Agricultural productivity

Agricultural productivity: trends and policies for growth

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Summary

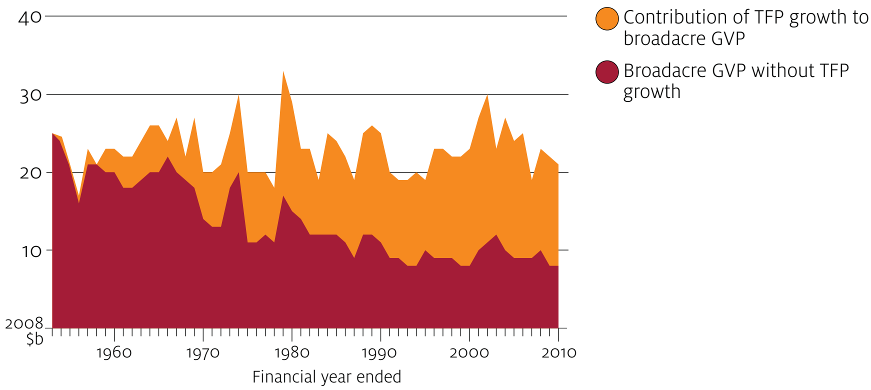
- In agriculture, total factor productivity (TFP) growth reflects improvements in the efficiency with which farmers combine market inputs to produce outputs. It is an important determinant of profitability in the farm sector.
- TFP growth for the broadacre farm sector (non-irrigated crops, beef and sheep) averaged 1.2 per cent a year between 1977–78 and 2009–10. Over this period, TFP growth rates differed between the main farm types: 1.6 per cent a year for cropping; 1.1 per cent a year for mixed crop–livestock; 1.4 per cent a year for beef and 0.5 per cent a year for sheep.
- In recent years, the gap between the TFP growth rates of the cropping and livestock industries has been narrowing. TFP among cropping specialists (and to a lesser extent, mixed cropping–livestock farms) has been growing more slowly whereas the growth rate in the livestock industries has been increasing.
- Dairy industry TFP growth has averaged 0.3 per cent a year since 1978–79. Growth in output has been driven largely by growth in inputs, reflecting a trend toward more intensive dairy production systems.
- There are a number of opportunities for governments and industry to consider in promoting productivity growth. These include investing in R&D and extension, building the knowledge and skills of farmers, facilitating structural adjustment and reducing regulatory burdens.

Importance of productivity growth

Productivity growth is an important determinant of agriculture output. It reflects improvements in the efficiency with which farmers combine market inputs to produce outputs. It is also a key mechanism by which farmers maintain profitability and the competitiveness of the agriculture sector. These motivators, among others, maintain interest in the determinants of agricultural productivity growth.

Over time, ongoing improvements in productivity have enabled Australian farmers to increase output using relatively fewer market inputs. Compared with its value if farmers only had access to 1950s production technologies, almost two-thirds of the gross value of broadacre production in recent years can be attributed to productivity improvements (Figure 1).

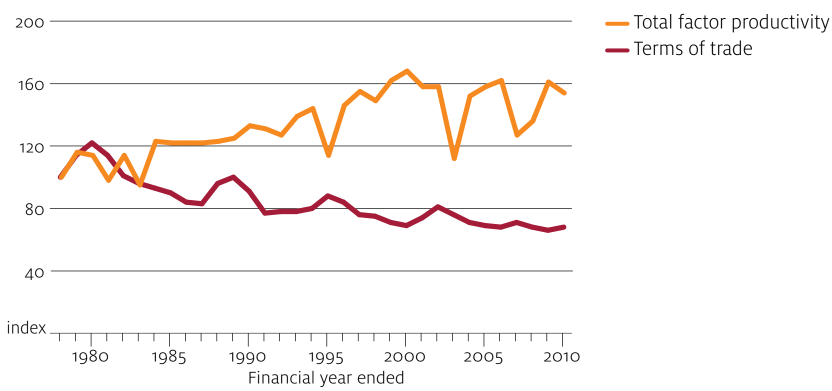
FIGURE 1 Contribution of total factor productivity growth to the gross value of broadacre production, 1952–53 to 2009–10



Note: Given total output growth (*Ó*) equals total input (*Í*) growth plus TFP growth (*Á*), relative to a base year, and assuming farmers are price takers, broadacre GVP can be decomposed into two components: the input contribution to broadacre GVP in year *t* equals $GVP_t \times (Í_t / Ó_t)$ while the contribution of TFP contribution equals $GVP_t \times (Á_t / Ó_t)$.

For farmers, productivity growth helps maintain profitability in the face of a declining trend in the terms of trade (output prices relative to input prices). Although changes in the terms of trade may induce farmers in profit-maximising to choose combinations of inputs and outputs that reduce their overall productivity (O'Donnell 2010; Productivity Commission 2008), these are often short-run effects only. Consequently, ongoing productivity improvements are generally the predominant way for most farmers to offset ongoing cost pressures and maintain profits in the long run (Figure 2).

FIGURE 2 Broadacre total factor productivity and the farmer terms of trade, 1977–78 to 2009–10



Note: Total factor productivity shown here relates to broadacre (non-irrigated) agriculture only, although the farmer terms of trade covers all Australian agriculture.

For governments concerned with ensuring the ongoing competitiveness and sustainability of the agriculture sector, promoting efforts to increase productivity remains a priority. Productivity growth is important for maintaining farm incomes and is an element of the response to the challenges of climate change. Productivity growth can also contribute to broader societal objectives. For example, it can provide environmental benefits by reducing agriculture's reliance on inputs such as land, water and chemicals (Productivity Commission 2005).

Notwithstanding its obvious importance, productivity is best considered in policy terms as a means to an end, rather than an end in itself (Banks 2010). Factors beyond higher incomes, such as leisure time, environmental amenity and longevity and distributive issues, affect economic development and the wellbeing of Australians (Boarini et al. 2006). Nevertheless, raising material living standards through productivity growth is important insofar as it contributes to improving the wellbeing of farmers and society more broadly.

Trends in agricultural productivity

Measures of agricultural productivity at the national, industry and regional levels are useful for monitoring and evaluating changes in industry performance over time. In turn, they underpin strategic investment decisions and guide policies aimed at improving farm performance. A brief overview of ABARES productivity estimates is in Box 1.

Total factor productivity (TFP) is the key indicator ABARES uses to measure broadacre and dairy productivity. TFP compares the total market outputs produced (crops and livestock) relative to the total market inputs used (land, labour, capital, materials and services). Although common in practice, reliance on a single input or partial factor productivity (PFP) measure (such as crop yield per hectare) may result in a misleading assessment of productivity for policy making. This is because the combined effects of all changes in farm production systems, among other things, productivity, input substitution and quality effects are incorrectly attributed solely to one input. For this reason, TFP better reflects farmers' overall productivity.

Box 1 **ABARES productivity estimates**

ABARES estimates TFP as the ratio of a quantity index of total market outputs relative to a quantity index of market inputs. Multiple outputs and inputs are aggregated using a Fisher index. Annual TFP growth rates (percentage change over time) are derived by fitting an exponential trend line.

ABARES has published statistics and analysed the productivity of Australia's broadacre (non-irrigated cropping and grazing) and dairy industries since the early 1990s using data collected through its national farm survey program. Broadacre farms have been surveyed annually using a consistent methodology since 1977–78 and dairy farms since 1978–79.

The Australian and New Zealand Standard Industrial Classification (ANZSIC) (ABS 2006) defines broadacre and dairy industries as:

- Crops industry (ANZSIC06 Class 0146 and 0149) – farms engaged mainly in growing cereal grains, coarse grains, oilseeds, rice and/or pulses
- Mixed crop–livestock industry (ANZSIC06 Class 0145) – farms engaged mainly in running sheep or beef cattle, or both, and growing cereal grains, coarse grains, oilseeds and/or pulses

...continued

Box 1 **ABARES productivity estimates** **...continued**

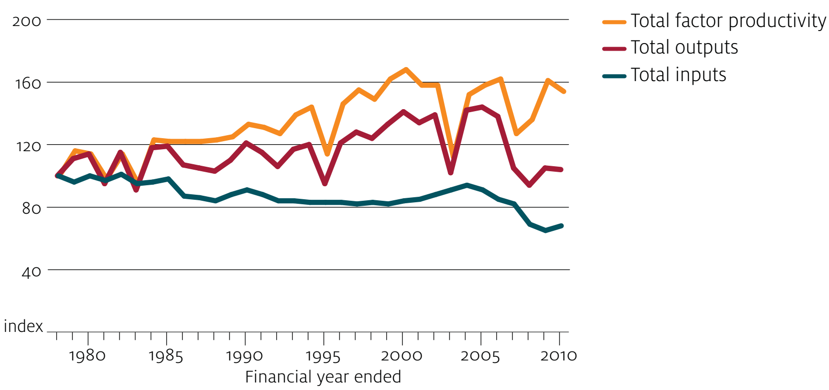
- Beef industry (ANZSIC06 Class 0142) – farms engaged mainly in running beef cattle
- Sheep industry (ANZSIC06 Class 0141) – farms engaged mainly in running sheep
- Sheep–beef industry (ANZSIC06 Class 0144) – farms engaged mainly in running both sheep and beef cattle. TFP estimates are not reported separately for these farms, although they are included within the aggregate broadacre estimates.
- Dairy industry (ANZSIC06 Class 0160) – farms engaged mainly in farming dairy cattle.

Together, the broadacre and dairy industries account for the bulk of Australian agriculture: almost 70 per cent of the number of commercial-scale farm businesses and more than 90 per cent of the total area of agricultural land. In addition, the broadacre and dairy industries accounted for nearly three-quarters (62 per cent and 9 per cent, respectively) of the gross value of agricultural production in 2009–10.

Broadacre productivity growth

From 1977–78 to 2009–10, TFP growth in broadacre agriculture averaged around 1.2 per cent a year. This is due to the combined effects of output growth (around 0.5 per cent a year) and reduced input use (around 0.8 per cent a year) (Figure 3). However, aggregate estimates mask considerable variation between individual farms. For example, recent research by ABARES indicates that, although productivity is increasing overall, the best performing farms have, on average, achieved a productivity growth rate that is around 25 per cent higher than that of average farms (Hughes et al. 2011).

FIGURE 3 Trends in broadacre total factor productivity, total inputs and total outputs 1977–78 to 2009–10



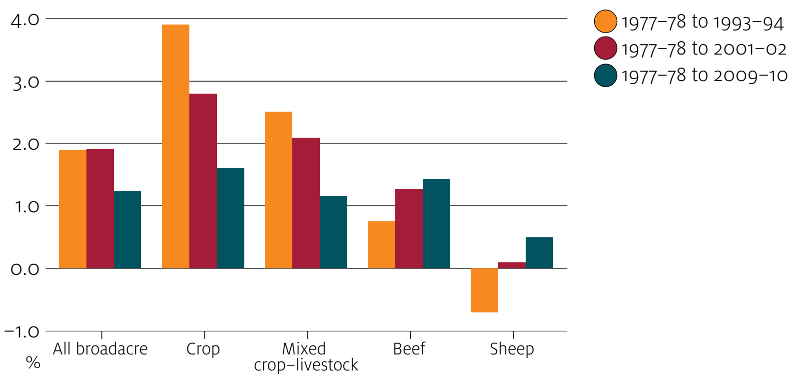
Average productivity growth in the cropping industry has exceeded that of the livestock industries (Table 1). TFP growth of cropping specialists averaged 1.6 per cent a year between 1977–78 and 2009–10, higher than beef (1.4 per cent), mixed crop–livestock (1.1 per cent) and sheep (0.5 per cent) farms. Although the precise reasons are not well understood, there may have been fewer opportunities to substitute capital for labour in the livestock industries, and the longer production cycles observed in the livestock industries may slow the rate of technological progress (Mullen 2007).

TABLE 1 Average annual broadacre productivity growth by industry, 1977–78 to 2009–10 (%)

	All broadacre	Cropping	Mixed crop–livestock	Beef	Sheep
Total factor productivity					
TFP	1.2	1.6	1.1	1.4	0.5
Inputs	–0.8	1.2	–1.7	0.1	–2.4
Outputs	0.4	2.8	–0.6	1.5	–1.9
Partial factor productivity					
Land	1.4	1.5	0.9	1.8	0.1
Labour	2.4	3.3	2.2	2.2	1.2
Capital	2.0	3.4	2.5	0.9	1.8
Materials	–1.8	–1.6	–1.5	–2.0	–1.7
Services	1.1	1.7	1.0	0.9	0.4
Input use					
Land	–1.0	1.3	–1.5	–0.3	–2.0
Labour	–2.0	–0.5	–2.8	–0.7	–3.1
Capital	–1.6	–0.6	–3.1	0.6	–3.7
Materials	2.2	4.4	0.9	3.5	–0.2
Services	–0.7	1.1	–1.6	0.6	–2.3

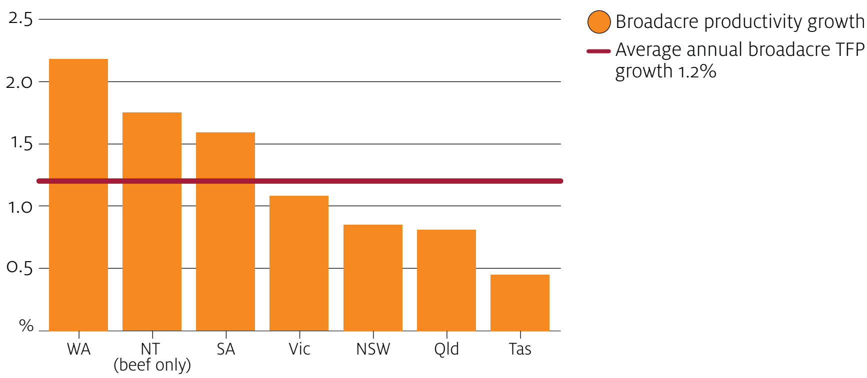
The gap between the productivity growth rates of the cropping and livestock industries is narrowing. More specifically, the rate of TFP growth of cropping specialists (and to a lesser extent, mixed crop–livestock farms) is slowing whereas the rate of TFP growth in the livestock industries has been increasing (Figure 4).

FIGURE 4 Broadacre total factor productivity growth, by industry, 1977–78 to 2009–10



Trends in broadacre productivity growth across the states and territories reflect differences in the structure of the broadacre industry in each jurisdiction, as well as differences in average farm size, natural resource endowments and climate. For example, Western Australia has achieved the highest broadacre TFP growth, reflecting the dominance of large, efficient, cropping enterprises (Figure 5).

FIGURE 5 Broadacre productivity growth, by state, 1977–78 to 2009–10



Cropping industry productivity

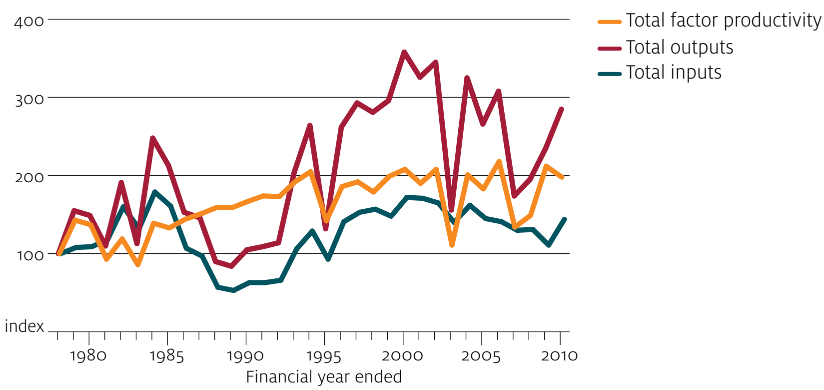
The cropping industry has grown strongly over the 33 years from 1977–78 to 2009–10 (Figure 6). Notwithstanding periods of extreme volatility, total output from specialist cropping farms has, on average, grown at around 2.8 per cent a year over this period (Table 1). Relatively strong input growth (1.2 per cent a year) and TFP growth (1.6 per cent a year) contributed to expanding production between 1977–78 and 2009–10.

The growth in aggregate input use in the cropping industry since the 1990s has largely stemmed from growth in material inputs, such as fertiliser, fuel, crop chemicals and seed (Table 1). Greater understanding of cropping systems, including plant physiology and the determinants of soil fertility, has resulted in increasing use of crop chemicals and fertilisers (especially nitrogen and soil ameliorants such as lime and gypsum).

Technical change, through growers' adoption of new technologies and management practices, has been the main driver of long-run productivity growth of cropping specialists (Hughes et al. 2011). However, the rate of technical change, and in turn productivity growth among cropping specialists, has slowed during the past decade (Figure 6). Recent ABARES research has found that poorer climate conditions post-2000 have had a significant effect on the cropping industry, reducing the output of cropping specialists by 13 per cent post-2000, relative to output for the period 1977–78 to 1999–2000 (Hughes et al. 2011).

Even after controlling for deteriorating climatic conditions, a slowdown in productivity growth remains evident among cropping specialists (Hughes et al. 2011; Sheng et al. 2011b). While diminished public R&D intensity is likely to have played a role, other factors are also likely to be involved. For example, Stephens et al. (2011) report that, in the four southern mainland states, the high-input high-yield cropping systems of the 1980s and 1990s were vulnerable to the drier and more variable climate in the 2000s.

FIGURE 6 Trends in cropping specialists total factor productivity, total inputs and total outputs 1977–78 to 2009–10



Productivity growth rates differ across the three agroecological regions defined by the Grains Research and Development Corporation (GRDC 2011). Cropping specialists in the western region have, on average, achieved the highest annual TFP growth rates (2 per cent), compared with cropping specialists in the northern (1.7 per cent) and southern (1.5 per cent) regions (Table 2). The agroecological regions reflect differences in average climate, soil fertility water holding properties, and geography which, among other factors, bear on farmers' capacities to improve their production systems. For example, the southern region is more sensitive to climate variability than the western and northern regions, such that climate conditions post-2000 explain most of the observed decline in productivity in that region in recent years (Hughes et al. 2011).

TABLE 2 Average annual cropping total factor productivity growth, by region, 1977–78 to 2009–10 (%)

	Productivity growth	Output growth	Input growth
All cropping specialists	1.6	2.8	1.2
Western region	2.0	4.3	2.3
Northern region	1.7	1.3	–0.4
Southern region	1.5	3.1	1.6

Note: All cropping specialists also include cropping specialists from outside the Grains Research and Development Corporation agroecological regions

Livestock industry productivity

Livestock industries have continued to lift their productivity, although productivity growth remains at a lower rate than the cropping industry (Table 3 and Table 4).

Several factors contributed to improvements in beef industry productivity over the past 30 years. Genetic improvement of the beef herd, and improved pasture, herd and disease management have reduced mortalities and increased branding rates (calves marked as a percentage of cows mated) (ABARE 2006).

TABLE 3 Average annual beef total factor productivity growth, by region, 1977–78 to 2009–10 (%)

	Productivity growth	Output growth	Input growth
All beef	1.4	1.5	0.1
Northern region	1.3	1.2	–0.1
Southern region	1.0	1.5	0.5

TABLE 4 Average annual sheep total factor productivity growth, by region, 1977–78 to 2009–10 (%)

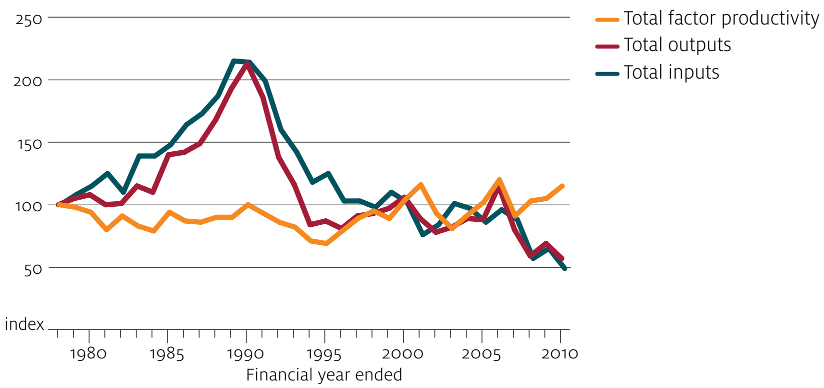
	Productivity growth	Output growth	Input growth
All sheep	0.5	–1.9	–2.4
Pastoral zone	0.5	–1.5	–2.0
Wheat–sheep zone	1.0	–0.8	–1.8
High-rainfall zone	0.4	–2.9	–3.3

Long-run TFP growth in the northern region (1.3 per cent a year) has exceeded that in the southern region (1 per cent a year) (Table 3) (See Map 1 in Thompson & Martin 2011). In the northern region, the brucellosis and tuberculosis eradication campaigns of the 1980s led to improvements in cattle management systems, including improved grazing and land management practices and better mustering techniques. In addition, expansion of the feedlot sector and the live export trade led to a shift in herd structure, to a higher proportion of Bos indicus breeds and more breeder operations, to increase turn-off of smaller and younger cattle for the live export market (Gleeson et al. 2003; Martin et al. 2007). Between 1977–78 and 2009–10, these management changes improved productivity, with increased branding rates (from 61 per cent to over 70 per cent) and reduced death rates (from around 8 per cent to around 2 per cent).

Although better pasture and herd management practices have resulted in improved productivity in the southern beef industry, the generally smaller scale of operations may have constrained productivity growth. In addition, drought greatly affected properties in the southern region in recent years.

In the sheep industry the low average annual rate of TFP growth between 1977–78 and 2009–10 (0.5 percent) obscures consolidation and subsequent gains achieved by the industry since the partial recovery following the collapse of the Wool Reserve Price Scheme in 1991 (Figure 7). Changes in the composition of the sheep flock and land management practices delivered significant productivity growth. In particular, the strong shift to prime lamb production, characterised by a higher proportion of ewes in flocks and use of non-merino rams (leading to a higher incidence of twinning) have been important developments. In addition, increased use of improved pasture species and fodder crops has improved ewe fertility and reduced lamb mortality, leading to higher lamb turn-off rates and to higher average slaughter weights (ABARE 2007).

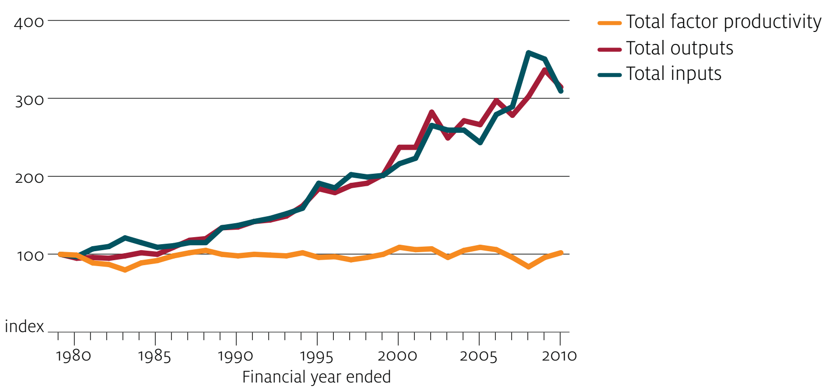
FIGURE 7 Trends in sheep specialists total factor productivity, total inputs and total outputs, 1977–78 to 2009–10



Dairy productivity growth

Between 1978–79 and 2009–10, TFP growth in the dairy industry averaged 0.3 per cent a year. In contrast to broadacre industries, growth in total input use (4.2 per cent a year) and total outputs (4.5 per cent a year) was substantially higher (Figure 8).

FIGURE 8 Trends in dairy total factor productivity, total inputs and total outputs 1978–79 to 2009–10



In recent decades, dairy farmers have responded to adjustment pressures by increasing the size and intensity of their production systems. Since 1990, milk production per farm increased by around 5.5 per cent a year, due to larger herds and higher stocking rates (ABARES 2011). Improved milking shed design and equipment, genetics, soil and feed testing, artificial insemination and mastitis control programs have also played a role (Mackinnon et al. 2010).

However, it is clear that output growth has largely been driven by growth in inputs, particularly fodder and fertiliser (Table 5). Dairy farmers have made significant changes to maintain and improve their production capacity through greater use of supplementary feeding and improved pastures and fodder crops (Harris 2005; Mackinnon et al. 2010). This has especially been the case in drier years, where low or zero water allocations have necessitated dairy farmers substituting purchased fodder for on-farm feed supplies. For example, the quantity of grains and concentrates used per cow doubled between 1991–92 and 2006–07, from 0.9 tonnes to 1.8 tonnes (Ashton & Mackinnon 2008).

TABLE 5 Growth in average annual dairy industry partial factor productivity and input use, 1978–79 to 2009–10 (%)

	PFP	Input use
Land	2.6	1.9
Labour	3.6	0.9
Capital	3.5	1.0
Materials	–4.0	8.5
Services	0.4	4.1

Potential policy responses

Governments have a strong interest in promoting productivity growth in all industry sectors because it is the dominant mechanism by which material living standards in an economy are improved in the long term. Growth in labour force participation, capital investment and improvements in the terms of trade will also contribute to growth in per person income. However, in an economy facing resource constraints, clearly evident in agriculture, productivity growth is the only way to grow aggregate income (Productivity Commission 2008).

Beyond the farm sector per se, agricultural productivity growth has implications for the performance of the economy as a whole, including:

- higher wages, capital returns and profits
- larger tax revenue
- resources that can be released for use elsewhere
- lower prices for consumers
- greater environmental benefits to the extent that farmers use resources such as land, water and chemicals more efficiently (Productivity Commission 2005, 2008).

Evidence of a slowdown in productivity growth in some agricultural industries is cause for concern, not least because productivity growth is also an important element of the solution to the challenges currently facing the agricultural sector, including climate change, declining terms of trade and increasing pressure on the natural resource base. Given limitations to the availability of land, water and other resources, the extent to which the sector responds to these challenges, as well as to the opportunities presented by rising global incomes and population growth, will depend largely on increases in productivity.

Through the Council of Australian Governments' Primary Industries Ministerial Council, governments have maintained their commitment to enhancing agricultural productivity. The Primary Industries Ministerial Council seeks to develop and promote sustainable, innovative and profitable agriculture that would not otherwise be possible because of the limitations imposed by the division of constitutional powers within the Federation of Australia.

This paper concludes by considering opportunities for governments (and industry) to promote productivity through:

- investing in R&D and extension
- building the knowledge and skills of farmers
- facilitating structural adjustment
- reducing regulatory burdens.

Investing in R&D and extension

Public investment in R&D and extension is an effective lever for governments to promote agricultural productivity growth. Many of the technologies and management practices that have driven agricultural productivity growth are the outputs of public investments in R&D, their adoption being accelerated through extension programs. Past investment in R&D and extension by Australian governments has accounted for nearly one-third of annual productivity growth in broadacre agriculture over the past 50 years or so—equivalent to average TFP growth of 0.6 per cent a year (Sheng et al. 2011a).

Notwithstanding a wide spectrum of potential opportunities, the extent to which governments should increase expenditure on R&D and extension has been subject to considerable discussion over many decades (Industries Assistance Commission 1976; Productivity Commission 2011b). Key considerations have included the nature, magnitude and distribution of benefits likely to accrue to society as a whole, and the likelihood of them being realised without government involvement. Although a satisfactory method of determining the optimal level of public R&D and extension has thus far proved elusive, improving the efficiency of the R&D and extension system remains an important goal.

In essence, an efficient system attempts to maximise the payoffs to public investments while minimising the transaction costs across multiple R&D and extension providers and jurisdictions. At an aggregate level, this also requires finding the optimal balance in allocating scarce funds between R&D that generates maximum payoffs over the longer run and extension that brings forward farmers' adoption of currently available innovations. Governments and industry stakeholders are continuing to explore avenues for improving the R&D and extension system's efficiency—a first step being to improve the quality of data necessary to measure its performance.

Building farmers' knowledge and skills

Farmer educational attainment recurs as a factor that has a positive and significant impact on productivity growth (Kokic et al. 2006; Nossal & Lim 2011; Zhao et al. 2009). As well as being directly related to productivity growth, broadly speaking, education positively contributes to farmers' innovativeness, in terms of the number of new practices or technologies implemented by farm businesses that they are likely to continue using. Nossal and Lim (2011) found that grain growers with tertiary qualifications were more likely to be high innovators compared with those with secondary school education.

To the extent these findings apply to established farmers, there may be scope for them to improve their productivity by continuing formal education and training. As agricultural systems become more complex, farmers need more advanced skills to better manage risks and to locate and apply new technologies and management practices. Given constraints on farmers' time and travel, advanced communication technologies may increase their access to more flexible learning opportunities.

Facilitating structural adjustment

Over time, structural adjustment can contribute to industry productivity growth. Exits by less efficient farm businesses releases resources for use by more efficient farms, which are able to expand and increase productivity, by realising economies of size and implementing new technologies and management practices. For example, between 1989–90 and 2009–10, milk production increased by around 50 per cent, even though the number of farms halved.

Although structural adjustment has long been a typical feature of agricultural industries, its pace may vary in response to policy settings. While rising productivity served to counter the persistent downward pressures on farm incomes, governments have, over many decades, provided assistance to mitigate these pressures. However, much of this has not been of great help to the low income marginal farmer, but has tended to inhibit desirable productivity growth within agriculture (Musgrave 1977; Productivity Commission 2009).

Some policy settings can impede structural adjustment insofar as they diminish incentives to pursue efficiency gains, improve risk management or exit farming. Assistance provided to farm businesses during drought can lead to less efficient farmers delaying decisions to leave farming, by creating an expectation that governments will financially support their businesses during drought. Farm support can also constrain more efficient farmers' wanting to expand their scale of operations if it becomes capitalised into, and thus raises, land values.

Reducing regulatory burdens

Governments use a range of regulatory arrangements to achieve various efficiency or equity objectives on behalf of the broader community. Although some regulations benefit farmers, other regulations, which are unnecessarily burdensome, complex or redundant, can constrain productivity growth and impose heavy costs on farm businesses. This might occur where regulations:

- limit opportunities for farmers to employ innovative or lower cost approaches to meet the intended outcomes of the regulation
- discourage innovation if compliance burdens associated with some regulations create a disincentive for farmers to implement innovations
- reduce the value of farmers' property rights or constrain land-use options (Productivity Commission 2007, 2011a).

Where an existing regulatory approach is appropriate, more flexible settings can, in some cases, enable farmers to improve productivity and to meet broader community objectives in ways that minimise costs to society as a whole. This is especially relevant where society expects farmers to perform dual roles; as providers of food and fibre, as well as ecosystem services. For example, more flexible approaches to managing native vegetation on farmland may provide a given level of ecosystem services at lower cost (Davidson et al. 2006).

In 2007, the Productivity Commission reviewed regulatory burdens on businesses in the primary industries, finding that governments impose a heavy burden of regulation on farm businesses (Productivity Commission 2007). While the review identified a range of reforms that would reduce regulatory burdens on farm businesses, the extent to which these gains have been realised is not clear. Consequently, the need to review regulations affecting farm businesses, to ensure previously identified reforms have occurred and to determine whether there may be better, less costly approaches to achieve policy objectives is ongoing.

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