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Productivity in Australia's broadacre and dairy industries

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Contents

Tables

Figures

Boxes

Summary

Productivity growth in Australia's agricultural sector is a key measure for assessing industry performance. In the long term, productivity growth reflects a key mechanism by which farmers can increase profits and maintain international competiveness. ABARES publishes productivity estimates over the period 1977–78 to 2015–16 for the broadacre industries, and 1978–79 to 2015–16 for the dairy industry.

Broadacre

In the Australian broadacre agriculture sector (the non-irrigated cropping and extensive livestock industries), average productivity growth averaged 1.1 per cent per year over the period 1977–78 to 2015–16. This growth was largely driven by reduced input use (particularly land, labour and capital), rather than by output growth. Input use declined by 0.9 per cent per year, and there was modest output growth of 0.1 per cent per year from 1977–78 to 2015–16.

Across the broadacre industries, productivity growth was variable between industries. Over the period 1977–78 to 2015–16, average annual productivity growth in the cropping industry was 1.5 per cent per year, compared with beef (1.2 per cent), sheep (0.2 per cent) and mixed-crop-livestock (0.9 per cent).

Dairy

In the dairy industry, productivity growth averaged 1.4 per cent per year between 1978–79 and 2015–16. This was a result of a 1.2 per cent per year increase in output and a 0.2 per cent per 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 a 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). Improving productivity is the main way farmers can maintain and increase profitability, and helps offset the effects of the major negative influences that are beyond their control, such as seasonal conditions and market prices of outputs and inputs.

Productivity growth is defined as an 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 caution should be exercised in 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 2015–16 and summarises some of the previous research on the drivers of agricultural productivity.

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 (Zhao et.al, 2012). 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 crop–livestock 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 crop–livestock farms. Broadacre industries accounted for about 60 per cent of the total gross value of Australian agricultural production in 2015-16.

Drivers of agricultural productivity growth

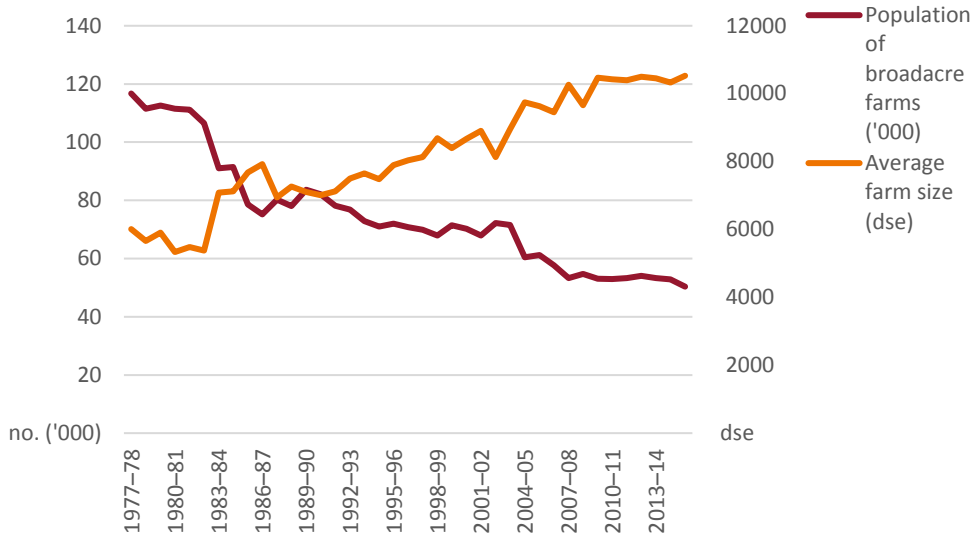
Technological progress is the main driver of long term productivity growth. Public and private investment in research, development, and extension (RD&E) has contributed significantly to agricultural productivity growth in Australia (Sheng et al. 2011a). In 2014–15, RD&E funding in the rural sector amounted to $3.3 billion, of which around half comprised of private RD&E investments (Millist et al. 2017). RD&E funding grew in real terms by 2.6 per cent per year over the 10 years to 2015–16. 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.

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). However, once the impact of climate is removed, productivity growth of cropping farms may have regained a stronger pace since 2006–07 (Hughes et al. 2011).

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 2015-16 (Figure 1). 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 are in a stronger position to fund investment (Sheng & Chancellor, 2018). Additionally, technology providers are more likely to produce solutions that meet the needs of large farms (Jackson & Martin 2014).

Figure 1 Farm population and average farm size, all broadacre industries, Australia, 1977–78 to 2015–16



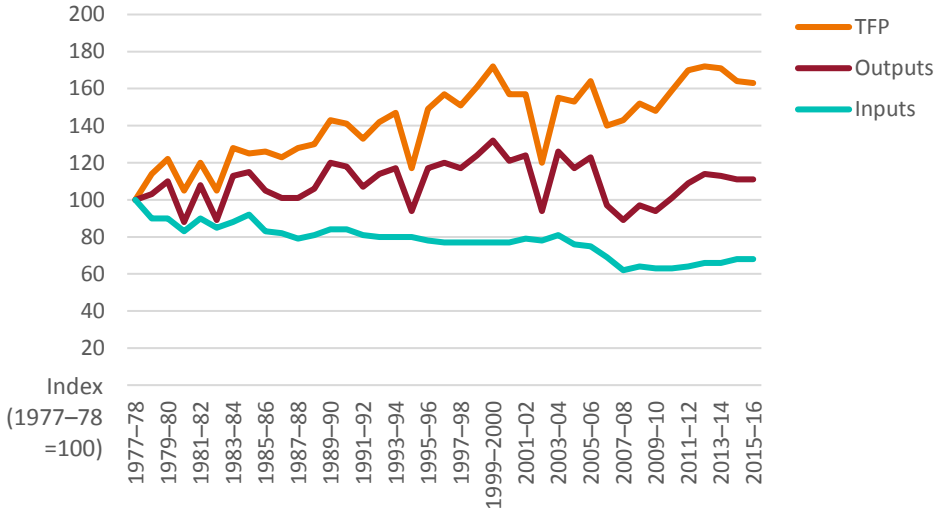
Note: Average farm size is measured in dry sheep equivalents (dse).
Source: ABARES

Farm managers play a pivotal role in increasing farm productivity. Farming is a complex production process. Managers require knowledge and a broad range of skills to maintain and improve profits, given uncertainty about seasonal conditions, emergence of new and more advanced technologies, 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 greater 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 per year between 1977–78 and 2015–16, primarily as a result of declining input use and modest output growth (Table 2, Figure 2). Total input use in the broadacre industries declined between 1977–78 and 2015–16, at an average annual rate of 0.9 per cent per year. Over the same period of time, broadacre output increased by 0.1 per cent per year. However, there was significant variation in these measures over time, mostly because of changing seasonal conditions.

Figure 2 Total factor productivity, output and input, all broadacre industries, Australia, 1977–78 to 2015–16



Source: ABARES Australian Agricultural and Grazing Industries Survey

Over the period 1977–78 to 2015–16, a decline in total input use occurred in beef, sheep and mixed crop-livestock industries, but not in the cropping industry (Table 1). The pattern of change in specific inputs (land, labour, capital, materials and services) also varied between industries. For example, while all industries used less labour in 2015–16 than in 1977–78, and most reduced the inputs of land (except cropping) and capital (except beef), use of materials increased significantly in cropping (4.1 per cent per year) and moderately in beef (2.0 per cent per year) and mixed crop-livestock (0.5 per cent per year), suggesting that production in these industries has become more heavily reliant on the use of inputs such as chemicals, fertilisers, seeds, fuel, electricity etc.

Table 1 Broadacre growth in input use, average annual change, by Industry, Australia, 1977–78 to 2015–16

	All broadacre (%)	Cropping (%)	Beef (%)	Sheep (%)	Mixed crop-livestock (%)
Land	–1.0	1.4	–0.2	–2.8	–1.5
Labour	–2.2	–0.8	–0.7	–3.5	–2.9
Capital	–1.5	–0.1	0.4	–3.9	–2.9
Material	1.7	4.1	2.0	–0.8	0.5
Services	–0.7	1.0	0.3	–2.7	–1.7
Total Inputs	**–0.9**	**1.2**	**–0.2**	**–2.9**	**–1.8**

Table 2 Total factor productivity, output and input growth, broadacre industries, Australia, 1977–78 to 2015–16

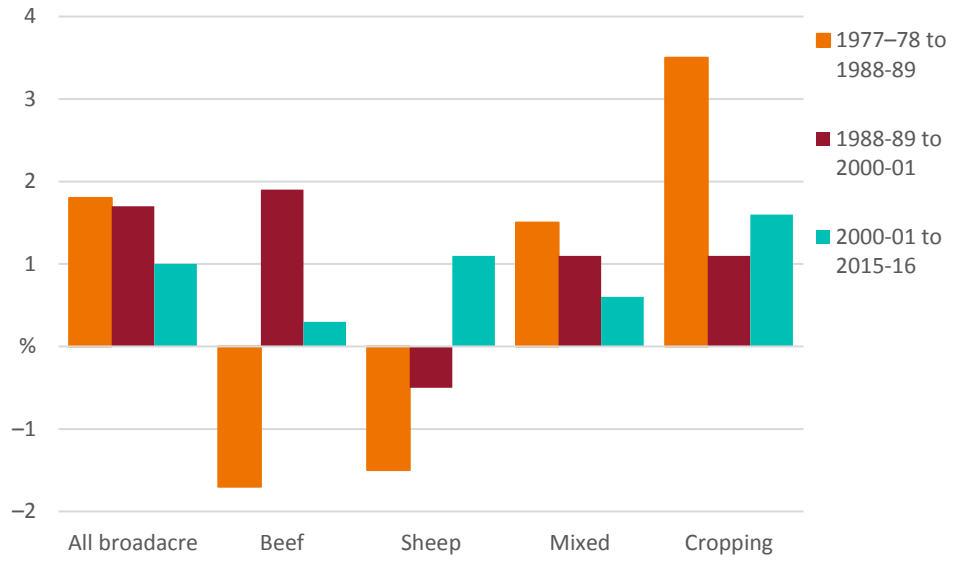
	Growth rate between 1977–78 and 2015–16 (%)	Growth rate in 2015–16 (%)*
All broadacre		
Total factor productivity	1.1	0.0
Output	0.1	0.0
Input	–0.9	0.0
Cropping		
Total factor productivity	1.5	4.3
Output	2.7	13.7
Input	1.2	9.4
Mixed crop–livestock		
Total factor productivity	0.9	–10.8
Output	–0.9	–14.1
Input	–1.8	–3.3
Sheep		
Total factor productivity	0.2	–18.9
Output	–2.7	–22.2
Input	–2.9	–3.3
Beef		
Total factor productivity	1.2	–2.7
Output	1.1	–2.7
Input	–0.2	0.0

Source: ABARES Australian Agricultural and Grazing Industries Survey
* Note: Residual measure. Care should be taken when interpreting this data, as single year agricultural productivity estimates are susceptible to volatility induced by climate and seasonal conditions

Three key trends can be identified from the varying productivity growth rates across broadacre industries (Table 2). First, the cropping industry has had higher average productivity growth than livestock industries over the long term, averaging 1.5 per cent per year between 1977–78 and 2015–16, compared with mixed crop–livestock (0.9 per cent), beef (1.2 per cent) and sheep (0.2 per cent). The cropping industry's higher growth could be a result of more rapid developments in cropping technologies and reallocation of resources towards more efficient crop production (Mullen 2007, Sheng et al. 2016a).

Second, the difference in productivity growth rates between cropping and livestock industries is narrowing (Figure 3). This can be attributed to a slowdown in the productivity growth of the cropping industry since the late 1990s (Sheng et al. 2011b), productivity improvement in the beef industry between 1988–89 and 2000–01 (Figure 3) and increased productivity growth in the sheep industry from 2000–01 to 2015–16. The decline in the productivity in the sheep industry decelerated after the removal of the wool reserve price scheme in 1991 and became positive in the years after 2000–01 resulting from industry consolidation and shifts by farmers from wool production to cropping and sheep meat production.

Figure 3 Total factor productivity growth, average annual change, by broadacre industry, Australia, 1977–78 to 2015–16



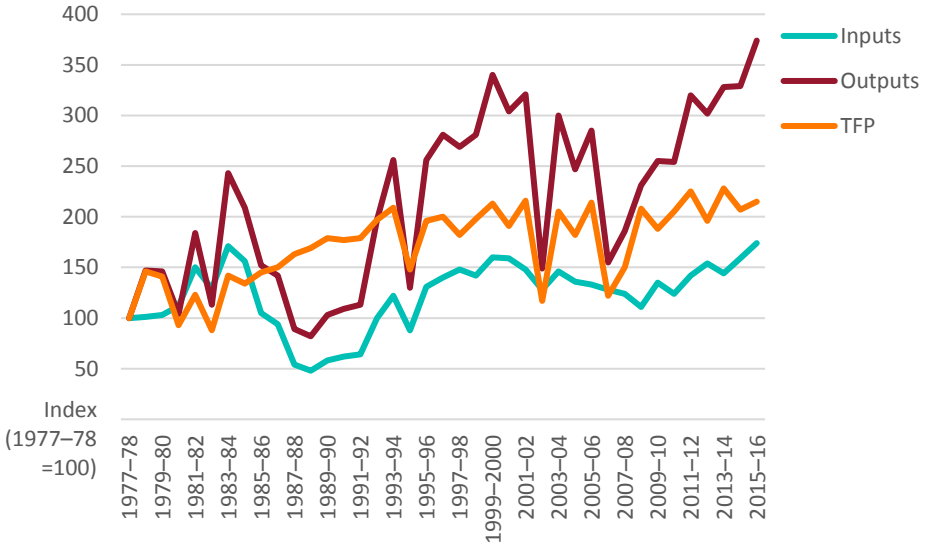
Source: ABARES Australian Agricultural and Grazing Industries Survey

Third, from 1977–78 to 2015–16 the mixed crop-livestock industry experienced modest productivity growth of 0.9 per cent per year on average. The increase in productivity in this industry was a result of input use declining more rapidly than output. Input use declined 1.8 per cent per year, whilst outputs fell by 0.9 per cent per year. In the past two decades, mixed crop–livestock 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 for cropping specialists grew on average by 1.5 per cent per year between 1977–78 and 2015–16. This was driven by strong output growth (2.7 per cent per year) relative to input use growth (1.2 per cent per year) (Table 2, Figure 4).

Figure 4 Total factor productivity, output and input, cropping industry, Australia, 1977–78 to 2015–16



Source: ABARES Australian Agricultural and Grazing Industries Survey

Jackson (2010) and Knopke et al. (2000) attribute 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 2015–16 cropping farms have operated larger farms, with average farm sowing areas increasing nearly threefold. Materials inputs including fertiliser, fuel, crop chemicals, and seed have increased by an average of 4.1 per cent per 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).

Increases in material, services, and land inputs have been offset partially by falls in labour and capital inputs (Table 1). However, from the period 1977–78 to 2015–16, total input growth in the cropping industry increased by 1.2 per cent per year – the only broadacre industry to record an increase in total input growth. Additionally, the cropping industry was the only industry to

record an increase in land input, suggesting a shift in land use towards cropping, and away from livestock and mixed broadacre production.

The cropping industry is made up largely by winter grains production in the three regions across wheat-sheep zone: Southern, Northern, and Western (GRDC, 2015). Across the Eastern seaboard, the cropping industry is characterised by a large number of small cropping farms. These regions tend to have a diverse winter crop, with smaller farms which often supplement their income through livestock production or off-farm sources of income. In the Western region, cropping farms tend to be less numerate, but much larger and more specialised. Productivity growth in the cropping industry was strong across all regions, but inter-regional productivity differences were driven by structural and climatic differences. Over the period 1977–78 to 2015–16, productivity growth was strongest in the Southern region at 1.8 per cent per annum. The Northern and Western regions both recorded growth at 1.3 per cent per annum.

Table 3 Total factor productivity, output and input growth, cropping industry, by GRDC region, Australia, 1977–78 to 2015–16

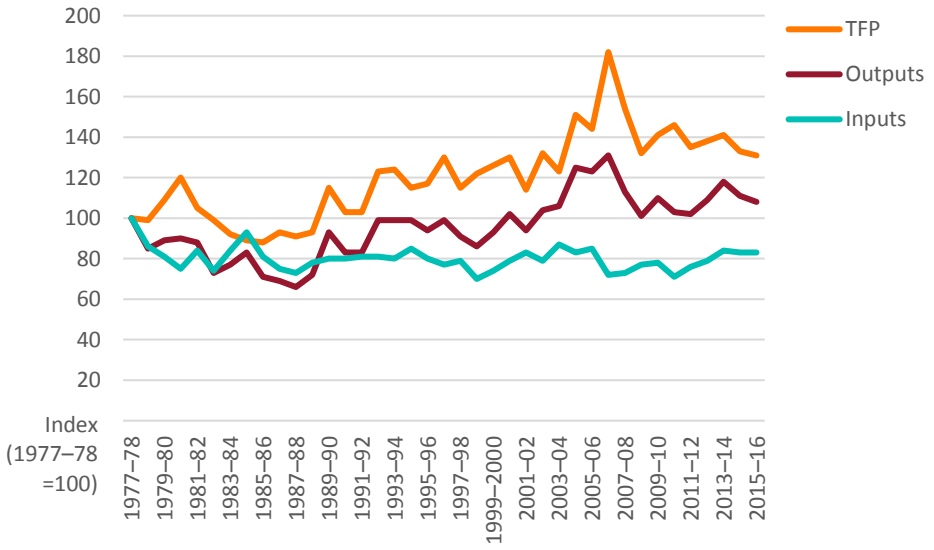
Region	TFP (%)	Output (%)	Input (%)
Northern	1.3	2.0	0.7
Southern	1.8	2.8	1.0
Western	1.3	3.8	2.4

Notes: Grains Research and Development Corporation regions.
Source: ABARES Australian Agricultural and Grazing Industries Survey

Beef

Beef productivity growth in the Australian beef industry averaged 1.2 per cent per year between 1977–78 and 2015–16. Output increased by 1.1 per cent and inputs declined by 0.2 per cent per year (Table 2, Figure 5). 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). However, between 1977–78 and 2015–16, whilst average productivity growth in the beef industry (1.2 per cent per year) outpaced that of the sheep industry (0.2 per cent per year), it remained lower than the productivity growth rate for the cropping industry (1.5 per cent per year).

Figure 5 Total factor productivity, output and input, beef industry, Australia, 1977–78 to 2015–16



Source: ABARES Australian Agricultural and Grazing Industries Survey

Labour input use in the beef industry declined an average of 0.7 per cent per year over the period 1977–78 to 2015–16. This was the smallest decline in labour input use of any broadacre industries. Additionally, the beef industry was the only broadacre industry to record an increase in capital input over the period 1977–78 to 2015–16 (0.4 per cent per year).

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. 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).

From 1977–78 to 2015–16 productivity growth was higher for Northern beef farms (1.2 per cent per year) compared with their Southern counterparts (0.9 per cent per year) (Table 4). Output growth was similar for the Northern and Southern regions, at 1.0 and 1.2 per

cent per year on average respectively. The primary difference between the two regions was a result of reduced input use in the North (–0.2 per cent per year) and increased input use in the South (0.3 per cent per year), particularly of fertiliser and chemicals.

Table 4 Total factor productivity, output and input growth, beef industry, by region, Australia, 1977–78 to 2015–16

Region	TFP (%)	Output (%)	Input (%)
Northern	1.2	1.0	–0.2
Southern	0.9	1.2	0.3

Source: ABARES Australian Agricultural and Grazing Industries Survey

Beef Productivity and Farm Size

Productivity in the beef industry varies substantially with farm size. From 1977–78 to 2015–16, average annual productivity growth on large beef farms (total cash receipts >$1m) was 2.2 per cent a year, 0.8 per cent a year on medium-sized farms (total cash receipts $200k – $1m) and 0.6 per cent a year on small farms (total cash receipts < $200k) (Table 5). The significantly higher productivity growth of large farms in recent decades has been entirely driven by faster output growth, with large farms increasing output more than 5 times faster than small farms. Large farms are the only ones to have increased input use in the beef industry (Table 5).

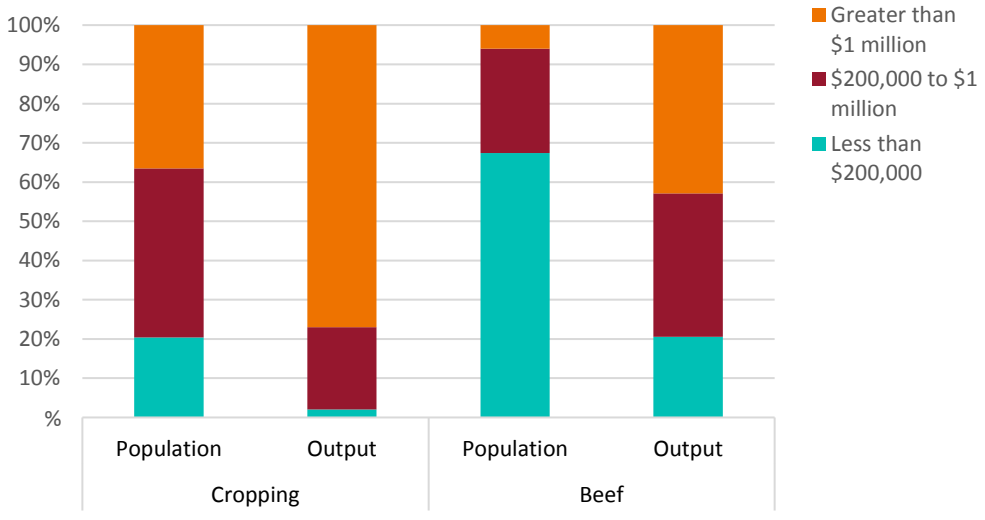
Table 5 Total factor productivity, output and input growth, beef industry, by size, Australia, 1977–78 to 2015–16

Farm Size Category	TFP (%)	Output (%)	Input (%)
Small	0.6	0.5	-0.1
Medium	0.8	0.3	-0.5
Large	2.2	2.7	0.5

Source: ABARES Australian Agricultural and Grazing Industries Survey
Note: Farm size definitions - Small (total cash receipts <$200k), Medium (total cash receipts $200k – $1m), Large (total cash receipts >$1m)

Small farms account for a higher proportion of farms in the beef industry than in most other agricultural industries. For example, in the cropping industry, small farms account for around one fifth of the total population, and produce less than 5% of industry output. However, in the beef industry, small farms account for over two thirds of the population, and produce around 20% of total output value (Figure 6).

Figure 6 Proportions of farm population and output, cropping and beef farms, 2013–14 to 2015–16



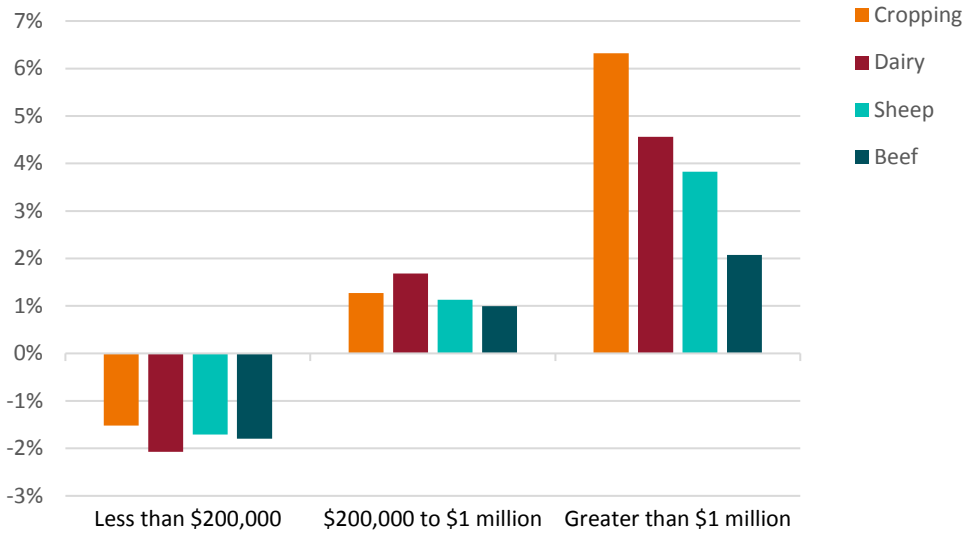
Source: ABARES Australian Agricultural and Grazing Industries Survey

Smaller beef farms tend to use more inputs per unit of output compared with larger farms. For example, the labour input (which often consists wholly of the non-wage imputed labour of the operator) is relatively fixed across different-sized farms. In contrast, the quantity of output produced by smaller beef farms is substantially lower than that of large farms, and as a result,

estimated labour productivity on small farms is also lower. The same is true for other inputs such as capital and land.

Reflecting the productivity advantage, larger beef farms are more profitable than their smaller counterparts (Figure 7). The relatively high number and proportion of small farms in the beef industry reduces average estimated productivity and profitability of the beef industry. Accordingly, average estimates in the beef industry should be treated with some caution.

Figure 7 Rate of return by farm size and industry, 2013–14 to 2015–16



Source: ABARES Australian Agricultural and Grazing Industries Survey and Australian Dairy Industry Survey

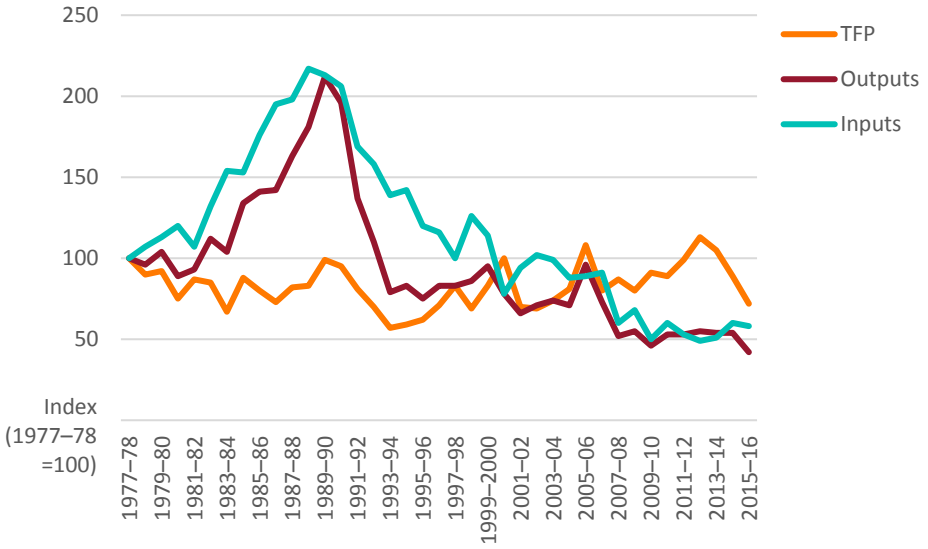
One reason for the continued relatively high proportion of small farms in the beef industry is that the profitability of beef farms does not increase as strongly with farm size as it does in other industries such as cropping, sheep and dairy (Figure 7). If larger farms were substantially more profitable than smaller farms, greater consolidation would be expected.

The relatively small economies of scale in the beef industry largely reflects the technology that is available. Most importantly, there appears to be a limit to how many cattle individual workers can manage, that doesn't change greatly with farm size. In contrast, technological developments in the cropping industry such as larger and more sophisticated machinery give the largest farms a productivity advantage over others. Looking ahead, new technology such as remote monitoring of livestock and pastures, virtual fencing, and automated yards and troughs may provide a similar channel for productivity growth in the beef industry.

Sheep

Productivity growth in the sheep industry averaged 0.2 per cent per year from 1977–78 to 2015–16 (Table 2). Sheep industry productivity declined between 1978–88 and 1993–94 but has since rebounded (Figure 8). 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 and reduced use of all the five categories of inputs (labour, capital, land, materials and services) (Figure 8, Table 1). Sheep numbers were further reduced by farmers destocking their properties during periods of drought. Productivity growth in the sheep industry since the early 1990s has also been attributed to advances in animal breeding and genetics and improved herd, disease and fodder management (Gray et al. 2014b).

Figure 8 Total factor productivity, output and input, sheep industry, Australia, 1977–78 to 2015–16



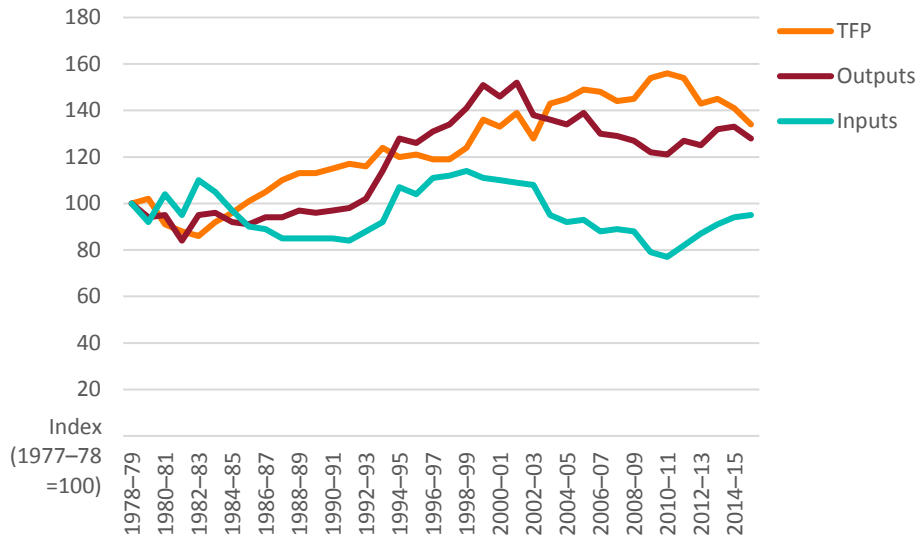
Source: ABARES Australian Agricultural and Grazing Industries Survey

Other development in the sheep industry are also worth noting. 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.

Dairy

Productivity growth in the Australian dairy industry averaged 1.4 per cent per year between 1978–79 and 2015–16 (Figure 9). This was driven by output increasing by an average of 1.2 per cent per year and input use declining by an average of 0.2 per cent per year. The decline in input use in the dairy industry has been driven by declines in the use of labour (–2.4 per cent per year), capital (–1.6 per cent per year), and land (–1.2 per cent per year). These falls have been offset by increases in the inputs of materials (3.4 per cent per year) and services (0.5 per cent per year).

Figure 9 Total factor productivity, output and input, dairy industry, Australia, 1978–79 to 2015–16



Source: ABARES Australian Dairy Industry Survey

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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