# 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

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| 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

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| --- | --- | --- | --- |
| ANZSIC06 subdivision/groupa | Value added | Hours worked | Investmentb |
| **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]](#footnote-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**

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| *Net capital stock per hour worked*b | *Capital income share*c |
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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).

### 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

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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

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*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).

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| 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. |
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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)

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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)

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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]](#footnote-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.

### 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]](#footnote-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.

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| 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). |
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#### 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

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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

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*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]](#footnote-4)

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

#### 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)

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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.

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| 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*.* |
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##### 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 3b | Growth in cycle 4b | 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]](#footnote-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]](#footnote-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]](#footnote-9) A review of the various pharmaceutical incentive schemes in place over cycles 3 and 4[[10]](#footnote-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)

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]](#footnote-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

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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).

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]](#footnote-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.

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

2009-10 $m

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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]](#footnote-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.

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

2009-10 $m

|  |
| --- |
| *Machinery and equipment* |
|  |
| *Non-dwelling construction* |
|  |
|  |

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]](#footnote-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.

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.

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. [↑](#footnote-ref-1)
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. [↑](#footnote-ref-2)
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. [↑](#footnote-ref-3)
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. [↑](#footnote-ref-4)
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). [↑](#footnote-ref-5)
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). [↑](#footnote-ref-6)
7. ANZSIC06 class 1841 ‘Human pharmaceutical and medicinal product manufacturing’. [↑](#footnote-ref-7)
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. [↑](#footnote-ref-8)
9. This is consistent with the observed increase in imports, discussed above. [↑](#footnote-ref-9)
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). [↑](#footnote-ref-10)
11. Authors’ estimates of Pharmaceutical Benefits Scheme payments and other pharmaceutical expenses paid by consumers based on data from AIHW (2012). [↑](#footnote-ref-11)
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). [↑](#footnote-ref-12)
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. [↑](#footnote-ref-13)
14. Ammonia and ammonium nitrate are key inputs to fertilisers and explosives. [↑](#footnote-ref-14)