Productivity in Australia's broadacre and dairy industries

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Summary

• From 1977–78 to 2014–15, productivity in the broadacre industries grew by 1.1 per cent per year on average as a result of declining input use (–1 per cent a year) and modest output growth (0.1 per cent a year).

• From 1977–78 to 2014–15 average annual productivity growth in the cropping industry was 1.5 per cent a year, compared with beef (1.3 per cent), sheep (0.3 per cent) and mixed livestock–crops (0.9 per cent).

• Since 2001–02 the sheep industry has exhibited strong annual productivity growth (2.7 per cent a year) compared with the cropping (2.1 per cent), beef (0.5 per cent) and mixed livestock–crops (1.2 per cent) industries.

• Climate conditions have significantly affected the productivity of cropping farms. However, adjusting for the effects of climate, the productivity of cropping farms grew strongly from 1977–78 to 1993–94 (2.5 per cent a year), slowed between 1994–95 and 2006–07 (0.2 per cent) and increased between 2006–07 and 2014–15 (1.7 per cent).

• In the dairy industry, productivity growth averaged 1.5 per cent a year between 1978–79 and 2014–15. This was a result of a 1.3 per cent a year increase in output and a 0.2 per cent a year decline in input use.

Introduction

Productivity growth is an important measure of performance for Australian agriculture because in the long term it reflects changes in the efficiency with which farmers use land, labour, capital and intermediate inputs (for example, chemicals, fodder and purchased services) to produce outputs such as crops, meat, wool and milk.

Productivity growth is the key mechanism by which farmers maintain profits. Profitability improves farmers’ livelihoods and attracts investment and resources into agriculture. It also helps farmers:

• finance ongoing expenditure on farm inputs
• meet debt-servicing obligations
• fund investments in new technologies
• earn a return on their entrepreneurial ability and capital investments.
Productivity growth helps farmers offset the impact on profitability of a declining trend in farmer terms of trade (output prices relative to input prices) (Figure 1). Improving productivity is the main way farmers can meet the challenges of uncertain seasonal conditions and other factors beyond their control.

**FIGURE 1** Agricultural total factor productivity and farmer terms of trade, Australia, 1948–49 to 2013–14

Productivity growth is the increase in output beyond associated increased input use (or a decrease in the quantity of inputs needed to produce a unit of that output). ABARES preferred measure of productivity is total factor productivity (TFP), the ratio of gross output to total inputs. TFP takes into account a wide range of inputs used and outputs produced (Zhao et al. 2012). Long-term TFP growth is a key indicator of the underlying efficiency of farm businesses. However, short-term variations in TFP can reflect changes in seasonal conditions, so readers should be cautious when interpreting year-to-year movements of TFP numbers.

ABARES produces productivity measures for the Australian broadacre and dairy industries (Box 1). This article updates ABARES productivity statistics to include data for 2014–15 and summarises some of the previous research on the drivers of agricultural productivity.

**Drivers of agricultural productivity growth**

In the long term, technological progress is the main driver of productivity growth. Public and private investment in research and development (R&D) has contributed significantly to agricultural productivity growth in Australia (Sheng et al. 2011a). Farmers have captured developments in technology and knowledge by investing in higher-yielding, pest and disease-resistant crop varieties, superior planting and harvesting techniques, and better livestock genetics.
Box 1 ABARES productivity estimates

ABARES estimates total factor productivity (TFP) as the ratio of a quantity index of gross output relative to a quantity index of total input. Outputs cover crops and livestock products. Inputs include land, labour, capital, materials and services. The Fisher index is used to aggregate across different outputs and inputs into quantity indexes. Calculating average TFP growth rates is based on fitting an exponential trend line to the annual productivity indexes.

TFP estimates for the broadacre and dairy industries are based on data collected through ABARES farm surveys. ABARES surveys approximately 1,600 broadacre farms and 300 dairy farms each year. Farm data are collected through face-to-face interviews with farmers about farm business operations during the preceding financial year. Interview questions cover farm management, production of crops and livestock products, labour use, expenditure, assets and debt positions, government assistances and off-farm activities.

ABARES classifies broadacre and dairy farms in accordance with the Australian and New Zealand Standard Industrial Classification (ANZSIC) (ABS 2013):

**Crops industry (ANZSIC06 class 0146 and 0149)**—farms engaged mainly in growing cereal grains, coarse grains, oilseeds, rice and/or pulses.

**Mixed livestock–crops industry (ANZSIC06 class 0145)**—farms engaged mainly in running sheep or beef cattle (or both) and growing cereal grains, coarse grains, oilseeds and/or pulses.

**Beef industry (ANZSIC06 class 0142)**—farms engaged mainly in running beef cattle.

**Sheep industry (ANZSIC06 class 0141)**—farms engaged mainly in running sheep.

**Sheep–beef industry (ANZSIC06 class 0144)**—farms engaged mainly in running both sheep and beef cattle. In this article, TFP estimates are not reported separately for these farms. However, they are included within the aggregate broadacre estimates.

**Dairy industry (ANZSIC06 class 0160)**—farms engaged mainly in farming dairy cattle.

A farm is classified into an industry if more than 50 per cent of its receipts are generated by that particular enterprise. Farms that do not meet this criterion for any single enterprise are considered mixed livestock–crops farms. The broadacre industries accounted for about 60 per cent of the total gross value of Australian agricultural production in 2014–15.
In the short term, measures of productivity growth for agricultural industries are sensitive to climate variability (Hughes et al. 2011; Sheng et al. 2011b). Much of the productivity growth between the late 1970s and mid 1990s was the result of generally above average rainfall, which increased cropping yields and contributed to strong pasture growth. A slowdown in productivity growth since the mid 1990s is partly a result of adverse seasonal conditions, particularly during the 2000s (Sheng et al. 2011b).

Reforms in Australian agricultural industries have also affected productivity. For example, the removal of marketing and price support mechanisms has contributed directly and indirectly to productivity growth of the broadacre industries (Gray et al. 2014a). These reforms led to structural change through the amalgamation of farms, better risk management and changes in the mix of agricultural commodities produced. These changes altered the allocation of resources between farms, with more efficient producers tending to gain a greater market share over time (Sheng & Jackson 2016; Sheng et al. 2016b).

Farm size increased over the four decades to 2014–15 (Figure 2). Individual farms have expanded and some small farms have left the industry. ABARES has found that larger farms tend to have higher productivity than smaller farms, partly because they use different technologies (Sheng et al. 2014). Large farms may benefit more from adopting innovations than small farms because they have the capacity to fund investment, and technology providers are more likely to produce solutions that meet the needs of large farms (Jackson & Martin 2014).

**FIGURE 2** Farm population and average farm size, all broadacre industries, Australia, 1977–78 to 2014–15

![Diagram showing farm population and average farm size](image-url)

Note: Average farm size is measured in dry sheep equivalents (dse).

Source: ABARES
Farm managers also have a significant bearing on the productivity of farms. Farming is a complex production process. Managers require knowledge and a broad range of skills to maximise profits given uncertainty about seasonal conditions and future prices. Good managers are more likely to make use of information and change technology when it is advantageous to do so. This allows them to produce maximum output from a given set of inputs, leading to higher productivity (Nossal & Lim 2011).

**Broadacre productivity**

Productivity growth in the broadacre industries averaged 1.1 per cent a year between 1977–78 and 2014–15 as a result of declining input use and modest output growth (Table 1, Figure 3). From 2001–02 to 2014–15 productivity growth increased by an average of 1.4 per cent a year as a result of a faster decline in input use than in output production (Table 1).

Total input use in the broadacre industries declined between 1977–78 and 2014–15 at an average annual rate of 1 per cent a year. Land use, which accounts for the largest share of total broadacre input use, declined on average by 1 per cent a year. Similarly, use of capital declined by 1.5 per cent and labour by 2.2 per cent a year. In contrast, use of material inputs including fertiliser, crop chemicals and fodder increased significantly, reflecting a trend towards more intensive management systems for livestock and crop production.

Despite declining input use, broadacre output increased by 0.1 per cent a year between 1977–78 and 2014–15. However, this varied substantially over time, mostly because of changing seasonal conditions.

**FIGURE 3** Total factor productivity, output and input, all broadacre industries, Australia, 1977–78 to 2014–15

Source: ABARES Australian Agricultural and Grazing Industries Survey
Three key trends can be identified from the varying productivity growth rates across broadacre industries. First, the cropping industry has had higher average productivity growth than livestock industries over the long term. For the cropping industry, TFP growth averaged 1.5 per cent a year between 1977–78 and 2014–15, compared with mixed livestock–crops (0.9 per cent), beef (1.3 per cent) and sheep (0.3 per cent) (Table 1). The cropping industry's higher growth could be a result of more rapid developments in cropping technologies and reallocation of resources towards crop production in the three decades to 2006 (Mullen 2007; Sheng et al. 2016a).

### TABLE 1 Total factor productivity, output and input growth, broadacre industries, Australia, 1977–78 to 2014–15

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>All broadacre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Output</td>
<td>0.1</td>
<td>−0.4</td>
</tr>
<tr>
<td>Input</td>
<td>−1.0</td>
<td>−1.8</td>
</tr>
<tr>
<td>Cropping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>1.5</td>
<td>2.1</td>
</tr>
<tr>
<td>Output</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Input</td>
<td>1.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Mixed livestock–crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>0.9</td>
<td>1.2</td>
</tr>
<tr>
<td>Output</td>
<td>−0.8</td>
<td>−1.6</td>
</tr>
<tr>
<td>Input</td>
<td>−1.8</td>
<td>−2.8</td>
</tr>
<tr>
<td>Sheep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>0.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Output</td>
<td>−2.6</td>
<td>−3.3</td>
</tr>
<tr>
<td>Input</td>
<td>−2.9</td>
<td>−5.9</td>
</tr>
<tr>
<td>Beef</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total factor productivity</td>
<td>1.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Output</td>
<td>1.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Input</td>
<td>−0.2</td>
<td>−0.3</td>
</tr>
</tbody>
</table>

Source: ABARES Australian Agricultural and Grazing Industries Survey
Second, the difference in productivity growth rates between cropping and livestock industries is narrowing (Figure 4). This can be attributed to a slowdown in the productivity growth of the cropping industry since the late 1990s (Sheng et al. 2011b) and productivity improvements in the beef industry in the 25 years to 2014–15 (Figure 4). High productivity growth in the sheep industry from 2001–02 to 2014–15 is the result of a larger decline in input use than output (Table 1). This follows the removal of the wool reserve price scheme in 1991 and subsequent industry consolidation, as well as shifts by farmers from wool production to cropping and sheep meat production.

Figure 4

Total factor productivity growth, by broadacre industries, Australia, 1977–78 to 2014–15

Third, from 1977–78 to 2014–15 the mixed livestock–crops industry experienced modest productivity growth of 0.9 per cent a year on average. The increase in productivity in this industry was a result of a fall in output (–0.8 per cent a year) and a greater decline in the use of input (–1.8 per cent a year). In the two decades to 2014, mixed livestock–crops farms have tended to specialise in either crop or livestock enterprises (McKenzie 2014). This structural change has shifted inputs away from this industry and into specialised crop and livestock production.

Cropping

Productivity in the cropping industry grew on average by 1.5 per cent a year between 1977–78 and 2014–15. This was driven by strong output growth (2.6 per cent a year) relative to input growth (1.2 per cent a year) (Table 1, Figure 5).
Jackson (2010) and Knopke et al. (2000) attributed strong productivity growth in the cropping industry in the 1980s and 1990s to developments in technology such as larger machinery, new plant varieties, improved water management and a better understanding of harvesting and planning strategies. Productivity growth in the cropping industry has slowed since the late 1990s (Sheng et al. 2011b). This has been attributed to drought, the slower spread of new technology, a slowdown in the development of breakthrough technologies, the effects of knowledge constraints, loss of a profitable break crop and a shift in research priorities away from productivity-related factors (Jackson 2010).

Output has grown strongly in the cropping industry, but input use has also increased. This is largely due to increased land and material input use. From 1977–78 to 2014–15 cropping farms have operated larger farms, with average farm sowing areas increasing nearly threefold. Material inputs including fertiliser, fuel, crop chemicals and seed have increased by an average of 4 per cent a year. Improved understanding of cropping systems, including plant physiology and determinants of soil fertility, has expanded the use of fertiliser and crop chemicals (especially nitrogen and soil ameliorants such as lime and gypsum).

Cropping farms continue to face climate risks. A 2017 ABARES study (Hughes et al. forthcoming) quantifies the impact of climate conditions on cropping farm productivity (Box 2).

The Grains Research and Development Corporation (GRDC 2015) identifies three broad cropping regions across Australia: northern, southern and western. The three regions all experienced productivity growth between 1977–78 and 2014–15 but vary in their output and input growth (Table 2). Variations in climate conditions, soil fertility and operating environment across the regions contribute to differences in crop varieties and production systems. For example, climate and soil conditions in the northern region enable farmers to diversify crop production (GRDC 2015). In contrast, farmers in the western region have practised no-tillage extensively over the longest period (Llewellyn et al. 2012).
Box 2 Effect of climate on cropping farm productivity

ABARES productivity estimates are subject to significant climate effects, including large decreases in drought years. This can make it difficult to discern underlying trends in farm performance, both in the short term due to annual climate variability and in the longer term due to climate change.

Over the 20 years to 2013, the CSIRO and Australian Bureau of Meteorology have observed marked changes in Australia’s climate, including reductions in average winter rainfall in southern Australia and general increases in temperature (CSIRO & BoM 2014). Evidence suggests these trends are partly due to climate change (CSIRO 2012; CSIRO & BoM 2016). A 2017 ABARES study (Hughes et al. forthcoming) quantifies the effects of climate on the productivity of Australian cropping farms from 1977–78 to 2014–15. The research further presents climate-adjusted productivity estimates, which measure the performance of cropping farms after climate effects have been removed.

The climate-adjusted figures suggest that productivity grew strongly during the 1980s and early 1990s but slowed considerably from around 1993–94 (Figure 6). However, evidence suggests that productivity growth of cropping farms has been rising since 2006–07 at 1.7 per cent a year. Around 85 per cent of total productivity gains since 1977–78 occurred from 1987–88 to 1993–94 and from 2007–08 to 2013–14.

**FIGURE 6** Average climate-adjusted productivity, cropping farms, Australia, 1977–78 to 2014–15

![Graph showing average climate-adjusted productivity](image)

Note: The method used by Hughes et al. (forthcoming) for calculating productivity differs slightly from that used in this article. Estimates therefore vary.
Source: Hughes et al. forthcoming

continued ...
In the two decades to 2014–15, climate conditions deteriorated across many grain-growing regions. Map 1 shows the average effect of climate on productivity levels from 2000–01 to 2014–15 (relative to long-term average conditions). Southern New South Wales and northern parts of the western GRDC region were significantly affected by adverse climate conditions from 2000–01 to 2014–15, due largely to declines in average winter rainfall. However, from 2000–01 onward some regions also experienced slight improvements, including the high rainfall zones of southern Australia, and parts of coastal northern New South Wales and southern Queensland. The results show that farms have become less sensitive to adverse climate shocks over the decade to 2014–15. This suggests that cropping farms are adapting to the longer-term changes in climate by focusing on technologies that improve productivity in dry years. Anecdotal evidence suggests that farmers have adopted a variety of management practices, including conservation tillage, to exploit summer soil moisture in anticipation of reduced winter rainfall.

**MAP 1** Average climate effect on productivity levels, cropping farms, Australia, 2000–01 to 2014–15

Note: Climate effect is relative to the period 1914–15 to 2014–15.
Source: Hughes et al. forthcoming

**TABLE 2** Total factor productivity, output and input growth, cropping industry, by GRDC region, Australia, 1977–78 to 2014–15

<table>
<thead>
<tr>
<th>Region</th>
<th>TFP (%)</th>
<th>Output (%)</th>
<th>Input (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>1.3</td>
<td>1.9</td>
<td>0.6</td>
</tr>
<tr>
<td>Southern</td>
<td>1.9</td>
<td>2.9</td>
<td>1</td>
</tr>
<tr>
<td>Western</td>
<td>1.4</td>
<td>3.7</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Source: ABARES Australian Agricultural and Grazing Industries Survey
**Beef**

Productivity growth in the Australian beef industry averaged 1.3 per cent a year between 1977–78 and 2014–15. Output increased by 1.1 per cent and inputs declined by 0.2 per cent a year (Table 3 and Figure 7). In the four decades to 2012–13, productivity improvements in this industry were partly realised through improved pastures, herd genetics and disease management, which lowered mortalities and increased branding rates (calves marked as a percentage of cows mated) (Jackson et al. 2015).

**FIGURE 7** Total factor productivity, output and input, beef industry, Australia, 1977–78 to 2014–15

Climate, pastures, industry infrastructure and proximity to markets vary significantly for beef enterprises in northern and southern Australia. These factors have contributed to differences in production systems such as in herd structure and farm operations.

From 1977–78 to 2014–15 productivity growth was higher for northern beef farms (1.4 per cent a year) compared with their southern counterparts (0.6 per cent a year) (Table 3). This difference was a result of reduced input use in the north and increased input use in the south, particularly of fertiliser and chemicals.

Beef farms in the southern region face a more varied climate and are more sensitive to drought conditions. This can lead to increased feed costs and destocking and restocking cycles that affect output growth. Beef farms in the southern region are also smaller and less profitable. This is likely to contribute to lower average productivity growth (Jackson & Valle 2015).
Productivity growth in the sheep industry averaged 0.3 per cent a year from 1977–78 to 2014–15 (Figure 8). Sheep industry productivity declined between 1978–88 and 1993–94 but has since rebounded. Sheep industry productivity grew by an average of 2.7 per cent a year from 2001–02 to 2014–15, the highest growth within the broadacre industries (Figure 4).

The Australian sheep industry has undergone significant adjustment since the early 1990s, when price support mechanisms for wool were removed. Many farmers shifted their enterprise mix from wool to cropping, resulting in lower sheep numbers. Numbers were further reduced by farmers destocking their properties during periods of drought. Productivity growth in the sheep industry has also been attributed to advances in animal breeding and genetics and improved herd, disease and fodder management (Gray et al. 2014b).

From the early 1990s to 2013 a significant increase in the share of ewes in flocks and a corresponding decline in that of wethers contributed to long-term growth in lamb production. However, wool production declined at a faster rate (Dahl et al. 2013). During that period, increased use of non-Merino rams, first-cross ewes and specialty meat breeds, combined with increased emphasis on selection and breeding for meat production traits, boosted productivity through higher lamb growth rates and greater incidence of twinning. Improved pastures and greater use of fodder crops and supplementary feed improved ewe fertility, reduced lamb mortality rates and increased average slaughter weights.

### TABLE 3 Total factor productivity, output and input growth, beef industry, by region, Australia, 1977–78 to 2014–15

<table>
<thead>
<tr>
<th>Region</th>
<th>TFP (%)</th>
<th>Output (%)</th>
<th>Input (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northern</td>
<td>1.4</td>
<td>1</td>
<td>−0.3</td>
</tr>
<tr>
<td>Southern</td>
<td>0.6</td>
<td>1.2</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Source: ABARES Australian Agricultural and Grazing Industries Survey

### Sheep

Productivity growth in the sheep industry averaged 0.3 per cent a year from 1977–78 to 2014–15 (Figure 8). Sheep industry productivity declined between 1978–88 and 1993–94 but has since rebounded. Sheep industry productivity grew by an average of 2.7 per cent a year from 2001–02 to 2014–15, the highest growth within the broadacre industries (Figure 4).

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### FIGURE 8 Total factor productivity, output and input, sheep industry, Australia, 1977–78 to 2014–15

![Total factor productivity, output and input, sheep industry, Australia, 1977–78 to 2014–15](image)

Source: ABARES Australian Agricultural and Grazing Industries Survey
Dairy

Productivity growth in the Australian dairy industry averaged 1.5 per cent a year between 1978–79 and 2014–15 (Figure 9). This was driven by output increasing by an average of 1.3 per cent a year and input use declining by an average of 0.2 per cent a year.

**FIGURE 9** Total factor productivity, output and input, dairy industry, Australia, 1977–78 to 2014–15

The drivers of productivity growth in the dairy industry were substantially different after the deregulation reforms implemented in 2000. Throughout the 1980s and 1990s, many dairy farms transitioned to more intensive production systems. This reduced labour and land requirements but increased material inputs such as fertiliser and supplementary feed (Ashton et al. 2014). Productivity improvements during this period were driven by output increasing faster than input use, as farmers adopted new technologies such as rotary dairies, artificial insemination and improved pastures (Harris 2011).

In the 2000s many smaller farms exited the dairy industry following deregulation and total output declined. Productivity growth during this period was driven by input use declining faster than output, as resources such as land, labour and capital shifted towards the most efficient farms. In particular, deregulation appears to have facilitated the movement of resources from farms using the year-round production system, in which calving and milk production are spread evenly throughout the year, to those using the seasonal production system, in which production periods are more synchronised with pasture availability. This resource reallocation effect boosted industry productivity at a time when on-farm technological progress was slowing (Sheng & Jackson 2016).
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