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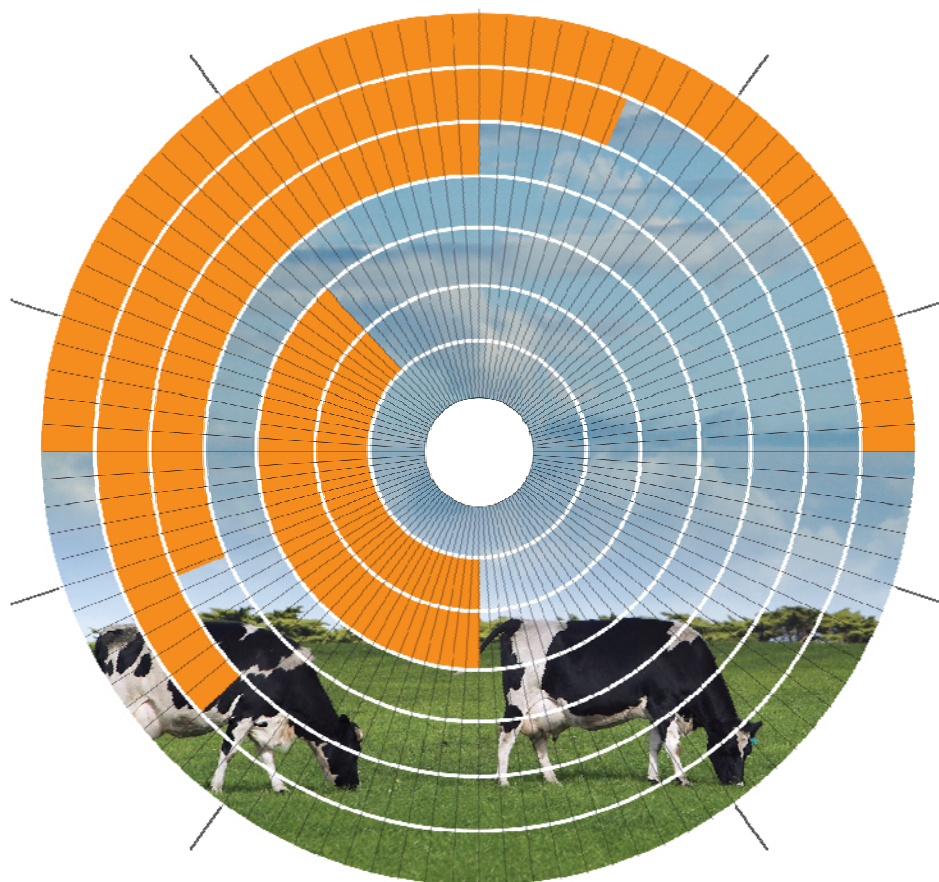
# Productivity in the Australian dairy industry

## Pursuing new sources of growth

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Research by the Australian Bureau of Agricultural  
and Resource Economics and Sciences

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# Summary

The allocation of research, development and extension (RD&E) funds by Dairy Australia on behalf of the industry requires the challenging task of balancing a number of competing priorities. As highlighted in Dairy Australia's latest Strategic Plan (Dairy Australia 2011), emerging business pressures include the need to improve resource use efficiency as well as manage changing societal expectations around environmental stewardship and animal welfare.

Improving productivity can be an important means to for address these challenges, where such efforts serve to promote profitability, improve natural resource use and facilitate adaptation to business pressures. Since the late 1970s, the Australian dairy industry has achieved considerable improvements in farm productivity through the adoption of new technologies and management practices, along with structural changes within the industry. Ongoing pressures mean that dairy farmers will need to continue finding productivity improvements to remain profitable in the longer term.

To support Dairy Australia's broader information needs in allocating RD&E funding, ABARES has conducted a comprehensive assessment of dairy farm performance by analysing farm survey data and gathering information and views from dairy farmers and others at a series of regional workshops. The results of this study highlight key trends in: the Australian dairy industry; productivity growth at industry and farm level by region; drivers of productivity growth; constraints to future growth; and the effect of farm operating risk on productivity and profitability.

Productivity is a measure of how effectively farmers combine inputs to produce outputs. Based on this measure, growth in productivity in the Australian dairy industry has occurred over the past three decades at an average annual rate of 1.6 per cent, although rates of growth have differed across regions. Differences in productivity growth rates by region reflect changes in regional industry structure, the extent of uptake of new technologies among farms within a region, and the characteristics of each region that affect the types of farming systems used. Productivity growth has been underpinned by growth in input use in the Gippsland, Murray, South Australia, Tasmania and Western Victoria regions. In contrast, productivity growth in the New South Wales, Subtropical and Western Australia regions has resulted from a significant contraction in dairy activities.

There have been two key drivers of the observed growth in dairy farm productivity. First, at an industry level there have been reductions in the total resources used in the dairy industry, particularly since the early 2000s as many farmers exited the industry. With a large proportion of these farms being relatively less efficient than remaining farms, the rate of decline in total resources used for dairy has been greater than the rate of decline in total outputs, resulting in increases in the ratio of outputs to inputs—that is, growth in total factor productivity (TFP).

However, growth in productivity during the 2000s was constrained somewhat by widespread and prolonged drought. Many farmers were required to use additional inputs such as purchased feeds, but with constant or reduced milk production. Drought also affected the potential for ongoing productivity growth indirectly by reducing farm incomes in several years and therefore reducing or delaying investments in new technologies.

The second key driver of productivity growth has been the result of widespread adoption of new technologies and management practices that have allowed dairy farmers to reduce the quantity of inputs required to produce a given quantity of output. At the farm level, this has been

reflected in increases in the quantity of outputs produced exceeding increases in the quantity of inputs used—particularly purchased feeds and other materials. These changes have coincided with increases in average farm sizes and intensity, where many technologies (such as rotary milking sheds) have enabled the development of more efficient and larger scale dairy operations. At the industry level, the rate of productivity growth arising from the adoption of new technologies depends on the extent of adoption by individual farmers, as well as the size of the productivity gains made at the farm level.

A wide variety of technologies and management practices has contributed to productivity growth either directly or indirectly. Technological progress—including improvements to milking shed design and layout, milking equipment, herd genetics, pasture varieties, feeding systems—was widely recognised by workshop participants as a key driver of long run productivity growth in the Australian dairy industry. Workshop participants also viewed other changes such as improved education and training as being important, but their direct productivity benefits were often less tangible.

Improved milking shed layouts have contributed to productivity growth by reducing the length of time taken for milking and, in turn, the quantity of labour required. Similarly, automated milking technologies have allowed farmers to reduce their labour use without affecting milk output. Workshop participants suggested robotic milking systems were a potential source of future productivity growth because of reduced labour requirements, although the large capital investment and the possible need for significant changes to existing pasture-based dairy systems may limit the uptake of robotic milking on many dairy farms.

The seasonal pattern of milk production on dairy farms has important implications for input use and, hence, farm productivity. Dairy farmers typically choose calving patterns to maximise their profitability, largely subject to seasonal price incentives and feed supply factors, which then determines the seasonal demand for feed and the quantity of other inputs required. Even though some systems are inherently more input intensive than others, the results of analysis suggest that a more important determinant of farm-level TFP is the way that individual farmers manage these systems.

Pasture management — including fertiliser use, pasture varieties, and pasture management practices — have also contributed to past productivity improvements by allowing farmers to reduce the time and materials required to obtain pasture growth. Many participants at the workshops felt that further productivity gains could be achieved by improving understanding of pasture management under various situations.

The use of grains and concentrates to supplement pasture based feeding has become an increasingly large component of dairy farm inputs in recent decades. Workshop participants suggested further productivity gains could be achieved by using feeding systems that are better targeted to the dietary needs of individual cows.

Feedback from the workshops combined with analysis of ABARES farm survey data suggest that the affects of new technologies and management practices can differ according to the particular circumstances of individual farms. A major theme that emerged from the workshops was the importance of developing, understanding and using more efficient farming systems to drive further productivity growth.

Many of the constraints to future productivity growth are already being faced by dairy farmers. The more important of these constraints relate to the nature of milk supply contracts, the type of farming systems required to meet contract requirements, and the physical and climatic

characteristics of individual farms. Developing a better understanding of the ways dairy farmers can manage such constraints is an important area for further research.

Overall, workshop participants agreed that significant productivity gains could still be made from wider adoption of leading technologies and best management practices already available. In addition, an increased understanding of alternative dairy systems for differing circumstances will also be important for future productivity growth. In this regard, it was suggested at several workshops that dairy farmers would benefit from access to information about the most efficient systems for their region. It was generally agreed that the most effective way of achieving this was through direct interaction between farmers and information providers, rather than through more generic published information.

Workshop participants also highlighted some constraints likely to face dairy farmers in the future from issues such as animal welfare and the environment. While addressing such issues might generate benefits for society as a whole, required changes to dairy farm operations could constrain productivity growth. A better understanding of the effects of such issues on farm productivity and profitability, along with potential solutions, is also an area for further research.

There is also scope for more research to be done on the nature and effects of risk in the Australian dairy industry. Potential areas of research include the extent to which various random events contribute to variation in farm profit, and the effectiveness of different risk management strategies used by farmers. In this regard, many dairy farmers voiced their need for better information on strategies to manage the risks posed by varying input and output prices and seasonal conditions.

In addition, given Australia's small domestic capacity for R&D relative to larger economies, realising benefits from international collaborations and research spillovers remains a priority. While some organisations, including Dairy Australia, have developed strong international research linkages, more can be done. For example, in considering opportunities to enhance public extension initiatives, decision makers could consider the scope for emphasising extension initiatives directed at accelerating foreign knowledge and technology spill-ins, rather than limiting the concept of extension to indigenously generated knowledge. At the same time, Australia's rural RD&E system will need to invest in maintaining sufficient capacity and developing networks to identify, adapt, and exploit technologies and knowledge developed outside Australia.

# 1 Introduction

The Australian dairy industry has achieved considerable improvements in farm productivity since the late 1970s. The adoption of new technologies and management practices, along with structural changes within the industry, has led to more efficient milk production. However, ongoing adjustment pressures mean that dairy farmers will need to continue finding productivity improvements to remain profitable. These pressures include meeting societal expectations about environmental stewardship and animal welfare, which are increasingly shaping dairy production systems. In addition, the need to develop better risk management tools for dairy farmers is expected to become increasingly important.

Dairy Australia commissioned ABARES to analyse the drivers of productivity in the dairy industry to support the broader information needs required for allocating research, development and extension funds across competing priorities and regions that are characterised by markedly different agro-ecological environments, production systems and markets. The key aims of this study are to identify:

- the main drivers of past industry productivity growth
- current constraints to improving productivity and potential sources of future productivity growth
- areas where further research can contribute to improving long-term industry performance.

To gather regional perspectives, ABARES and Dairy Australia held a series of workshops with dairy farmers, consultants, milk processors, and representatives from various state departments responsible for agriculture. The workshops provided opportunities to gather industry views and feedback on drivers of past performance; opportunities for future productivity gains; current obstacles to improving farm performance; and preferred industry investment priorities to overcome these obstacles. Workshops were held in each of the eight dairy regions throughout Australia: Tasmania (Burnie), Gippsland (Warragul), Murray (Shepparton), Western Victoria (Terang), New South Wales (Berry), South Australia (Mount Gambier), Western Australia (Bunbury) and Subtropical (Brisbane).

The information obtained from the workshops was combined with the results from a supporting analysis of data collected through the ABARES annual Australian Dairy Industry Survey. The results informed a range of issues relating to: dairy farm productivity; use of milking technologies, pasture and feed; labour availability, skills and succession planning; herd fertility; animal welfare; and managing risk.

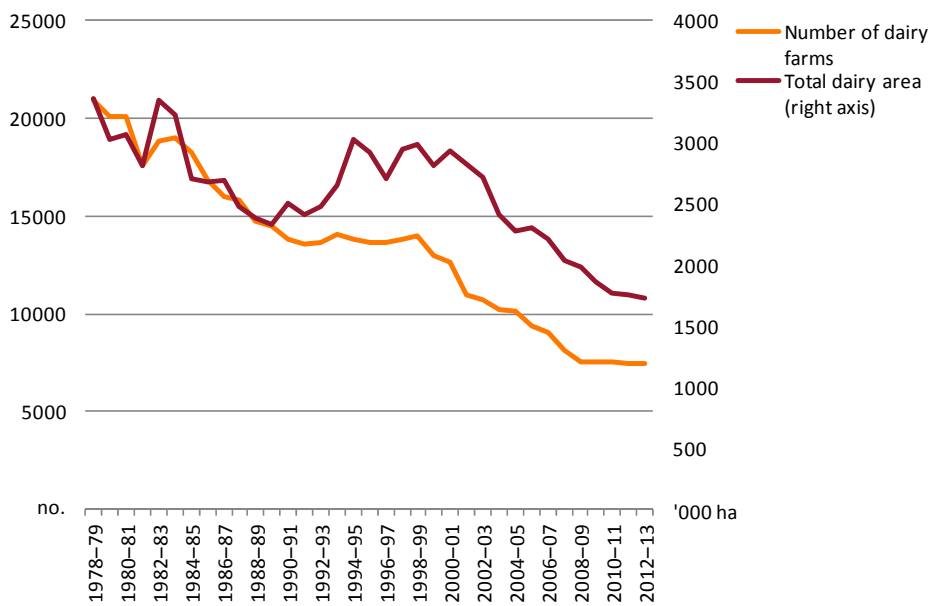
Chapter 2 provides a brief overview of relevant trends in the Australian dairy industry; Chapter 3 examines productivity growth at industry and farm level by region; Chapter 4 presents the main drivers of productivity growth that were identified by workshop participants, and discusses their views on constraints to future growth and research priorities; Chapter 5 discusses various sources of farm operating risk and their affect on productivity and profitability; and Chapter 6 provides a summary of the future for productivity growth in the dairy industry in light of the foregoing discussion.



## 2 Trends in the Australian dairy industry

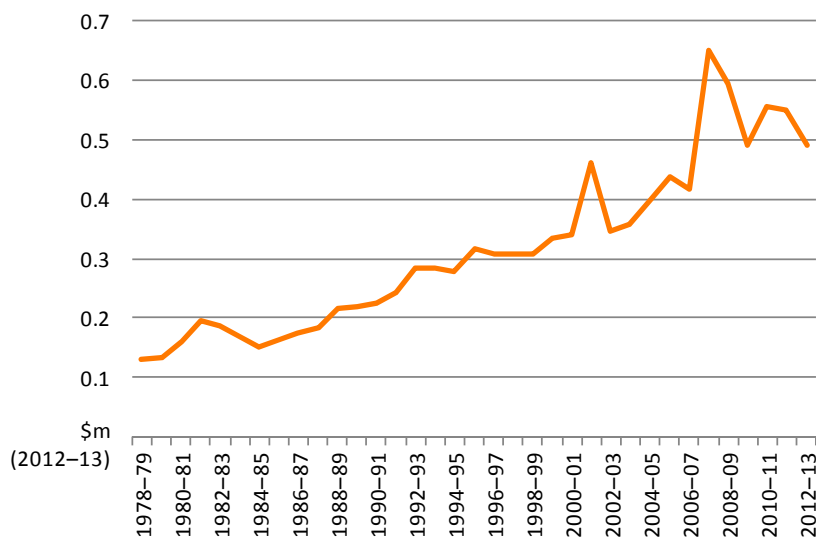
The structure of the Australian dairy industry has changed markedly over the past 30 years, driven by a range of factors such as the removal of both government support and regulated milk prices, changing world dairy product markets, and prolonged drought. During this period, the number of dairy farms in Australia has fallen by nearly two-thirds, the total area used for dairying has halved (Figure 1), and the milk product processing and distribution sectors have been significantly rationalised. Despite fewer resources being used for milk production, this restructuring has promoted a more efficient industry and has enabled growth to occur in the gross value of Australian dairy production per farm in real terms (Figure 2).

**Figure 1 Number of dairy farms and total dairy area, Australia**



Source: ABARES

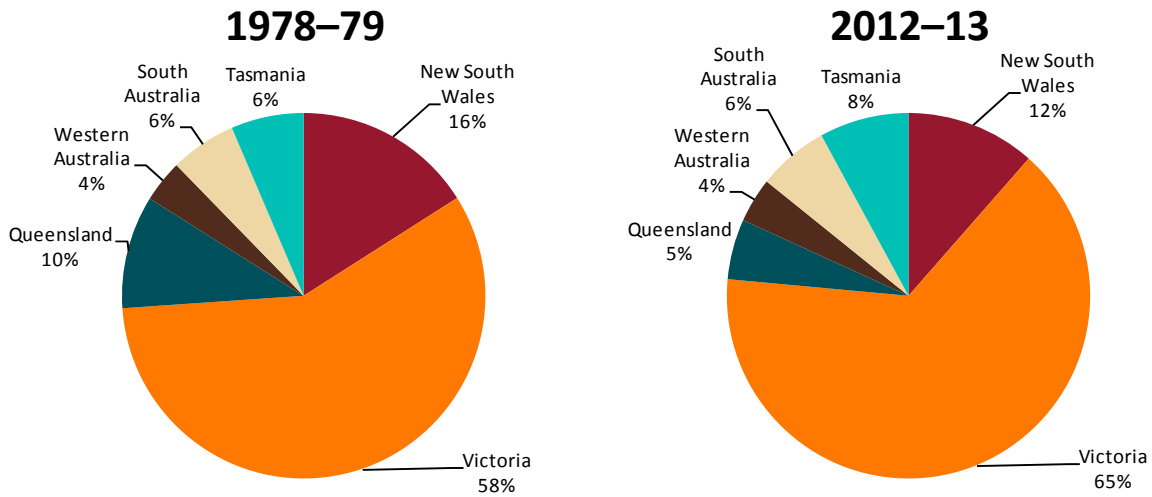
**Figure 2 Gross value of milk production per farm, Australia**



Source: ABARES

The concentration of Australian milk production among the states has shifted considerably, with the southern states expanding and the northern states contracting. In particular, Victoria's share of production increased from 58 per cent in 1978–79 to around 65 per cent in 2012–13 (Figure 3). Tasmania's share of production also increased, from 6 per cent in 1978–79 to 8 per cent in 2012–13. In comparison, New South Wales fell from 16 per cent to around 12 per cent, while Queensland fell from 10 per cent to 5 per cent over the period from 1978–79 to 2012–13. The share of milk production from Western Australia and South Australia remained steady at 4 per cent and 6 per cent respectively over the period.

Figure 3 Share of milk production, by state, Australia



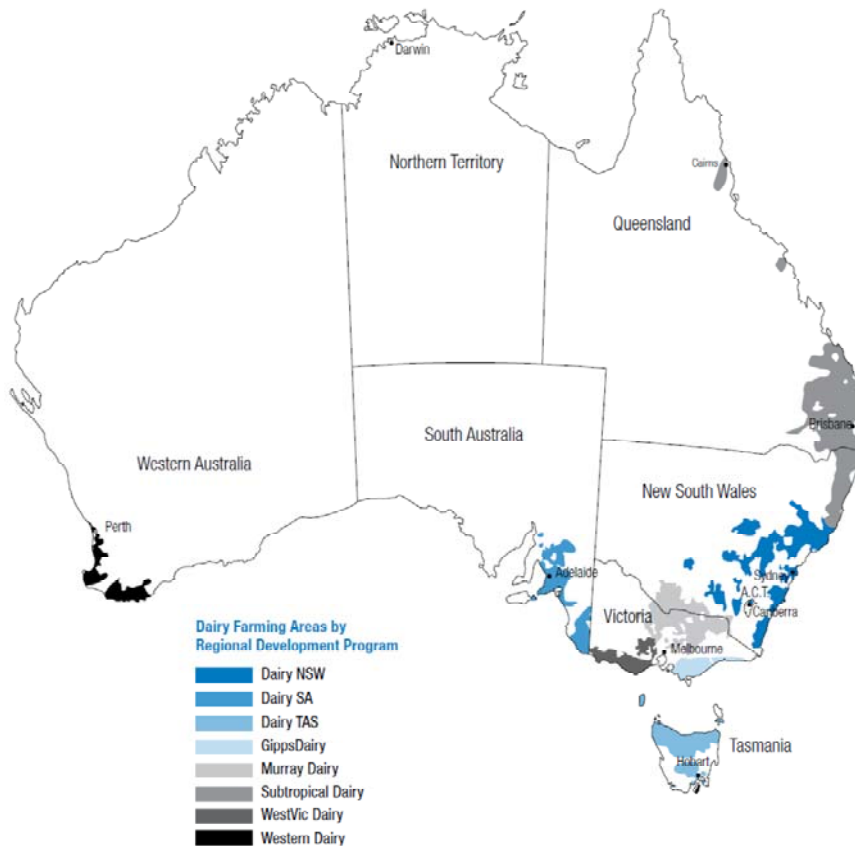
Source: ABARES

These shifts ultimately reflect differences in a range of factors across the regions that affect the profitability and productivity of dairy farms. Factors such as varying climate and landscape characteristics, industry concentration of farms, location and proximity of milk processing capacity, and milk supply contract and pricing arrangements have influenced past productivity growth and are likely to affect opportunities for future growth.

Dairy farmers have adapted by increasing both the size and intensity of their operations, with more cows per farm, higher stocking rates, and greater use of supplementary feeding. Farmers have also adopted a range of new technologies, resulting in dairy farms becoming more capital intensive and less reliant on labour. The affect of such changes on farm productivity and profitability are complex, particularly within the context of a dynamic farm operating environment where changes in market prices or seasonal conditions are largely beyond a farmer's control.

The affects of various adjustment pressures on dairy industry performance (reflected in both productivity and profitability) are best considered within the particular circumstances facing each of the 8 Australian dairy regions (Map 1). A key difference between each of the regions is the relative mix of farm production systems with contrasting seasonal milk flows.

Map 1 Australian dairy regions



Source: ABARES

Milk processors supplying the domestic market with fresh milk and other dairy products with a short-shelf life encourage farmers to supply milk on a year-round basis to ensure continuity of supply. Farms located in the Subtropical, New South Wales and Western Australia dairy regions predominantly provide year-round supply for the domestic sector. In some areas (for example, in parts of the Subtropical region), the prevailing climate and pasture varieties suggest farmers would achieve greater productivity gains if they were better able to match milk supply with seasonal pasture availability. However, the market signals received by these farmers through milk supply contracts often lock them into higher cost year-round supply. Nevertheless, ABARES analysis (reported in the next chapter) shows that many of the farmers in these regions have achieved productivity gains by managing their farming systems within the constraints they face.

In contrast, milk processors that primarily manufacture dairy products (such as cheese and milk powders) typically structure incentives for farmers to supply milk on a seasonal basis, although a number of these also supply fresh milk and other products to the domestic market. Many of these processors are concentrated in the dairy regions of south eastern Australia. Here, there is less need to ensure continuity of milk supply throughout the year because it greatly exceeds domestic consumption of fresh milk and other products, leaving a surplus for manufactured products. As a consequence, milk supply contracts for dairy farmers in Victoria, South Australia and Tasmania tend to accommodate seasonal milk production, thus allowing greater flexibility to tailor farming systems to suit regional conditions.

### 3 Productivity growth

Productivity is a measure of how effectively farmers combine inputs to produce outputs. This study uses total factor productivity (TFP) as the most appropriate measure of dairy productivity because it takes into account all market inputs and outputs for a farm business. Inputs include labour, land, capital (machinery, sheds and buildings), materials (including purchased feed) and services. Dairy farm outputs are predominantly milk and livestock, but may also include crop production.

In the dairy industry, productivity is often considered in terms of milk production relative to a single input. Commonly used measures include milk production per cow per year, or feed conversion efficiency (milk produced relative to herd feed consumption). While such measures can be useful when all other inputs remain constant, this is rarely the case. A major shortcoming of such partial productivity measures is attributing production improvements to changes in a single input when, in fact, other inputs have also been changing.

A more comprehensive measure of productivity growth used in this report is TFP, which reflects ongoing improvements in the efficiency with which farmers combine all inputs to produce outputs. Over time, it reflects the ability of dairy farmers to use fewer inputs to produce the same quantity of output, or to produce more output using the same quantity of inputs. At the farm level, productivity growth usually occurs as a result of farmers adopting new technologies and management practices. At an industry level, the exit of less efficient farmers, among other things, also contributes to productivity growth.

The importance of productivity growth is generally underscored by its key role in enabling farmers to maintain longer-term profitability and for processors to remain competitive in world markets. Analysing the factors that have influenced productivity in the past provides insights into how dairy farmers may be able to improve their future productivity.

#### **Profitability and productivity**

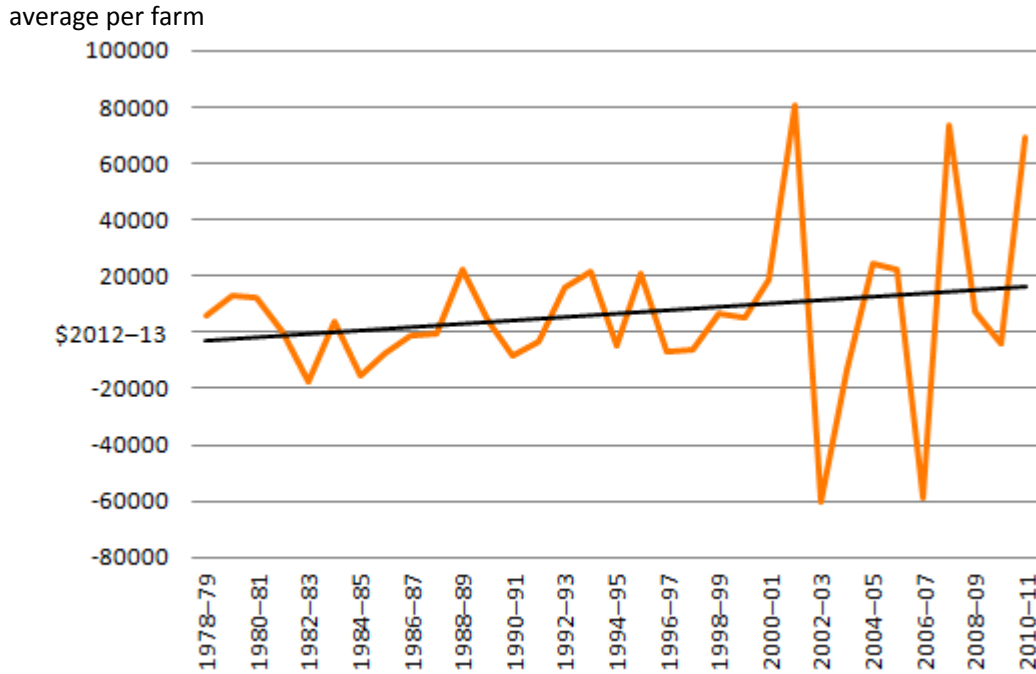
From a farmer's perspective, profitability is generally the main objective, rather than productivity. Profitability is important for the capacity of a farm business to meet on-going expenditures on farm inputs and debt servicing obligations, as well as the capacity to make new investments in farm capital and technologies. Overall, profitability provides a return to farmers' entrepreneurial ability and their capital investment.

Over the period since 1978–79, there have been large variations in farm business profit for Australian dairy farmers, particularly since the early 2000s when farm gate milk prices became more closely aligned with volatile world dairy product prices (Figure 4). Over the same period, drought has adversely affected profits in some years by lowering milk production and increasing farm input expenditure, particularly on fodder.

Despite the wide movements observed in average farm business profit, the long term trend for the Australian dairy industry in real terms (inflation adjusted) has been slightly upward over the period from 1978–79 to 2010–11. This suggests that productivity gains have enabled the dairy industry on average to maintain or improve profitability over the longer term despite falling terms of trade (the ratio of prices received to prices paid) (Figure 5). Although the terms of trade for dairy farmers declined by 78 per cent between 1978–79 and 2011–12, the rate of decline slowed over the last decade.

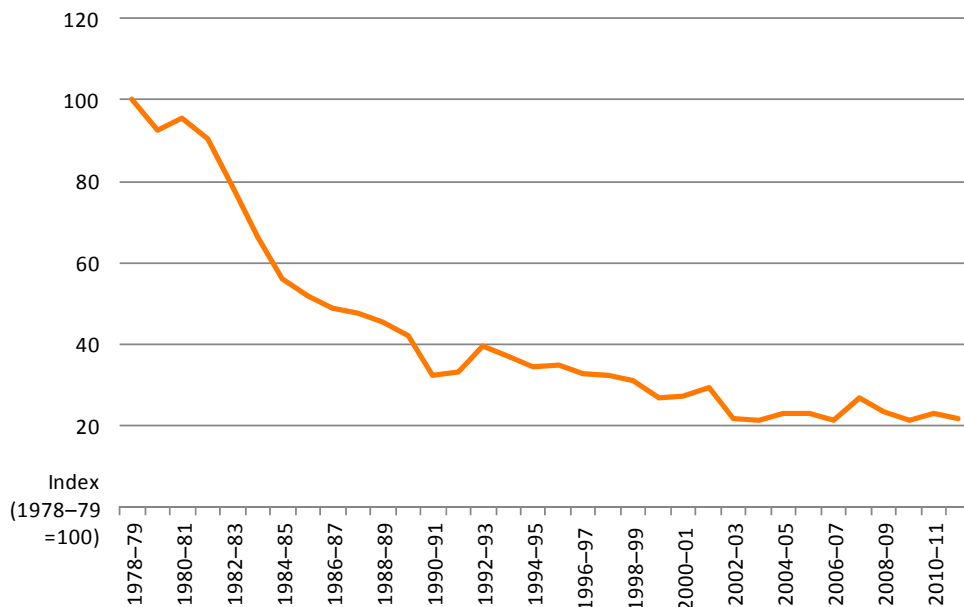
With little control over input prices and output prices, farmers typically rely on productivity growth to maintain profitability—by seeking more efficient ways to combine inputs to produce outputs. In the face of declining terms of trade over the longer term, farms with very low productivity growth may also have falling profits.

**Figure 4 Farm business profit, Australian dairy, 1978–79 to 2010–11**



Source: ABARES

**Figure 5 Dairy farmers' terms of trade, 1978–79 to 2011–12**

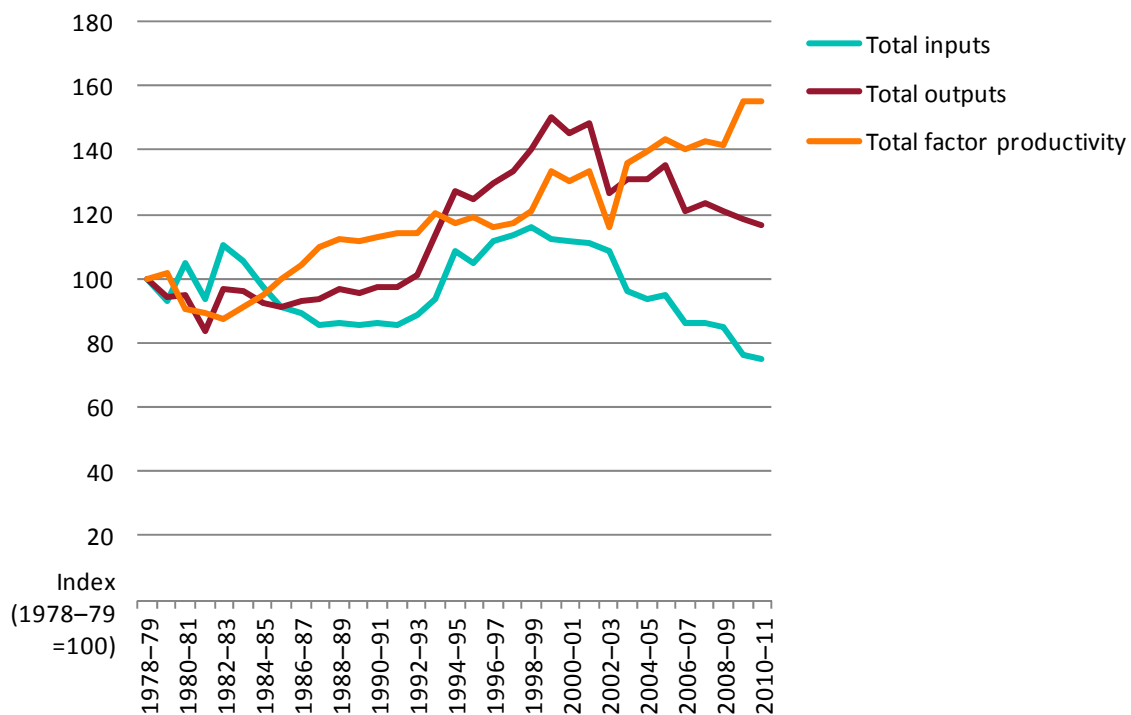


Source: ABARES

## Industry trends in total factor productivity

At the industry level, TFP for Australian dairy farms has increased at an average annual rate of 1.6 per cent from 1978-79 to 2010-11. This compares favourably with all broadacre agriculture (1.0 per cent), broadacre cropping (1.5 per cent) and the beef industry (0.9 per cent). While many factors have been influential, this growth has occurred over a period when dairy farmers have increasingly moved toward more intensive and automated systems, which have reduced labour and land requirements per unit of output produced. At the same time, the industry has consolidated into fewer and larger farms, particularly following deregulation of milk marketing arrangements in 2000 and the ensuing exit of many smaller farms. Since around 2000, much of the growth in industry-level TFP has been driven by reduced input use, with total industry output declining at a slower rate (Figure 6).

Figure 6 Dairy industry productivity, inputs and outputs, 1979–80 to 2010–11

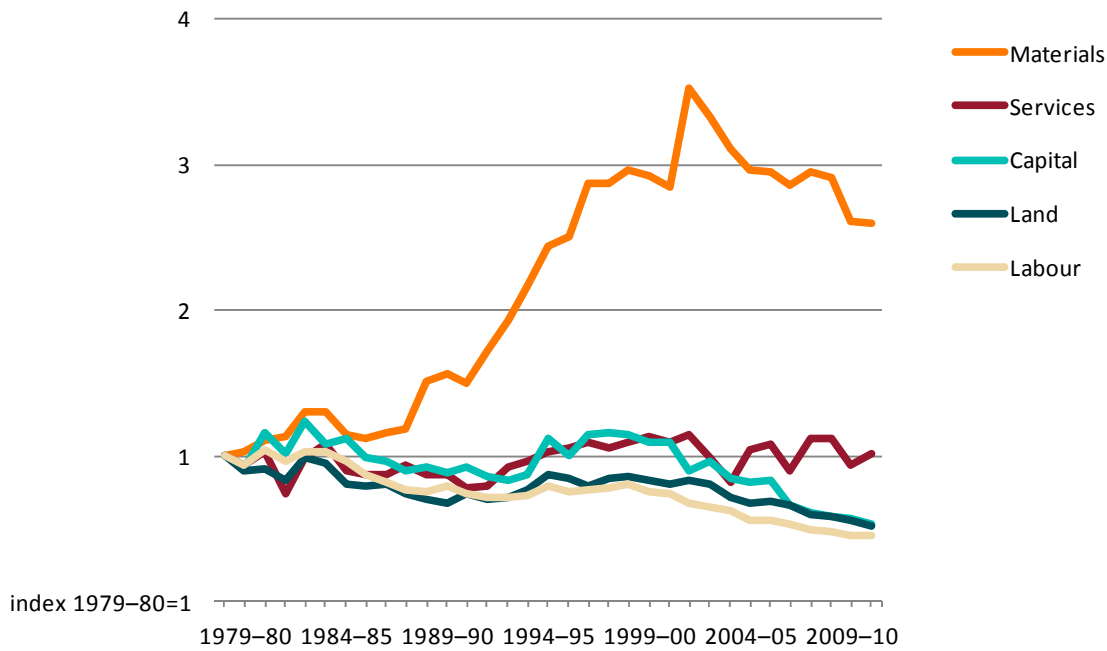


Note: Figures are aggregates at the industry level.

Source: ABARES

The index of total input use masks significant shifts in the mix of inputs used by dairy farmers (Figure 7). At the industry level, dairy farmers have increasingly used material inputs, but less land, labour and capital inputs. Although this tendency peaked in the early 2000s, the increased reliance on material inputs such as fodder and fertiliser (and, in some regions, service inputs such as contracts as well) has generally remained above historical levels and is now a feature of dairy farming systems in Australia.

Figure 7 Quantity of inputs used in the Australian dairy industry, 1979–80 to 2010–11

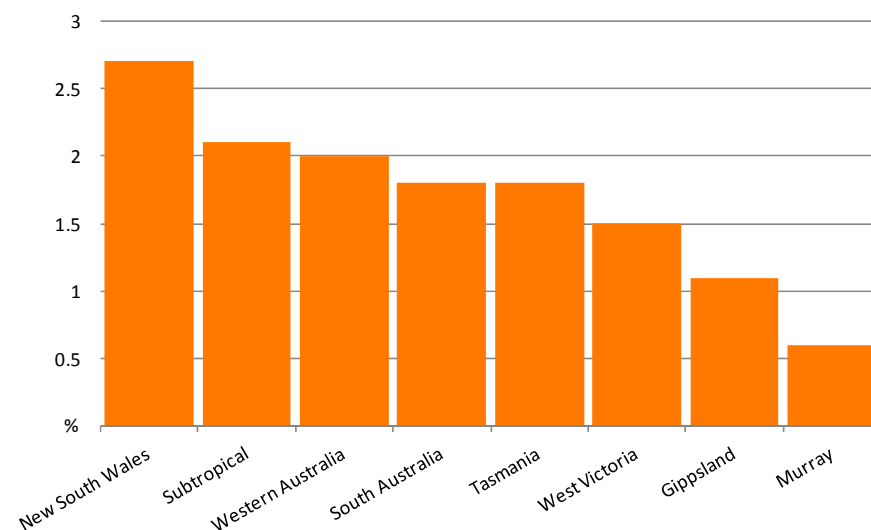


Note: Figures are aggregates at the industry level.  
Source: ABARES

## Regional trends in total factor productivity

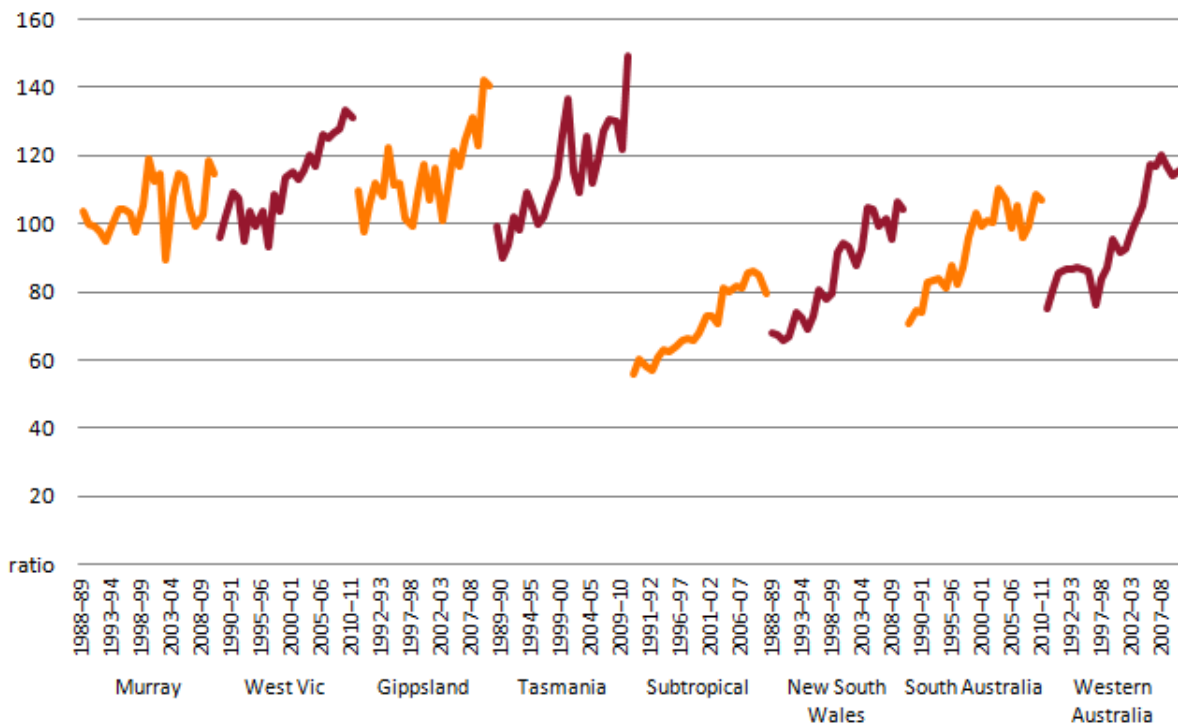
Average productivity growth over the period since 1988–89 has differed among the dairy regions. New South Wales (2.7 per cent) and Subtropical (2.1) realised the highest average annual TFP growth rates (Figure 8). In contrast, the performance of Gippsland (1.1 per cent) and Murray (0.6 per cent) has been significantly lower. In part, these varying rates reflect the initial productivity levels in each region. For example, the Subtropical and New South Wales regions started from a much lower base in terms of the technologies being used relative to other regions (Figure 9). The higher rates of TFP growth recorded by these two regions was partly a result of dairy farmers adopting technologies that were already more common in other regions.

Figure 8 Average annual TFP growth, by region, 1988–89 to 2010–11



Note: Figures are aggregates at the industry level.  
Source: ABARES

Figure 9 Total factor productivity, by region 1988–89 to 2010–11



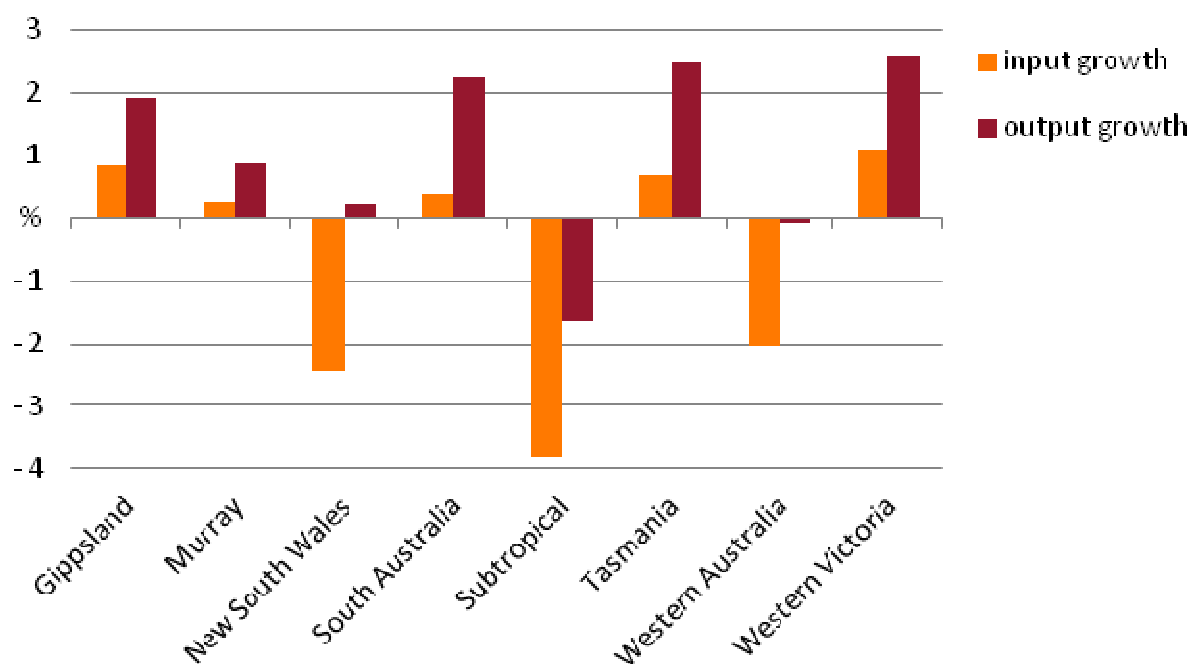
Note: Figures are aggregates at the industry level.  
Source: ABARES

In addition, ongoing adjustment pressures over many years have resulted in large numbers of dairy farmers leaving the industry or, to a much lesser extent, moving regions. Industry productivity growth has been highest in regions that have undergone the most significant structural adjustment. Because those exiting were, in the main, among the less efficient dairy farmers, overall industry productivity has risen.

While productivity growth has occurred in all regions, this outcome has been achieved in different ways and is illustrated by differences in input and output growth rates (Figure 10). In the Gippsland, Murray, South Australia, Tasmania and Western Victoria regions, output growth has been achieved by increases in productivity and input use. In contrast, productivity growth in the New South Wales, Subtropical and Western Australian regions has occurred at a time of significant contraction in input use, releasing inputs that were being used less efficiently. These differences reflect relative changes in regional industry structure, the uptake of new technologies and changes in each region's operating environment in response to shifts in relative profitability.



Figure 10 Average annual output and input growth by region: 1988–89 to 2010–11



Note: Figures are aggregates at the industry level.

Source: ABARES

The demand for constant, year-round milk supply in the Subtropical, New South Wales, Western Australia, and South Australia regions appears to have affected productivity growth. In these regions processor demand for excess seasonal milk is weak, so milk supply contracts provide the incentive for farmers to align their production systems accordingly. However, year-round production affects farm productivity because purchased feed inputs are usually higher than in other systems, since pasture-based feeding is often not sufficient to maintain milking during the off-peak period.

In the Murray region, relatively low productivity growth can be at least partly attributed to the occurrence of drought over the past decade. Here, the use of irrigated pasture and crops allow dairy production to occur where rainfall tends to be lower on average and more variable than in most other regions. Prolonged drought during the 2000s resulted in historically low irrigation water allocations over several years that affected both dairy production and productivity. Reduced availability of home-grown fodder meant many dairy farmers purchased additional feed that did not result in a proportional increase in output. In other cases, farmers dried-off cows, which led to a decline in output without a proportional fall in total input use.

In comparison, the Gippsland and Western Victoria regions have more reliable annual rainfall supporting largely seasonal, pasture-based milk production that is less input-intensive than other dairy farming systems (such as year-round milk production). Much of the gain in productivity growth in these regions appears to have been associated with increased stocking rates and, in turn, more milk produced without any significant increase in the use of other inputs.

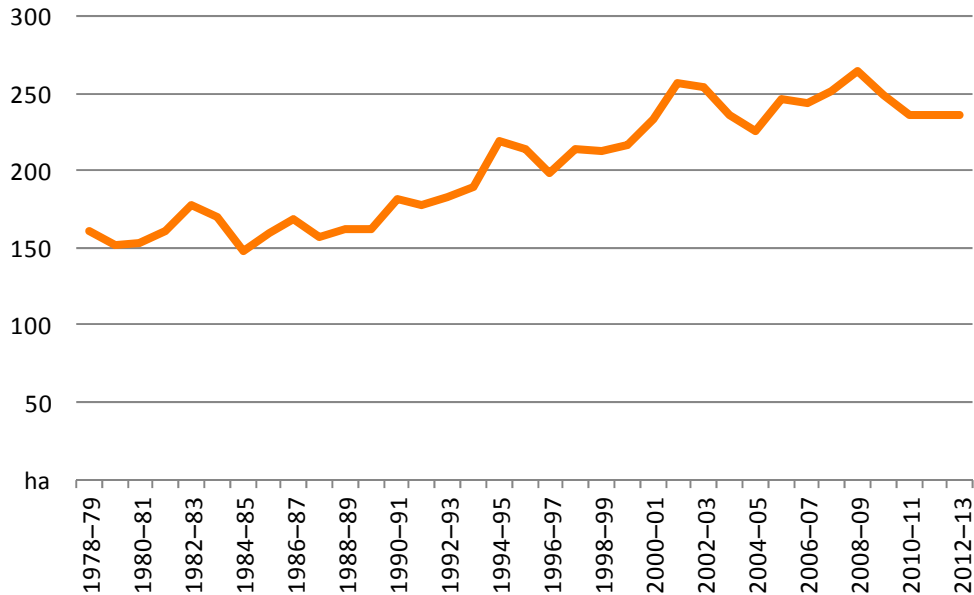
## Farm-level trends in inputs and outputs

In the preceding discussion, the trends in inputs and outputs are based on aggregates across the whole dairy industry. As the number of dairy farms in Australia has fallen over the past 30 years,

the total quantity of resources used in milk production has declined. However, while there are now fewer dairy farms, average farm size has increased by around 47 per cent (Figure 11). As a consequence, a different picture of resource use emerges when inputs and outputs are expressed at the farm level (Figure 12). Reflecting increasing farm sizes, the average use of both inputs and outputs at the farm level has been increasing.

**Figure 11 Area operated by dairy farmers, 1978–79 to 2012–13**

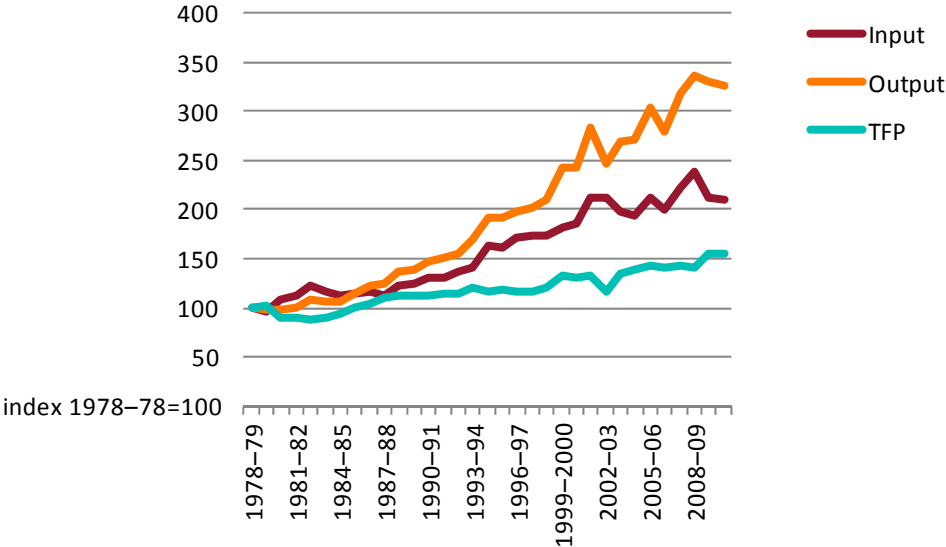
average per farm



Source: ABARES

It is well established that larger farms tend to have higher productivity growth. Given the extent of farm consolidations over the past 20 years, it is likely that expanding farm size has accounted for part of the growth in productivity. At the same time, the exit of smaller and less efficient farms will have contributed to productivity growth. Some technologies — such as rotary dairies — are better suited to larger scale farming, while larger farms tend to have greater scope to make changes to their total input mix, and may also have greater capacity to invest in new technology and practices because of their generally higher cash flow and greater ability to borrow.

Figure 12 Average annual output and input growth per farm, 1978–79 to 2010–11 average per farm



Source: ABARES

## 4 Drivers of productivity growth

At the workshops conducted by Dairy Australia and ABARES, participants identified a wide range of technologies and management practices that have directly or indirectly influenced productivity growth. At the farm level, new technologies increase productivity because they allow farmers to combine inputs more efficiently to produce relatively more output. A major theme from the workshops was the importance of the development, understanding and use of more efficient farming systems for driving further productivity growth. Beyond farm-specific innovations, broader changes (such as improved education and training) were also viewed as being important by some workshop participants, although their direct productivity benefits were often less tangible. At the industry level, the rate of productivity growth depends on the rate at which new technologies are adopted by individual farmers, as well as the size of the productivity gains made at the farm level using that technology.

This chapter examines the contribution of various technologies and management practices to productivity growth based on feedback from the workshops and analysis of ABARES farm survey data, namely: milking shed technologies; calving patterns and feeding systems; labour; and animal health and welfare.

### Milking shed technologies

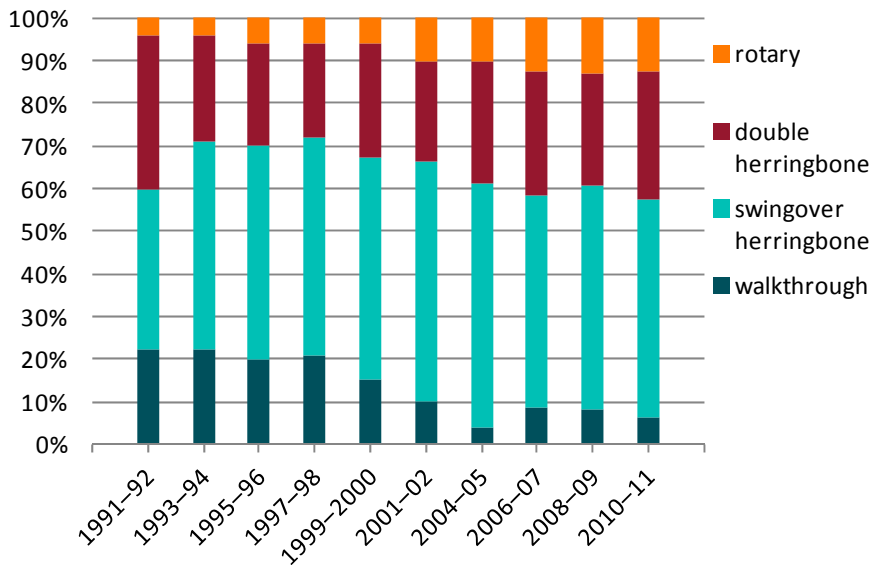
Changes to milking shed technologies were viewed by workshop participants as a key driver of past productivity growth. According to data collected in ABARES dairy industry survey, many farms appear to have upgraded milking equipment around the time of industry deregulation in 2000, possibly as a result of financial assistance provided by the Australian Government to help the industry adjust. Most changes to milking shed technology occurred within three years of deregulation (Harris 2005).

The affects on productivity of milk shed technologies have been varied, largely depending on the nature of the particular technology. Generally, these technologies have resulted in more efficient farm operations (such as higher-throughput shed layout), substituting capital for labour (such as automatic cup removers), or reducing the quantity of other inputs used (such as automatic feeding systems to reduce waste). Each of these technologies is considered in more detail below.

### Milking shed layout

ABARES biennial survey of dairy technology shows increases in the proportion of herringbone and rotary milking sheds, but fewer walkthrough sheds since the early 1990s (Figure 13). Herringbone (swingover and double) and rotary sheds provide improved layouts for higher throughput relative to the older-style walkthrough sheds. In particular, rotary sheds are better suited to handling larger herd sizes and have become increasingly common on large dairy farms. Their share of all dairy farms has increased from 4 per cent in 1991–92 to around 12 per cent in 2010–11 (Figure 13). The decline of walkthrough sheds is because of their smaller capacity and inability to handle larger herds efficiently.

Figure 13 Percent of dairy farms by type of milking shed



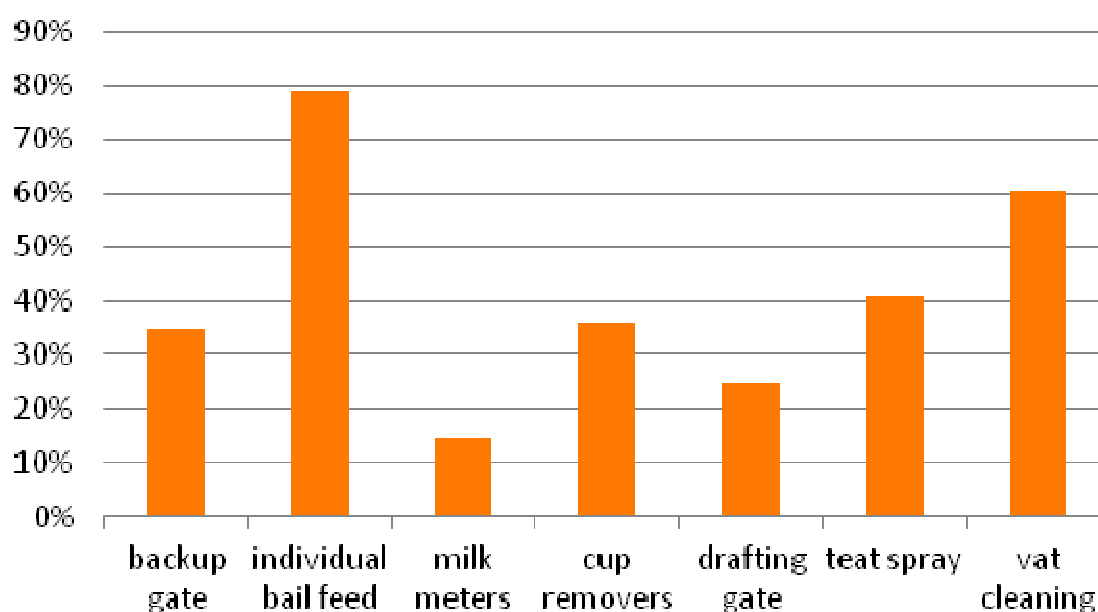
Source: ABARES

In general, improved milking shed layouts have contributed to productivity growth by reducing the length of time taken for milking and, in turn, the quantity of labour required. In addition, larger dairy farms are also likely to have realised productivity improvements through economies of scale where they have replaced older, smaller milking sheds with higher capacity ones. Although the total factor productivity performance of some dairy farms with older shed-types has been relatively high, these tend to be smaller farms that have been able to maintain particularly good managerial control over the use of farm inputs.

### Automated milking

The equipment used in milking sheds has moved increasingly toward automated technologies (such as automatic cup removers, automatic drafting, and automated cleaning). Automatic cup removers were used by 36 per cent of farms in 2010-11, while automated vat cleaning was used by around 60 per cent of dairy farms (Figure 14).

Figure 14 Percent of dairy farms with automated technologies, 2010–11



Source: ABARES

These technologies have allowed farmers to reduce their labour use without affecting milk output. In particular, increasing the labour efficiency of milking can significantly affect productivity because around half of total farm labour is spent milking. In addition, information collected via automated equipment (such as milk meters, electronic cow identification and herd management software) has enabled farmers to better manage cow health and feeding requirements, which have indirectly contributed to productivity.

Workshop participants suggested robotics (automatic milking systems) were a potential source of future productivity growth because of reduced labour requirements. Unlike the other automated technologies mentioned above, robotics are usually part of an integrated dairy farming system that involves close interaction between herd management, shed layouts and feeding systems. In particular, a key aspect of robotic milking is the voluntary movement of cows to present themselves for milking without the need for human interaction. In some cases, this may mean changes to paddock layout in order to keep cows relatively close to the robotic milkers.

Workshop participants suggested a variety of reasons that were likely to limit the adoption of robotics. In the first instance, the capital investment required is large—robotic milkers are much higher cost than smaller-scale automation options. A further reason is the possible need for significant changes to existing pasture-based dairying systems that may be required on many farms. Further, limited access to reliable, ongoing machinery maintenance and repair services has partly deterred further uptake of automated and robotic technologies in many regions. Specifically, participants at the Subtropical, New South Wales and Western Victoria workshops commented on the shortage of service providers. They also noted that accessing service providers was particularly difficult in areas that are distant from larger regional centres. Moreover, participants believed that the need to learn new skills to operate the technology and risks that the technology might not work effectively were constraining investment in robotic technologies, and automatic technologies more generally.

There is little difference in the use of automated technologies among farms by TFP group, according to ABARES dairy technology survey (Table 1).

**Table 1 Percent of farms with automated technologies, by TFP group**

percent of farms

Technology	Lower		Upper	
	bottom 25% by TFP	middle 25% by TFP	middle 25% by TFP	top 25% by TFP
Automatic cup removers	48	52	48	52
Yard backup gate	39	46	51	53
Vat cleaning systems	71	75	75	74
Teat disinfectant system	44	53	57	51
Milk meters	19	17	14	16
Drafting gates	22	34	36	34
Individual cow bail feed	74	87	82	73
Rapid exit stalls	13	14	10	11

Note: Farms are allocated to each group by their TFP ratio, such that 25 per cent of farms are in each group. Totals do not sum to 100 because farms may have more than one technology.

Source: ABARES

However, the data do reveal differences in labour use among farms with various automated technologies, in particular, faster milking resulting in less labour per cow milked. For example, farms using automatic yard backup gates milked around 211 cows per operator on average compared with 155 cows per operator for those farms without this technology (Table 2).

**Table 2 Milking time and cows per operator, by automated technology**

Technology	Farms with automated technologies		Farms without automated technologies	
	Milking time	Handling	Milking time	Handling
	Cows per minute	Cows per operator	Cows per minute	Cows per operator
Automatic cup removers	2.1	199	2.1	165
Yard backup gate	2.4	211	1.8	155
Teat disinfectant system	2.2	203	2.0	159
Drafting gates	2.6	236	1.9	155
Individual cow bail feed	2.2	186	1.9	165
Rapid exit stalls	2.2	183	2.1	182

Source: ABARES

## Calving patterns and feeding systems

The mix of calving patterns and feeding systems used by dairy farmers has important implications for farm input use and, hence, productivity. Both are interrelated, with the choice of calving pattern being affected, in part, by climate, landscape and the seasonal availability of feed. However, in some cases pricing incentives and milk supply contract arrangements may encourage farmers to use other combinations of calving patterns and feeding systems than they might otherwise have used.

### Calving patterns

Dairy farmers typically choose calving patterns to maximise their profitability, subject to seasonal price incentives and feed supply, as well as other factors. Calving patterns commonly range from seasonal to year-round (Box 1), with the mix of these varying within and among the

regions (Figure 15). In turn, the choice of calving pattern determines the seasonal demand for feed and the quantity of other inputs required to produce annual milk output.

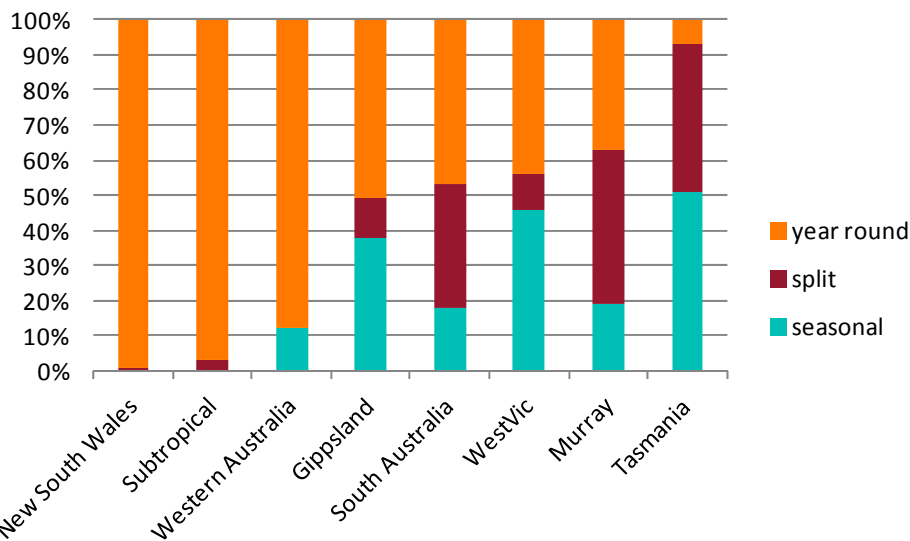
**Box 1 Common calving patterns**

**Seasonal calving:** The majority of cows are calved within a single period from either July to November or March to June. For a spring calving, seasonal milk production peaks in spring, before gradually tapering off over summer and autumn. Cows are dried off for a period through winter. For an autumn calving, seasonal milk production peaks in autumn, before gradually tapering off over winter and spring. Cows are dried off for a period through summer.

**Split calving:** Cows are calved in batches, usually one group in spring and the remainder in autumn. Split calving 'smooths' milk production through the year insofar as there are two peaks in production, and less of a drop in production out of season compared with seasonal calving.

**Year-round calving:** Cows may be calved continuously throughout the year or in batches periodically through the year. Milk production is relatively constant throughout the year.

**Figure 15 Calving system by region, Australia**

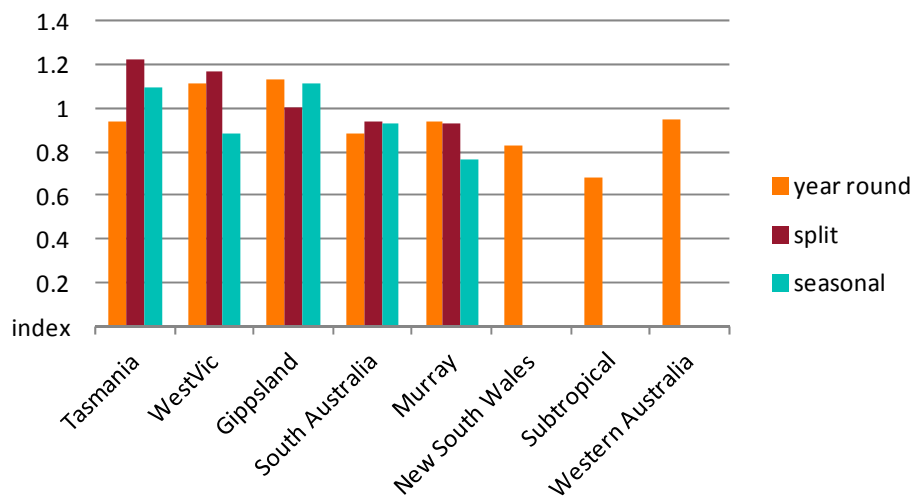


Source: ABARES

Anecdotal feedback from the workshops suggests that while some calving systems are inherently more input intensive than others, a more important determinant of farm-level TFP is the way that individual farmers manage these systems within the context of their own particular operating environment. When examined by region, the survey results show that differing calving systems achieved the highest average TFP in each region (Figure 16).



Figure 16 Average TFP by calving system, by region, Australia



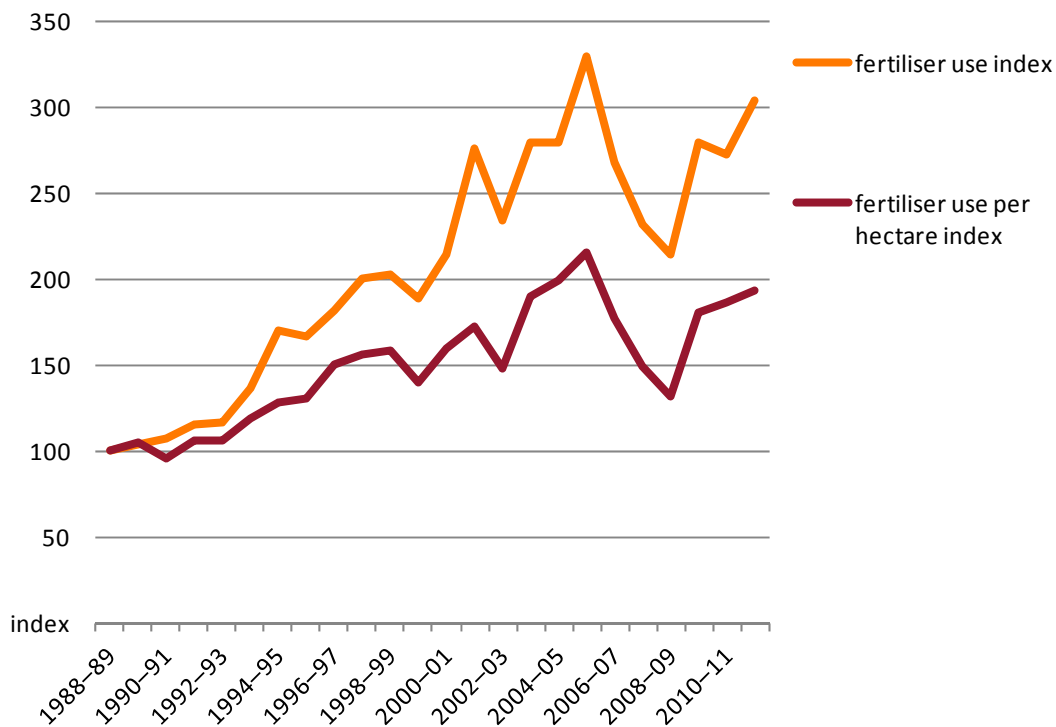
Source: ABARES

### Pasture management and fertiliser use

Pasture management is an important aspect of dairy farm productivity because of the relationship between feed inputs and milk yields. Several workshop participants cited the adoption of perennial ryegrass and increased use of specialist species as contributing to past productivity improvements because of high nutrient values and potential to fill feed gaps by growing year-round, depending on climatic conditions. Changes to pasture management practices have also contributed to past productivity improvements by allowing farmers to reduce the time and materials required to obtain a given quantity of pasture growth. Many participants at the workshops felt that further productivity gains could be obtained through greater uptake of current knowledge and by improving understanding of pasture management under various situations and developing grass varieties with higher nutritional value and greater drought tolerance.

A key aspect of pasture management involves fertiliser use, which workshop participants identified as a key driver of past productivity growth. The management and use of fertilisers, particularly nitrogen based fertilisers, has been important in achieving improvements in pasture yields and quality, with fertiliser use per farm increasing by around 5 per cent a year on average between 1988–89 and 2009–10 (Figure 17) and resulting in greater pasture production per hectare.

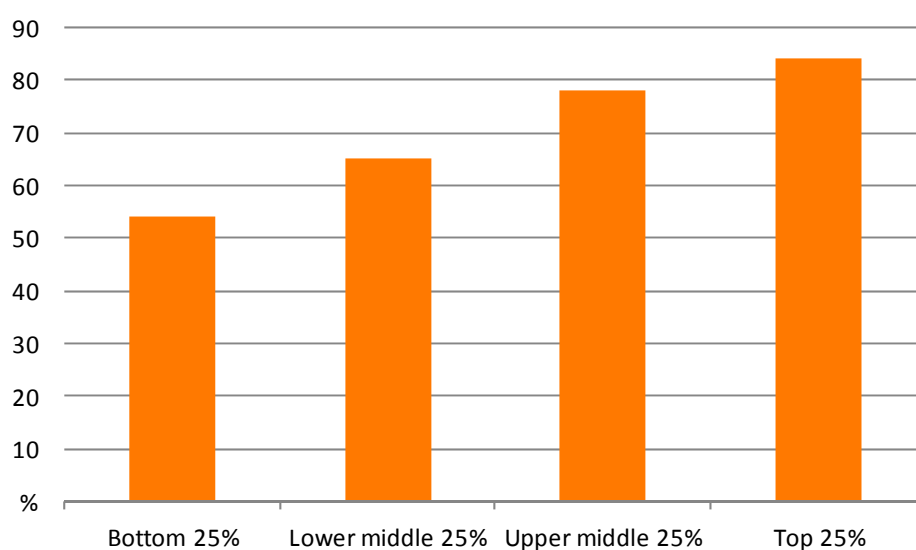
Figure 17 Trends in fertiliser use



Source: ABARES

Workshop participants also noted that farmers' use of fertilisers was becoming more efficient, with improved knowledge of nutrient management and soil testing. An estimated 63 per cent of dairy farmers undertook soil tests in 2010-11. Further, a higher proportion of better performing farms (as measured by TFP) used soil tests in 2010-11 (Figure 18), suggesting that soil testing helped farmers to better manage their fertiliser inputs with consequent benefits for productivity. On average, better performing farms were estimated to have used more than twice the quantity of fertiliser per hectare on dairy pastures and fodder crops than lower performing farms in 2010-11.

Future research and extension priorities about fertiliser use that participants raised at the workshops included: developing strategies to encourage greater adoption of soil testing; increasing farmers' knowledge of optimal fertiliser application rates for particular situations; and improving knowledge around using effluent as a fertiliser.

**Figure 18 Percent of farms using soil tests, by TFP group**

Source: ABARES

## Irrigation

Most dairy farms across Australia use irrigation to some extent. The use of irrigation for pastures and crops has important productivity implications by potentially increasing the quantity and quality of pasture or crops produced and, subsequently, affecting milk production on these farms.

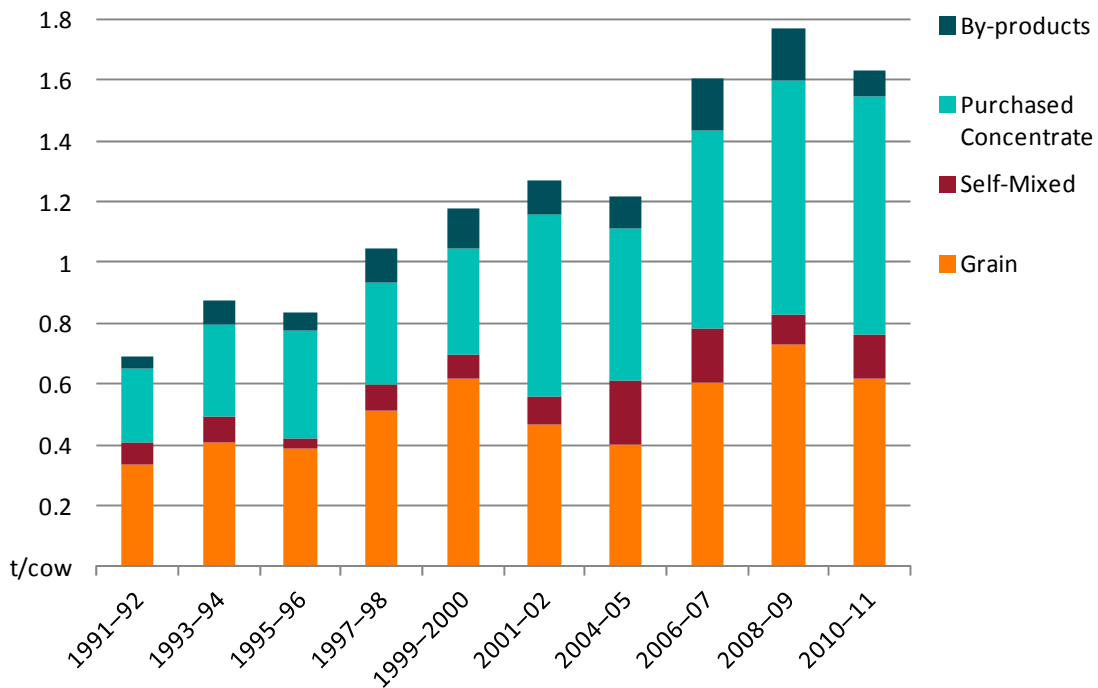
Several workshop participants felt that further productivity gains could be achieved if a greater number of dairy farms undertook water use efficiency improvements to on-farm irrigation infrastructure and related irrigation management practices. Although many participants in the main irrigation regions of Murray, New South Wales and South Australia noted the uptake of more efficient technologies had allowed them to reduce their water use and produce fodder more efficiently over the past decade, there was scope for improvement. In particular, a common view was that centre pivot irrigation systems and the use of computerised irrigation technologies would help reduce labour and water use. Some also suggested that irrigation technologies powered by solar energy may hold opportunities for reducing feed production costs.

In Tasmania, current expansion of irrigation water supply infrastructure will allow many dairy farms to use irrigation to supplement annual rainfall. Participants at the Tasmanian workshop viewed this as being a source of future productivity growth for dairy farms in the region because it would allow more feed to be produced on farm and enable dairy farmers to increase milk output. However, workshop participants recognised there was a need for further research to inform farmers about the most effective way to use irrigation with various farming systems in the region.

## Supplementary feeding

The use of grains and concentrates to supplement pasture based feeding has become an increasingly large component of dairy farm inputs in recent decades (Figure 19). At the same time, there has been greater attention to the nutritional value of various feed mixes, both of which have resulted in higher average milk yields per cow.

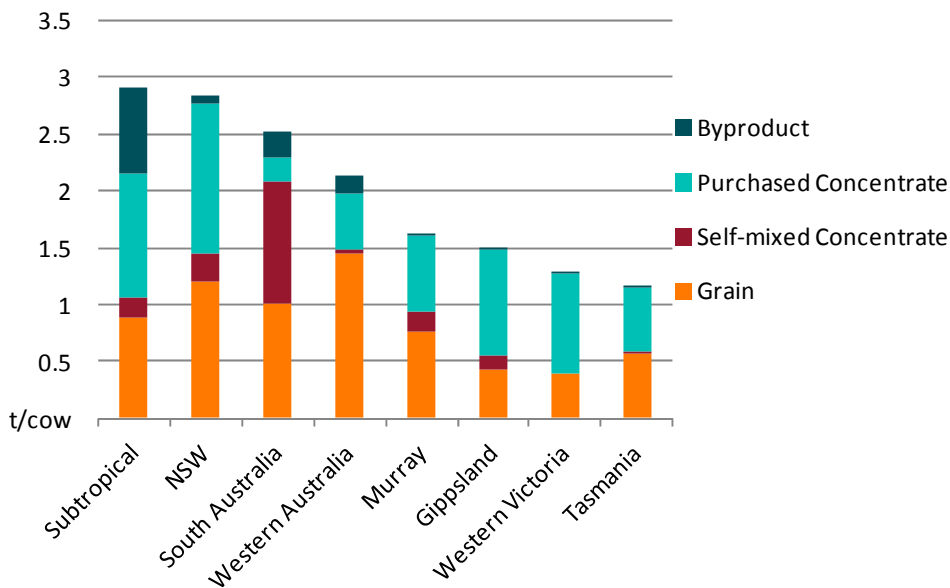
Figure 19 Grains and concentrates fed per cow, 1991–92 to 2010–11



Source: ABARES

While dairy farming in Australia is largely pasture-based, supplementary feeding is widely practised across all regions. The quantity of supplementary feed used per cow tends to be highest in those regions where a high proportion of farms supply milk on a year-round basis. Also, farmers in regions that have less reliable rainfall (that is, Murray, Subtropical, New South Wales and Western Australia) tend to use greater quantities of conserved or purchased fodder to meet seasonal pasture shortfalls. Those regions with relatively consistent annual rainfall and more seasonal milk supply (that is, Tasmania, Gippsland, Western Victoria and South Australia) tend to have a higher proportion of pasture in their feed mix than the other regions (Figure 20).

Figure 20 Grains and concentrates fed per cow in 2010–11, by region



Source: ABARES

Workshop participants suggested that feeding systems have become more targeted over the past two decades as farmers have obtained and used more information on cow nutrition. For example, workshop participants noted the increased use of pre-calving diets since the late 1990s has improved cow and heifer health. In addition, drought prompted some experimentation with feed rations as a way of overcoming pasture shortages. However, workshop participants suggested dairy farms could further enhance productivity by using feeding systems that are better targeted to the dietary needs of individual cows. Also, further productivity gains may be possible through wider use of feed analyses that allow farmers to compare the digestibility and metabolisable energy of various rations.

Workshop participants also highlighted the importance of maintaining flexibility in sourcing feed to manage exposure to climate and market risks, although they noted that periodic shifts between intensive feeding and pasture-based feeding were constrained by the ability of cows to adapt and the need to change on-farm infrastructure.

## Labour

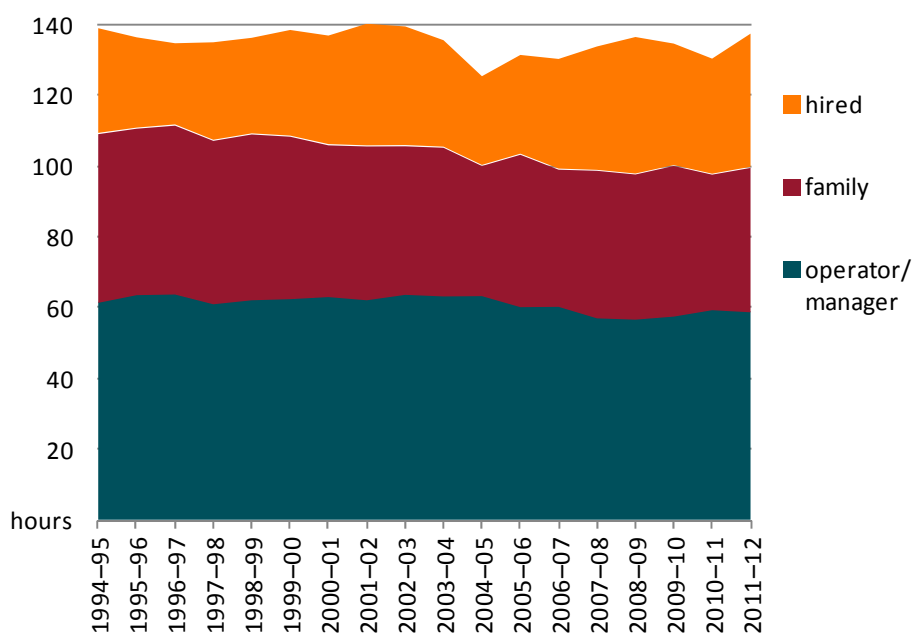
Many of the drivers of productivity growth discussed so far in this report have been facilitated by increases in the skills, knowledge and experience of dairy farmers and their employees. The continued availability of skilled labour is an important determinant of future farm productivity as skilled workers generally have a higher capacity for selecting and applying innovations that improve farm efficiency (Liao & Martin 2009; Nossal & Lim 2011; Zhao et al. 2009). Liao and Martin (2009) found that a higher proportion of farm managers educated at post secondary school level made more innovative changes than those with secondary education or below. This may be because education and training improves farm operators' decision-making skills and awareness of possible innovations, and their attitude towards change (Kilpatrick 2000).

Reflecting the decline in the total number of dairy farms, the number of people employed in the Australian dairy industry fell by 35 per cent between 2000–01 and 2010–11 (ABS 2002, 2012). At the same time, increasing average dairy herd sizes mean that milk output per unit of labour (a partial productivity measure of labour efficiency) has increased over recent decades as more farms have introduced labour-saving technology (such as automated milking).

These changes are partly reflected in the average total number of hours worked on dairy farms each week. Although ABARES farm survey data indicate the average total hours worked on farm per week has changed little since the mid-1990s, there have been some changes in the composition of these hours. The average hours worked declined for dairy farm operators (from 63 hours per week to 59 hours per week) and family members (from 43 hours per week to 41 hours per week), but increased for hired labour (from 31 hours per week to 38 hours per week) (Figure 21).

**Figure 21 Average weekly hours worked by dairy farm workers**

average per farm



Source: ABARES

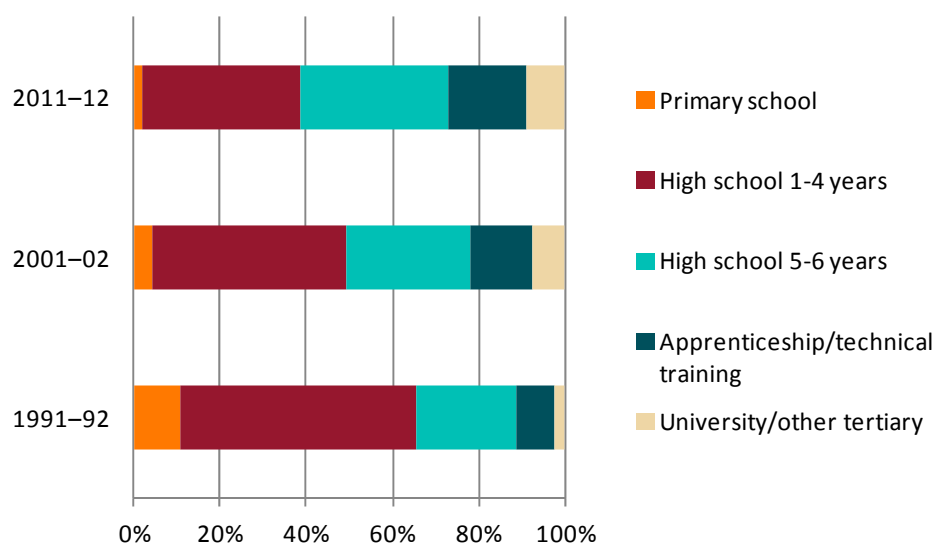
Feedback from the workshops suggests that there have also been changes in the mix of activities performed by farm labour. For example, improvements in milking times have allowed farmers to spend more time on activities such as pasture or herd management. As a consequence, changes in the way labour is used—including improvements in the skills and knowledge of farmers—are likely to have contributed to productivity growth.

Participants at the regional workshops commented on the increasing difficulty they encountered in finding skilled farm workers. Broadly speaking, obtaining workers with general dairy farm skills was viewed as difficult, more so for those seeking managers. In addition, they observed that remote farms found it particularly difficult to find suitable labour. Workshop participants suggested three main strategies to help overcome labour issues: increasing access to seasonal workers from overseas; broadly promoting the benefits of working in the dairy industry; and advertising dairy-related training and work opportunities in high schools.

## Education and training

Acquiring skills has become increasingly important as farming systems have become more complex. Reflecting this, workshop participants commented that successful farmers had improved their ability to manage a range of inputs concurrently and acquired the necessary skills to use new technology. On average, the level of formal education attained by dairy farmers has generally increased over the past 30 years, with higher proportions of farmers now completing apprenticeships/technical training and university/other tertiary courses than previously (Figure 22).

Figure 22 Highest level of education attained by dairy farm operators



Source: ABARES

Dairy farmers have access to training from a variety of sources, ranging from tertiary institutions to informal farmer information events. However, the range of training available varies by region. In small or more disperse regions there is less dairy-related training available. Participants at the Western Australia workshop commented that most training for new workers in the region was done on farm and as a consequence, farm managers had to spend more time training new staff. Participants at the Subtropical workshop remarked they found it difficult to access training, particularly for farms that were distant from regional centres. Workshop participants suggested more training was needed in two key areas: people and business management skills for farm managers; and basic dairy farm operation skills for new workers, particularly in regions where dairy farms are less concentrated.

Workshop participants also pointed to difficulties in setting aside time to participate in training opportunities. While they recognised the benefits of acquiring new skills, they had difficulties leaving the farm to attend training, particularly in the case of smaller farms. In some cases, sending farm workers on courses was also limited by time constraints because it is difficult to cover the workload of employees while they are away.

### Access to information

Dairy farmers have access to a wide range of information that may complement or replace more formal training courses. However, the magnitude of information available means farmers need to know how to select information effectively. Workshop participants commented on how difficult it can be to select desired information. Nevertheless, innovations in information and communication technology were recognised as a source of past productivity growth. For example, participants at the New South Wales workshop cited improvements in farm reporting systems that have enabled information to be collected for more precise farm management and improved tracking of farm finances.

Workshop participants noted a decline in government extension services since the 1990s, but an increase in the number of training activities organised by organisations such as Dairy Australia or farm consultants. Workshop participants identified the main sources of knowledge transfer as sellers of new products, other farmers, employees passing on knowledge gained at recent

training courses, and consultants. However, in the latter case, some participants noted that remote and less concentrated areas are often not well serviced by farm consultants.

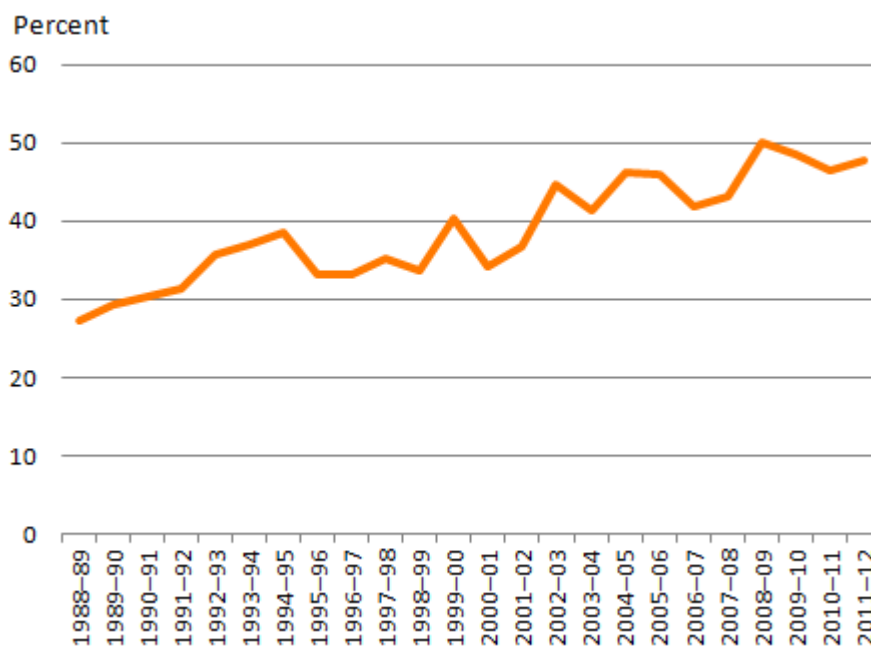
Some participants also highlighted the importance of personal communication between farmers as an ongoing source of new knowledge and productivity growth. Other farmers were often seen by some as a more credible source of information on new technologies or management practices than other sources, as their advice was based on personal experience. Some also saw benefits in communicating with farmers and consultants from different regions to obtain a range of different ideas.

Workshop participants saw potential improvements in synthesising and managing information as a major source of future productivity growth. They provided several examples of mobile phone technologies that could improve their ability to access the right information at the right time, including: mobile phone applications to track herd and pasture data, which could then be accessed anywhere on farm; mobile phone applications that synthesise management guidelines; satellite systems that monitor herd movements and pasture rotations; and information management tools that allow farmers to track costs and revenues more frequently and accurately.

### Succession planning

Succession planning is becoming increasingly important for dairy farmers as the current workforce ages. In 2011–12, almost half the dairy farm operators in Australia were over the age of 55. In comparison, less than a third of dairy farmers were older than 55 in the late 1980s (Figure 23). The ageing of Australian farmers on average poses a range of important issues for farming families to consider, including: the timing and best means of transferring the farm to younger family members; funding retirement; and catering for family members not involved in the farm business. Such issues can indirectly affect farm productivity by delaying new investments, particularly where older farmers may be less willing to adopt new technologies or management practices.

Figure 23 Proportion of dairy farm operators over the age of 55



Source: ABARES Australian dairy industry survey



Managing succession is closely related to the dairy industry's ability to attract and retain new workers. Participants at the workshops suggested dairy farmers could better manage succession by: seeking potential new farmers to take over the farm from both within their immediate family and outside it; retaining existing workers with potential to take on management of the farm by providing a desirable work environment and development opportunities; and mentoring younger farmers and building relationships through events such as those organised by the Young Dairy Network Australia. Workshop participants also suggested more specific guidance on developing succession plans was needed to encourage farmers to develop plans early and implement them effectively.

## **Animal health and welfare**

Awareness of the need to maintain good animal health and welfare on dairy farms has increased over the past thirty years. A wide variety of factors (including improved farm management practices, animal monitoring technology and increases in animal vaccinations) has resulted in better standards of animal health and welfare over this period, with consequent effects on farm productivity by ensuring outputs are improved. These improvements can be considered within three broad areas: genetics, herd health and animal welfare.

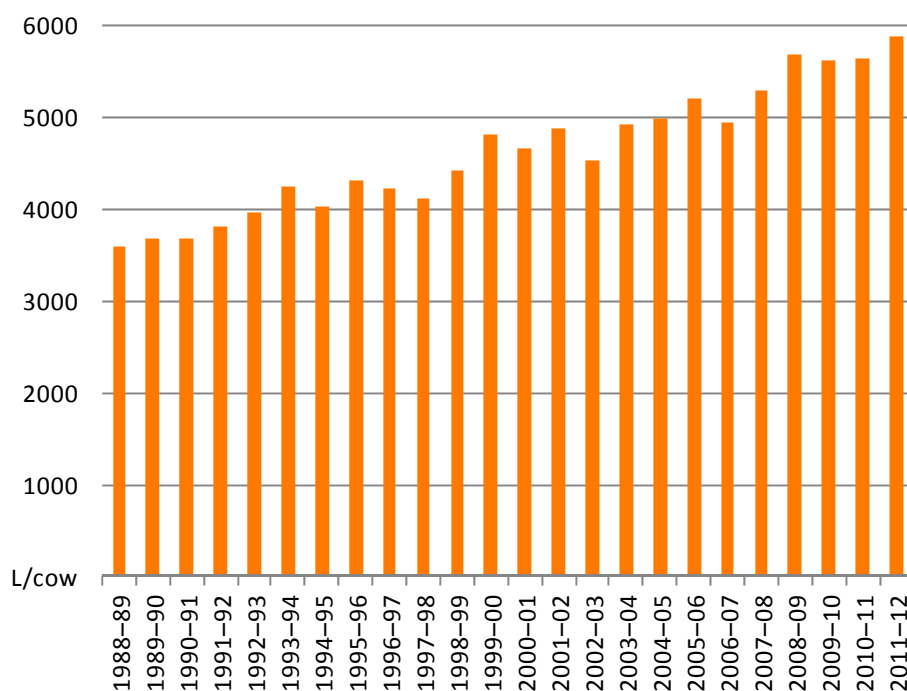
### **Improved genetics**

Advances in breeding and genetics have allowed dairy farmers to select cows for a range of traits, such as higher milk yield, longevity and reduced health problems. In selecting the traits to focus on, workshop participants highlighted the importance of considering whether a cow's genetic traits are suited to individual farm systems.

The above developments have collectively contributed to improved milk yields per cow (Figure 24), increasing at an annual average rate of 2.2 per cent a year from 1988–89 to 2011–12. However, previous research has suggested the focus on breeding higher yielding cows has affected cow fertility (Oltenuacu and Broom 2010; Robinson 2010). In turn, fertility problems affect cow lactation and therefore farm productivity. In response, dairy farmers have adopted a variety of management practices to improve cow fertility, including artificial insemination, genetic selection, heat detection programs and transition diets.

Lower fertility can also mean farmers have difficulty achieving planned milk production, with the resulting increase in labour and materials and possible reduction in output causing farm productivity to decline. Workshop participants suggested further research in this area was needed to combat declining fertility rates, including: identifying desired traits more reliably; improving the reliability of progeny testing to determine the breeding value of bulls; and, exploring the use of cross-breeding in order to improve fertility, longevity and calf survival.

Figure 24 Average milk yield per cow, Australia



Source: ABARES

## Herd health

Managing herd health is a critical part of dairy farm management because of the link with human food consumption. Herd health also has important implications for farm productivity as cows are the basic units of production on a dairy farm. Diseases can directly affect on farm productivity by reducing milk yields or cow fertility.

In particular, mastitis (caused by bacterial infection of udders) is an important animal health concern for dairy farmers because it is the most common disease that affects milk quality and production. Practices and technologies that reduce the incidence of mastitis allow farmers to obtain greater milk production and superior milk quality, while small changes in milk quality can affect the price received for milk.

Farmers have improved the management of mastitis and other diseases through: improvements in genetics that have allowed farmers to select cows based on health traits; improved monitoring of animal health and milk quality through milk meters; practices that have reduced exposure to disease-causing bacteria; and, greater use of vaccines.

Despite these improvements, the incidence of some types of mastitis may be increasing. Over the past decade, increasing intensification has created greater exposure to bacteria found in cattle manure that causes environmental mastitis. As herd sizes and stocking rates have increased, laneways and areas around troughs and calving pads have become more likely to collect mastitis-causing bacteria (Dairy Australia 2011; Mein 2011).

Workshop participants recognised mastitis as an ongoing concern that may continue to affect farm productivity. They suggested mastitis and other diseases may be better prevented in future by: increasing adoption of milk meters to record dairy herd health and production data; obtaining more precise individual cow cell counts to monitor the likelihood of cows having mastitis, either by increased herd testing or using inline meters; improving mastitis diagnosis; developing animal medicines that are easier to apply and cover a number of diseases in a single

application; providing alternatives for farmers to reduce the use of antibiotics to avoid resistance; and, providing adequate animal health training for new farm workers.

### **Animal welfare**

Australian dairy farmers are increasingly focused on demonstrating they meet society's expectations of animal welfare. Workshop participants indicated that most dairy farmers seek to demonstrate they adhere to established animal welfare standards to ensure societal concerns do not affect their ability to sell dairy products. Workshop participants signalled their interest in promoting the industry's good animal welfare practices. They suggested that liaising with animal welfare groups may assist the industry to meet society's expectations and promote their practices. Workshop participants identified the transport of bobby calves as an area where animal welfare considerations were particularly important.

At the same time, it was noted that some activities to improve animal welfare may actually be detrimental to farm productivity where additional inputs are required without an associated increase in outputs. It was suggested that further research be undertaken to fully understand the potential effects of increased expectations regarding animal welfare on farm productivity and possible solutions that result in positive outcomes for both animal welfare and productivity growth.

## 5 Managing risk

Dairy farming in Australia is an inherently risky business, and some risk must be taken to earn a return. As such, risk management is an important part of farm business decision making, where account should be taken of both the expected level of profit (returns) and the variability of profit (risk). Risk management should be viewed as maintaining the ability to exploit favourable conditions and limiting exposure to undesirable consequences (Makeham and Malcolm 1988).

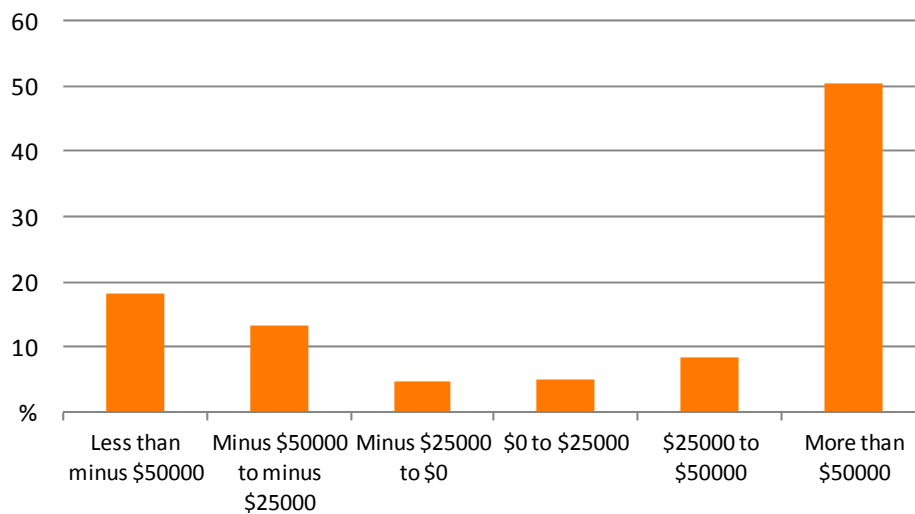
It is useful to distinguish between two types of risk: business and financial (Ho et al. 2013). Business risk reflects variation in the production system that alters the quantities and prices of outputs produced and inputs used by the farm. Quantities produced vary from year to year because of factors such as changes in weather conditions, pests and diseases, labour supply, and so on. At the same time, prices of inputs and outputs vary as the demand and supply of goods and services change, while changes in government policies can cause variation in both quantities and prices.

Financial risk refers to the gearing ratio, or the relative proportions of debt and equity that make up the total capital of the farm. Financial risk is important because the chance there will be insufficient cash flow to meet debt servicing requirements increases in line with the proportion of debt used to fund the business (because of higher interest costs). However, debt is an important source of capital for the growth and operation of farm businesses, including making investment in new technologies.

Risk is primarily a farm-level concern, with the magnitude and sources of risk, as well as the effect of risk management efforts varying from farm to farm depending on a range of farm-specific factors. For individual farms, risk is best described by the distribution of possible values of farm profit that could be earned in a particular year, which defines the likelihood that the farm will generate sufficient profit to meet ongoing requirements. Based on such a distribution, understanding the combinations of events that cause particular values of farm profit to be identified allows plans to be made to deal with these events.

A recent example where research of this kind has been done in the Australian dairy industry is the Dairy Directions project. As described by Malcolm et al. (2012), this research involves the construction of detailed farm business models, including the explicit representation of stochastic variables that cause variation in farm profit. The outputs of this analysis are distributions of farm profit associated with different possible farm systems. This research included representation of the fact that farms are not exposed to one risk at a time. It is the joint occurrence of multiple unfavourable events that has the greatest effect on farm profit. Furthermore, the analysis included representation of temporal and dynamic aspects of risk, as the cumulative effects of a run of years when unfavourable conditions prevail are far greater than the effects of a single bad year.

Although farm-level analysis is required to comprehensively understand risk and how it affects farm management in the Australian dairy industry, some insight into the overall variability of farm profit can be obtained from industry-level data. For example, Figure 25 illustrates the distribution of profit earned by dairy farms in 2011–12.

**Figure 25 Distribution of dairy farms by farm business profit, 2011–12**

Source: Source: ABARES

As shown, there is a significant variation in the returns earned by farms in any particular year. This reflects the diversity of climatic and market conditions that exist across the Australian dairy industry, plus the importance of farm-specific factors in determining profit, such as the combined effect of the intended production plan and the unpredictable seasonal and market conditions that eventuate. The variability of profit faced by a given farm also depends on the short-term, tactical responses farmers can employ to mitigate undesirable effects of variation in the operating environment (Pannell, Malcolm and Kingwell 2000). In the longer term, farmers can make strategic decisions to alter the nature of their farm systems. This will alter both the production plan, and the effect of variation in market conditions on realised profit (Malcolm et al. 2012).

### **Risk and productivity**

Given the above, productivity is also subject to risk because of the range of possible outcomes that affect inputs and outputs. In this context, risk and productivity are related in two ways. First, short term variation in measured productivity from year to year can occur as a result of changes in factors such as varying seasonal conditions where fewer outputs may be produced from a given set of inputs even though the underlying relationship (technologies used) between outputs and inputs remains unchanged. Second, risk has a systematic effect on the productivity performance of farms and industries because it influences the strategic farm management decisions that ultimately determine the nature of farm systems, and because it is a driver of structural adjustment. Each of these effects is discussed briefly below.

The presence of risk means that farmers don't necessarily choose the farming system that maximises profit or productivity under expected (or average) seasonal and market conditions, but instead choose a system that reflects their beliefs about the likelihood that particular events will occur and their risk preferences (Hardaker et al. 2004). O'Donnell et al. (2010) showed that when this is the case, farmers with different beliefs and preferences can rationally make decisions that cause significant differences in observed productivity between farms.

Furthermore, the presence of risk means that farmers will typically choose systems that give them the capacity to respond to unexpected events as they occur. Although this means profit and productivity are not necessarily maximised in 'average' years, doing this allows the farm to

survive and grow over the medium to long term (Malcolm et al. 2012). For dairy farmers, retaining the capacity to respond to changing conditions may take many forms, such as keeping a reserve of readily saleable assets, conservation of fodder when climatic conditions are favourable, retaining the ability to switch between home-grown and purchased feed as market conditions change, maintenance of unused borrowing capacity, and having a relatively high equity ratio.

Given that productivity is defined as the ratio of outputs to inputs, the use of risk management tools such as these will not necessarily increase or decrease productivity in any given year. This is unsurprising since these decisions are not made with productivity in mind. Instead, they are made with profit in mind, and in particular with the objective of maintaining the ability to react to changes in production, market and financial conditions as they occur.

Structural adjustment in the Australian dairy industry has been an important source of past industry-level productivity and profitability growth. The driving force for structural adjustment is differences between farmers and farm systems that create comparative advantage (Clark and Malcolm 2013). In general, this process means that over time, farmers with the greatest capacity to manage farms profitably may acquire the resources currently being used on other, less profitable farms.

Risk management is one factor that contributes to comparative advantage, and hence contributes to structural adjustment. In particular, comparative advantage lies with farmers who have the greatest ability to correctly identify and quantify risk, and to construct farm systems that are sufficiently flexible to take advantage of relatively favourable conditions, while limiting the affect of relatively unfavourable conditions. This involves making good decisions when choosing the nature of farming systems, such as how much land to operate, the intensity of the farming system, and appropriate ratios of debt to equity.

There is scope for more research to be done on the nature and effects of risk in the Australian dairy industry. Potential areas of research include the extent to which various stochastic variables contribute to the realised variation in farm profit, and the effectiveness of various risk management strategies used by farmers. This research would necessarily involve farm-level analysis, and would relate more closely to profitability than to productivity in or by itself.

### **Developing risk management tools**

As described above, the key components of risk management are identifying and quantifying the risk faced by particular farms and developing responses that allow farmers to take advantage of relatively favourable conditions, while avoiding exposure to unacceptable outcomes when conditions are relatively unfavourable.

Accordingly, an effective risk management tool would contain a representation of the physical, biological and financial characteristics of individual farms, and of the random events that cause variation in farm revenue and costs. Using such a tool, distributions of farm profit could be produced under various scenarios for the farm, and the effects on risk and return of possible changes to the farm system could be identified. Although key risks such as climate conditions and milk prices are likely to be important for all farms, the extent to which this is the case will vary from farm to farm, and other factors, such as the level of gearing, may be much greater sources of risk for some farms than others.

Farmers themselves are in the best position to identify and evaluate the risks they face, and various farm business consultants and other service providers, such as lenders, can be engaged to assist as required. Given the highly farm-specific nature of this analysis, the private sector is

the most appropriate source of such services. Nonetheless, as noted above there is scope for more basic research on the quantification and valuation of the risk associated with different farming systems, and for investigating the effects of alternative risk management strategies.

## 6 The future for productivity growth

Ongoing pressures mean that dairy farmers will need to continue finding productivity improvements to remain profitable in the longer term. The previous chapters of this report explored the drivers of past productivity growth in the Australian dairy industry. Identifying potential sources of future productivity gains and making appropriate investments in research, development and education are important issues for the industry.

Considering future productivity drivers should be framed within the context of the way inputs are used to produce outputs. Dairy farming systems include a complex array of activities that contribute to the end goal of producing milk and other farm outputs using a range of inputs. As discussed previously, TFP is a measure used to capture these relationships by expressing the total quantity of farm inputs and farm outputs as a ratio. The TFP of an individual farm at any point in time is determined by the inherent nature of the technologies and management practices used in converting inputs to outputs, as well as random factors that might affect the production process. At the industry level, TFP is measured as the ratio of all inputs used by the industry to produce total farm output, while growth in productivity is measured as the change in TFP through time.

One of the drivers of past growth in TFP was the exit of relatively less efficient farms from the industry. It is likely that the number of dairy farms in Australia will continue to decline and this will be an ongoing driver of productivity growth where the remaining farms are those with relatively greater efficiency.

A more important driver of past productivity growth was the adoption of new technologies and management practices that allowed farmers to combine inputs more efficiently to produce relatively more output. Analysis of ABARES survey data, combined with feedback from the dairy industry workshops, indicate there is substantial scope for future productivity gains by wider adoption of existing technologies and management practices. The rate of productivity growth will depend on both the extent of adoption across the industry as well as the size of the productivity gains made at the farm level. Seeking greater understanding of why some technologies have not been adopted may provide an important pathway for future productivity growth.

Workshop participants also identified a range of technologies and management practices that had potential to contribute to future growth in productivity. In particular, participants indicated that having information about the most efficient farming system to use in particular circumstances, such as by region, will be a key driver of future productivity growth. The following were the key aspects of dairy farming systems seen as having the greatest potential to contribute to future productivity growth:

- Robotic milking systems, because of reduced labour requirements, although the large capital investment and the possible need to make significant changes to existing pasture-based farming systems may limit uptake on many dairy farms.
- Improved understanding of pasture management under various situations to boost pasture production or optimise the use of inputs.
- Feeding systems that are better targeted to the dietary needs of individual cows with the potential to minimise waste and boost production per cow.



- Improved knowledge of optimal fertiliser use to boost pasture production.
- Availability of skilled labour, education, training and access to information, while having a less direct affect on TFP, are important for facilitating efficient farming systems.

There are a number of constraints to future productivity growth, many of which are already being faced by dairy farmers. Periodic drought, slowing rates of technology development and adoption, and fluctuations in farmers' investment confidence, all influence the rate of productivity growth. In addition, the economic incentives facing dairy farmers in particular circumstances may not be conducive to farmers making investments in new technologies and management practices. Further analysis of the relationships between milk supply contracts, types of farming system required to fulfilling contract requirements, and the physical and climatic characteristics of individual farms would provide greater understanding of the role these factors play in affecting productivity growth.

In addition, dairy farmers are being increasingly required to deal with issues such as environmental and animal welfare obligations, where actions to address such issues affect productivity on farms by increasing input use without any increase in output. Having greater understanding of the affect of such issues on dairy farming systems will help guide farmers' business management and investment activities.

# References

- ABS (Australian Bureau of Statistics) 2012, *2011 Census of Population and Housing*.
- ABS 2002, *2001 Census of Population and Housing*.
- Clark, D, Malcolm, B and Jacobs, J 2013, 'Dairying in the Antipodes: recent past, near prospects', *Animal Production Science*, vol. 53, pp. 882-93.
- Dairy Australia 2011, *Environmental mastitis increasing*, Media release, 18 July, [www.dairyaustralia.com.au/Standard-Items/Media-Releases/Environmental-mastitis-increasing.aspx](http://www.dairyaustralia.com.au/Standard-Items/Media-Releases/Environmental-mastitis-increasing.aspx).
- Hardaker, J, Huirne, R, Anderson, J and Lien, G 2004, *Coping with Risk in Agriculture*, CABI Publishing, Cambridge, MA.
- Harris D 2005, *Industry Adjustment to Policy Reform: A case study of the Australian dairy industry*, report for the Rural Industries Research and Development Corporation, August.
- Ho, C, Newman, M, Dalley, D, Little, S and Wales, W 2013, 'Performance, return and risk of different dairy systems in Australia and New Zealand', *Animal Production Science*, vol. 53, pp. 894-906.
- Kilpatrick, S 2000, 'Education and training: impacts on farm management practice', *The Journal of Agricultural Education and Extension*, vol. 7, no. 2, pp. 105-116.
- Liao, B and Martin, P 2009, *Farm innovation in the broadacre and dairy industries, 2006-07 to 2007-08*, ABARE research report 09.16, Canberra, November.
- Makeham, J and Malcolm, B 1988, *The Farming Game Now*, Cambridge University Press, Cambridge.
- Malcolm, B, Ho, C, Armstrong, D, Doyle, P, Tarrant, K, Heard, J, Leddin, C and Wales, W 2012, 'Dairy Directions: A decade of whole farm analysis of dairy systems', *Australasian Agribusiness Review*, vol. 20, pp. 39-58.
- Mein, GA 2011, *Review and recommendations on mastitis issues in the Victorian dairy industry*, A review for the Gardiner Foundation.
- Nossal, K and Lim, K 2011, *Innovation and productivity in the Australian grains industry*, ABARES research report 11.6, Canberra, July.
- O'Donnell, C, Chambers, R and Quiggin, J 2010, 'Efficiency analysis in the presence of uncertainty', *Journal of Productivity Analysis*, vol. 33, pp. 1-17.
- Oltenucu, PA, Broom DM 2010, 'The impact of genetic selection for increased milk yield on the welfare of dairy cows', *Animal Welfare*, Supplement S, 19, 39-49.
- Pannell, D, Malcolm, B and Kingwell, R 2000, 'Are we risking too much? Perspectives on risk in farm modelling', *Agricultural Economics*, vol. 23, pp. 69-78.
- Zhao, S, Sheng, EY and Kee, HJ 2009, *Determinants of total factor productivity in the Australian grains industry*, Conference paper 09.16.