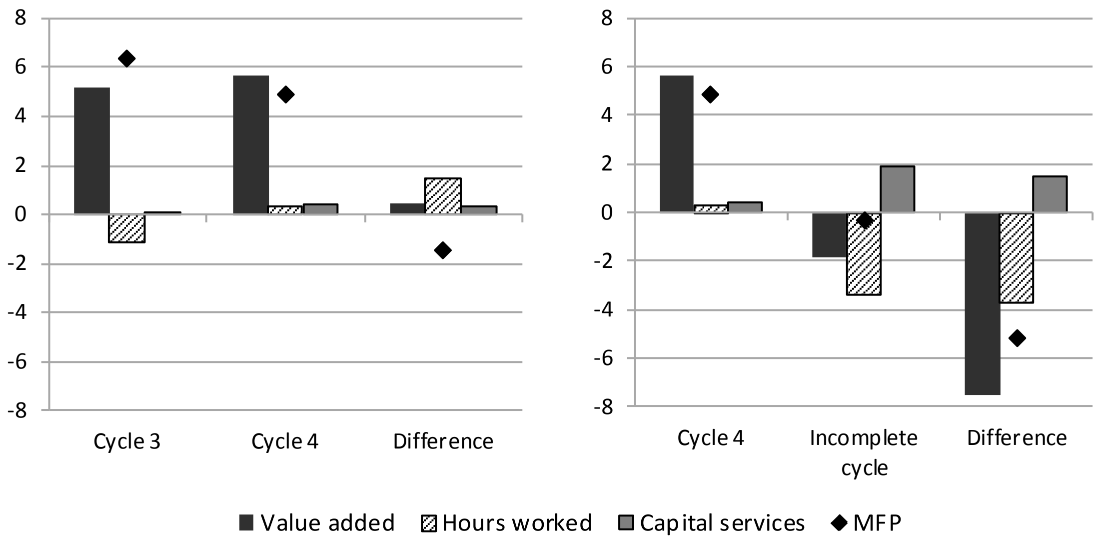
NM made a very small contribution to the decline in Manufacturing MFP between cycles 3 and 4. It made a more significant negative contribution between cycle 4 and the incomplete cycle.

NM had very high MFP growth in the last two complete cycles (figure D.10). While its MFP growth did fall between the cycles, its MFP growth in cycle 4 was higher than all the other subsectors.

- VA growth was strong in both cycles 3 and 4 and increased slightly between the cycles. NM had the highest VA growth rate in cycle 4.
- The change from labour shedding in cycle 3 to near zero growth in cycle 4 was the main driver for the fall in MFP between the cycles.
- There was a very slight increase in the near-zero rate of capital inputs growth.

Figure D.10 **NM MFP growth 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.

Between cycle 4 and the incomplete cycle, MFP growth fell sharply to being close to zero in the incomplete cycle.

- Like many other subsectors, NM experienced VA contraction in the incomplete cycle. Because the VA growth was so high in cycle 4, the fall in VA growth was sharp.
- There was also an increase in capital inputs growth which further contributed to the fall in MFP growth.
- On the other hand, NM also experienced labour shedding in the incomplete cycle, and this helped to reduce the fall in MFP between cycles.

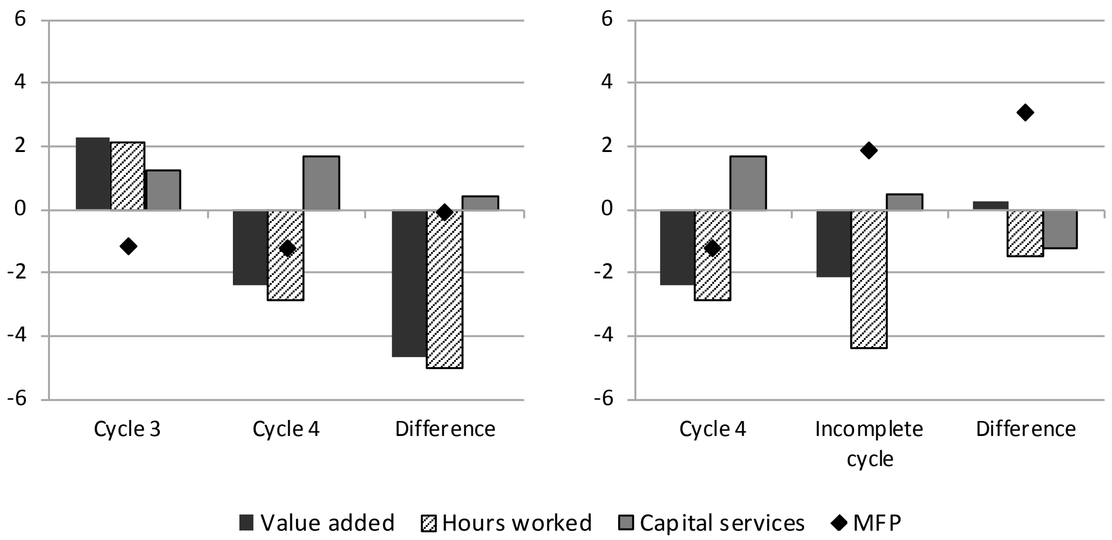
Wood and paper products

WP made a near zero contribution to the change in Manufacturing MFP between cycles 3 and 4.[2] Between cycle 4 and the incomplete cycle, WP made a moderate contribution to the recovery in Manufacturing MFP.

2 It may seem inconsistent that WP had slightly lower MFP growth in cycle 4 than cycle 3, yet made a small offsetting positive contribution to the decline in MFP growth for Manufacturing in total over the same period (figure D.2). This outcome occurs as the weights used to calculate WP's contribution to Manufacturing MFP fell from cycle 3 to cycle 4.

Figure D.11 **WP MFP growth 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.

WP's MFP growth (which was negative in both cycles 3 and 4) remained little changed between the last two complete cycles. Underlying this were sizable, offsetting movements in the proximate causes (figure D.11).

- WP went from experiencing VA growth in cycle 3 to VA contraction of around the same level in cycle 4.
- Similarly, labour inputs growth went from positive to negative, and was able to offset the decline in VA growth, leaving MFP growth little changed between cycles.
- There was a slight increase in capital inputs growth.

MFP growth recovered between cycle 4 and the incomplete cycle, largely due to further contraction in inputs growth.

- The rate of VA decline remained largely unchanged.
- Labour shedding intensified. Of all the subsectors, WP experienced the steepest decline in hours worked in the incomplete cycle.
- Capital inputs growth fell.

E Sensitivity analysis of MFP estimates

Much of the analysis in this paper relies on the validity of the subsector multifactor productivity (MFP) estimates produced in this study. It is, therefore, worthwhile examining how sensitive these estimates are to different data and assumptions used in their estimation (given the limitations discussed in appendix A). The first part of this appendix tests the sensitivity of the MFP estimates by recalculating them using alternate treatments of capital data. The second part of this appendix discusses whether survey error in the measures of inputs and outputs is a likely explanation of MFP growth rates over cycle 4 becoming negative.

The analysis suggests that, regardless of the data source used or the scenario compared against, there was a notable decline in Manufacturing MFP from cycle 3 to cycle 4, and that it was generally driven by the three subsectors focused on in this paper.

E.1 Effects on MFP of using different data and assumptions

Using an alternative investment measure

As noted in the body of the report, and in more detail in appendix A, the two main capital investment series published by the ABS diverge for Manufacturing over the period of cycle 4 (2003-04 to 2007-08), before showing signs of convergence in the incomplete cycle. The gross fixed capital formation (GFCF) series grows faster in cycle 4 relative to private new capital expenditure (PNCE). The former is used by the ABS and in this paper to form the capital input used to derive MFP estimates[1], but it does raise the question as to whether MFP estimates would be materially different if the PNCE levels (rather than just its subsector shares) were used instead.

The methodology for testing such an assumption is straightforward. Rather than using the GFCF-based measure of non-dwelling construction and machinery and equipment (the two principal asset types that form the majority of Manufacturing

[1] Total GFCF for Manufacturing is apportioned to the Manufacturing subsectors by the use of PNCE shares in this paper. See appendix A for more detail.

investment), PNCE is used instead. No change is made for the other asset types — Research and Development (R&D) and Software.[2]

The gap between GFCF and PNCE is largest in cycle 4 (the period of poor productivity) and so the choice of investment series used has the greatest effect over the 2003-04 to 2007-08 period. Table E.1 shows the resulting change in (income-share weighted) capital services growth for each of the subsectors. The effect, on aggregate, is that income-share weighted capital services growth for Manufacturing in total is 1.1 percentage points slower (per year) over cycle 4 when the PNCE measure is used (relative to the GFCF measure).

Table E.1 **Growth in income-share weighted capital services in cycle 4**
Average annual growth rate (per cent)

Subsector	*GFCF-apportioned growth*	*PNCE-derived growth*	*Difference*
Food, beverage & tobacco products	2.1	1.0	-1.1
Textile, clothing & other mfg	0.5	-0.1	-0.6
Wood & paper products	1.7	0.6	-1.1
Printing & recorded media	1.8	0.8	-0.9
Petroleum, coal, chemical & rubber prod.	3.7	2.6	-1.1
Non-metallic mineral products	0.4	-0.6	-1.0
Metal products	4.6	2.9	-1.7
Machinery & equipment mfg	1.4	0.8	-0.6
Aggregate of subsectors	*2.5*	*1.4*	*-1.1*
Total Manufacturing (ABS)[a]	**2.4**	**na**	**na**

[a] Corresponding figure published by the ABS.

Sources: ABS (*Estimates of Industry Multifactor Productivity, 2010-11,* Cat. no. 5260.55.0.001); authors' estimates based on ABS (*Private New Capital Expenditure and Expected Expenditure,* various issues, Cat. no. 5625.0).

The greatest effect in moving to a PNCE-based measure is in Metal products, where capital services growth is much slower under the PNCE-based measure. In addition, the PNCE-based measure gives Non-metallic mineral products and Textiles, clothing and other manufacturing negative capital services growth over cycle 4, compared with positive growth under the GFCF-based measure.

The change in capital services has an effect on MFP growth, and in turn affects the contributions made by the different subsectors over the period from cycle 3 to cycle 4. Table E.2 shows the capital contribution made to MFP growth for the GFCF- and PNCE-based measures between cycles 3 and 4.

2 That is, GFCF-apportioned measures of R&D and Software are used. There are no PNCE data for these asset classes.

Table E.2 **Subsector contributions to the change in Manufacturing MFP growth between cycles 3 and 4, based on GFCF-apportioned and PNCE-based capital services measures**[a]

Percentage points

Subsector	*GFCF-apportioned MFP*	*PNCE-based MFP*	*Difference*
Food, beverage & tobacco products	-0.73	-0.65	0.08
Textile, clothing & other mfg	-0.40	-0.38	0.02
Wood & paper products	0.03	0.05	0.02
Printing & recorded media	-0.35	-0.33	0.02
Petroleum, coal, chemical & rubber prod.	-0.81	-0.81	0.00
Non-metallic mineral products	-0.07	-0.05	0.02
Metal products	-0.42	-0.25	0.17
Machinery & equipment mfg	-0.32	-0.28	0.05
Aggregate of subsectors[b]	**-3.08**	**-2.70**	**0.38**

a Note that the contributions are negative, as growth in capital inputs reduces MFP growth. **b** The sum of contributions. Based on methodology discussed in Parham (2012).

Source: Authors' estimates.

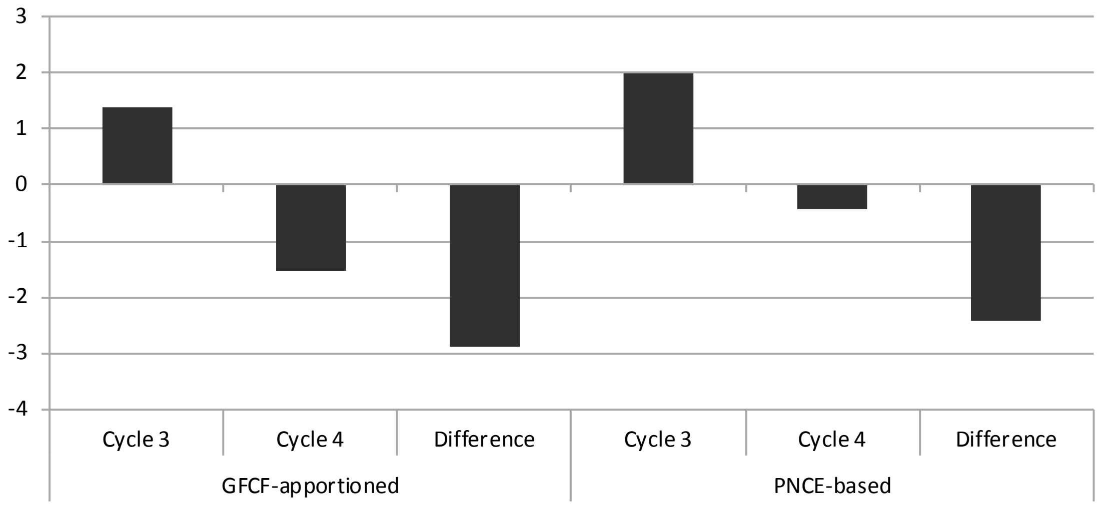
The use of a PNCE-based capital services measures reduces the decline in productivity from cycle 3 to cycle 4, but there is still a marked decline in Manufacturing MFP regardless of which series is used. Within Manufacturing, the use of the PNCE-based measure of capital services does have an effect on contributions of the different subsectors; the largest being on Metal products.[3] The PNCE-based measure still indicates that Petroleum, coal, chemical and rubber products and Food, beverage and tobacco products contributed the most to the MFP decline from cycle 3 to cycle 4, while Metal products makes a lesser contribution compared with Textiles, clothing and other manufacturing, Printing and recorded media and Machinery and equipment manufacturing.

In short, PNCE represents a lower level of investment relative to GFCF and therefore raises the level of MFP in both cycles. In doing so, although it has a more positive effect on MFP in cycle 4, it preserves most of the difference between the two cycles and therefore does not significantly affect the decline in MFP that occurs from cycle 3 to cycle 4 (figure E.1).

3 Metal products is more sensitive to the use of the PNCE-based relative to other subsectors because its share of PNCE was rising over cycle 4. Under the GFCF-apportionment method used in the body of this paper, this meant its share of GFCF was rising over cycle 4 — effectively giving the subsector a rising share of a rising investment series.

Figure E.1 **Rates of MFP growth in Manufacturing based on capital measure used**

Average annual growth rate (per cent)



Data source: Authors' estimates.

Effect of removing R&D from the capital services measure

The estimates of MFP presented in this paper are consistent with the present ABS treatment of R&D expenditure, which is to record such expenditure as a capital input, rather than an intermediate input.[4] It is worthwhile checking the extent to which growth in R&D contributes to growth in subsector capital services, given the variety of R&D intensities at that level of disaggregation.

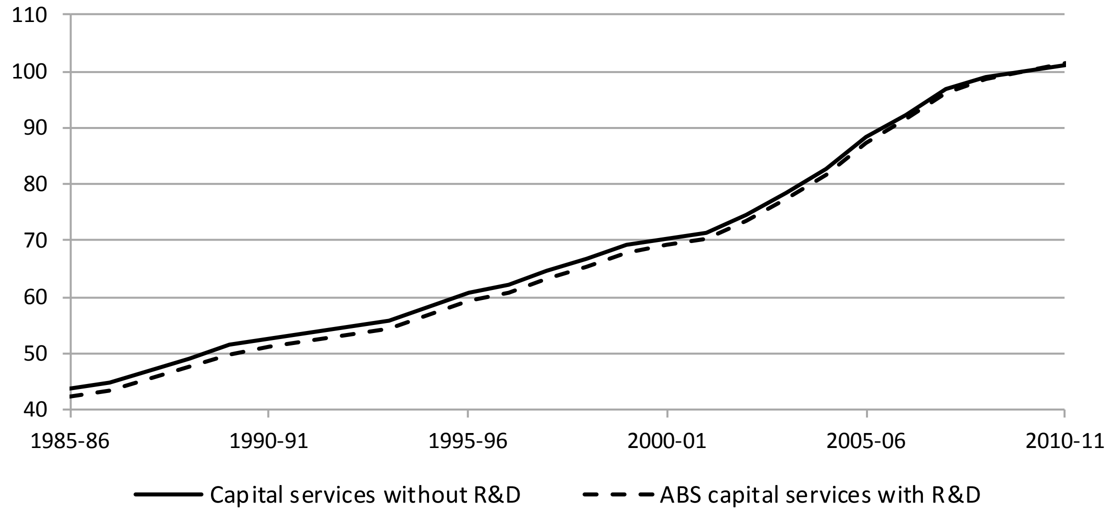
R&D expenditure makes up a small proportion of investment, but grew more quickly than the rest of investment over cycle 4. Because the lag between when R&D is undertaken and when output associated with that R&D occurs can be large, it is possible that the growth in R&D expenditure in cycle 4 could manifest as a productivity decline.

A way to test this hypothesis is to remove R&D from the capital services measure published by the ABS for Manufacturing in total. The effect on the resulting capital services index is very small (figure E.2), with capital services growth being marginally slower when R&D is excluded.

4 Prior to 2008-09, current R&D expenditure was recorded as intermediate inputs by the ABS. The ABS has backcast its capital measures to reflect the change in the treatment of R&D so that its measures remain comparable over time.

Figure E.2 **Manufacturing capital services with and without R&D**

Index 2009-10 = 100



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

While there is no great effect in aggregate, it could be possible that excluding R&D could have a proportionally greater effect on particular R&D intensive subsectors within Manufacturing. This is most readily shown by the contribution to capital services made by R&D (table E.3). For example, in cycle 3, R&D contributed a total of 0.07 to the 2.47 percentage points growth in Manufacturing capital services. At the subsector level, there is little effect of R&D on total capital services growth.

Table E.3 **Contributions to capital services growth attributable to R&D**

Percentage points

Subsector	*Cycle 1: 1988-89 to 1993-94*	*Cycle 2: 1993-94 to 1998-99*	*Cycle 3: 1998-99 to 2003-04*	*Cycle 4: 2003-04 to 2007-08*
Food, beverage & tobacco products	0.01	0.00	0.01	0.01
Textile, clothing & other mfg	0.00	0.00	0.00	0.00
Wood & paper products	0.01	0.00	0.00	0.00
Printing & recorded media	0.00	0.00	0.00	0.00
Petroleum, coal, chemical & rubber prod.	0.01	0.01	0.02	0.02
Non-metallic mineral products	0.00	0.00	0.00	0.00
Metal products	0.02	0.01	0.01	0.01
Machinery & equipment mfg	0.03	0.02	0.03	0.02
Manufacturing	0.07	0.05	0.07	0.03
Manufacturing[a] (all assets)	**1.25**	**1.40**	**2.47**	**1.17**

[a] Denotes the total capital services growth for Manufacturing as a whole.

Source: Authors' estimates.

It seems reasonable to conclude, then, that R&D has not had a large effect on capital services growth, and so even if there were a lag between investment and output linked to R&D, the effect of the investment is so small as not to alter the observed trends in MFP in Manufacturing at either the aggregate or subsector level.

E.2 Is survey error a likely explanation of MFP growth falling below zero?

A statistical error can be introduced when data derived from a survey are used to represent a population. This error can be quite large (depending on the survey sample design).

Because many variables used to calculate MFP are derived from survey data, there is a question as to whether the observed trends are what actually happened in the economy, or are the result of sampling or other measurement error. This section determines what the size of the error would have to be in order for MFP growth in Manufacturing to have been zero over cycle 4. This benchmark of zero MFP growth is chosen because the absolute decline in MFP in cycle 4 is the focus of this paper.

It follows that if the change needed for MFP growth to have been zero over cycle 4 is unreasonably large, then it is less likely to have been the result of errors. If, however, the change required is small, then the likelihood of the result being driven by error is more likely — meaning the estimates may be less reliable.

Because MFP growth was less than zero in cycle 4 for Food, beverage and tobacco products, Petroleum, coal, chemical and rubber products, Metal products, and for Manufacturing as a whole, an increase in value added or a large decline in hours worked and capital services would have been necessary in each to achieve zero MFP growth over the same period. The magnitude of these changes required are sufficiently large in each these subsectors so as to indicate that the decline in productivity is unlikely to be the result of statistical error in the data. (Note that this analysis does not address other measurement issues that may affect the data, such as unmeasured quality improvements or the effect of capital lags.)

Table E.4 shows the changes needed for 2007-08 relative to what occurred in that year.[5] For example, in order for Food, beverage and tobacco products to have had zero MFP growth in cycle 4, its value added would needed to have been greater by

[5] 2007-08 is the end-point of the aggregate Manufacturing productivity cycle, and so changes in the rate of growth over cycle 4 can be effected by changing the level of value added, hours worked and capital services for that year.

$4.1 billion in 2007-08 (or an additional 18 per cent relative to what actually occurred).

Table E.4 **Changes needed in selected subsectors and Manufacturing in total to achieve zero MFP growth in cycle 4[a]**

	Change to 2007-08 estimate	*Difference[b]*
Value added	Additional value added (2009-10 $m)	Per cent
Food, beverage & tobacco products	4 154	18
Petroleum, coal, chemical & rubber prod.	3 345	17
Metal products	753	3
Aggregate of subsectors	*6 951*	*6*
Hours worked	Additional hours worked ('000)	Per cent
Food, beverage & tobacco products	-108.1	-25
Petroleum, coal, chemical & rubber prod.	-64.0	-32
Metal products	-22.0	-7
Aggregate of subsectors	*-201.2*	*-10*
Net capital stock[c]	Additional net capital stock (2009-10 $m)	Per cent
Food, beverage & tobacco products	-11 251	-38
Petroleum, coal, chemical & rubber prod.	-8 144	-29
Metal products	-3 597	-8
Aggregate of subsectors	*-23 230*	*-15*

[a] Specifically, the changes needed to achieve zero MFP growth for Food, beverage & tobacco products, Petroleum, coal, chemical & rubber products, Metal products and aggregate Manufacturing are shown here, separately. [b] Percentage difference relative to actual 2007-08 values. [c] Capital inputs are calculated using capital services indexes, which in turn relate to a weighting of productive capital stock (appendix A). Rather than present the weighted productive capital stock, changes in the net capital stock are used here instead to show the magnitude of capital change needed to achieve the outcomes under each of the relevant scenarios.

Source: Authors' estimates.

In terms of value added, the amount of additional output needed to have had zero MFP growth over cycle 4 (rather than negative MFP growth) is quite large for aggregate Manufacturing (an additional 6 per cent), but is even larger for Food, beverage and tobacco products and Petroleum, coal, chemical and rubber products (18 and 17 per cent, respectively). Because Metal products is closer to zero MFP growth to begin with, it requires a comparatively smaller amount of additional value added growth (3 per cent) to achieve zero MFP growth.

A 10 per cent reduction in hours worked would have been necessary in 2007-08 for Manufacturing in total to have achieved zero MFP growth during for cycle 4. A larger reduction in hours worked for 2007-08 are necessary to have achieved zero MFP growth in Food, beverage and tobacco products — in the order of 25 per cent relative to what actually occurred. This reduction is large as it effectively reverses the particularly strong growth of hours worked that Food, beverage and tobacco products experienced over cycle 4.

A reduction of 32 per cent of hours worked in 2007-08 (relative to what actually occurred) would have been necessary for Petroleum, coal, chemical and rubber products to have achieved zero MFP growth in cycle 4. The reason why this reduction is so proportionately large is that Petroleum, coal, chemical and rubber products is particularly capital intensive, and so a reduction in hours worked has a smaller effect on increasing MFP, relative to other subsectors.

In terms of capital services, in order to achieve zero MFP growth for Manufacturing in cycle 4 there would have had to have been a reduction in capital services growth that equates to around 15 per cent of net capital stock. The reductions are comparatively larger for Food, beverage and tobacco products and Petroleum, coal, chemical and rubber products to have achieved zero MFP growth in cycle 4 (38 and 29 per cent, respectively). The reduction necessary in Food, beverage and tobacco products is large as the subsector is relatively labour intensive (and so, reductions in capital inputs have a smaller effect on increasing MFP). The reduction in Petroleum, coal, chemical and rubber products is large as it effectively reduces the very strong capital services growth that occurred in the subsector over cycle 4. The net capital stock of Metal products would have needed to have been 8 per cent smaller in 2007-08 for that subsector to have achieved zero MFP growth.

The changes in proximate causes that would have been necessary to achieve zero MFP growth in cycle 4 are large for aggregate Manufacturing and even larger for Food, beverage and tobacco products and Petroleum, coal, chemical and rubber products. For those two subsectors, the scale of how much additional value added or reduced hours worked and capital services suggests that the negative MFP estimate is unlikely to have been caused simply by random statistical error in the data. The changes necessary for Metal products to have achieved zero MFP growth over cycle 4 are smaller relative to Food, beverage and tobacco products and Petroleum, coal, chemical and rubber products, and are therefore more likely to be sensitive to any statistical error in the underlying statistics. Nevertheless, the required changes for Metal products are still substantial in absolute terms.

F Additional information on Petroleum, coal, chemical and rubber products

Additional data about the Petroleum, coal, chemical and rubber products (PCCR) subsector (which is chiefly discussed in chapter 4) are presented in this appendix. These additional data include a longer-term view of how the composition of PCCR has changed through time, some trade and assistance data, and more detailed hours worked information.

F.1 A longer-term view of the composition of PCCR

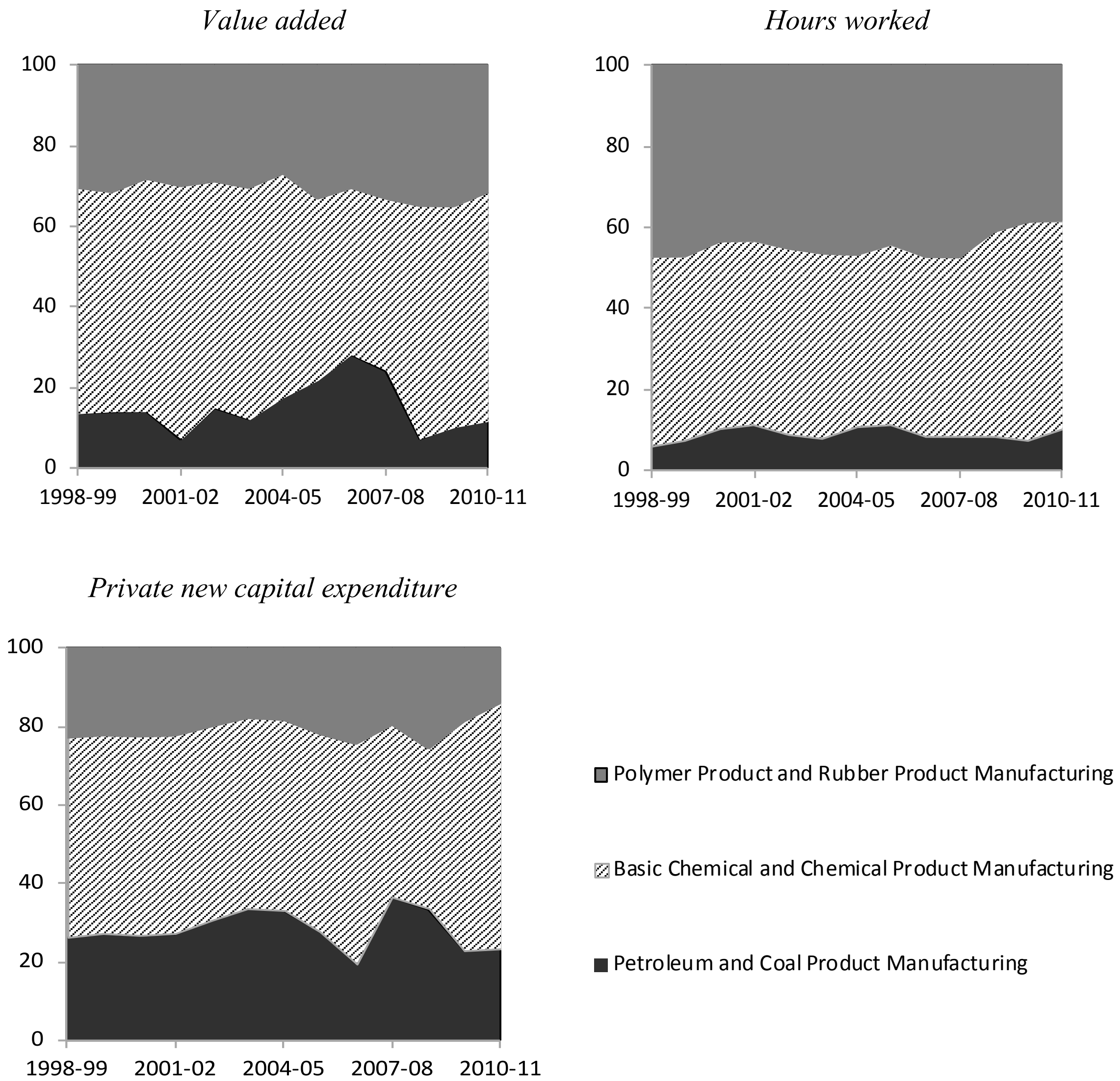
The composition of the PCCR subsector was discussed in terms of the share that each subdivision comprised of value added, hours worked and investment in 2009-10. Figure F.1 shows how these shares have changed, over the period covering cycle 3 through to the incomplete cycle, for each of the three PCCR subdivisions: Petroleum and coal product manufacturing (‘Petroleum’), Basic chemical and chemical production manufacturing (‘Chemicals’), and Polymer product and rubber product manufacturing (‘Polymers’).

Disaggregating the PCCR value added (from the ABS National Accounts) is difficult as there is no real measure published for the PCCR subdivisions. Attempts to derive estimates for real value added at the subdivision level by deflating nominal values using producer price indexes (PPIs) yielded measures[1] that are not consistent with the estimates from the National Accounts (table F.1).

1 Deflating disaggregated nominal value added data by using PPIs for output can only provide a broad approximation of real value added derived from double deflation. Double deflated real value added involves separate deflation of gross output and intermediate inputs using separate price indexes for each. If there are changes in intermediate input prices that are different to those of output prices, then deflating the nominal value added data by output deflators will differ from a double deflated series.

Figure F.1 **Composition of PCCR — value added, hours worked and investment[a]**

Percentage shares



a Current price data used for value added and private new capital expenditure. Data for net capital stock are not available at this level of disaggregation.

Data sources: ABS (unpublished Survey of New Capital Expenditure data); ABS (*Australian Industry,* various issues, Cat. no. 8155.0); ABS (*Australian Manufacturing,* various issues, Cat. no. 8221.0); ABS (unpublished Labour Force Survey data).

Table F.1 Comparison of PCCR output measures and prices

Average annual growth rate (per cent)

	Cycle 3	*Cycle 4*	*Incomplete cycle*
Value added			
PCCR (real)[a]	**1.8**	**-0.6**	**-2.3**
Petroleum and coal product mfg (nominal)	0.5	32.9	-24.9
Basic chemical and chemical product mfg (nominal)	3.3	4.0	5.1
Polymer product and rubber product mfg (nominal)	2.8	14.3	-5.9
Sum of subdivisions (nominal)	*2.8*	*11.9*	*-4.3*
Petroleum and coal product mfg (real)[b]	-12.5	10.0	-21.3
Basic chemical and chemical product mfg (real)	2.7	0.4	3.0
Polymer product and rubber product mfg (real)	1.0	9.8	-7.2
Sum of subdivisions (real)	*-2.4*	*0.9*	*-3.6*
Sales and service income[c]			
Petroleum and coal product mfg (nominal)	9.1	7.9	-5.9
Basic chemical and chemical product mfg (nominal)	9.8	11.7	3.8
Polymer product and rubber product mfg (nominal)	8.8	6.3	-9.0
Sum of subdivisions (nominal)	*9.2*	*8.7*	*-3.0*
Petroleum and coal product mfg (real)	-4.9	-9.8	-2.0
Basic chemical and chemical product mfg (real)	9.0	7.0	0.6
Polymer product and rubber product mfg (real)	7.0	2.6	-10.3
Sum of subdivisions (real)	*1.9*	*-1.7*	*-2.5*
Price deflators			
Output PPI: Petroleum and coal product mfg	14.8	20.9	-4.5
Output PPI: Basic chemical and chemical product mfg	0.7	3.5	2.1
Output PPI: Polymer product and rubber product mfg	1.8	4.1	1.4
Output PPI: PCCR[d]	*7.7*	*11.6*	*-0.9*
Input PPI: Petroleum and coal product mfg	11.6	21.1	-1.3
Input PPI: Basic chemical and chemical product mfg	1.0	6.1	-1.5
Input PPI: Polymer product and rubber product mfg	1.3	6.1	-0.8
Input PPI: PCCR[d]	*6.2*	*13.0*	*-1.3*
Sales and service income: PCCR[d]	*7.4*	*10.4*	*-0.5*

[a] National accounts chain volume measure of PCCR value added [b] Deflated series using output PPIs. The 'sum of subdivisions' series generated by estimating a PPI for PCCR by using subdivision PPIs and current price value added weights. [c] Sales and service income from ABS *Business Indicators*. The real 'sum of subdivisions' series generated by estimating a price deflator for PCCR by using subdivision deflators and current price sales and service income weights. [d] Deflators estimated using relevant subsector deflators weighted by nominal sales and service income shares.

Sources: Authors' estimates based on ABS (*Australian System of National Accounts*, *2010-11*, Cat. no. 5204.0), ABS (*Business Indicators, Australia, September 2012*, Cat. no. 5676.0), ABS (*Producer Price Indexes, Australia, December 2012*, Cat no. 6427.0).

The data show the difficulty in trying to reconcile value added growth for the subdivisions with value added growth for the subsector. For example, value added growth for PCCR was 1.8 and -0.6 per cent a year in cycles 3 and 4, respectively; however from the subdivision data deflated using output producer price deflators the growth rates are -2.4 and 0.9 per cent a year for those cycles. One set of data suggests accelerating value added growth, while the other suggests declining.

One reason for the discrepancy is that the value added data for the subsector and the subdivisions come from different sources. The subdivision data are sourced from ABS publications based on the *Manufacturing Census* and *Economic Activity Survey*. The subsector data are also based on these sources, together with a range of other information the ABS uses in compiling the National Accounts.[2]

The sales and service income measures are closer to value added growth for PCCR. It is for this reason that the sales and service income measures are used in chapter 4 to help explain what occurred at the subdivision level in terms of output trends.

F.2 PCCR trade

One of the trends discussed in chapter 4 was the rising volume of imports of chemical and plastic products (table 4.3). Data for imports — available on a Standard International Trade Classification (SITC) basis rather than an Australian and New Zealand Standard Industrial Classification (ANZSIC) basis — showed that the fastest volume growth from cycle 3 to cycle 4 occurred in the 'Organic chemicals' and 'Plastics in non-primary form' groups.

Within 'Organic chemicals', growth was particularly strong in subgroup 515: 'Organo-inorganic compounds, heterocyclic compounds, nucleic acids and their salts, and sulphonamides', with import growth rising from -0.8 to 7.4 per cent a year over cycles 3 and 4, respectively.

'Plastics in non-primary form' consists of three subgroups in the SITC 3 and 4 classifications — codes 581 to 583. All these subgroups experienced an acceleration of import growth from cycle 3 to 4, with the largest contribution coming from 'Plates, sheets, film, foil and strip, of plastics', and the fastest growth occurring in 'Tubes, pipes and hoses, and fittings therefor, of plastics'. 'Plates, sheets, film, foil

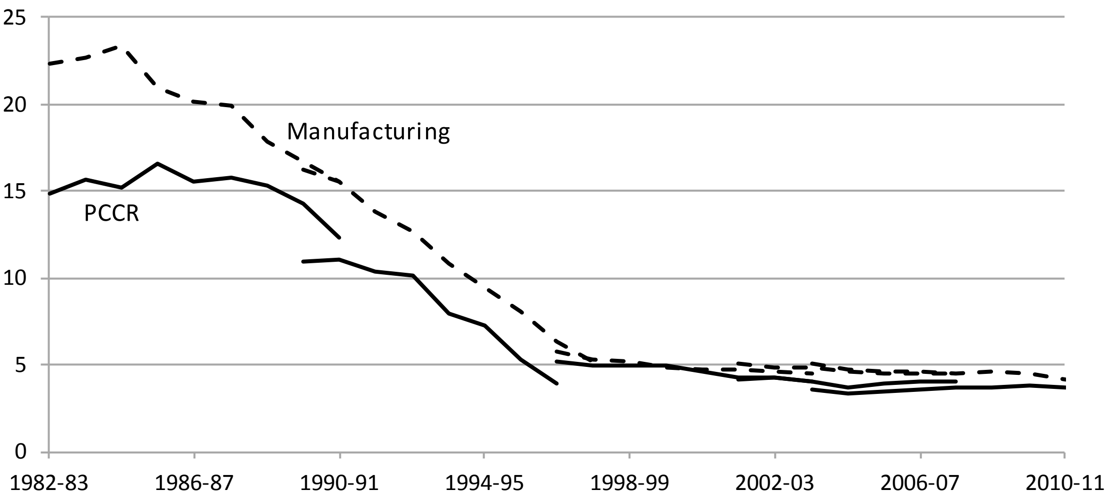
2 National Accounts estimates are calculated using data from a range of different sources that are then 'confronted' using information from the input-output tables. This ensures that the production of each industry is balanced with the use of each industry (ABS 2013b, pp. 544, 564). Accordingly, the National Accounts estimates are considered to be more accurate than those from a single industry survey.

and strip, of plastics' make up about 80 per cent of imports by value (based on UN 2013 trade data), growth in the import volume of 'Plates, sheets, film, foil and strip, of plastics' was approximately 3.9 per cent a year over cycle 3 and accelerated to 7.3 per cent a year over cycle 4. The volume of imports of 'Tubes, pipes and hoses, and fittings therefor, of plastics' fell during cycle 3 by approximately 4.4 per cent a year before rising to around 16.1 per cent a year over cycle 4.

Effective rates of assistance

The combined value of budget and tariff assistance to both PCCR and Manufacturing, expressed as a share of their value of output, has been constant at around 5 per cent since the mid-1990s (figure F.2). Prior to this, from the early 1980s to the mid-1990s, the effective rate of assistance to PCCR and Manufacturing in total declined — with PCCR starting at a lower level of assistance than Manufacturing.

Figure F.2 **Effective rates of assistance, PCCR and Manufacturing[a]**
Per cent



[a] Breaks in the series are represented by gaps in the chart, and overlaps are included to show the effects of the methodological and data changes made in moving between series.

Data source: PC (2011).

F.3 PCCR hours worked and employment

Group-level hours worked data

It is difficult to determine which parts of each subsector are behind the changes in hours worked between cycles 3 and 4. Table F.2 uses additional unpublished ABS data to estimate contributions by the groups in each subdivision (where applicable). However, limitations in the data at this lower level of disaggregation were larger over cycle 4. In particular, there was an increase in the number of hours worked that the ABS was unable to allocate to specific ANZSIC groups within each subdivision (that is, were allocated to 'not further defined' categories). Accordingly, the data should be considered as indicative only.

The data indicate that hours worked in PCCR declined in cycle 3 as hours worked in Chemicals and Polymers declined at a rate sufficient to offset the growth in hours worked in the (relatively small) Petroleum subdivision. In cycle 4, however, hours worked growth in Petroleum and Polymers was sufficient to almost exactly offset a decline in hours worked in Chemicals (table F.2). Of interest is the slowing decline in hours worked growth in Chemicals (from cycle 3 to cycle 4) and the reversal of hours worked growth (from a decline to growth) in Polymers.

Table F.2 **Contribution of PCCR groups to PCCR subdivision hours worked growth[a]**
Percentage points

ANZSIC subdivision/group	*Contribution over cycle 3*	*Contribution over cycle 4*	*Difference*
Petroleum refining	**3.8**	**1.1**	**-2.7**
Basic chemical and chemical product manufacturing	**-1.5**	**-0.7**	**0.8**
Basic chemical manufacturing	-1.2	-0.1	1.1
Basic polymer manufacturing	-0.4	0.2	0.5
Fertiliser and pesticide manufacturing	-0.8	0.1	0.9
Pharmaceutical and medicinal product manufacturing	0.6	-0.5	-1.1
Cleaning compound and toiletry preparation mfg	0.2	-0.7	-0.9
Other basic chemical product manufacturing[b]	0.0	0.4	0.3
Polymer product and rubber product manufacturing	**-1.4**	**0.5**	**1.9**
Polymer product manufacturing	-1.0	3.7	4.7
Natural rubber product manufacturing	-0.4	-0.1	0.3
Other[b]	0.0	-3.2	-3.2

[a] Data for subdivisions were benchmarked against the aggregate for Manufacturing (appendix A). Group level data were then used to apportion these subdivision growth rates. [b] Includes hours worked allocated to the subdivision, but not further defined to group level.

Source: Authors' estimates based on ABS (unpublished Labour Force Survey data).

- The rate of hours worked decline slowed in the Chemicals subdivision, driven by a strong slowdown in the decline of hours worked in Basic chemical manufacturing and an increase in the number of hours worked in Basic polymer[3] and Fertiliser and Pesticide manufacturing.
- The rate of hours worked went from negative to positive in the Polymers subdivision, with strong growth coming from the Polymer product manufacturing group. Almost all of this growth, however, was offset by a decline in employment from the not further defined category. Given that most of the employment in this subdivision is in Polymer product manufacturing, it is likely that the contribution from the group itself was smaller than shown in table F.2.

[3] Contrary to the name of the group 'Basic polymer manufacturing' (ANZSIC group 182) is part of the Chemicals subdivision rather than the Polymers subdivision.

G Additional information on Food, beverage and tobacco products

This appendix provides additional information on Food, beverage and tobacco product (FBT) manufacturing, as discussed in chapter 5.

G.1 Data comparability issues for FBT

Comparability of FBT data over time is affected by changes in industry classification. For some variables, there are also differences in FBT data taken from alternative ABS surveys.

ANZSIC classification changes

The change in industry classification, from ABS *Australian and New Zealand Standard Industrial Classification 1993* (ANZSIC93) to *Australian and New Zealand Standard Industrial Classification 2006* (ANZSIC06), affects the data presented in chapter 5. Box G.1 provides details of the broad correspondence between ANZSIC06 and ANZSIC93 at the industry group level.

Five of the eleven ANZSIC06 groups are directly comparable with ANZSIC93 groups or classes. The most significant changes are in two of the remaining six groups:

- Bakery product manufacturing, where Non-factory bakery was in Retail trade under ANZSIC93 but moved into Bakery product manufacturing under ANZSIC06
- Other food manufacturing, where the ANZSIC93 group was split into Seafood processing, Sugar and confectionery manufacturing and a narrower Other food manufacturing group under ANZSIC06. There were also some other additions to the new Other food manufacturing group, both from within FBT and from outside Manufacturing.

Box G.1 **Effects on FBT subsector of change from ANZSIC93 to ANZSIC06**

ANZSIC changes at the industry group level are summarised below. The extent of the additions/leakages cannot be readily quantified, but some indication is given of the likely importance of the change.

ANZSIC06 group	*Main ANZSIC93 group/class*	*Extent of change; Additions/leakages*
111 Meat & meat product mfg	211 Meat & meat product mfg	**No change**
112 Seafood processing	217 Other food mfg (*part*) 2173 Seafood processing	**Moderate change** Plus part of ANZSIC93 Wholesale trade division (Fish wholesaling *(part)*)
113 Dairy product mfg	212 Dairy product mfg *(part)*	**Minor change** Less part of ANZSIC93 212
114 Fruit & veg. processing	213 Fruit & veg. processing	**No change**
115 Oil & fat mfg	214 Oil & fat mfg	**No change**
116 Grain mill & cereal product food mfg	215 Flour mill & cereal food mfg *(part)*	**Moderate change** Less parts of ANZSIC93 215 Plus part of ANZSIC93 212 Plus part of ANZSIC93 218
117 Bakery product mfg	216 Bakery product mfg	**Major change** Plus part of ANZSIC93 Retail trade division (Bread and cake retailing *(part)*) Plus parts of ANZSIC93 215
118 Sugar & confectionery mfg	217 Other food mfg (*part*) 2171 Sugar mfg 2172 Confectionery mfg	**No change** at group level
119 Other food mfg	217 Other food mfg (*part*)	**Major change** Less parts of ANZSIC 217 (2171, 2172, 2173) Plus parts of ANZSIC93 215 Plus part of ANZSIC93 Wholesale trade division (Grocery wholesaling nec *(part)*)
121 Beverage mfg	218 Beverage & malt mfg	**Moderate change** Plus part of ANZSIC93 217 Less part of ANZSIC93 218
122 Cigarette & tobacco product mfg	219 Tobacco product mfg	**No change**

(part) indicates partial allocation to corresponding ANZSIC06 group.

Source: ABS (*Australian and New Zealand Standard Industrial Classification, 2006,* Cat. no. 1292.0).

Value added

Real value added (VA) for FBT in aggregate, the output volume measure used in the estimation of FBT multifactor productivity (MFP) for this paper, is from the ABS National Accounts (Cat. no. 5204.0). Data at a more disaggregated level are not available from the National Accounts, so a more disaggregated examination of FBT required the use of data from a different ABS source, the *Economic Activity Survey*[1] (EAS).

There are limitations on the comparability of real VA derived from EAS and that published in the National Accounts.

- EAS data are subject to breaks in series, as a result of ANZSIC changes (as discussed above) and other changes in the EAS survey over time.
- Real VA estimates have been derived from EAS data by using a different process of deflation than that used in the National Accounts.

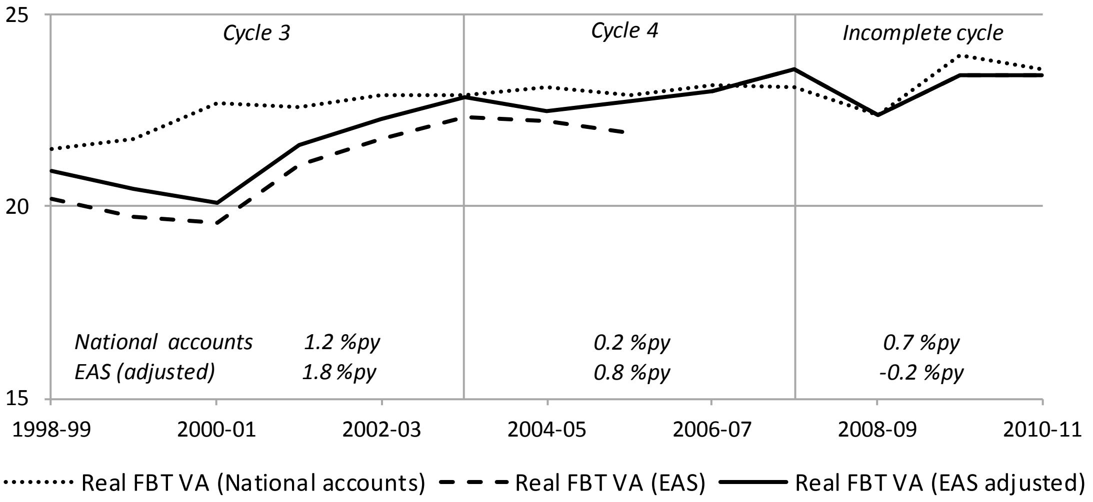
Figure G.1 compares real VA for FBT in total from the ABS National Accounts with two real VA series derived from the EAS — one with breaks in series and an approximate series adjusted for breaks. The adjusted EAS series is a backcast series based on information about the two breaks in series and is relatively crude. However, while the adjusted series does not exactly align with the National Accounts VA data, in both series growth in cycle 4 was lower than in cycle 3. Figure G.2 shows the approximate adjusted series for Food manufacturing and for Beverage and tobacco product (BT) manufacturing that underlie the FBT aggregate.

Further details about the limitations on comparability related to breaks and deflation are provided below.

1 This is the current survey that underlies the ABS (*Australian Industry,* Cat. no. 8155.0) — earlier data comes from its predecessor, the Manufacturing Census (*Manufacturing Industry, Australia,* Cat. no. 8221.0).

Figure G.1 **Real VA of FBT**[a]

2009-10 $bn

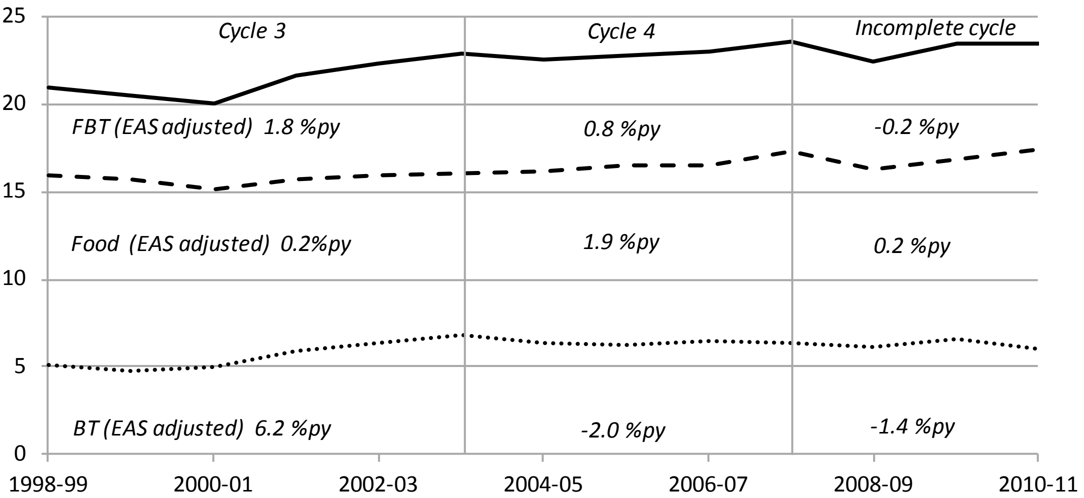


[a] National accounts value added is a chain volume measure. EAS data are deflated by producer price index for output. To the extent that output and intermediate input prices have grown at different rates, the real VA series derived from EAS will differ from the doubled deflated National Accounts series. Deflators on an ANZSIC06 basis are applied to ANZSIC93 and ANZSIC06 data.

Data sources: ABS (*Australian System of National Accounts, 2010-11*, Cat. no. 5204.0); Authors' estimates based on ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0); and ABS (*Producer Price Indexes, June 2012,* Cat. no. 6427.0).

Figure G.2 **Adjusted real VA of FBT and its subdivisions**[a]

2009-10 $bn



[a] EAS data deflated by producer price index for output. To the extent that output and intermediate input prices have grown at different rates, the real VA series derived from EAS will differ from the doubled deflated National Accounts series. Deflators on an ANZSIC06 basis are applied to ANZSIC93 and ANZSIC06 data.

Data sources: Authors' estimates based on ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0); and ABS (*Producer Price Indexes, June 2012,* Cat. no. 6427.0).

Break in series

The first two years of the EAS data are understated by around 1 per cent because of a change in survey methodology (ABS 2001).[2] The change to ANZSIC06 from 2006-07 led to net additions to FBT so all prior years are understated — VA in FBT on an ANZSIC06 basis is on average 2.4 per cent higher than on an ANZSIC93 basis for the years for which overlapping data are available.[3]

At a lower level of disaggregation (ANZSIC groups), there is no equivalent information about the effects of these breaks in series. Data at the ANZSIC group level presented in chapter 5 will therefore be less comparable over time.

Deflators

Real VA estimates derived from the EAS are based on nominal VA deflated using the producer price index (PPI) for output. A process of double deflation is used in the National Accounts — that is, output and intermediates are deflated separately. Sufficient data are not available to derive real VA from EAS using double deflation.

To the extent that output and intermediate input prices have grown at different rates, the real VA series derived from EAS will differ from a series that has been double deflated. The derived real VA series for Food and BT are therefore only broadly comparable with the real VA series for FBT from the National Accounts.

For Food, these two price series have tracked closely over the period examined (figure G.3).[4] However, for BT there is a larger difference. If output prices are growing faster than input prices (as is the case for BT over cycle 4), then the use of an output deflator on VA will lead to a higher rate of real VA growth than a double deflated series.

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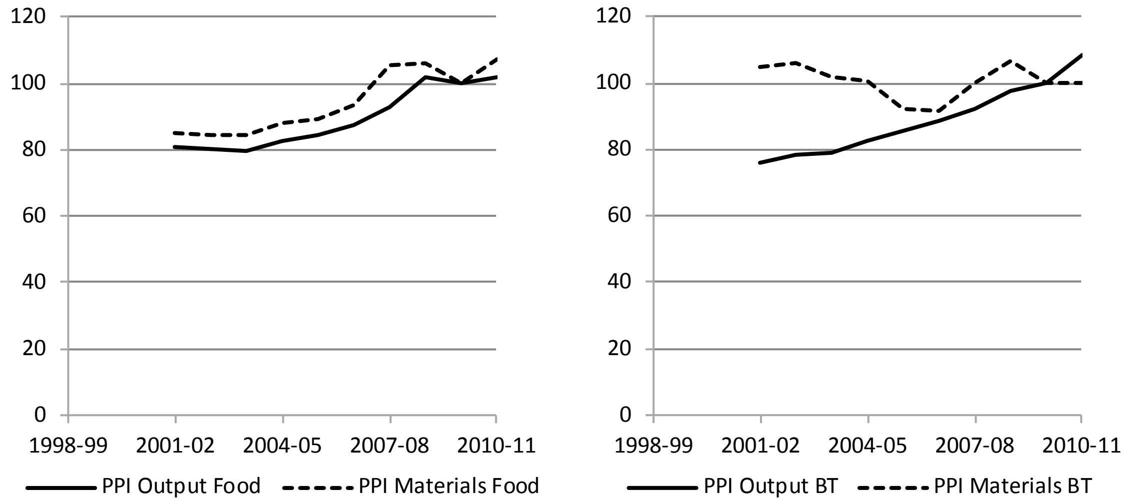
2 See appendix A for further details.

3 ABS (*Manufacturing Industry, Australia,* Cat. no. 8221.0, 2006-07) provided backcast data for 2005-06 and 2004-05 in ANZSIC06 that can be compared with ANZSIC93 data from ABS (*Manufacturing Industry, Australia,* Cat. no. 8221.0, 2005-06). The equivalent percentages are 3.7 for Food and 0 for BT.

4 The figure presents subdivision PPIs for Food and BT from 2001-02. For 1998-99 to 2000-01, aggregate PPIs were not available as PPIs for two ANZSIC groups were not available. Real VA estimates for Food and BT were derived as the sum of ANZSIC group level estimates, using the PPIs for the closest available ANZSIC group/class to backcast the missing PPI series.

Figure G.3 **Producer price indexes by FBT subdivision**[a]

Index 2009-10 = 100



[a] Deflators are for ANZSIC06 so will not match the ANZSIC93 data.

Data source: ABS (*Producer Price Indexes, June 2012,* Cat. no. 6427.0).

At the ANZSIC group level there are no intermediate input prices available so a similar comparison cannot be made. For this reason (and because of the change in ANZSIC) only limited use is made in chapter 5 of derived real VA by ANZSIC group. Limitations on the comparability of these estimates with those at a more aggregated level should be noted.

Labour

The labour input measure used by the ABS in its MFP estimates for Manufacturing in aggregate is an index of annual hours worked. This index is based on data from the ABS *Labour Force Survey* (LFS) but adjustments have been made by the ABS including for changes in survey methodology (appendix A). Hours worked indexes for each of the eight subsectors were derived from the hours worked series for Manufacturing, using information (from the same survey) about the distribution of hours worked across Manufacturing subsectors.

There are two issues related to the use of the ABS LFS data for FBT that are worth examining, given the large turnaround in hours worked trend:

- the possible impact of ANZSIC classification change on the LFS series
- how the LFS data compare with an alternative source, the ABS EAS.

Impact of ANZSIC classification change on LFS data

ABS LFS data are available as an ANZSIC06 time series, with data prior to August 2006 converted (or backcast) by the ABS from earlier industry classifications. The LFS data was dual coded in ANZSIC93 and ANZSIC06 from August 2006 until November 2008 (ABS 2008d, p. 5). This dual coded data, supplemented by 2006 ABS Census data, was used to calculate the percentages to split the earlier ANZSIC data. The dual coding and backcasting was done at the ANZSIC group level.

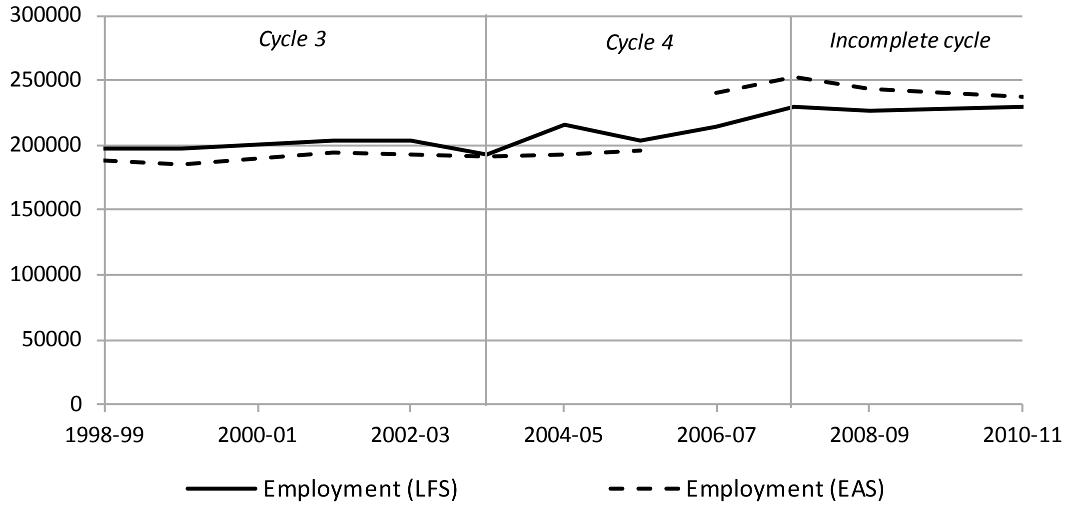
The implication of this backcasting process is that there may be some imprecision in the ANZSIC06 series prior to 2006, particularly where ANZSIC06 classes within a group had different growth rates over time. For example, take the case of activities moved into a new ANZSIC06 class, that is, one split from other activities in an ANZSIC93 class. If the activities moved into this new class had grown more rapidly than the other activities in the ANZSIC93 class, then backcasting the new class on the basis of the percentage shares from the dual coded data may lead to it being overestimated in earlier years.

The new ANZSIC06 Bakery product manufacturing (non-factory) class, which was previously part of the ANZSIC93 Bread and cake retailing class, may be affected by the need to make such assumptions based on dual coded data. But no information is available to assess whether Bakery product manufacturing (non-factory) was growing faster than the other activities within Bread and cake retailing. The implications for hours worked estimates for Bakery are discussed further in section G.4.

Comparison of alternative sources of employment data

The ABS collects employment data and hours worked data in the LFS but only employment data in the EAS. Figure G.4 compares employment estimates from these two surveys. The EAS data are affected by the ANZSIC06 change in 2006-07, while the LFS data have been adjusted for comparability over time by the ABS. While these two employment series are not directly comparable, there are some broad similarities in trend, with apparent faster growth in cycle 4 than cycle 3 in both series. The cycle growth rates for the LFS series are sensitive to the use of 2003-04 as the end of cycle 3 and beginning of cycle 4. This year is a low point in the series, which is not observed in the EAS series. (This is the year identified by the ABS as a peak year for market sector MFP and therefore a cycle year). This is likely to lead to a lower growth rate in cycle 3 and a higher growth rate in cycle 4 than the EAS series (abstracting from the break in the latter series).

Figure G.4 **Comparison of data sources for employment in FBT**[a]
Number of persons



a FBT employment from EAS has been adjusted for 1998-99 and 1999-00 for change in survey methodology (appendix A), but has not been adjusted for change to ANZSIC06 in 2006-07.

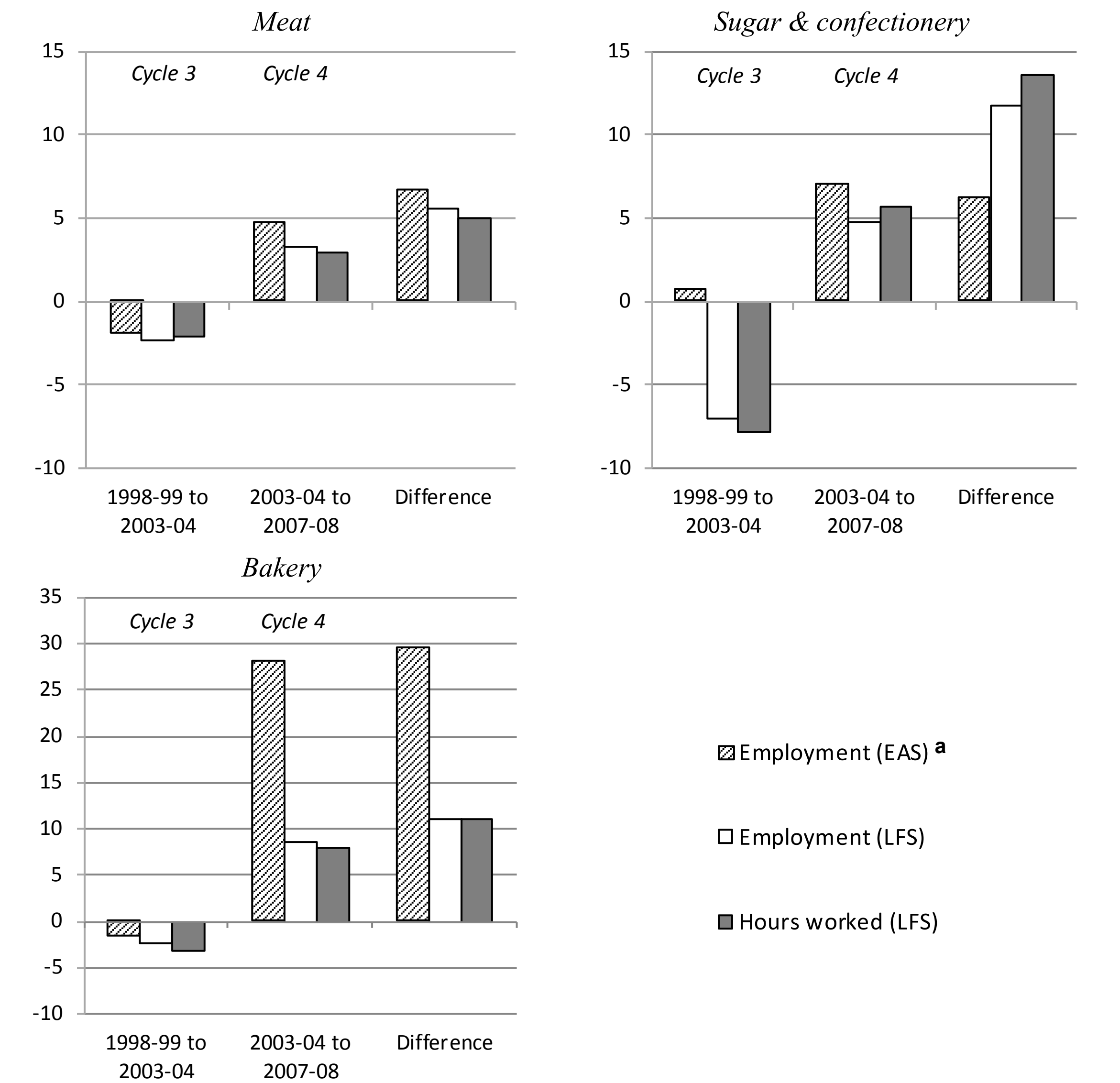
Data sources: Authors' estimates based on ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0); and ABS (unpublished Labour Force Survey data).

One source of difference between surveys can be the difference in the accuracy of the details given by different types of respondents. Household surveys, such as the LFS, sometimes provide a less accurate picture of the distribution of employment across *industries* than business surveys, such as the EAS. This is because employees may provide a less accurate description of the industry in which they are employed than their employers. This problem is likely to be greater the more detailed the industry breakdown. In the LFS, where there is insufficient detail collected from the survey respondent to allocate to the most detailed level of industry code, 'not further defined' (nfd) codes are used. Since 2000, there has been some growth in allocations to nfd industry categories as a result of changes to coding practices (ABS 1999, 2003, 2005). See Connolly et al. (2013) for further discussion of differences between EAS and LFS employment estimates.

The extent of the difference between LFS and EAS data for employment varies across ANZSIC group within FBT. For example, figure G.5 compares labour input (hours worked and employment) measures based on LFS data and on EAS data for the three ANZSIC groups that contributed most to the large increase in hours worked growth for FBT in total between cycles 3 and 4.

Figure G.5 **Comparison of data sources for labour input, selected ANZSIC groups within FBT**

Average annual growth rate (per cent)



[a] 2007-08 employment imputed as midpoint of 2006-07 and 2008-09 EAS data — no disaggregated EAS data was published in 2007-08. 1998-99 EAS data has been adjusted for change in survey methodology by applying the adjustment factor identified by ABS for FBT on average (appendix A). No adjustment has been made for the ANZSIC06 change in 2006-07, which affects Bakery but not Meat and Sugar and confectionery.

Data sources: Authors' estimates based on ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0); and ABS (unpublished Labour Force Survey data).

- For Meat, EAS employment grew more strongly between cycles than LFS employment or hours worked.
- For Sugar and confectionery, the opposite was the case. LFS employment and hours worked grew more strongly between cycles than EAS employment — mainly due to employment falling in the LFS but rising in the EAS over cycle 3.

- For Bakery, the ANZSIC change hampers comparisons. The large difference over cycle 4 is attributable to the addition of Non-factory bakery to Bakery in the EAS from 2006-07, while the LFS has been backcast to include Non-factory bakery throughout the period.

Shift-share analysis of labour intensity

Average labour intensity in FBT, measured as employed persons per million dollars of real VA,[5] increased by 21.2 per cent between 2003-04 and 2006-07 (table G.1). This is a significant increase, compared with the 5.8 per cent decline between 1998-99 and 2003-04 (cycle 3) — although the change in ANZSIC classification in 2006-07 is a factor in the increase (with the addition of non-factory baking).

Around 72 per cent of this increase (15.2 percentage points) was the result of changes in labour intensity of the FBT industry groups (the 'shift' effect), rather than a change in the relative size of the FBT groups in VA terms (the 'share' effect) or the interaction of the shift and share effects (the 'dynamic' effect).

Bakery manufacturing made the largest contribution to the 'shift' effect in labour intensity but part of this was due to changes in ANZSIC. (Nevertheless, labour intensity in FBT would still have increased and the 'shift' effect would still have dominated if Bakery manufacturing was excluded from the analysis.)

Table G.1 **Shift-share analysis of FBT labour intensity, 2003-04 to 2006-07**
Percentage points

ANZSIC group	*'Shift'*	*'Share'*	*'Dynamic'*	*Total*
Meat	1.7	0.7	0.0	2.4
Seafood	0.9	-1.2	-0.5	-0.8
Dairy	-1.5	1.1	-0.2	-0.5
Fruit & vegetables	2.3	-1.3	-0.4	0.5
Oil & fat	0.1	-0.6	-0.1	-0.6
Grain & cereal	-0.1	-0.1	0.0	-0.2
Bakery	8.8	6.5	4.4	19.7
Sugar & confectionery	0.0	0.7	0.0	0.7
Other food	-0.8	-1.1	0.1	-1.8
Soft drink	0.3	0.7	0.1	1.0
Wine	2.9	-1.4	-0.5	0.9
Other BT	0.5	-0.6	-0.1	-0.1
Total FBT	**15.2**	**3.1**	**2.9**	**21.2**

Sources: Authors' estimates based on ABS (*Manufacturing Industry, Australia*, various issues, Cat. no. 8221.0); and ABS (*Producer Price Indexes, Australia, June 2012*, Cat. no. 6427.0).

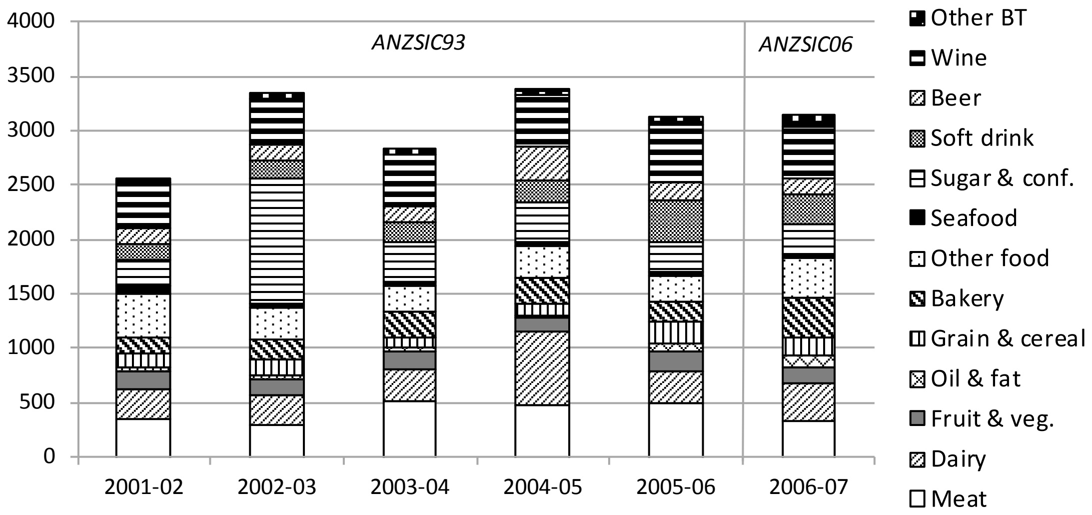
5 Real VA is calculated by deflating nominal industry VA for each ANZSIC group with the relevant producer price index for output.

G.2 FBT in aggregate

Investment

Figure G.6 shows available data for investment by ANZSIC group/class over the period 2001-02 to 2006-07. Large projects result in some lumpiness in investment.

Figure G.6 **Investment[a] by ANZSIC groups/classes[b] within FBT**
$m



[a] Investment is total acquisitions (expenditure on the acquisition of capital including plant, machinery and equipment, buildings, and other assets) and is not net of disposals of assets. [b] Affected by ANZSIC change so groups/classes are only broadly comparable. Baking includes Non-factory bakery only in 2006-07.

Data source: ABS (*Manufacturing Industry, Australia*, various issues, Cat. no. 8221.0).

Over the period 2003-04 to 2006-07 (which is the closest available to cycle 4) more than half of the investment in FBT is likely to have been in four FBT groups/classes — Wine (16 per cent), Meat (15 per cent) and Dairy (13 per cent), and Sugar and confectionery (10 per cent).[6]

Linkages between FBT and other parts of the economy

FBT includes resource processing of agricultural products but also more elaborately transformed products. Table G.2 (third column) shows that intermediate inputs make up around 70 per cent of the value of FBT output, the highest intermediates share of all subsectors within Manufacturing. Large shares of FBT's intermediate

6 This is based on an alternative data source (ABS EAS) to that used in the capital services estimates. Investment in the EAS is around 80 per cent of the authors' estimates of FBT gross fixed capital formation.

inputs come from Agriculture (44 per cent), Services (30 per cent), and other parts of FBT (17 per cent).

FBT provides inputs to a range of other parts of the economy. Table G.2 (third row) shows that FBT provides between 0.4 and 6.6 per cent of total intermediates used by other sectors of the economy and 5.2 per cent of intermediates used by Manufacturing in total.

Table G.2 **FBT input-output linkages, 2008-09[a]**

Percentage shares of total intermediate inputs

	TO											
			Manufacturing[b]									
FROM	*Ag.*	*Mining*	*FBT*	*TCO*	*WP*	*PRM*	*PCCR*	*NM*	*MP*	*ME*	*Total Mfg*	*Serv-ices[c]*
			Share of total intermediate inputs									
Ag			**43.7**								13.0	
Mining			**0.8**								14.9	
FBT	**4.3**	**0.5**	**17.1**	**6.6**	**0.4**	**0.5**	**1.7**	**0.4**	**0.1**	**0.4**	**5.2**	**2.7**
TCO			**0.3**								0.7	
WP			**2.2**								2.3	
PRM			**0.2**								0.4	
PCCR			**3.2**								6.1	
NM			**0.8**								1.7	
MP			**0.8**								16.6	
ME			**0.4**								2.3	
Total Mfg.	16.4	15.3	**25.2**	43.6	27.3	35.7	27.7	34.7	40.1	51.8	35.2	15.1
Services			**30.3**								36.9	
All sectors	*100*	*100*	***100***	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*
			Total intermediate inputs as a share of output									
All sectors	*50.4*	*33.2*	*67.4*	*43.0*	*54.2*	*42.6*	*46.1*	*53.2*	*59.5*	*49.9*	*55.5*	*44.0*

[a] Based on industry by industry flow (direct allocation of imports). For simplicity, only selected linkages are included. Only includes domestically produced intermediates. [b] FBT is Food, beverage & tobacco products; TCF is Textile, clothing & footwear; WP is Wood & paper products; PRM is Printing & recorded media; PCCR is Petroleum, coal, chemical & rubber products; NM is Non-metallic mineral products; MP is Metal products; ME is Machinery & equipment manufacturing. [c] Services includes non-market sector industries.

Source: Authors' estimates based on ABS (*Australian National Accounts: Input-Output Tables*, *2008-09*, Cat. no. 5209.0.55.001, Table 5).

A high proportion of FBT output is for final use rather than as intermediate inputs to other industries (table G.3).

Table G.3 **Breakdown of FBT output into industry and final use, 2008-09[a]**
Percentage of total supply

	FBT	*Total Manufacturing*
Industry use	*40.5*	*53.6*
Final use		
Final consumption	36.8	17.0
Exports	21.8	21.9
GFCF[b]	0.9	7.5
Total	**100**	**100**

[a] Based on industry by industry flow (direct allocation of imports). [b] Gross fixed capital formation. Includes change in inventories.

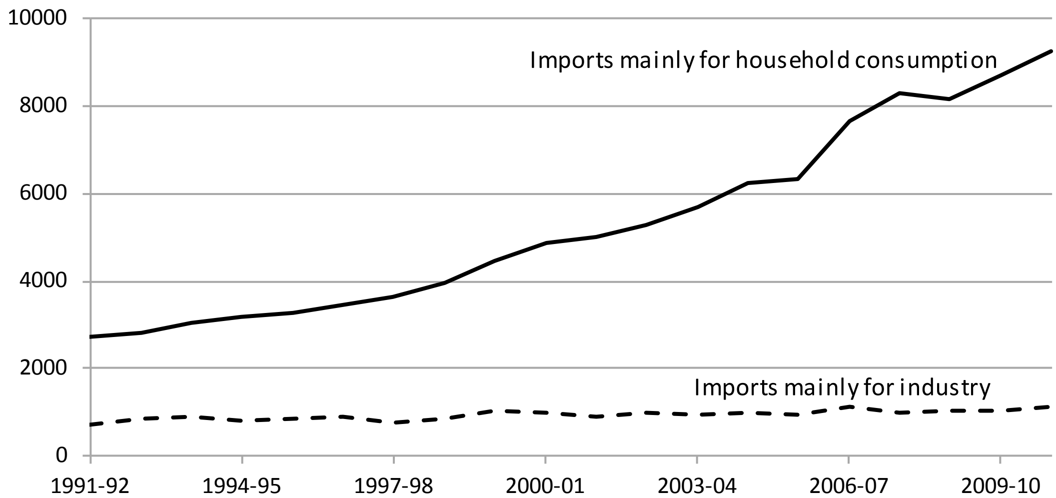
Source: Authors' estimates based on ABS (*Australian National Accounts: Input-Output Tables*, *2008-09,* Cat. no. 5209.0.55.001, Table 5).

Trade and assistance

Imports for final consumption or inputs for industry?

ABS estimates of imports of food and beverages, classified as 'mainly for industry' or 'mainly for household consumption', suggest that most of the increase in imports has been in final consumption goods rather than intermediate inputs. Food and beverage imports for consumption have risen strongly, particularly over cycle 4, while imports for industry use have been relatively stable (figure G.7).

Figure G.7 **Food and beverage product imports by economic category[a]**
2009-10 $m



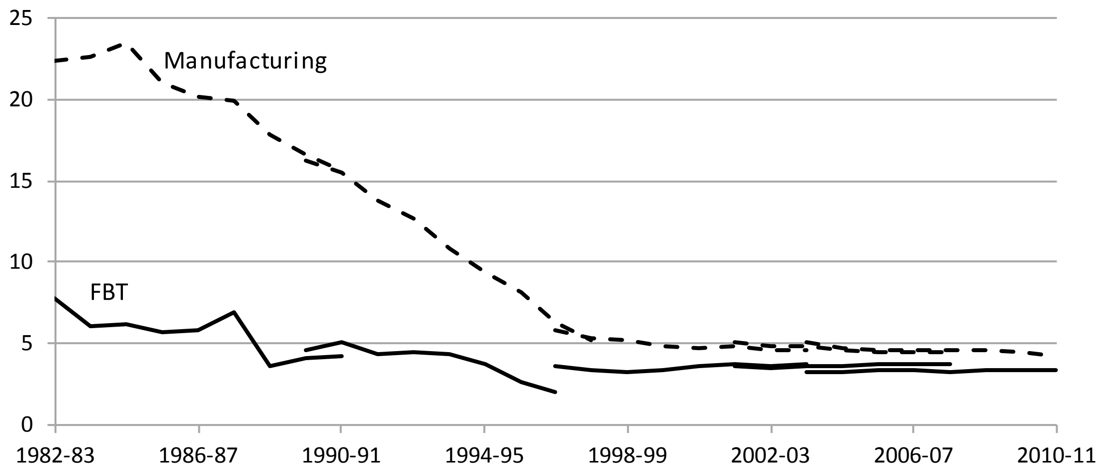
[a] Balance of Payments Broad Economic Category basis.

Data sources: Authors' estimates based on ABS (*International Merchandise Imports, Australia*, March 2013, Cat. no. 5439.0) and ABS (*International Trade Price Indexes, Australia*, March 2013, Cat. no. 6457.0).

Effective rates of assistance

Over the last 15 years, there has not been a substantial change in the rate of assistance for FBT as a whole. The combined value of budget and tariff assistance to both FBT and Manufacturing, expressed as a share of their value of output, has been constant at less than 5 per cent (figure G.8). Prior to this, from the early 1980s to the mid-1990s, the effective rate of assistance to FBT and Manufacturing in total declined — with FBT starting at a considerably lower level of assistance than Manufacturing on average.

Figure G.8 **Effective rates of assistance, FBT and Manufacturing[a]**
Per cent



a Breaks in the series are represented by gaps in the chart, and overlaps are included to show the effects of the methodological and data changes made in moving between series.

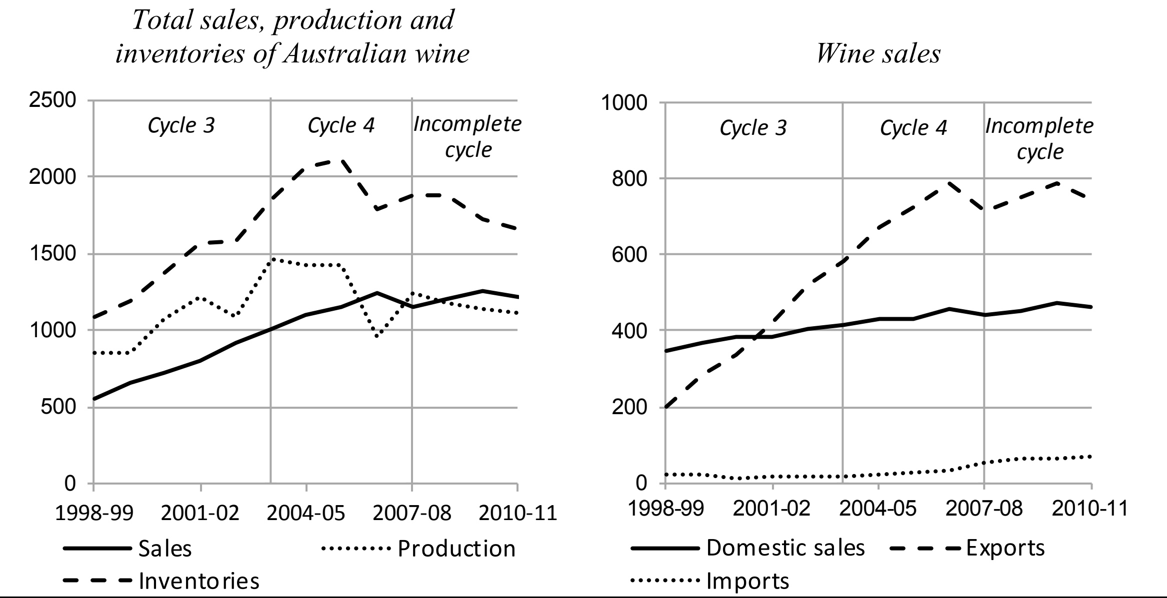
Data source: PC (2011).

G.3 Wine manufacturing

Excess supply of wine relative to demand

Strong production growth in cycle 3 and record levels of production in the first three years of cycle 4, contributed to a structural oversupply of wine. The gap between the volume of inventories held by Australian wineries and wine sales widened by 9.6 per cent a year during cycle 3 and peaked in the middle of cycle 4 (2005-06). The gap fell significantly by 43.3 per cent during the 2006-07 drought year (figure G.9, left panel). At the end of cycle 4, wine inventories were around 62 per cent greater than total sales.

Figure G.9 **Sales and inventories of Australian wine**[a]
Volume (megalitres)



[a] Inventory only includes wineries crushing more than 400 tonnes annually. Sales of Australian wine only includes winemakers with sales of 250 000 litres or more in either of the previous two years.

Data source: ABS (*Australian Wine and Grape Industry*, various issues, Cat. no. 1329.0).

International competition and competitiveness pressures

Expansion of Australian wine production in the mid to late 1990s was particularly focused on the growth of Australian wine exports

> The vision is that by the Year 2025 the Australian wine industry will achieve $4.5 billion in annual sales by being the world's most influential and profitable supplier of branded wines, pioneering wine as a universal first choice lifestyle beverage. (Australian Wine Foundation, Winemakers' Federation of Australia, and Peter Fuller & Associates 1996, p. 4)

The volume of Australian exports grew by 23.8 per cent a year during cycle 3, growing from 201 million litres in 1998-99 to 584 million litres in 2003-04 (figure G.9, right panel). By 2001-02, exports overtook domestic sales as the largest contributor to total Australian wine disposals.

Export growth slowed to 5.2 per cent a year over the most recent complete productivity cycle (cycle 4), driven by a combination of: growing competition from other new-world wine producing nations, such as Chile, South Africa and New Zealand; the strength of the Australian dollar against our major export markets; the relatively high cost of Australian labour; and increased energy and water costs (Bailey 2011). These factors also contributed to a 29.9 per cent per year growth, although from a relatively low-base, of imports cleared for the Australian market during this period (figure G.9, right panel).

Industry consolidation

The ABS reported some consolidation in the number of wine making businesses during cycle 4, with a decline of 1.5 per cent per year of those crushing over 50 tonnes of grapes a year (table G.4). While some consolidation is also reported by industry sources, this has only been experienced by producers crushing over 10 000 tonnes of grapes a year (box G.2). The number of smaller producers, on the other hand, is shown to be consistently growing during the same period (table G.4).

Table G.4 **Number of wine makers in Australia, by tonnes crushed**

	Australian Bureau of Statistics Wine and Grape Industry Survey[a]				*The Australian and New Zealand Wine Industry Directory*[b]				
Year	50-400[a]	401-10 000	10 001 or more	**Total**	Less than 49	50-499	500-9 999	10 000 or more	**Total**
1998-99	163	92	21	**276**					
2003-04	185	151	28	**364**					
2004-05	187	155	24	**366**	1 028	628	193	41	**1 899**
2007-08	174	140	28	**342**	1 280	719	203	35	**2 299**
2009-10	156	158	22	**336**	1 348	766	200	25	**2 420**

[a] ABS only includes wineries which crush 50 tonnes or more of grapes. [b] *Wine Industry Directory* producer totals also include producers whose wine crush is 'unknown or unspecified'.

Sources: ABS (*Australian Wine and Grape Industry*, various issues, Cat. no. 1329.0); Winetitles (2013).

This growth in the number of wine-making business, especially from smaller family-owned or 'lifestyle' operations, should only have a marginal effect on output. By the end of cycle 4 (2007-08), large wine producers crushing over 10 000 tonnes of grapes a year, were responsible for over 83.1 per cent of wine production.[7]

Moreover, five of the largest wine producers in Australia have a 43.1 per cent share of the domestic market (Richardson 2012), with significant restructuring amongst these manufacturers reported between 2001 and 2003 (box G.2) in response to increasing consolidation at the retail end (The Age 2003).

7 Derived from producer statistics in ABS (*Australian Wine and Grape Industry*, Cat. no. 1329.0).

Box G.2 **Examples of consolidation in Wine manufacturing**

2001

Southcorp acquired Rosemount Estates from the Oatley family for $1.5 billion effective 1 January 2001 (Southcorp 2001).

2002

(July) Brian McGuigan Wines Limited merged with Simeon Wines Limited, which created the fourth largest wine company at the time (Martin 2002).

2003

(April) Constellation Brands Incorporated (2003) announced that it would acquire BRL Hardy Limited, Australia's largest wine producer. The transaction reportedly made Constellation Brands the world's largest wine company at $1.7 billion in wine sales.

(October) McGuigan Simeon Wines Limited acquired Miranda Wines Pty Ltd, which allowed the company to enter the cask and sparkling wine markets (McGuigan Simeon Wines Limited 2004).

2004

(June) Foster's Group (2004a) announced the outcome of a comprehensive review of its Global Wine Trade business. Some infrastructure consolidation activities were reported, with planned capital investment expected to fall by at least 40 per cent compared with that announced at the full year 2004 (of approximately A$150 million).

(September) Foster's Group (2004b) announced the development of a purpose-built bottling and warehousing operation. The high speed bottling facility was intended to have initial capacity of 10 million cases per annum but with a 'modular, scaleable design to a potential capacity of over 24 million cases per annum.' The facility consolidated the majority of Beringer Blass' Australian wine production and packaging to the Wolf Blass winery. Capital expenditure associated with the project was estimated at $69 million, with commissioning and full operation expected by June 2006.

2005

(April) Foster's Group (2005b) announced the takeover of Southcorp to 'create the world's leading premium wine company.'

(August) Foster's Group (2005a) announced outcomes of its initial review of the combined Foster's-Southcorp wine production operations in Australia. The review identified surplus wine processing capacity and approved plans to consolidate wine processing facilities. Foster's proposed to sell its Lower Hunter Valley winery and the smaller of its Coonawarra wineries as soon as practical.

2006

(June) Foster's Group (2006) announced its intention to sell two Australian wineries, as well as surplus production and packaging facilities in the Upper Hunter Valley, Barossa Valley, and selected facilities at Penfolds Nuriootpa.

(continued on next page)

Box G.2 **(continued)**

2007

(November) Hardy Wine Company announced that from 2008 it would consolidate its winemaking and packaging currently taking place at its Buronga winery, to its Berri Estates winery, the largest in Australia. Both are located in the River Murray inland regions of central Australia (Constellation Brands Incorporated 2007).

2008

(August) Constellation Wines Australia (formerly Hardy Wine Company) announced the proposed sale of three of 10 production facilities, in addition to the sale of more than 20 vineyard properties; consolidation of bottling operations; portfolio streamlining and rationalization of more than 30 per cent of the company's Australian stock keeping units. The company's Australian employment was reported to be impacted by more than 20 per cent, or 350 positions, primarily associated with assets expected to be sold (Constellation Brands Incorporated 2008).

2012

(July) Accolade Wines and Treasury Wine Estates entered into reciprocal bottling and packaging contracts that would see, by January 2013, Accolade Wines bottle for Treasury Wine Estates in the United Kingdom and Treasury Wine Estates bottle for Accolade Wines in Australia. The announcement reportedly resulted in 175 redundancies at Accolade's Reynella bottling and distribution facility (Accolade Wines 2012).

G.4 Bakery product manufacturing

Scope of Bakery product manufacturing

In-house supermarket bakeries not included

In-house supermarket bakeries do not appear to be included in ABS statistics for Bakery product manufacturing. Due to confidentiality, the ABS cannot specify where the large supermarket bakeries are included. However, in the ABS EAS*,* for example, the ABS classifies a business to its single predominant industry class, irrespective of any diversity of activities undertaken unless its secondary activity alters subdivision statistics by 2 per cent where the primary and secondary activities are in different ANZSIC divisions (ABS 2012f). In-house bakeries in supermarkets would be a secondary Manufacturing activity of supermarkets, where the primary activity is Retail trade (a separate ANZSIC division to Manufacturing). Given the large size of Manufacturing and Retail trade it would not be expected that in-house supermarket bakeries would affect either of the divisions by 2 per cent.

Change in ANZSIC classification to include Non-factory bakery

A major implication of the introduction of ANZSIC06 for the analysis of Bakery product manufacturing is that there is a limited time series available. The shift of Non-factory bakery from Retail trade to Manufacturing in ANZSIC06 is a major break in series and the effects differ across surveys. The ABS has backcast data from the ABS LFS into ANZSIC06. Data from the ABS EAS (as published in Cat. nos 8221.0 and 8155.0) have not been backcast by the ABS.

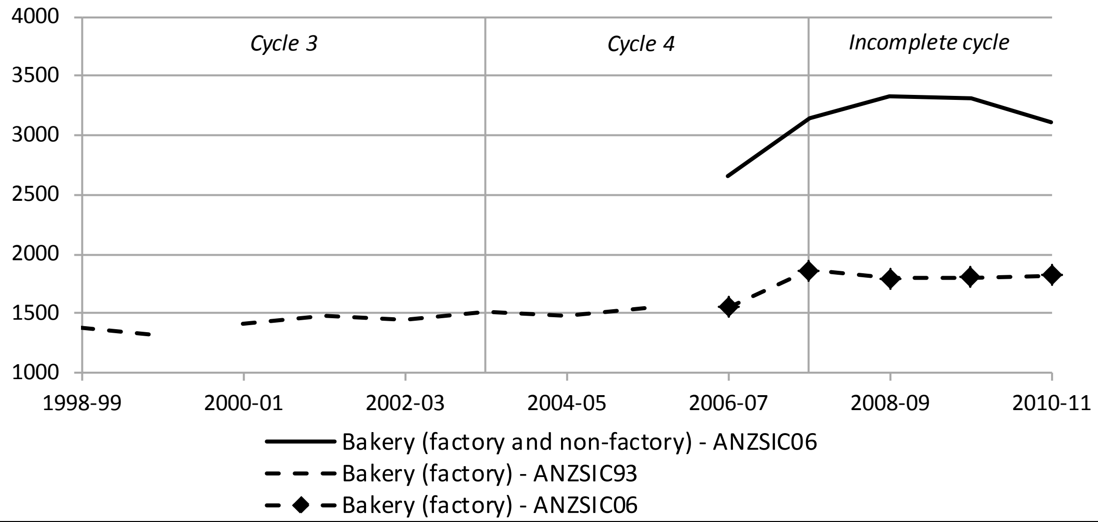
Comparisons of Factory bakery under ANZSIC93 and ANZSIC06 (together with anecdotal evidence on Non-factory bakery in chapter 5), suggest that Non-factory bakery is more likely than Factory bakery to have been the main contributor to employment and VA growth in ANZSIC06 Bakery in total over cycle 4.

Value added

Figure G.10 shows that there was little growth in Factory bakery over cycle 3. Growth in Factory bakery from 2006-07 to 2007-08 was higher than over cycle 3 — but it should be noted that Factory bakery under ANZSIC06 also includes an expanded range of activities with additions from elsewhere in FBT manufacturing.

Figure G.10 **Nominal value added of Bakery product manufacturing**[a]

$m



[a] Breaks in series: change in survey methodology in 2000-01 (appendix A); shift from ANZSIC93 to ANZSIC06 in 2006-07 (ANZSIC06 Non-factory bakery added from outside Manufacturing; and ANZSIC06 Bakery (factory) included additional activities not in ANZSIC93 Bakery (factory)).

Data sources: ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0).

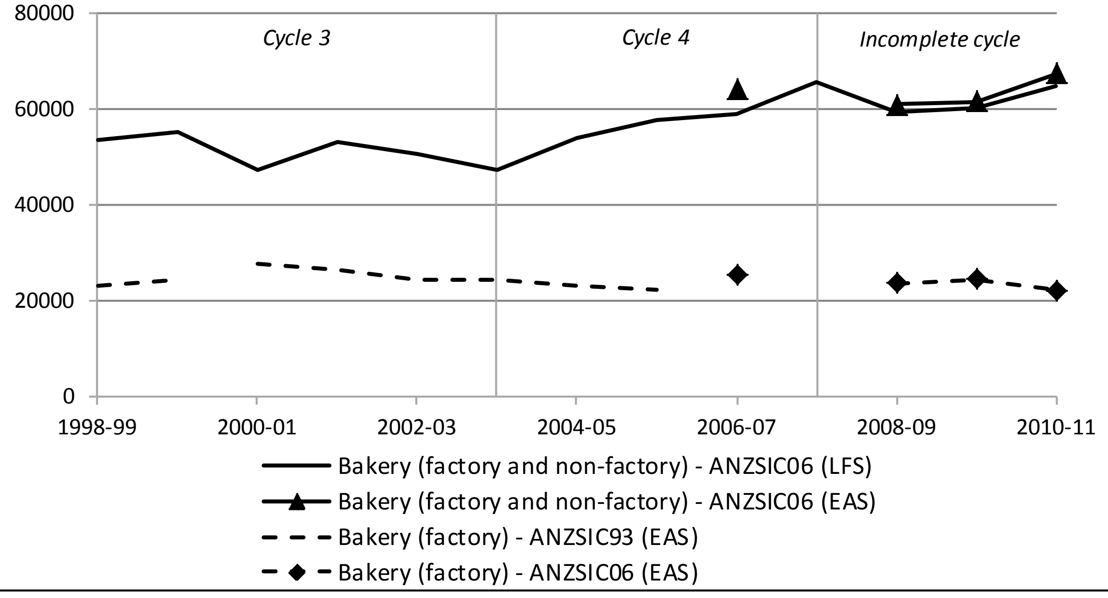
Very limited information is available on the growth of Non-factory bakery prior to 2006-07. Box 5.10 in chapter 5 provided some qualitative indicators of stronger growth in Non-factory bakery than Factory bakery over the longer term. The ANZSIC93 class ‘Other food retailing’ (in which Non-factory bakery was included under ANZSIC93) does have stronger growth in turnover over cycle 4 than cycle 3 (ABS 2009). However, this increase in growth could also be attributable to the other retailing activities in this ANZSIC93 class in addition to Non-factory bakery.

Labour

Factory bakery and Non-factory bakery employment can be compared on a similar basis to that used for VA. Missing EAS data for 2007-08 (when the ABS did not publish ANZSIC group data for employment) hamper the comparison. But there is an alternative source of data from the LFS for total Bakery (including Non-factory).

EAS data suggest that employment in Factory bakery has been relatively stable (figure G.11). Therefore, while the EAS and LFS data are not directly comparable (as discussed in section G.1), this suggests that Non-factory bakery was more likely to be behind the increase in growth in the LFS employment series over cycle 4. However, the LFS employment series has been backcast into ANZSIC06 and is subject to potential measurement error (as discussed in section G.1).

Figure G.11 **Employment in Bakery product manufacturing[a]**



[a] Breaks in series: change in survey methodology in 2000-01 (appendix A); shift from ANZSIC93 to ANZSIC06 in 2006-07 (ANZSIC06 Non-factory bakery added from outside Manufacturing; and ANZSIC06 Bakery (factory) included additional activities not in ANZSIC93 Bakery (factory)).

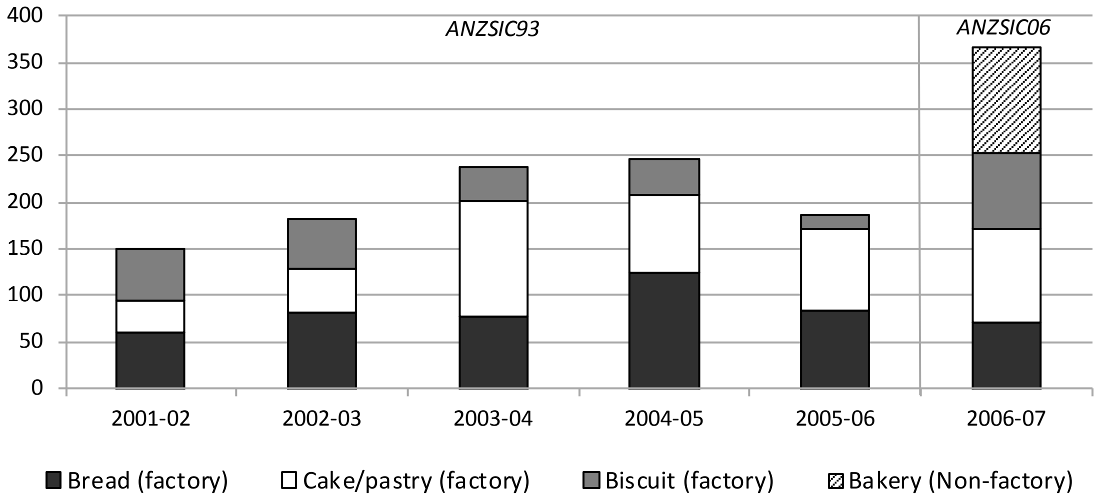
Data sources: ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Experimental Estimates for the Manufacturing Industry*, various issues, Cat. no. 8159.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0); ABS (unpublished Labour Force Survey data).

Capital

Limited data are available for investment in Bakery product manufacturing. Figure G.12 shows Non-factory bakery investment was around 30 per cent of the Bakery total in 2006-07. Earlier data for Non-factory bakery are not available.

Figure G.12 **Investment[a] of Bakery product manufacturing[b]**

$m



[a] Current prices. Investment is total acquisitions (expenditure on the acquisition of capital including plant, machinery and equipment, buildings, and other assets) and is not net of disposals of assets. [b] Affected by ANZSIC change so groups/classes are only broadly comparable. Baking includes Non-factory bakery only in 2006-07.

Data source: ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0).

H Additional information on Metal products

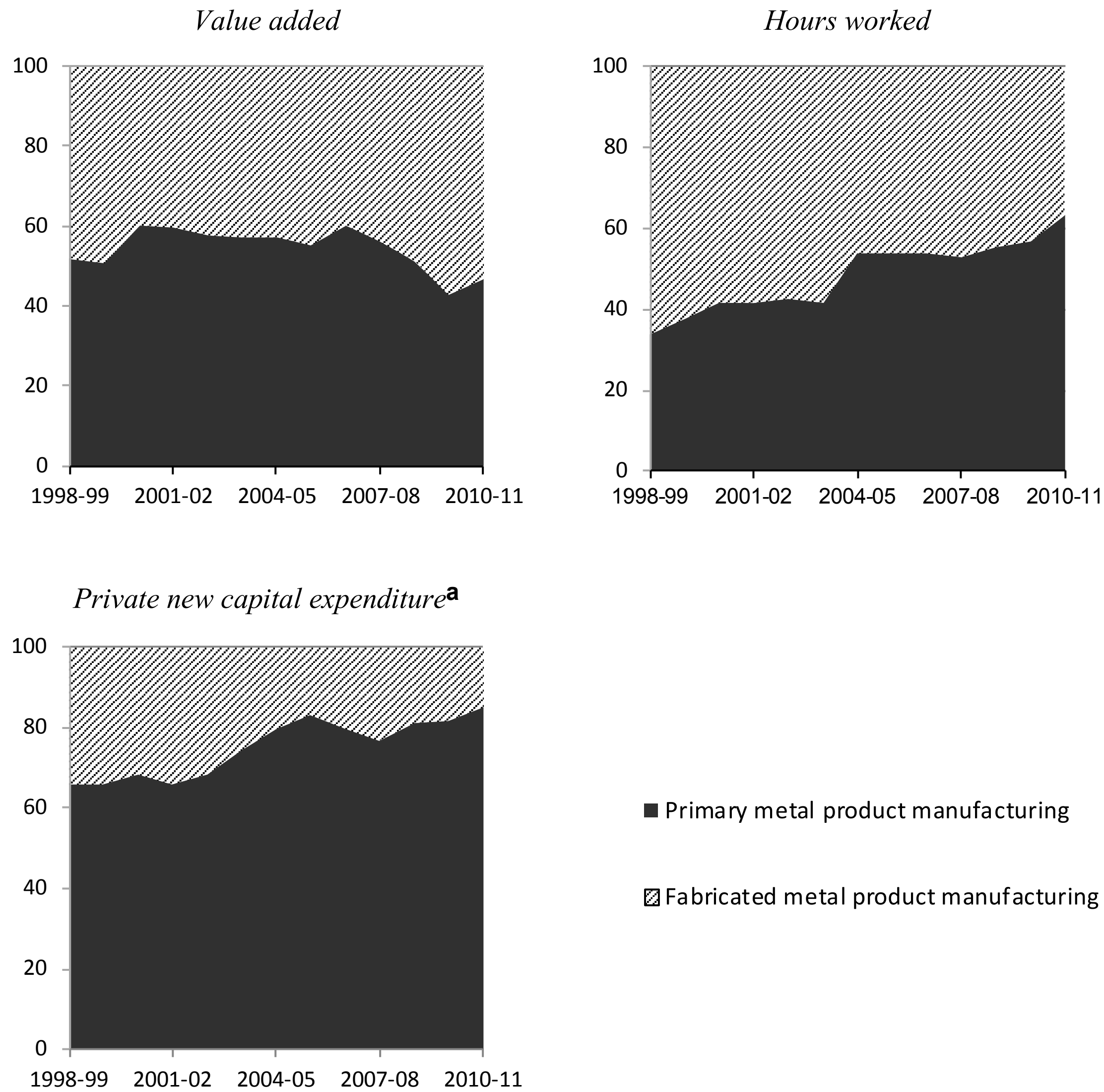
Additional data about the Metals products (MP) subsector (which is chiefly discussed in chapter 6) are presented in this appendix. It provides a longer-term view of how the composition of the subsector has changed through time by examining different output series and price deflators. This appendix also includes information about trade, a broader discussion of ‘capital-lags’ (and how they relate to the subsector), and a closer look at different labour input measures for MP.

H.1 A longer-term view of the composition of Metal products

In chapter 6, the composition of the MP subsector was discussed in terms of the share that each subdivision comprised of value added (VA), hours worked and private new capital expenditure in 2009-10. Figure H.1 shows how these shares have changed over the period covering cycle 3 through to the incomplete cycle.

Figure H.1 **Composition of Metals products — value added, hours worked and investment**

Percentage shares



[a] Current price data used for value added and private new capital expenditure. Data for net capital stock are not available at this level of disaggregation.

Data sources: ABS (unpublished Survey of New Capital Expenditure data); ABS (*Australian Industry,* various issues, Cat. no. 8155.0); ABS (*Australian Manufacturing,* various issues, Cat. no. 8221.0); ABS (unpublished Labour Force Survey data).

As with other subsectors, examining the value added growth at the subdivision level is difficult because there is no *real* measure of value added published for the MP subdivisions. This is particularly important for the MP subsector as large changes in prices for metal products, particularly primary metals, occurred over cycle 4.

As with Petroleum, coal, chemical and rubber products, table H.1 shows that it is difficult to reconcile estimates of real growth derived from data available for the MP subdivisions with that of the subsector. For example, real value added growth for MP was 1.3 and 4.5 per cent a year in cycles 3 and 4, respectively. However, the subdivision data (deflated using output producer price deflators[1]) give growth rates of 6.7 and 1.4 per cent a year in those cycles — reversing the trends of growth. Real sales and service income also suggests faster growth in cycle 3 than in cycle 4.

One reason for the discrepancy is that the value added data for the subsector and the subdivisions come from different sources. The subdivision data are sourced from publications based on the *Manufacturing Census* and *Economic Activity Survey*. The subsector estimates from the ABS National Accounts are compiled using these surveys and other sources.

Despite these discrepancies, the subdivision estimates for real value added and real sales and service income show higher growth in Fabricated metals than Primary metals over cycle 4. It is for this reason that chapter 6 concludes that the real value added growth for MP reported in the National Accounts in cycle 4 is more likely to have come from Fabricated metals rather than Primary metals. The Bureau of Resource and Energy Economics data in table 6.3 also provide little evidence of output volume growth of primary metal products over cycle 4.

1 Deflating disaggregated nominal value added data by using producer prices data for output can only provide a broad approximation of real VA derived from double deflation. Double deflated real VA involves separate deflation of gross output and intermediate inputs using separate price indexes for each. If there are changes in intermediate input prices that are different to those of output prices, then deflating the nominal value added data by output deflators will differ from a double deflated series.

Table H.1 **Comparison of output measures and prices for Metal products**
Average annual growth rate (per cent)

	Cycle 3	*Cycle 4*	*Incomplete cycle*
Value added			
MP (real)[a]	**1.3**	**4.5**	**0.3**
Primary metal product mfg (nominal)	10.6	10.6	-12.1
Fabricated metal product mfg (nominal)	5.8	11.7	-0.5
Sum of subdivisions (nominal)	*8.4*	*11.1*	*-6.7*
Primary metal product mfg (real)[b]	8.9	-2.6	-10.2
Fabricated metal product mfg (real)[b]	3.8	6.8	-3.9
Sum of subdivisions (real)[b]	*6.7*	*1.4*	*-7.0*
Sales and service income[c]			
Primary metal product mfg (nominal)	9.3	13.2	-10.9
Fabricated metal product mfg (nominal)	9.9	10.3	-1.3
Sum of subdivisions (nominal)	*9.5*	*12.2*	*-7.4*
Primary metal product mfg (real)	3.8	-2.1	-16.9
Fabricated metal product mfg (real)	7.7	4.7	-5.0
Sum of subdivisions (real)	*4.7*	*-0.1*	*-12.7*
Price deflators			
Output PPI: Primary metal product mfg	1.6	13.5	-1.9
Output PPI: Fabricated metal product mfg	2.0	4.6	3.7
Output PPI: MP[d]	*1.7*	*9.4*	*0.3*
Input PPI: Primary metal product mfg	2.2	16.1	9.0
Input PPI: Fabricated metal product mfg	1.4	8.7	-2.5
Input PPI: MP[d]	*1.8*	*12.4*	*3.0*
Sales and service income: MP[d]	*4.5*	*12.3*	*6.1*

[a] National accounts chain volume measure of MP value added [b] Deflated series using output prices from ABS *Producer Price Indexes* (PPI) publication. The 'sum of subdivisions' series generated by estimating a PPI for MP by using subdivision PPIs and current price value added weights. [c] Sales and service income from ABS *Business Indicators* publication. The real 'sum of subdivisions' series generated by estimating a price deflator for MP by using subdivision deflators and current price sales and service income weights. [d] Deflators estimated using relevant subsector deflators weighted by nominal sales and service income shares.

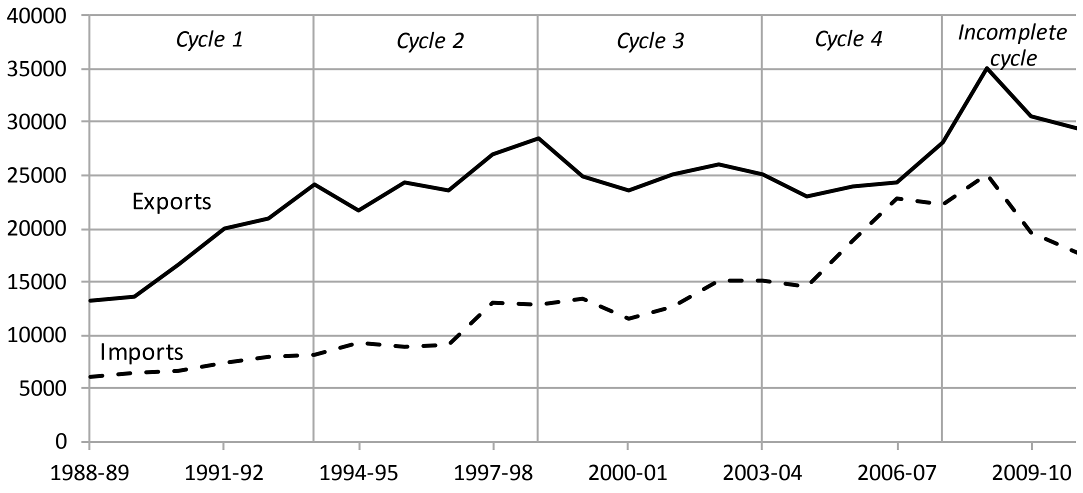
Sources: Authors' estimates based on ABS (*Australian System of National Accounts*, 2010-11, Cat. no. 5204.0); ABS (*Business Indicators, Australia, September 2012*, Cat. no. 5676.0) and ABS (*Producer Price Indexes, Australia, December 2012*, Cat. no. 6427.0).

H.2 Trade in metal products

Unlike much of Manufacturing, Australia has a trade surplus in metal products, although this surplus narrowed over cycles 3 and 4 (figure H.2). While additional steel imports have played a role in narrowing this gap (figure 6.6), more disaggregated data indicate that the bulk of the trade movement has been driven by changes in the rate of import and export of refined gold.

Figure H.2 **Real exports and imports of metal products**

2009-10 $m



Data sources: Authors' estimates based on ABS (*International Trade in Goods and Services*, various issues, Cat. no. 5368.0); and ABS (*International Trade Price Indexes, Australia,* various issues, Cat. no. 6457).

Changes in the Australian and New Zealand Standard Industrial Classification (ANZSIC) for Metal products make it difficult to identify the parts of the subsector experiencing changes in the volume of trade. An alternative classification system, the Standard International Trade Classification (SITC), allows metal products to be disaggregated into different product groups, but not ones that concord to Primary or Fabricated metals under an ANZSIC system. Data on the changes in these SITC groups (in real terms) are presented in table H.2.

The only groups to see real export growth over cycle 4 were alumina and gold-related products. The growth in alumina exports is consistent with the growth in alumina production discussed in chapter 6. All of the SITC MP product groups experienced a growth in imports with iron, steel and gold-related groups showing the greatest increases in import volumes over cycle 4. However, between cycles, the strongest growth in both imports and exports was in gold-related products, which corresponds to Australian operations that import gold, refine it further and then re-export it (ABARE 2008).

Table H.2 **Real exports and imports of metal products on an SITC basis[a]**

	Cycle 3		Cycle 4		Difference	
	Growth	*Contrib.*	*Growth*	*Contrib.*	*Growth*	*Contrib.*
Exports	% py	% pts	% py	% pts	% py	% pts
285: Aluminium ores and concentrates (incl. alumina)[b]	4.9	0.5	5.8	0.8	0.8	0.1
67: Iron & steel	-11.4	-0.7	-1.9	-0.1	9.5	0.7
68: Non-ferrous metals	1.4	0.3	-1.2	-0.3	-2.6	-0.7
69: Manufactures of metals, nes[c]	-1.2	0.0	-6.9	-0.2	-5.7	-0.1
97: Gold, non-monetary (excl. gold ores & concentrates)	-5.7	-3.2	6.2	3.4	11.9	6.6
Total exports	**-3.1**	**-3.1**	**3.6**	**3.6**	**6.6**	**6.6**
Imports						
285: Aluminium ores and concentrates (incl. alumina)[b]	-2.4	0.0	9.3	0.0	11.7	0.0
67: Iron & steel	5.3	0.9	6.9	1.3	1.5	0.3
68: Non-ferrous metals	-3.9	-0.4	7.3	0.6	11.2	1.1
69: Manufactures of metals, nes	6.9	1.3	10.5	2.2	3.6	0.9
97: Gold, non-monetary (excl. gold ores & concentrates)	-1.5	-0.8	14.3	7.4	15.8	8.2
Total imports	**0.9**	**0.9**	**11.5**	**11.5**	**10.6**	**10.6**

[a] Contributions do not add to total due to rounding. [b] Deflated using additional United Nations trade data and should be treated as indicative only. Note that category 285 is very small in terms of the real value of imports, hence its near zero contribution. [c] Export price deflators for category 69 are unavailable, and so are deflated by category 68 instead. Data for this row should be treated as indicative only.

Sources: Authors' estimates based on ABS (*International Trade in Goods and Services*, various issues, Cat. no. 5368.0); ABS (*International Trade Price Indexes, Australia,* various issues, Cat. no. 6457.0); and UN (2013).

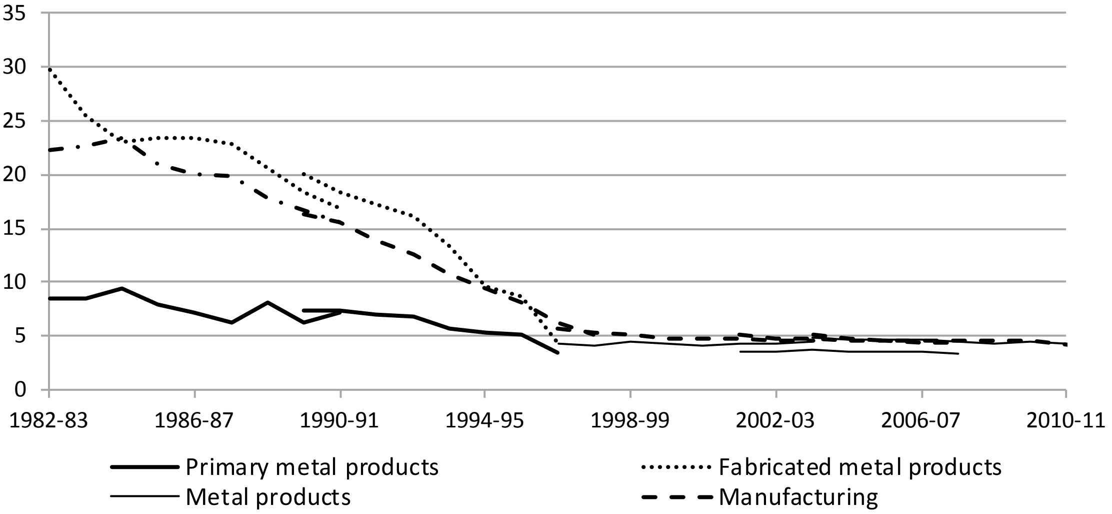
Effective rates of assistance

The combined value of budget and tariff assistance to both MP and Manufacturing, expressed as a share of their value of output, has been constant at around 5 per cent (figure H.3) since the mid-1990s. Additional data regarding the effective rates of assistance for Primary and Fabricated metals are available prior to 1996-97.[2] These data show that the effective rate of assistance for Fabricated metals was relatively higher than that of Primary metals.

2 These data are not available beyond 1996-97.

Figure H.3 **Effective rates of assistance, Metal products and Manufacturing**[a]

Per cent



a Breaks in the series are represented by gaps in the chart, and overlaps are included to show the effects of the methodological and data changes made in moving between series.

Data source: PC (2011).

H.3 Input-output linkages of Metal products

As discussed in section 6.2, the use of output from Metal products has changed over the period of cycles 3 and 4. An increasing share of Fabricated metals and Basic ferrous metal products are being used in construction, with a lesser share being used in other parts of Manufacturing. Table H.3 provides additional data on the value of products supplied by Metal products and its two subdivisions to other parts of the economy.

Broadly speaking, the share of Metal products output that is exported or used by Construction and Mining has been rising through time (mainly) at the expense of use by domestic Manufacturing. At the subdivision level, it becomes clear that the growth in exports was being driven by Primary metals, where strong growth in metal prices led to a higher value of exported products (although not necessarily a higher volume of exports). The growth in the Metal products used by Construction and Mining is mainly Fabricated metals, but also 'Basic ferrous metals' and 'Basic ferrous metal products' groups within Primary metals.

Table H.3 **Downstream users' share of total supply[a] from Australian Metal product manufacturing**

Percentage shares

	Metal products[b]	*ME and transport*[c]	*Total Mfg*	***Constr.***	***Mining***	*Total industry uses*	*Exports*	*Final use (net of exports)*
Metal products								
1994-95	27.2	12.4	46.1	**11.9**	**1.5**	68.2	26.5	5.3
2001-02	20.5	8.8	35.1	**11.4**	**1.8**	57.7	38.1	4.2
2008-09	21.5	9.9	34.2	**14.3**	**2.8**	59.2	36.2	4.6
Primary metals								
1994-95	34.4	15.2	52.5	**3.5**	**0.6**	59.3	38.9	1.8
2001-02	25.1	9.3	37.6	**4.9**	**1.1**	46.4	53.2	0.4
2008-09	26.0	10.8	38.7	**5.8**	**0.9**	48.5	49.9	1.6
Fabricated metals								
1994-95	14.5	7.4	34.9	**26.7**	**3.0**	84.0	4.6	11.4
2001-02	10.8	7.6	29.7	**25.2**	**3.4**	82.0	5.7	12.3
2008-09	10.8	7.6	23.5	**34.4**	**7.3**	84.5	3.9	11.7

[a] The last three columns in the table sum to 100 and represent 'total supply'. Total supply is the sum of all final uses (including export) and total industry use. Input-output tables are based on value (current prices) rather than volume measures. [b] There are some concordance issues between the ANZSIC93 and ANZSIC06. For better concordance with ANZSIC06, Metal products in 1994-95 and 2001-02 *include* Prefabricated buildings. [c] 'Machinery and equipment and transport'. Refers to 28 Machinery and equipment in ANZSIC93 for 1994-95 and 2001-02 and to sum of 23 Transport equipment and 24 Machinery and equipment in ANZSIC06 for 2008-09.

Source: Authors' estimates based on ABS (*Australian National Accounts: Input-Output Tables,* various issues, Cat. no. 5209.0.55.001).

H.4 Capital lags in Metal products

The strong investment growth in Metal product manufacturing over cycle 4 was also associated with larger projects that took longer to complete. Much of this was due to the size and scale associated with increasing the production of alumina. For example, the Alcan expansion at Gove first appeared as 'committed' on the October 2004 ABARE advanced project list, and was not completed until 2007 (ABARE 2004c, 2007).

Capital lags affect multifactor productivity (MFP) growth in periods where there is an acceleration or deceleration in growth of capital inputs. Provided investments are fully utilised over time, such lags have little effect on MFP in the long run.

For the case of Metal products, where the average length between investment and completion was between two and three years[3], the effect of lagging capital inputs is very apparent in the 2003-04 to 2007-08 productivity cycle — the period of strong capital inputs growth (table H.4). With a two-year lag of capital services, annual average MFP growth in that cycle improves by 0.6 of a percentage point but is still negative (-0.3 per cent); with a three-year lag, MFP improves by 1.8 percentage points and becomes positive (1.0 per cent).

Table H.4 **Effect of two- and three-year capital lags on MFP in Metal products**

	MFP growth			*Effect of the lag on MFP*[a]	
Cycle	*no lags*	*2 year lag*	*3 year lag*	*2 year lag*	*3 year lag*
	% py	% py	% py	% pts	% pts
1988-89 to 1993-94	1.0	0.3	0.2	-0.7	-0.8
1993-94 to 1998-99	1.1	1.3	0.8	0.2	-0.3
1998-99 to 2003-04	1.4	2.3	2.5	0.9	1.1
2003-04 to 2007-08	-0.9	-0.3	1.0	0.6	1.8
2007-08 to 2010-11[b]	0.1	-1.7	-2.4	-1.8	-2.5

[a] Relative to the case with no lags. [b] Incomplete cycle.

Source: Authors' estimates.

However, in the incomplete cycle 2007-08 to 2010-11, lagging capital inputs worsens rather than improves MFP. With no lags, MFP is positive (though close to zero) but a two- and three-year lag of capital inputs results in average MFP growth rates of -1.7 and -2.4 per cent a year, respectively.

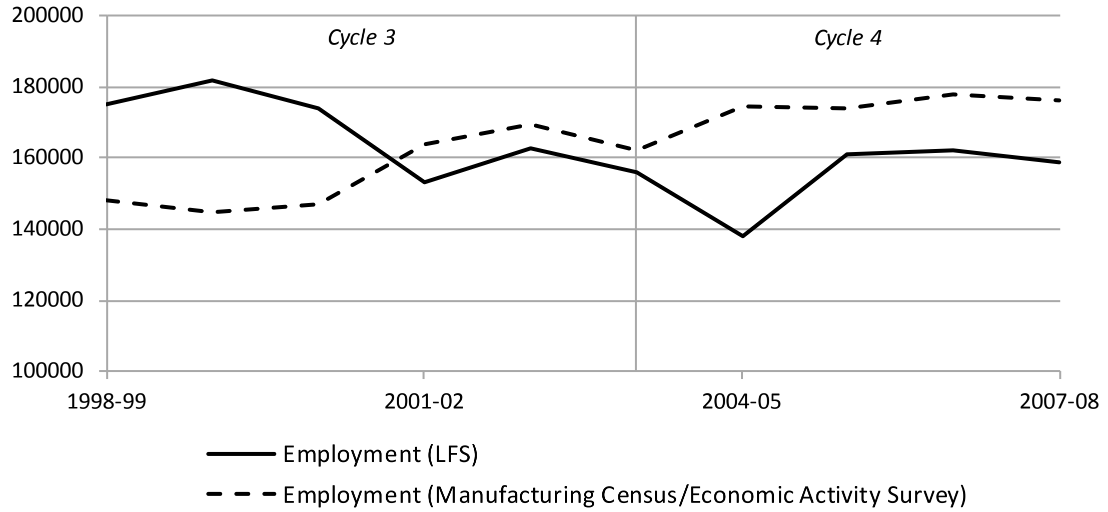
In effect, adjusting for lags in capital only 'pushes' the period of the poor productivity performance to a later period as strong growth of the lagged capital is shifted into the incomplete cycle (which also had poorer output growth relative to cycle 4). The implication is, however, that there may be some underutilised capacity within the Metal products subsector, which could be employed if the operating environment improves.

3 The average length of lags is calculated using investment data from the Deloitte Access Economics Investment Monitor (database).

H.5 Metal products labour data

There are two sources of ABS data available to investigate employment growth in Metal products and its subdivisions — the *Labour Force Survey* (LFS) and the *Manufacturing Census/Economic Activity Survey* (EAS). These two sources indicate roughly similar levels of employment in Metal products in total, although with some difference in trend (figure H.4).

Figure H.4 **Employment in Metal products[a]**

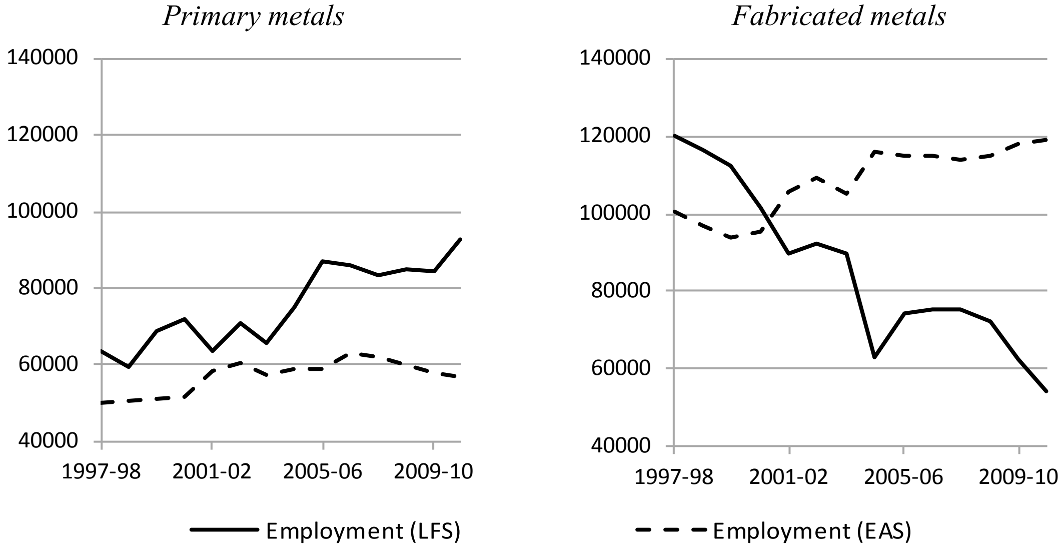


[a] There is a break in series for the Manufacturing Census/EAS data between 2005-06 and 2006-07 due to the change in ANZSIC classifications.

Data sources: ABS (unpublished Labour Force Survey data); ABS (*Manufacturing Industry, Australia,* various issues, Cat. no. 8221.0); ABS (*Australian Industry*, various issues, Cat. no. 8155.0).

However, in the Metal products subdivisions, the two different sources of data indicate substantially different levels and trends (figure H.5). In Primary metals, the LFS indicates stronger growth in employment relative to the EAS. In Fabricated metals, the LFS indicates a declining trend in employment, while the EAS indicates growth.

Figure H.5 **Employment in Metal products subdivisions**[a]



[a] There is a break in series for the Manufacturing Census/EAS data between 2005-06 and 2006-07 due to the change in ANZSIC classifications.

Data sources: ABS (unpublished Labour Force Survey data); ABS (*Manufacturing Industry,* various issues, *Australia,* Cat. no. 8221.0) and ABS (*Australian Industry*, *2010-11*, Cat. no. 8155.0).

A possible source of the discrepancies between the two data sources is that the surveys use different methods of industry identification. In the LFS, the employee indicates their industry of employment, while in the EAS the employer indicates their number of employees. Employer (business) surveys can be a more reliable basis for industry identification (appendix G). The EAS employment data also appear more consistent with output trends in this case. There was strong growth in Fabricated metal product employment over the period of cycle 4, which coincides with the value added growth in Fabricated metals over the same period.

It is possible to disaggregate the growth in employment in Fabricated metals along the same lines as output (box 6.1) in order to try and identify those industry classes responsible for employment growth. This approach is hampered by the unavailability of data at this level of disaggregation after 2006-07 (table H.5).

Table H.5 **Estimated contributions to growth in employment in Fabricated metals**

	Period 1 (cycle 3): 1998-99 to 2003-04		*Period 2: 2003-04 to 2006-07*		*Difference between periods*
	Change in employment	*Contrib. to growth*	*Change in employment*	*Contrib. to growth*	*Change in employment*
	number	% pts	number	% pts	number
2221 Structural steel fabricating	-3 934	-0.5	5 387	0.6	9 321
2223 Architectural aluminium product manufacturing	1 956	0.2	2 033	0.2	77
2229 Other structural metal product manufacturing	1 065	0.1	4 809	0.6	3 744
2291 Spring and wire product manufacturing	-773	-0.1	-368	0.0	405
2292 Nut, bolt, screw and rivet manufacturing	190	0.0	19	0.0	-171
2293 Metal coating and finishing	1 577	0.2	947	0.1	-630
Selected classes[a]	*81*	*0.0*	*12 827*	*1.5*	*12 746*
All other fabricated metal prod.	*8 556*	*1.1*	*-3 827*	*-0.5*	*-12 383*
22 Fabricated metals	*8 637*	*1.1*	*9 000*	*1.1*	*363*

[a] Includes the ANZSIC06 classes listed above. These are the classes for which there was no change in definition between ANZSIC93 to ANZSIC06. See box 6.1 for further details.

Sources: Authors' estimates based on ABS (*Australian Manufacturing*, various issues, Cat. no. 8221.0), ABS (*Australian Industry*, various issues, Cat. no. 8155.0) and ABS *(Experimental Estimates for the Manufacturing Industry,* various issues, Cat. no. 8159.0).

The strongest employment growth in the period that overlaps cycle 4 occurred in Structural steel fabricating and Other structural metal product manufacturing, and the strongest employment growth between cycles was in the former. This matches with the trends observed in the nominal value added growth for the subdivision (table 6.4).

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