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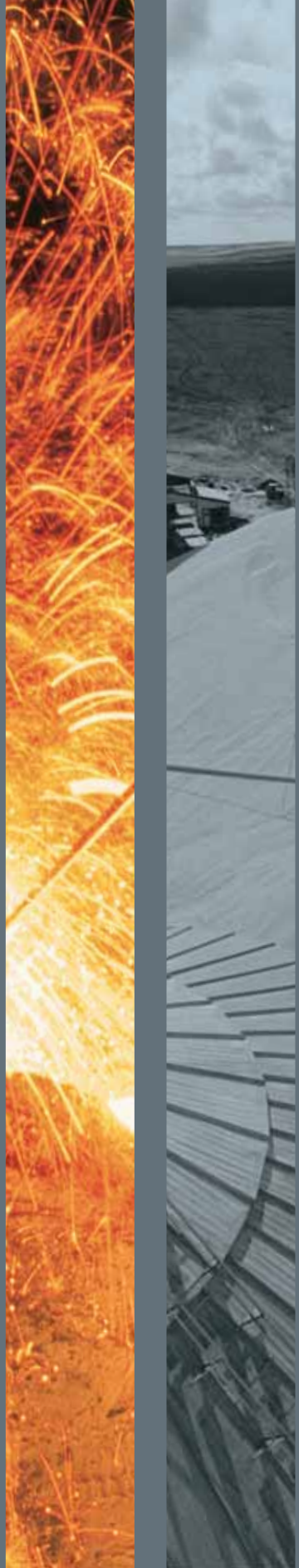

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Productivity movements in Australian agriculture

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- Productivity growth in broadacre agriculture has been highly volatile, but positive over the long term, averaging 1.5 per cent a year between 1977-78 and 2006-07. Dairy productivity growth has averaged 1.2 per cent a year between 1988-89 and 2006-07.
- Cropping specialists continue to outperform livestock industries over the long term with 2.1 per cent annual average productivity growth. However, productivity growth in crop and mixed crop-livestock industries is showing signs of slowing down.
- Regional disparities influence productivity growth rates, while seasonal conditions and access to markets are among other factors affecting overall performance in the farm sector. Recent drought conditions across Australia have diminished some regional advantages, with high performing regions more difficult to distinguish.
- Productivity gains in broadacre agriculture are partly influenced by farms changing their input mix. In particular, inputs of materials and services have increased by 2.4 per cent a year, while there has been a long-term decline in the use of other inputs.

In Australia, productivity growth has been the main source of long-term income growth in the economy. Improvements in terms of trade also played a role in the most recent decade. However, over the long term the economy has experienced a steady terms of trade decline. Productivity growth has also been the major driver of growth in Australia's agriculture sector. In fact, agricultural productivity growth has typically exceeded productivity growth in the rest of the economy.

Agriculture, similar to much of the economy, experienced a surge in productivity growth during the 1990s. While productivity growth may have begun to slowdown, long-term agricultural productivity growth rates continue to exceed that of the rest of the economy. This is largely because of technological progress, but also partly because farmers have adjusted in a number of ways, including by releasing resources such as labour to other sectors of the economy (PC 2008).

It has been highlighted stronger productivity growth would reduce or negate the adverse impact on living standards of three looming long-term challenges: population ageing; sustainable water use; and climate change (PC 2008). Further, dealing with challenges such as the global financial crisis, global food security, water and resource availability and drought will require productivity growth. These challenges are particularly relevant for the agriculture sector and, as a result, there will continue to be an emphasis on agricultural productivity growth.

Over the long term, Australian farmers have adjusted input use and adopted new technologies to expand their agricultural output. The effect of these changes on agricultural production are reflected to some extent in growth in total factor productivity (TFP). Measuring TFP enables productivity movements and their determinants to be compared across industries, regions and countries.

While TFP growth in the agriculture sector is higher than most other sectors of the economy, it has become evident agricultural productivity growth rates have also eased over the past decade. This article provides an updated analysis of productivity growth in the broadacre and dairy sectors. Regional differences in agricultural productivity and changes in input use over the past 30 years are also discussed.

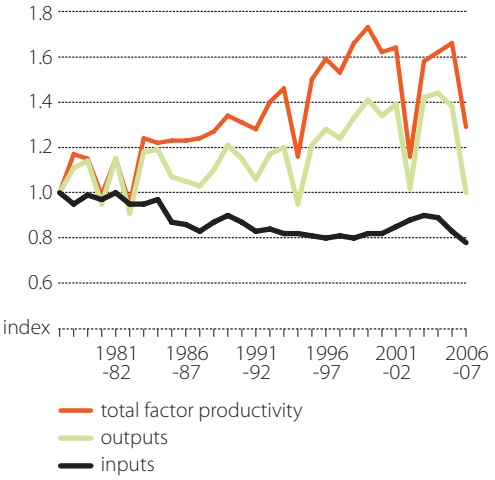
Trends in productivity growth

TFP measures total outputs relative to the inputs used in producing that output. Growth in TFP is often used as a measure of technological progress and is frequently used as an indicator of farm performance. Long-term TFP trends are considered to be the most reliable indicators, as the impact of year-to-year fluctuations are smoothed. These fluctuations are often sizeable because of factors such as variable seasonal and economic conditions.

Broadacre agriculture

Broadacre productivity growth has been highly volatile, however long-term trends are positive. Between 1977-78 and 2006-07, TFP growth averaged 1.5 per cent a year for the broadacre sector. This trend was accompanied by farms expanding output, while simultaneously reducing their input requirements (figure a). Output growth in the broadacre sector averaged 0.8 per cent a year over the period, with inputs declining at 0.6 per cent a year.

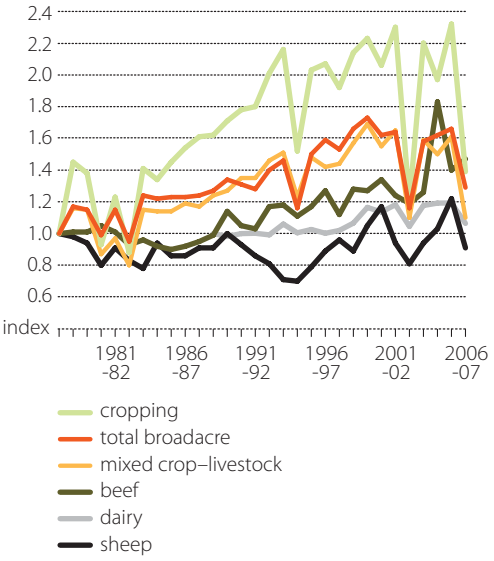
a Total factor productivity
broadacre and dairy industries



Fluctuations in broadacre TFP have been common, largely reflecting varying seasonal conditions. As many inputs used in agricultural production are often fixed in the short term, TFP fluctuations tend to coincide with movements in output. In figure a, it is shown that while input use declined quite consistently in broadacre agriculture, output growth was more variable. These sharp downturns in output growth are consistent with drought years in Australia, including 1980-81, 1982-83, 1994-95, 2002-03 and 2006-07. Despite these downturns, long-term productivity growth remained positive.

Within the broadacre sector, the cropping industry continued to outperform beef, sheep and mixed crop-livestock industries in terms of TFP growth (figure b). Cropping specialists achieved annual productivity growth of 2.1 per cent a year over the past three decades. The improved performance coincided with farms expanding output significantly, with only moderate increases in input use (table 1).

b Total factor productivity
broadacre and dairy industries



The mixed crop-livestock industry improved productivity by an average of 1.5 per cent a year. These farms expanded output only marginally and productivity gains were mostly achieved through more efficient use of inputs (they required fewer inputs to achieve a similar level of output) (table 1).

Beef specialists achieved the same average performance level as the mixed crop-livestock industry over the past three decades (table 1). Their productivity growth coincided with high output growth and relatively marginal growth in input use.

The sheep industry continues to lag behind the broadacre sector in terms of long term productivity growth. Between 1977-78 and 2006-07, the industry has experienced a decline in both output and input use (table 1). Possible reasons for underperformance in the sheep industry have been ambiguous and are discussed further in box 2.

1 Average annual input, output and TFP growth in broadacre industries, 1977-78 to 2006-07

	TFP growth	output growth	input growth
	%	%	%
Total broadacre	1.5	0.8	–0.6
Cropping	2.1	3.1	1.0
Mixed crop–livestock	1.5	0.1	–1.5
Beef	1.5	1.7	0.1
Sheep	0.3	–1.4	–1.8
Dairy **a**	1.2	5.1	3.9

a Dairy industry estimates from 1988-89 to 2006-07.

Dairy

Productivity growth amongst dairy specialists averaged 1.2 per cent a year between 1988-89 and 2006-07, reflecting high input and output growth (table 1). Dairy specialists began to expand their operations following deregulation in 2000. Some unproductive farms exited the industry while remaining farms began to increase the size and intensity of their operations in order to maintain profitability (Harris 2005). These dairy specialists have achieved strong output growth. Input growth was also higher during this expansion, particularly land and dairy herd purchases.

However, during the current decade, overall dairy production (in terms of milk products) has been falling. For example, milk production fell from a peak of 11.3 billion litres in 2001-02 to 9.1 billion litres in 2007-08. This suggests that while the average size of dairy farms has increased, the expansion in average farm size has not offset the fall in the total number of farms.

The observed strong output growth is hence a reflection of improvements achieved by specialist dairy farms, despite total industry production falling. These improvements have been achieved by farms increasing intensity (through higher stocking rates and more intensive

box 1 **Estimation technique and industry definitions**

Long-term TFP trends are estimated using regression techniques, rather than taking an average of TFP growth in each year-to-year period. Average TFP growth over multiple years is estimated by regressing the natural logarithm of the TFP index against time.

In this paper, total factor productivity is estimated for five broadacre industries and the dairy industry using data collected through ABARE's Australian Agricultural and Grazing Industries Survey (AAGIS) and Australian Dairy Industry Survey (ADIS). Industry defentions are based on the Australian and New Zealand Standard Industrial Classification (ANZSIC) (ABS, 2006, cat no. 1292.0). The industries are:

- **Cropping** – farms engaged mainly in growing cereal grains, coarse grains, oilseeds and/or pulses
- **Mixed crop-livestock** – farms engaged mainly in both growing crops and running sheep or beef cattle
- **Beef** – farms engaged mainly in running beef cattle (beef specialists) and those running both beef and sheep (mixed beef-sheep)
- **Sheep** – farms engaged mainly in running sheep (sheep specialist) and those running both beef and sheep (mixed beef-sheep)
- **Dairy** – farms engaged mainly in dairying

Under these definitions, farms with crop production accounting for the majority of its agricultural output will be included in cropping industry for productivity analysis. However, it therefore should be noted that in measuring relative inputs and outputs (to estimate TFP), cropping industry output includes not only crop outputs, but all other agricultural outputs produced by farms classified within the industry. This clarification is particularly relevant as many Australian agricultural farms produce multiple products.

Regional TFP estimates are provided for crop specialists, beef specialists and sheep specialists. In these estimates, farms classified as mixed beef-sheep are excluded.

feeding practices), improving pastures and increasing purchases of off-farm feed. New technologies and farm management practices have also lifted labour productivity and milk yields (Zhao et al. 2008).

Regional productivity trends in broadacre agriculture

Comparing productivity across regions provides an indication of possible factors driving productivity growth. For cropping specialists, regional estimates are based on the three Grains Research and Development Corporation (GRDC) agro-ecological regions. Beef specialist productivity estimates are compared between northern and southern beef regions as defined by Meat and Livestock Australia (MLA). The sheep specialists are divided into three geographical zones – pastoral, wheat-sheep and high rainfall.

Farm performance in the cropping industry followed a similar trend between GRDC agro-ecological regions with productivity growth in northern, southern and western regions

ranging from 2.0 to 2.5 per cent on average. However, the contribution of input and output growth to productivity growth differed between regions (table 2). The southern and western regions both experienced strong growth in outputs, with inputs expanding modestly also. These regions (particularly the western region) benefited from a significant shift into cropping from wool production and increases in the scale of cropping operations. Other factors

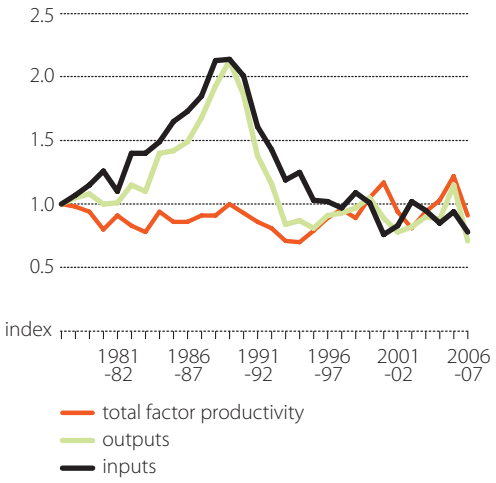
box 2 Is the sheep industry underperforming?

Long-term productivity growth in the sheep industry has been consistently below other broadacre sectors. While the industry has undergone significant adjustments over the past three decades, the cause of underperformance in terms of TFP has been only briefly discussed.

The sheep industry is mainly comprised of small farms, typically engaged in mixed operations with a combination of wool, lamb, sheep and other outputs. Output and input use in the sheep industry has changed over time in a different way to the overall broadacre industry (figure c). Growth in input use through the 1980s was not able to stimulate any significant productivity gains. During the 1990s, following the collapse of the wool reserve price scheme, there was a significant shift from wool into cropping as farmers took advantage of higher relative returns. As the industry was contracting, there was little investment, which may have limited the ability to introduce improved technology.

More recently, sheep productivity growth seems to be trending upwards (figure c). Between 1997-98 and 2006-07, productivity growth averaged 0.5 per cent a year, compared with -1.39 per cent for the broadacre sector overall during that period. If there were not two major droughts during this period, productivity growth would potentially have been even higher. This indicates a possible shift in sheep industry productivity growth may be underway, and the industry may not be performing as poorly as the long-term trend would suggest.

C Sheep industry

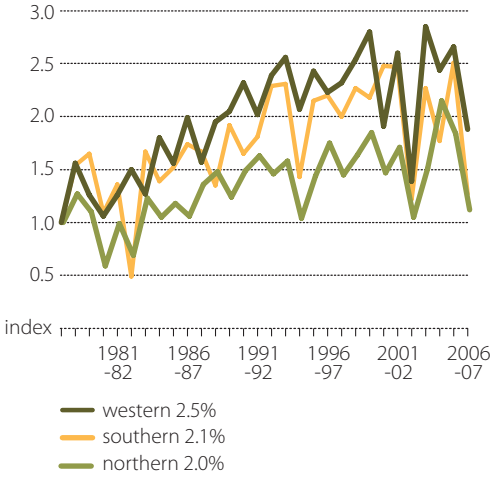


High prices and increasing export demand for Australian slaughter lamb in recent years is likely to have stimulated productivity growth with farms adopting new technologies and more efficient farm management practices. Domestic lamb prices have risen to historically high levels averaging 350 cents per kilogram between 2003-04 and 2007-08, compared with 194 cents per kilogram between 1993-94 and 1997-98. Some farmers have returned to the sheep industry and expanding production levels. Over the past decade there has also been a greater focus on finishing lambs to increase slaughter weight, use of improved pastures and supplementary feeding, as well as superior genetics (Nossal et al. 2008). The impact of these industry developments is likely to take some time to flow through in the form of long-term productivity growth.

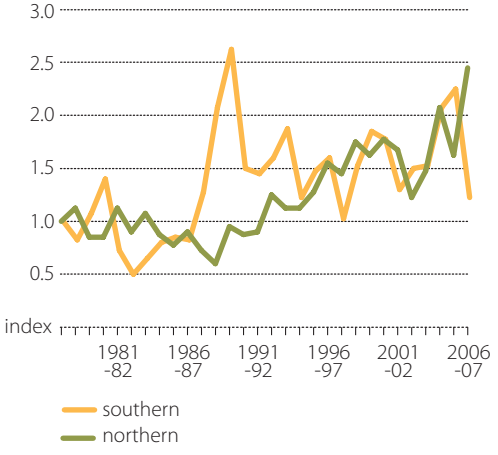
2 Annual growth of cropping specialists, 1977-78 to 2006-07

	TFP growth %	output growth %	input growth %
Northern region	2.0	1.3	-0.8
Southern region	2.1	3.8	1.7
Western region	2.5	4.4	2.0

d Total factor productivity
cropping specialists



e Total factor productivity
beef specialists



improving productivity included increased use of crop rotations, higher yielding varieties, and use of minimum tillage techniques.

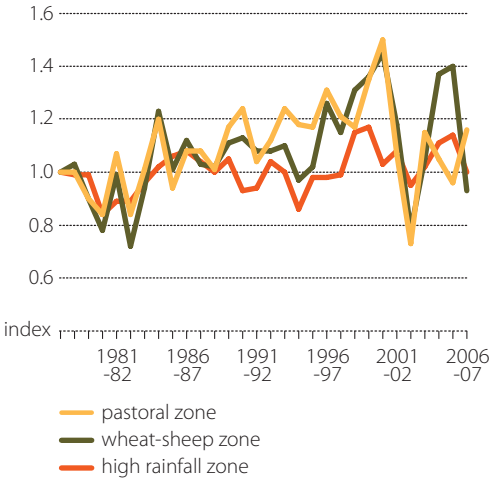
The northern region achieved lesser output growth, but simultaneously reduced input use. While productivity growth of cropping specialists has been consistently lower in the northern region (figure d), long-term growth has been only slightly lower than the southern region as fluctuations have been less significant.

Productivity differences are more obvious between northern and southern beef producing regions (figure e). Beef specialists in the northern region achieved annual average TFP growth of 1.2 per cent a year, compared with 0.8 per cent a year for the southern region (table 3). In the northern region, higher overall performance was mainly a reflection of dramatic productivity growth during the 1990s. In the current decade, productivity growth appears to be continuing to rise, with only the drought years of 2002-03 and 2004-05 causing drops in performance (figure e).

Productivity growth in the northern beef region has been partly because of the expansion in output occurring recent years. Farms in the northern region have expanded over the past two decades and the region is now dominated by large specialist farms with high stock numbers. The emergence of live export trade with Asia has also stimulated an expansion in output, with minimal additional input requirements. Other factors lifting productivity growth have included improved pest and disease control, higher fertility rates and increased turn-off weights.

In the southern beef region, productivity has been more variable, leading to lower overall productivity growth. In general, the

f Total factor productivity
sheep specialists



3 Average annual growth of beef specialists, 1977-78 to 2006-07

	TFP growth	output growth	input growth
	%	%	%
Northern region	1.2	1.3	0.1
Southern region	0.8	0	–0.9

4 Average annual growth of sheep specialists, 1977-78 to 2006-07

	TFP growth	output growth	input growth
	%	%	%
Pastoral	0.5	–1.5	–2.0
Wheat-sheep	0.9	0.0	–0.9
High rainfall	0.5	–2.2	–2.7

region has been more heavily impacted by seasonal conditions in recent years, causing notable fluctuations in productivity. This variability could therefore reflect destocking and subsequent rebuilding in response to drought (Nossal, Sheng and Zhao 2008). The southern region typically shows more vulnerability than their northern counterparts as southern farms are often smaller and more diversified.

Sheep specialists can be split into three geographical regions for productivity analysis – high rainfall, wheat-sheep and pastoral regions. These different farming environments have led to distinctive patterns in productivity growth, however long-term trends were similar (figure f), with productivity growth averaging between 0.5 per cent and 0.9 per cent a year over the past three decades (table 4).

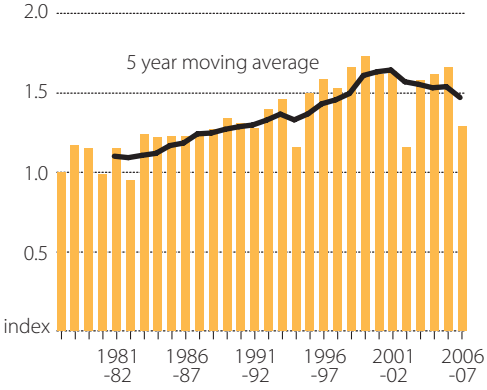
Productivity has been most variable in the pastoral region. Large specialist farms are more predominant in this region. These large farms demonstrated the strongest productivity gains during the 1980s and 1990s, however drought in recent years appears to have significantly affected the ability of these farms to continue improving performance. Productivity gains in this region have coincided with farms cutting back inputs more than outputs.

Over the long term, all sheep producing regions have achieved productivity gains while scaling back production, although input use has been reduced faster than output has fallen. In the wheat-sheep region, the reduction in inputs and outputs has been only slight relative to the other regions. This is most likely to reflect that farms in this region commonly undertake crop-grazing rotation and cropping productivity growth has been strong. The high rainfall region has had the largest decline in output and input use, however long-term productivity growth has remained at a similar level because of the ability of farms to cut input requirements at a faster rate. This has led to some efficiency improvements and translated to a positive measure of TFP growth.

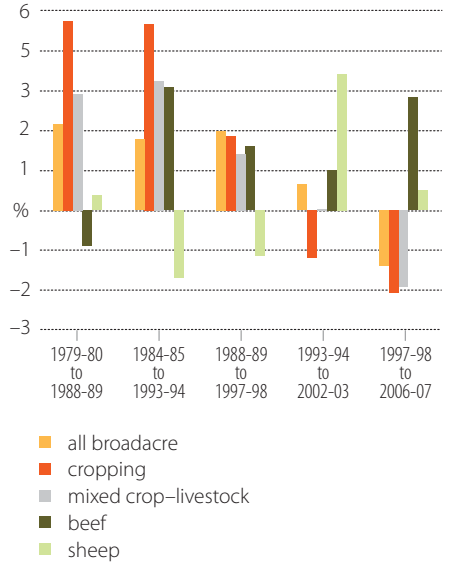
Is productivity growth slowing over time?

There are several indicators which suggest productivity growth may be slowing down in the agriculture sector. Similar to most Australian industries, productivity growth experienced a surge during the 1990s (figure g). Broadacre productivity growth was 3.6 per cent on average between 1989-90 and 1998-99, compared with an average 1.5 per cent between 1977-78 and 2006-07. The agriculture industry, along with many others, benefited from microeconomic reforms, improvement in market access and technological development.

g Total factor productivity
broadacre



h Broadacre TFP growth by industry
short-term trends



Since around the turn of the century, broadacre productivity growth appears to be slowing. Between 1997-98 and 2006-07, productivity growth began to show a negative trend, falling at an average rate of 1.4 per cent a year. Looking at productivity growth over relatively short time periods does not provide a reliable indication of long-term trends, however there appears to be some possibility productivity growth is showing the signs of slowing down. This trend also appears to be analogous with the more general slowdown in productivity growth occurring for the economy overall (PC, 2008).

In broadacre agriculture, it is obvious recurring droughts have influenced productivity growth, with severe downturns in output (and productivity) occurring during drought years 1994-95, 2002-03 and 2006-07 (figure g). However, drought may not be the only reason for the perceived slowdown in productivity growth.

Comparing productivity growth across broadacre industries shows the slowdown has been largely restricted to cropping industries (figure h). The beef industry has lifted productivity growth in the past decade and the sheep industry has also improved productivity performance compared with previous decades, although drought appears to have had a negative influence in the past few years.

Much of the productivity growth in cropping during the 1980s and 1990s was because of technological advances, including much

larger and more efficient planting and harvesting equipment. This enabled high substitution of capital for labour in crop production. The cropping sector increased productivity by an average of 4.7 per cent a year between 1984-85 and 1993-94. It appears the cropping sector may be approaching its limit in terms of the capital-labour substitution possible with currently available technologies and hence productivity growth rates have flattened accordingly. Combined with drought impacts, productivity growth in cropping has been negative over the past 10 to 15 years.

What else is behind productivity growth?

Input components

Productivity growth estimates often reflect more than simply a shift in the efficiency frontier. Gains can also be made via improvements in allocative efficiency – changing input mix to enable farms to lie on the efficiency frontier (PC 2008). As such, productivity gains in agriculture have come in part from substitution between inputs.

5 Partial productivity growth in the broadacre industries, average annual growth, 1977-78 to 2006-07

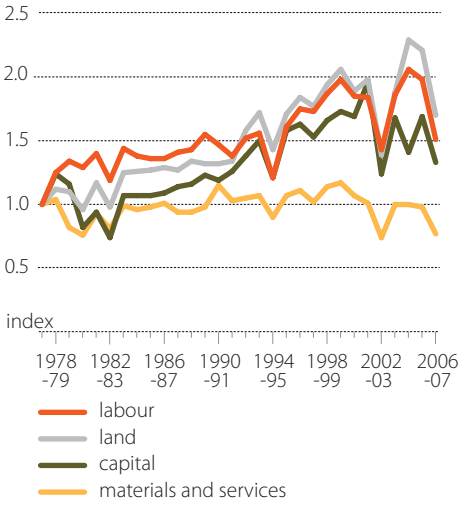
	input growth %	partial factor productivity growth %
All broadacre		
Land	–0.7	1.6
Labour	–1.7	2.5
Capital	–1.2	2.1
Purchased inputs	2.4	0.2
Cropping		
Land	1.3	1.9
Labour	–0.2	3.3
Capital	–0.4	3.5
Purchased inputs	4.0	0.6
Mixed crop–livestock		
Land	–1.3	1.3
Labour	–2.4	2.4
Capital	–2.5	2.5
Purchased inputs	1.8	0.3
Beef		
Land	–0.3	2.0
Labour	–0.7	2.3
Capital	0.7	1.0
Purchased inputs	3.5	–0.2
Sheep		
Land	–1.1	–0.3
Labour	–2.5	1.1
Capital	–2.9	1.5
Purchased inputs	–0.1	0.3

Examining the growth in inputs can be one way to observe how input use has changed over time (table 5). Changes in the amount of output produced relative to a single input factor, such as land, labour or capital, reflected in estimates of partial factor productivity (PFP) growth, also shows the changing efficiency with which farms use certain inputs (figure i).

During the 1980s and 1990s, productivity gains in agriculture came largely from substituting capital for labour. As a result, labour use in agriculture fell by an average of 1.7 per cent a year over the past three decades and farmers have increased their output per unit of labour by an average of 2.5 per cent a year (table 5).

More recently, productivity gains have corresponded with a general reduction in land, labour and capital use in agriculture (table 5). Lower input requirements are mostly attributable to technological progress, however additional use of materials and services has also enabled the reduction in other inputs. Use of materials and services, including fodder, seed, fuel, fertiliser, services etc, increased by 2.4 per cent a year between 1977-78 and 2006-07.

i Partial factor productivity in broadacre industries



It is questionable whether improving productivity via a switch to materials and services, in place of other inputs, is likely to be sustainable on an ongoing basis. Another concern is that some materials and services are relatively emissions-intensive inputs (eg fuel, fertiliser, etc). An emissions trading scheme is likely to have a relatively greater impact on these inputs, compared with land, labour or capital. It may become costly to continue expanding in this direction. In this case, improving productivity growth through increased use of materials and services, may become less attractive.

Future productivity gains could potentially come via improvements in the quality of materials and services. For example, the CPRS is likely to provide incentives for technological advances which are less energy intensive. This could simultaneously lift productivity growth and reduce the emissions impact of agricultural production. Alternatively, a new wave of technological progress could lead to another shift in input composition.

External factors

External factors continually influence productivity performance, including seasonal patterns, economic conditions and government policy. Recurring drought is an inherent part of Australian agriculture and part of the environment in which Australian producers must operate (ABARE, 2004). The impact of climate change is likely to have additional implications for productivity into the future. Management strategies which minimise the impacts of drought on output will have long-term productivity benefits as well as improve resilience of agricultural industries.

Similarly, there have been positive external influences affecting productivity growth. These include ongoing structural adjustments and changes in overseas demand for Australian agricultural exports. These changes have fuelled productivity growth by providing farmers with an incentive to innovate and expand output. These factors play an important role in facilitating developments within the industry.

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