Harvesting productivity:
ABARE-GRDC workshops on grains productivity growth

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Foreword

The Australian grains industry has faced considerable pressure over the years with variable seasonal conditions and fluctuating prices. ABARE research also shows that productivity growth in the grains industry appears to have slowed over the past decade. While drought has been a major reason for this downturn, it is not the only factor.

In response to the situation faced by the industry, the Grains Research and Development Corporation (GRDC) has commissioned ABARE to undertake a major research initiative: 'Harvesting Productivity'. The objective of the initiative is to better understand the drivers of productivity in the grains industry and how research and development can contribute to productivity growth.

As part of this broader initiative, ABARE conducted a series of workshops with grain growers and their consultants. The main objective of the workshops was to gather information on the use of specific on-farm technologies and management practices which may contribute to changes in productivity. Regional workshops were held in July 2009 with groups of grain growers and, separately, with groups of agricultural consultants in Toowoomba, Dubbo, Perth, Adelaide, Horsham and Melbourne.

In addition, a technical workshop was held in Canberra in August 2009 with a group of experts in the field of productivity analysis. Participants were drawn from academia and government research organisations. The purpose of the technical workshop was to discuss some of the findings from the regional workshops and to examine ABARE's methodology for calculating productivity estimates.

The outcomes from these workshops will provide valuable input into the interpretation of technical analysis being undertaken by ABARE to better understand the drivers of productivity and help guide future research and development.

Phillip Glyde
Executive Director
May 2010

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Summary

The objective of this report is to present the findings from a series of workshops on productivity in the grains industry. The workshops, held with groups of grain growers and agricultural consultants in July 2009, were structured to answer the following questions:

1. What were the reasons for strong productivity growth in the grains industry in the 1980s and 1990s?
2. What are the reasons for the apparent slowdown in productivity growth in the grains industry in the 2000s?
3. What should the Grains Research and Development Corporation (GRDC) focus on to increase productivity growth in the grains industry?

The most important drivers of productivity growth in the grains industry that were identified by workshop participants were: better understanding of cropping systems, increased use of new technology, expansion of grain farming areas, increased farm size and better plant varieties.

The main causes of the slowdown included: drought, the slower spread of new technology, a decline in the increment of technological progress, the effect of knowledge constraints, the loss of a profitable break crop, the expansion of cropping into less productive areas and a shift in research priorities away from productivity-related factors.

Participants suggested areas that should be targeted in the future to address the causes of the slowdown include better extension efforts to facilitate increases in human capital, the development of better varieties and improving farmers' abilities to manage risk.

This work builds on the outcomes of similar workshops conducted by ABARE for GRDC in 1999-2000. While many of the determinants of productivity raised in the previous workshops were also raised in 2009, the more recent workshops also incorporate changes which have occurred in the past decade, such as the increased importance of water use efficiency.

Workshops were held in a number of distinct production zones across Australia. While similar determinants of productivity were generally identified at each of the workshops, there were often differences in the relative importance of these determinants between regions. Although these differences are difficult to quantify given the relatively small number of people at each workshop, they are relevant when considering how to increase productivity growth in the grains industry.

1 Introduction

This report and the associated workshops are part of the broader Harvesting Productivity initiative being conducted by ABARE for the Grains Research and Development Corporation (GRDC). The objective of this initiative is to better understand the drivers of productivity in the grains industry and how research and development can contribute to productivity growth.

The impetus for this initiative is that productivity growth in the grains industry appears to have slowed over the past decade. Drought has been a major reason for this downturn, although other factors have also contributed.

The main objective of the workshops was to gather information on the use of specific on-farm technologies and management practices which may contribute to changes in productivity. Workshops were held in July 2009 with groups of grain growers and groups of agricultural consultants in Toowoomba, Dubbo, Perth, Adelaide, Horsham and Melbourne.

In addition, a technical workshop was held in Canberra in August 2009 with a group of experts in the field of productivity analysis. Participants were drawn from academia and government research organisations. The purpose of this workshop was to discuss some of the findings from the earlier workshops and to examine ABARE's methodology for calculating productivity estimates.

The outcomes from the technical workshop have been incorporated into ABARE's work program for 2009-10 and 2010-11. Specific issues raised by the experts have been described in a technical paper which will be released by ABARE in 2010.

Understanding how the factors identified in this report contribute to productivity growth requires some understanding of the economic theory and measurement of productivity. The following section provides a brief summary of the concept and measurement of productivity. Further details may be found in the forthcoming ABARE report *Factors driving total factor productivity* (ABARE forthcoming).

Section 2 of this report contains an explanation of the concept of productivity. This is followed by a description of the workshops in section 3. In section 4, the main drivers of productivity growth in the grains industry are summarised, and in section 5, factors considered to be responsible for the productivity slowdown are discussed. Finally, potential solutions to the slowdown are given in section 6 and conclusions are presented in section 7.

2 What is productivity?

Productivity is a measure of how effectively business operators combine inputs to produce outputs. As such, it is commonly measured as a ratio between outputs and inputs. Productivity growth results from an increase in the quantity of outputs produced from a given quantity of inputs or from producing at least the same quantity of outputs using a smaller quantity of inputs. Growth in productivity occurs as a result of improvements in technology, knowledge capacity and management skills.

In practice, there are a range of other factors that also influence productivity in agricultural industries. These factors include seasonal conditions, size of operations, human capital and changes to industry structure.

There are many ways to calculate productivity estimates and ABARE uses total factor productivity (TFP), which is the ratio of total outputs to total inputs. Another commonly used measure is yield, which is the ratio of output to the area of land used in production. The key difference between yield and TFP is that yield only includes one of the inputs used in production, while TFP takes into account all inputs.

An example helps to make this distinction clear. Holding the area of land used in production constant, an increase in output will always result in an increase in calculated yield. Still holding the area of land used in production constant, an increase in output will only cause total factor productivity to increase if the measured quantity of all other inputs used in production increases by a smaller amount.

TFP growth is thought to provide a better representation of technological progress and improvements in overall efficiency than other measures of productivity such as yield because variation in yields may simply be the result of changing the quantities of other inputs used in production. Despite this difference, the two measures are closely related because one of the strongest determinants of yield and TFP are seasonal conditions.

The treatment of seasonal conditions is an important aspect of the methodology used for calculating productivity estimates. Like other statistical agencies, ABARE does not include water as an input when calculating TFP estimates for non-irrigated farms. Because of this, one of the reasons drought causes productivity to fall is that it reduces the measured quantity of outputs by more than it reduces the measured quantity of inputs.

The main reason for not including water as an input when calculating productivity estimates is that water is not a market input for broadacre farms. That is, unlike other inputs to production, farmers do not choose how much water is available in a particular season—it is largely beyond their control. Because productivity is concerned with how effectively producers combine chosen quantities of inputs to produce outputs, rainfall should not necessarily be included as an input in the same way as other inputs such as fertiliser or seed.

However, farming practices do exist that alter the availability of water to crops for a given quantity of rainfall received. As such, farmers do to some extent have the ability to 'influence' how much water is available and the efficiency of utilisation of available water. Improving water use efficiency represents a potentially large source of productivity gains. Accordingly, there is an argument for taking water availability into account when calculating productivity estimates. ABARE is currently investigating this possibility.

There is also a practical difficulty associated with including water as an input to production. It is difficult to obtain a measure of plant available water during the growing season for every farm in the ABARE survey. Variation in soils and the timing of rainfall events across farms complicate the data requirements. Recent advances in weather information systems have increased the availability of data required to appropriately measure water availability.

It is important to note that, if achieved, this change will alter the interpretation of productivity estimates. Rather than representing the productivity of farm businesses to the extent that water availability is beyond the control of farmers, water-adjusted productivity estimates will reflect the productivity of the farm and whatever determines the amount of available water.

Total factor productivity growth in the Australian grains industry has averaged 1.9 per cent a year from 1977-78 to 2007-08, which is a faster rate than that of other broadacre agricultural industries and many other non-farm industries. However, productivity growth in the grains industry appears to have slowed. Over the past decade, annual TFP growth among cropping and mixed-crop livestock industries has averaged -2.9 per cent and -2.0 per cent a year, respectively. This compares with average annual growth exceeding 3 per cent a year for much of the 1980s and 1990s.

Productivity is important because it is one of the key factors that determine profitability. Another key factor is the terms of trade, which is the ratio of prices received to prices paid. Given that prices of inputs and outputs are largely determined on global markets, in the long term, productivity is one of the most important determinants of profitability which can be influenced by producers.

Producers seeking to maximise profits respond to changes in the production environment in a variety of ways, including by altering the mix of inputs used and outputs produced, using different technology or by changing the size of operations. While not necessarily a direct objective of farmers, all these changes may alter productivity.

An example of this relationship is the shift away from sheep to cropping in many regions of Australia over the past 30 years. This is recognised as one determinant of the strong productivity gains in the agriculture sector during the 1990s.

Productivity is also important because it is a major determinant of competitiveness, both of individual producers within industries and of Australian industries relative to those of competitor countries. This is not limited to agricultural industries—differences in productivity are a key determinant of trade patterns in all industries.

By increasing the quantity of outputs produced from a given quantity of inputs, productivity growth also represents at least part of the solution to a number of challenges currently facing Australia's agricultural industries. These challenges include the ongoing decline in the terms of trade, international competition and increased pressure on resources such as land, water and fertilisers.

Estimates of productivity growth are useful to illustrate trends and can be used in conjunction with other methods to identify the factors that might be causing these trends. However, estimates of productivity growth should be used carefully when considering prescriptions for increasing productivity.

Achieving maximum productivity growth on a particular farm depends on a large number of characteristics, some of which will be specific to the region, the operator, or the farm itself. This means there is no single way to maximise productivity for all farms.

Productivity statistics in isolation cannot demonstrate how a particular variable influences productivity growth. Further research is required to understand these relationships. It is important for producers, governments and research organisations to understand these relationships so efforts to increase productivity growth are appropriately designed and targeted.

3 The workshops

The workshops were designed to identify factors important for productivity growth in the grains industry. Workshops were held in July 2009 with groups of grain growers and agricultural consultants in Toowoomba, Dubbo, Perth, Adelaide, Horsham and Melbourne. Participants were selected based on their use of new technology and capacity to contribute to the project.

An objective of the project was to consider productivity from a range of perspectives. Accordingly, workshops were held in a cross section of production zones and grower workshops were held separately to those with consultants. Some of the differences uncovered by this approach are presented in appendix 1.

The information presented in this report reflects the views of the participants. This information is largely anecdotal and does not necessarily represent the views of all grain growers. For this reason, the information presented here aims to guide further research into the drivers of productivity growth, rather than to design specific prescriptions for increasing productivity growth.

At each workshop, participants were presented with a description of productivity and the results from some of ABARE's work in this area. This was followed by a discussion based on three questions:

- What were the drivers of productivity growth in the past?
- What has caused the slowdown of productivity growth?
- What can be done to increase productivity growth?

Most of the issues raised in response to these questions were also raised in similar workshops conducted by ABARE for GRDC in 2000. This suggests the fundamental drivers of productivity growth in the grains industry change slowly.

Furthermore, although the workshops were held in a variety of different production environments, the factors considered to be important for productivity growth were fairly common across the country. While the relative importance of various factors varied from place to place, broadly similar issues were raised at all the workshops.

Finally, the factors which are important for productivity growth are inter-related. For example, new machines helped to facilitate the development of more efficient farming systems, but so did advances in plant varieties, chemicals and operator skills. Because these factors are related, measuring their individual contribution to productivity growth is difficult.

4 Drivers of past productivity growth

At the workshops, participants identified a wide range of factors that influence productivity growth. In this section, the factors considered to be the most important are presented. Overall, the clear message from the workshops was that the development and utilisation of more efficient farming systems was the most important driver of productivity growth.

4.1 Knowledge about cropping systems improved

Increased understanding of cropping systems was the most frequently advanced reason for strong productivity growth in the 1980s and 1990s. This directly contributed to productivity growth by allowing farmers to make better decisions and, hence, use inputs more effectively to produce outputs.

Participants suggested that better knowledge of plant physiology and disease development allowed them to make more effective use of crop rotations, make better crop selections and use more sophisticated crop management practices.

It was also reasoned that increased knowledge of the determinants of the health and fertility of soils had facilitated the intensification of cropping systems, including increases in fertiliser and ameliorant use and changes to cropping practices. The combined effect of these changes was to increase nutrient levels and water holding capacity of soils, allowing crop production to increase.

The ABARE farm survey results support the argument that the intensity of cropping systems has increased. Specifically, the data show there has been a significant increase in the use of materials and services in the past 30 years. Materials and services refers to a category of inputs in the farm survey which contains nearly all the variable inputs to crop production, such as seed, fertiliser, chemicals and contracting services.

Much of the increase in materials and services during the 1980s and 1990s reflected greater use of fertilisers, particularly nitrogen, and soil ameliorants such as lime and gypsum. Improvements to chemical treatments for crop pests and diseases also contributed to the increased use of these inputs.

Workshop participants associated increased intensity of cropping systems with increased risk. They established that this was mainly because increasing the quantity of inputs used raises the upfront costs of cropping, but does not significantly reduce the chance of crop failure. There was a general belief that this increase in risk had previously been sufficiently offset by increased profitability, but that this had not been the case during the past decade.

Understanding of farming systems has increased through a wide range of research programs. The role of state departments of agriculture, research and development organisations and universities in conducting much of this research was acknowledged by many participants.

Workshop participants also suggested that the changing focus of these agencies toward non-production aspects of farming systems, such as natural resource management or conservation represented a threat to future productivity growth. This is discussed further in section 5.

4.2 The use of new technology increased

Technological progress is a fundamental driver of productivity growth. New machines, plant varieties and cropping systems are all examples of this progress in agricultural industries. At the farm level, new technologies increase productivity because they allow producers to combine inputs more efficiently and hence to produce more outputs from a given quantity of inputs.

At the industry level, the rate of productivity growth depends on the rate at which new technology is adopted by individual producers, as well as the size of the productivity gains made at the farm level from using that technology.

Workshop participants identified a range of new technologies which had contributed to productivity growth during the 1980s and 1990s. These included:

- greater disease resistance of crop varieties
- more efficient chemicals and fertilisers
- larger, more sophisticated machinery.

In isolation, each of these advances in technology contributed to productivity growth. Collectively, they also contributed to productivity growth by facilitating the development and use of new farming systems such as conservation farming.

Workshop participants suggested that the spread of knowledge about new systems and technologies throughout the grains industry accelerated in the 1980s and 1990s. This contributed to industry-level productivity growth by improving the farming systems used by many grain growers.

Overall, workshop participants agreed that significant productivity gains could still be made from more widespread use of existing farming systems. This was particularly the case for conservation farming systems and precision agriculture, where there was significant scope for increased understanding of these systems and the productivity gains they can generate.

4.3 The area used for crop production expanded

Workshop participants identified the expansion of grain farming areas over the past 20 years onto land previously used for grazing as a source of productivity growth. This expansion was considered to be another aspect of the intensification of farming systems discussed in section 4.1.

ABARE data show productivity growth for cropping specialists has been higher than for livestock specialists and mixed crop-livestock producers for most of the past 30 years. Possible reasons for this include the greater extent of mechanisation in cropping, potentially faster advances in crop genetics than in animal genetics and a greater scope to make changes to the technology used in crop production.

Because the productivity growth of cropping enterprises is greater than that of livestock enterprises, increasing the proportion of a farm used for cropping can be expected to increase farm-level productivity growth, as long as the higher productivity growth of the cropping enterprise is maintained on the new area being cropped.

Participants argued that increasing the area cropped generated productivity gains because it allowed them to take advantage of economies of scale and to utilise soil nutrients accumulated while the land was used for grazing. It was also argued that reducing livestock numbers increased the productivity of cropping enterprises by allowing producers to concentrate more resources on this enterprise.

Some participants argued that cropping and livestock operations were complementary, in the sense that crop outputs can be used as inputs to livestock operations. It was also argued that combining a livestock and cropping enterprise reduced farm-level risk through diversification.

However, these arguments were not supported by all participants. Others argued that because crop outputs were not valued at market prices, operating both enterprises usually resulted in the subsidisation of livestock enterprises, to the detriment of farm-level productivity and profitability. Users of conservation farming systems argued that damage to soils caused by livestock outweighed any diversification benefits.

Many participants noted that some areas of their properties were not particularly suitable for cropping and, accordingly, expansion of grain farming onto these areas was considered unlikely to generate farm-level productivity growth. It was widely agreed there is an optimal proportion of land to crop in order to maximise productivity growth.

4.4 Farms became larger

It is well established that larger farms tend to have higher productivity growth. Given the extent of farm consolidation in the past 20 years, it is likely that exploitation of this relationship has accounted for a significant proportion of productivity growth in the grains industry.

Workshop participants suggested one reason for this phenomenon is that, as farms consolidate, the better producers in a region tended to be the purchasers of the smaller farms and so larger farms tended to be run by the most efficient operators.

Another explanation is the theory of increasing returns to scale, where the cost of each unit of output falls as the quantity of output produced rises. It usually occurs when there are fixed costs which are spread more thinly over each unit of output as production increases. For agriculture it appears to be a reasonable concept—as farms consolidate there will be savings on fixed costs such as machinery and labour.

Recent analysis by ABARE has found an additional explanation—that larger farms in general use superior technology, which allows them to use different, more efficient combinations of inputs than smaller farms.

Possible reasons for this may be that new technologies are better suited to larger scale farming and that larger farms have more scope to make changes to the input mix. Larger farms may also have a greater capacity to invest in new technology and practices because of their generally larger cashflow and greater ability to borrow.

This explanation was supported by some workshop participants who identified that larger farms produced larger cash surpluses, which facilitated productivity growth when reinvested in the farm. However, other participants disagreed and argued that there was little correlation between farm size and utilisation of new farming systems or technology.

The relative importance of each of these explanations has implications for the potential sources of future productivity growth and hence the strategies which should be pursued to facilitate this growth. For example, rather than pursuing the 'get big' strategy, greater productivity growth may actually be achieved by increased use of superior technology by smaller farms. As an example, this may be through greater use of contractors in cropping programs.

4.5 Plant varieties improved

Workshop participants argued that better varieties had contributed to productivity growth by improving yields and facilitating the increased intensity of cropping systems. Greater disease resistance was identified as particularly important in this regard. The availability of early and late-sown varieties was also cited, as it allowed crops to be grown in areas previously unsuitable for cropping.

While workshop participants generally acknowledged the contribution of breeding programs to productivity growth, it was expressed that more work is required in this area. In particular, it was suggested at several workshops that future breeding efforts should be focused on overcoming current constraints on crop production such as water and nutrient availability and frost.

4.6 The use of conservation farming systems spread

The subject of conservation farming was raised at all workshops, and tended to polarise participants. Some indicated the adoption of these practices had generated significant productivity gains on their properties, while others explained that they had seen few benefits. These differences were often related to the length of time and the extent to which these practices had been adopted.

The term conservation farming refers to a range of cropping practices, including direct drill, minimum tillage, no-till and zero-till. Table 1 contains a summary of these practices and the differences in terminology between states.

For example, sowing crops with discs without disturbing the inter-row space is called zero-till in Western Australia and direct drill in other states. Similarly, the use of two cultivations prior to sowing is termed conventional farming in Western Australia, minimum tillage in New South Wales, Victoria and South Australia, and reduced tillage in Queensland.

1 Terminology used for conservation farming

<table>
<tr><th>sowing practice</th><th colspan="5">terminology by region</th></tr>
<tr><td>No prior cultivation</td><td>WA</td><td>NSW</td><td>Vic</td><td>SA</td><td>Qld</td></tr>
<tr><td>No inter-row disturbance</td><td>Zero-till (disc seeding)
No-till (knife points)</td><td colspan="3">Direct drill (narrow points) but increasingly termed no-till with worldwide adoption</td><td>Zero-till, direct drill</td></tr>
<tr><td>Full inter-row disturbance</td><td>Direct drill</td><td colspan="3">Direct drill (full disturbance)</td><td>Zero-till (wide points)</td></tr>
<tr><td>Prior cultivations</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>1</td><td>Conventional</td><td colspan="3">Minimum tillage</td><td>Minimum tillage</td></tr>
<tr><td>2</td><td>Conventional</td><td colspan="2">Minimum tillage</td><td colspan="2">Reduced tillage</td></tr>
<tr><td>3</td><td></td><td colspan="2">Reduced tillage</td><td colspan="2">Conventional</td></tr>
<tr><td>4+</td><td colspan="5">Conventional</td></tr>
</table>

Source: GRDC 1998.

The most significant characteristic of these practices is that they do not utilise cultivation to the same extent as conventional farming. These systems contribute to productivity growth by increasing soil quality and by reducing the amount of labour, fuel and capital used as inputs.

Conservation farming can improve soil quality by improving structure and increasing soil carbon, which results in increased water holding capacity, better soil structure and greater accessibility of soil nutrients (Lewis, Malcolm and Steed 2006).

Participants claimed the greatest benefit of these systems for cropping was greater water use efficiency, although improved timeliness of cropping operations such as sowing and spraying was also considered to be important.

In some instances it was suggested that the adoption of these systems may actually cause measured productivity to fall in the short run because these systems require an upfront investment in new machinery and knowledge, while the benefits take some time to become apparent. While this may be true, the available evidence suggests the adoption of these practices can contribute to productivity growth in the long run.

Various forms of conservation farming have existed in Australia since at least the 1980s, and uptake has gradually increased over the past 30 years. Workshop participants indicated that these systems did not become widespread until the late 1990s so they were unlikely to have contributed greatly to industry-level productivity growth prior to that.

It was also suggested that the uptake of these systems has increased dramatically in the past decade, primarily because they are considered to generate increases in water use efficiency. There was a commonly expressed view among participants that there will be a significant boost to productivity growth when seasonal conditions improve and the full benefits of these systems are realised.

The uptake of these practices has not been uniform across the country. Some states and regions have high rates of adoption, while conventional farming systems are still common in others. Many workshop participants linked the rate of uptake of these systems to prevailing climatic conditions, suggesting adoption was more likely in regions with lower rainfall where there is greater pressure on growers to improve water use efficiency.

Other participants argued the uptake of these systems was more likely to occur in highly profitable farming regions because producers in these areas have a greater ability to invest in new machinery. There is some support for this argument in the literature:

Farmers in precarious business situations either may not have the cash available in the short-term to purchase new technology, or a change may be perceived as imposing on the business extra production risk. Conversely, a business in a stronger economic position may be able to afford the perceived production risk in the short term, with the aim of achieving medium to long-term benefits, including business growth. (Lewis, Malcolm and Steed 2006, p 336)

On balance, this argument tended to be a minority view, with few participants suggesting that funding investment in new equipment had been a constraint in recent years. The collection of data which measures the availability of finance is a potential area for future work.

There was also wide variation in the extent to which conservation farming practices had been adopted by participants. This was particularly the case for sophisticated versions of these practices, such as precision agriculture, with some people arguing these technologies had generated large productivity gains and others arguing they were of little use to their operations.

Many of the concerns associated with precision agriculture related to a perceived gap between what could be measured and what could be managed with existing knowledge and technology. This is discussed further in section 5.4.

4.7 Water use efficiency increased

Workshop participants indicated that increased water use efficiency had been a major driver of productivity growth, particularly during the most recent drought. Increases in water use efficiency arise from better understanding of the interactions between soil characteristics and cropping systems. Measuring crop yields based on growing-season water availability is one example of the increased focus on water use efficiency.

The use of controlled traffic technology, which is an element of precision agriculture, was also identified as an important strategy for increasing the water holding capacity of soils. More generally, it was discussed that the main reasons for adopting conservation farming practices were increasing the water holding capacity of soils and improving the ability of plants to extract water from soils.

Many workshop participants suggested the development of crop varieties better suited to dry conditions should be a central focus of future crop breeding efforts. In particular, it was considered essential to develop varieties capable of responding to changes in water availability within a single growing season.

Understanding the relationships between plant density and yield under different rainfall scenarios was also identified as an aspect of water use efficiency which warranted further research. More generally, understanding the connections between specific management practices and crop production would be useful.

The availability of water is a major determinant of agricultural productivity. However, as discussed in section 2, there are theoretical and practical difficulties associated with incorporating a measure of water availability into productivity estimates. ABARE is currently investigating this possibility.

4.8 Growth in human capital

Many of the drivers of productivity growth have been facilitated by increases in human capital. This refers to the skills, knowledge and experience of farmers and others involved with decision-making on farms.

Increases in human capital theoretically contribute to productivity growth by facilitating the uptake of new technology and by improving management decisions and the quality of work performed by farmers. Workshop participants supported this argument, suggesting that a large part of productivity performance was explained by farmers being good at what they do.

Workshop participants argued the skills required of farmers had increased significantly in the past 20 to 30 years because farming systems had become more complex and intensive. For example, farmers currently need skills to manage 100 per cent cropping systems, operate sophisticated machinery and control pests and diseases in a more technically-demanding environment. They are also required to manage increasingly complex financial structures and marketing arrangements.

Many participants indicated they had increased the human capital available to their operations in a variety of ways, including employing consultants and other service providers, attending field days and formal training, and through interactions with other farmers.

In particular, while it is important to remember the workshops are not necessarily representative of the broader grains industry, the increasing use of agricultural consultants such as agronomists and farm management consultants was emphasised at all workshops. Participants identified that these consultants contribute to human capital by providing management advice to help farmers make better decisions about inputs and outputs, and by providing technical advice to help overcome specific problems.

Workshop participants also suggested that consultants facilitate the uptake of new technology or farming practices by providing complex technical support and data analysis. The use of these services was considered to reduce the risk of, and maximise the benefits from, adopting innovations.

Because of the increased complexity of farming systems, many participants suggested it was more efficient to outsource the collection and analysis of information about new systems to consultants. The ability of consultants to quickly assess the quality of published information was another reason cited for outsourcing this activity.

5 Causes of the slowdown

Productivity growth in the grains industry appears to have slowed in the past decade. From 1977-78 to 2001-02, productivity growth in the industry averaged 3.2 per cent a year, while from 1977-78 to 2007-08 the average was 1.9 per cent a year (ABARE 2009a). Long-term averages are used to describe the slowdown because of the volatility in productivity estimates from year to year caused by variation in seasonal conditions.

Similar to the drivers of productivity, the causes of the slowdown are inter-related and so it is not possible to attribute specific proportions of the slowdown to particular causes. Furthermore, the effect of drought has been significant, which has made the effects of other factors more difficult to observe. This section contains a discussion of the causes of the slowdown that were most commonly suggested by workshop participants.

5.1 The drought

Workshop participants were clear that drought was the most significant cause of slower productivity growth in the past decade. This is because productivity is the ratio of outputs to inputs, and in agricultural industries rainfall is a major determinant of output. ABARE data support this argument, as they show TFP declines significantly in years with particularly low rainfall (Nossal et al. 2009).

Furthermore, participants argued that drought had indirectly contributed to slower long-term productivity growth by lowering farm profits and hence reducing investment in new technology. Not all participants agreed with this, with others arguing that while the use of innovations involved upfront costs, they generated sufficient returns to justify the investment.

Participants also suggested that drought had contributed to lower productivity growth by reducing the confidence of farmers to the point where many were making sub-optimal decisions. Examples of this included the use of fallows in rotations rather than pasture or break crops, and stubble burning.

Conversely, it was also expressed that the drought had contributed to better understanding of the importance of water use efficiency, and to the adoption of farming systems designed to maximise water use efficiency. It was also suggested that drought had forced farmers to make decisions about input use to minimise risk. These changes were considered to have acted as a buffer against an even greater slowdown in productivity growth caused by the drought.

5.2 The spread of new technology has slowed

Workshop participants suggested another reason for lower productivity growth in the 2000s was slower uptake of new technology and farming systems. It was argued that, in contrast to the preceding decade, by the early 2000s most grain growers who were likely to adopt new technology had already done so and hence the growth in industry-level productivity caused by the spread of this technology declined. The exception appears to be conservation cropping systems which, according to participants, were not widely adopted until the late 1990s and early 2000s. There could therefore be a lag between the adoption of these cropping systems and productivity benefits, or alternatively, the benefits of conservation cropping have been offset by other factors and so productivity has not improved.

Understanding the effect of changes in the rate of adoption of new technology on industry-level productivity estimates requires some consideration of the distribution of farms by output quantity. This is because industry-level productivity estimates are the ratio of outputs to inputs for the whole industry, so this ratio is disproportionately influenced by the largest farms.

This consideration is particularly important in the grains industry, where it is estimated that in 2008-09 the largest 20 per cent of growers produced 86 per cent of total output. In fact, given this distribution many workshop participants indicated that, to maximise benefits, research and development efforts should be primarily focused on the largest growers. If this approach is followed, the challenge for research organisations will be to understand the characteristics of the largest growers, and how best to facilitate productivity growth in this group.

Workshop participants suggested the role of human nature in determining the spread of new technology was strong. It was indicated that there is a proportion of grain growers who are unlikely to ever adopt new technology to increase productivity, because they are not interested in doing so. For these growers, the primary purpose of farming is not necessarily maximising profit—instead lifestyle or other goals may be more important. The continued appreciation of agricultural land values in recent years was considered to be an important determinant of the sustainability of this situation.

When maximising profit is not a primary objective, growers are less likely to invest time and money in purchasing new equipment or learning new skills to increase productivity. Workshop participants indicated that growers in this category were often older, had little debt and, on average, were at least breaking even using existing production methods. Farmers nearing retirement age without a family member to pass the farm on to were also considered likely to be in this category.

5.3 The increment of technological progress has declined

Workshop participants indicated that another reason for the productivity slowdown was that advances in farming systems and technology in recent years have become smaller than in the past. For example, it was explained that the productivity gains generated from shifting from conventional to conservation cropping in 1999 were much greater than the increase generated from adopting yield mapping technology in 2009.

More generally, there was a perception among growers that, during the 1980s and 1990s, gains in varieties, chemicals and machinery delivered significant productivity growth. However, during the 2000s, changes in technology were perceived to have been smaller and related to fine-tuning existing systems rather than making fundamental changes.

This view was supported in the workshops with consultants. For example, they suggested productivity gains made in the past from advice about increasing the use of fertiliser and lime or switching from conventional to conservation farming were much greater than the gains being made now. This is because soil nutrients are no longer a limiting factor, and advice is more often about trading off the costs and benefits of changing various inputs.

A smaller increment of technological progress will reduce productivity growth for the most innovative producers, and hence contribute to slower industry-level productivity growth. This is different to the effect of changes in the rate at which new technology is adopted, discussed in section 5.2. Both are important for industry-level productivity growth and, given the highly skewed distribution of the grains industry, understanding the extent to which the largest growers have adopted existing technology would be useful.

5.4 Knowledge constraints have become binding

Participants identified that a number of knowledge constraints have become limiting factors in recent years. It was often suggested that, to an extent, productivity gains in the past had been made relatively easily by addressing well-understood limitations such as nutrient deficiencies, and that current constraints were much more difficult to solve.

Specifically, participants indicated there is currently insufficient knowledge to solve some of the problems which can be identified with sophisticated data collection methods such as yield mapping. At several workshops it was argued that 'we can measure much more than we can manage'.

Identified knowledge gaps include understanding of soil structure and biology, the interactions between fertiliser, soils and crops and other causes of intra-paddock yield variation.

Participants also suggested that relatively basic agronomic tests, such as those for nitrogen and phosphorus levels in soils, were often unreliable. In the past, inaccuracies in these tests were not as important because these nutrients were extremely depleted in many cases and so any increase in fertiliser was likely to result in yield increases. Now that nutrients are not the limiting factor for crop production in many cases, it is claimed that flaws in these tests are preventing producers from optimising these nutrients.

Another major knowledge constraint identified by workshop participants was the lack of reliable weather forecasts. Increasing the accuracy of four-day forecasts would help to increase productivity by improving the timeliness of processes such as sowing, fertilising and spraying. Participants also suggested that reliable forecasts of the growing season would help them to determine inputs based on the expected limitations of the season, also increasing productivity. This argument is discussed further in section 6.3.

5.5 The expansion of grain farming areas has a downside

As discussed in section 4.3 of this report, workshop participants identified that the expansion of grain farming areas in the 1980s and 1990s had contributed to productivity growth. However, it was also indicated that in more recent years the use of these new areas of land for cropping had contributed to the productivity slowdown.

Using relatively low-quality land for cropping will not necessarily reduce productivity, but making inappropriate decisions about how to use it will. For example, if seed and fertiliser are applied at a blanket rate across entire properties without considering differences in the productive capacity of land, farm-level productivity will suffer.

This argument was supported by workshop participants, who suggested that while these 'new' areas of land were suitable for cropping during the relatively wet decade of the 1990s, in the drier conditions of the 2000s, output from this land was low, and it had taken some time to adjust inputs downward to match the productive capacity of this land.

Participants also suggested that the productivity of ex-grazing land had initially been high because there was a bank of soil nutrients left over from livestock enterprises. Once this bank was depleted, fertiliser requirements increased, reducing the measured productivity of this land.

It was also suggested that the increased focus on cropping at the expense of livestock enterprises had contributed to slower farm-level productivity growth in recent years, because crop yields have been particularly low while livestock output has not fallen by as much.

There was some disagreement on this subject, with other participants arguing that maintaining livestock enterprises contributed little to farm productivity. In particular, users of conservation farming systems argued that the damage livestock cause to soils outweighs any diversification benefits they may provide.

5.6 Break crops have become less profitable

In several regions, participants suggested there was no longer a profitable break crop to include in rotations. They claimed this was because these crops are riskier to grow than cereals in dry years, and this risk was not currently compensated for with higher prices or agronomic benefits for subsequent rotations.

Because total factor productivity is the ratio of total outputs to total inputs, this change will not necessarily reduce productivity. If the quantity of inputs used to grow break crops is greater than the quantity of output produced, then productivity would fall if these crops were included in rotations.

However, this calculation needs to include the benefits of break crops for future rotations, which include nitrogen fixation and greater control over pests and diseases. Workshop participants indicated these benefits were less important now than in the past, because fertilisers and chemicals are readily available at less cost than the risk of loss incurred on a break crop in a poor year.

Reduced planting of break crops could also reduce productivity if these crops are replaced with fallows and seasonal conditions are sufficiently favourable to produce a crop, because producers will forgo the output of the break crop.

Cropping systems based exclusively on cereals are more risky than those which incorporate other crop types. Financial risk is likely to be increased because returns depend on a smaller range of commodity prices. Agronomic risks, such as resistance to herbicide and insecticide, are also higher because a smaller range of chemicals are available. At several workshops, participants expressed concern about the rate at which resistance to existing herbicides was developing.

Participants indicated that both plant breeding and market development efforts were needed to overcome this constraint. The development of crops specifically suited to Australian conditions was considered to be a crucial aspect of any such efforts.

5.7 Human capital constraints are becoming binding

Workshop participants suggested that another reason for the productivity slowdown was a decline in the stock of human capital available to the grains industry. The main reason identified for this was the ageing of the farmer population.

The demographic profiles of Australia's agricultural industries are constantly changing. The available data indicate the population of farmers in Australia is ageing, as the number of young people entering the industry is declining and the people currently in the industry are staying longer (Barr 2004).

Workshop participants reasoned that the reduced flow of young people into the industry had contributed to the slowdown in productivity growth because young people, with more recent training and new skills, were more interested in and capable of adopting innovations and applying new technology.

ABARE has recently analysed the relationship between operator age and productivity (Zhao et al. 2009). This study found productivity was highest for farmers between 55 and 60 years old. This may reflect the accumulation of skills and knowledge useful for the operation of a cropping enterprise.

The study also found that, while the productivity of younger farmers was relatively low, the growth of productivity of this group was much higher than for older farmers. Accordingly, increases in the skills and knowledge of relatively young farmers will have the greatest effect on overall productivity growth.

It was also argued that more young people contributed indirectly to productivity growth by encouraging older producers to invest in new technology. While the extent to which this argument is relevant for the grains industry is difficult to measure, it fits with the suggestion that factors other than profitability are an important determinant of productivity performance.

While the declining number of young people in the agriculture sector was a commonly suggested cause of the productivity slowdown because of the influence it has on human capital, few growers believed that the availability of suitable labour was a constraint to productivity growth in their operations. Mechanisation has reduced the number of people required to operate a given area of land, and so agricultural industries require fewer new entrants than in the past.

5.8 Research priorities have changed away from productivity

The public sector is the single largest purchaser and provider of agricultural research and development in Australia (Mallawaarachchi et al. 2009). As public perceptions about the appropriate role of government have shifted, so has the emphasis of public research and development efforts in agricultural industries.

Traditionally, public sector organisations conducted research and development on issues related to agricultural production, and extended the findings to growers. The rationale for this intervention was that there would otherwise be a market failure in the provision of this research and development caused by the structure of agricultural industries and the nature of the research.

More recently, the focus of public sector research in agricultural industries has shifted toward issues relating to natural resource management and sustainability (Marsh and Pannell 2000). Public sector spending on non-production aspects of agriculture is justified by the benefits this research generates for society as a whole.

This change in focus may have contributed to the productivity slowdown in several ways. A reduced focus on developing new and more efficient farming systems can be expected to reduce the rate at which innovations are created. Furthermore, public benefits such as improved environmental outcomes often involve reduced yields or increased costs to farmers, while the benefit of an improved environment is not included as output when estimating TFP.

Another aspect of this change in focus is a reduction in public sector extension efforts. There were a range of views on how this change may influence productivity growth. Some workshop participants suggested the reduced focus by state government agencies on extension activities had been beneficial for productivity growth because it had created a market for private operators who were able to provide superior, client-specific extension services.

However, purchasing extension services from private providers represents an increase in the market inputs used in production. This will reduce relative productivity growth, unless the increased quality of extension services is greater than the increase in cost.

It was also often expressed that many private consultants had received at least part of their training while working for state government departments of agriculture, and they were currently unable to train staff themselves, given current market conditions. This situation was considered to be a significant threat to the ongoing sustainability of private provision of agricultural extension services.

It was also clear that private sector organisations were not capable of replacing the basic, production-related research and development function of government agencies. This is because there is more likely to be market failure in the provision of long-term research into soils, plants and farming systems than the provision of extension services.

However, because the benefits of this research flow disproportionately to farmers rather than the community in general, it is not necessarily the case that public sector organisations should continue to provide these services. More generally, finding the most appropriate model for conducting research and development and extending the findings to producers in agricultural industries is an area for further research.

6 Future directions

Workshop participants had a range of suggestions on how GRDC could contribute to productivity growth in the grains industry. In general, there was support for the current GRDC strategy of dividing research funds between crop varieties and farming practices. However, there was less support for current models of extending this knowledge to growers.

6.1 Improve extension to grow human capital

A clear message from the workshops was that there remains significant scope for productivity growth to be increased by more widespread use of existing technology. Complete, rather than partial, adoption of new technology and systems was also considered to be an important potential source of productivity gains.

Participants argued that better extension of information was needed to increase human capital and facilitate the uptake and utilisation of innovations. Furthermore, it was thought that, with more skilled farmers, solutions to problems currently limiting productivity growth could be found and implemented. In general, participants indicated that GRDC should focus on providing information to producers about the most efficient systems.

Workshop participants suggested that operating new, more efficient farming systems required a greater level of skill than conventional cropping systems, particularly in the areas of information technology and data management. Better skills for farmers would facilitate the uptake of this technology and would help maximise benefits to those already using these technologies.

There was also a widely held view that improving the ability of farmers to make better decisions from a business management point of view would significantly improve productivity. It was expressed that agronomic or crop production skills were generally reasonable, but that business decision-making skills were not as good. This refers to decisions such as whether to expand the size of a farm, to buy equipment or to use a contractor.

At several workshops, participants indicated that access to region-specific cost-benefit analyses of the various farming system options available to them would be useful. There was also a perception that access to information from independent farm advisers, rather than machinery retailers, would increase growers' confidence to take up new technologies.

There was a widespread belief that the most effective way of achieving this increase in skills is through direct interaction between people and providing information specific to particular regions, rather than publishing relatively generic information in print or on the internet.

Recognising the logistical and cost implications of such an approach, it was suggested that it would be most effective for GRDC to focus on extension to consultants, rather than directly to growers.

This suggestion raises some questions about public versus private extension services. Private consultants were considered to be effective disseminators of new information and drivers of change, and so it seems sensible for GRDC to focus on them as a mode of extension. However, given that advisers sell information to growers, it is not clear what the most appropriate model for sharing this information is.

Workshop participants noted that the volume of research available to growers had increased significantly in recent years, and that because there was no review mechanism, it was often difficult to know what was accurate. Some participants suggested there was a role for GRDC in filtering and reviewing this literature. However, others thought this was a role that could be filled by private consultants.

Discussion of how GRDC could improve the skills of farmers led to a broader discussion about GRDC's role and research agenda. In these discussions, expectations of GRDC ranged from facilitating research on crop varieties and practices, to providing individually-tailored farm planning advice, to being an intermediary between grain growers and governments. Clear communication of GRDC's role and the regulations under which it operates would help manage these differing expectations.

6.2 Develop better varieties

Breeding improved crop varieties was considered to be an important avenue through which GRDC could contribute to increased productivity growth in the grains industry. Participants claimed that better varieties that make more efficient use of nutrients and water would have higher yields and make existing management problems easier to solve.

There was widespread support for GRDC's efforts in plant breeding. There was also recognition that these efforts would mainly continue as they had in the past, providing an increase in yields of around 1 per cent a year. However, when discussing GM technology, participants were optimistic that this technology would facilitate larger and more immediate productivity gains.

In particular, developing varieties with reduced susceptibility to current constraints such as frost and crown rot were high priorities. Enabling plants to adapt their growth to prevailing seasonal conditions was another desirable trait mentioned at nearly all workshops. This was particularly important for responding to significant changes in seasonal conditions within seasons, such as a relatively wet winter followed by a dry spring.

The development of a profitable break crop to include in cereal rotations was also a high priority among workshop participants. Breeding varieties of existing crops that were more reliable in dry seasons was one suggestion for achieving this. Participants also indicated they were interested in the adaptation of entirely new crops to Australian conditions.

6.3 Improve the ability of growers to manage risk

Workshop participants also discussed that having a greater ability to manage risk, particularly climatic risk, would result in productivity gains. Risk management was particularly important to growers because it is an important determinant of profitability, as well as productivity.

Managing climatic risk is important for productivity because water availability is often the limiting factor for crop production in Australia. This means that relatively less output can be produced in dry years than in others, regardless of the inputs used and management skills.

In a water-limited environment, productivity will be maximised when inputs are matched to the constraints of the season. That is, productivity will be highest if inputs are reduced in relatively dry years and increased in relatively wet years.

There are several approaches that can be used to choose the quantity of variable inputs to use. One approach is to form an expectation of future seasonal conditions and apply inputs based on this expectation. Given the present availability of seasonal forecasts, this expectation will typically be for average seasonal conditions, and hence an average quantity of inputs is applied.

The problem with this approach is that average seasonal conditions are seldom realised and, accordingly, suboptimal input quantities are usually applied. Productivity would be higher if inputs could be varied as actual seasonal conditions were realised. This could be achieved by the progressive application of inputs throughout the growing season.

An alternative approach is to apply inputs such as fertiliser in proportion to the amount extracted in the previous harvest. This reduces the requirement to form an expectation about future seasonal conditions and reduces the extent to which inputs are wasted in unfavourable seasons. However, this approach is likely to limit production in particularly favourable seasons.

While these approaches are feasible for inputs such as fertiliser, they are not useful for an input such as seed, because it cannot be varied once the growing season has started. A possible solution to this that was suggested by workshop participants was the development of crop varieties with variable growth habits.

Further research into increasing the extent to which inputs can be varied within seasons is likely to be a source of significant productivity gains. The development of more reliable seasonal forecasts was also identified as a potentially useful area of research.

7 Conclusions

This report has presented some answers to the following questions concerning the grains industry:

- What are the drivers of productivity growth?
- What has caused the slowdown of productivity growth?
- What can be done to increase productivity growth?

The main driver of productivity growth identified from the workshops was increased knowledge of farming systems. This knowledge facilitated the use of new and more efficient farming practices and the intensification of cropping systems. The influence of knowledge on productivity growth highlights the importance of maintaining a strong focus on research and development to continue to expand this understanding.

Participants were near-unanimous in selecting drought as the primary cause of the productivity slowdown. While there is little that can be done to increase rainfall, much can be done to increase farmers' abilities to manage drought. This includes undertaking research into farming practices that increase water use efficiency and improving risk management to reduce the effect of drought on farm production.

Research and development was the key solution to the slowdown identified by workshop participants. Specifically, participants suggested research and development efforts should be focused on increasing the human capital of farmers, improving cropping systems, developing better plant varieties and increasing the ability of farmers to manage risk. A strong focus on extension was considered to be critical for the success of future research and development efforts.

The workshops have identified areas where data collection would be useful to increase the understanding of productivity in the grains industry. This includes measuring the availability of finance for investment in new technology and the effect of specific management practices on crop production.

The information collected through this project has provided ABARE analysts with insight into the determinants of productivity in the grains industry and some of the constraints which must be overcome for productivity growth to increase. This information confirms many of the assumptions used in the analysis of productivity and will be used to guide future research.

appendix A Regional workshop summaries

Workshops were held in Toowoomba, Dubbo, Perth, Adelaide, Horsham and Melbourne to collect views from growers and consultants from the surrounding region about past drivers of productivity growth and the main factors behind the more recent slowdown in productivity growth. This appendix summarises the main trends and issues raised by workshop participants in each region. Participants were also asked to identify the priority areas which should be targeted by government and research organisations to increase productivity.

While the workshops were held with a relatively small number of producers and consultants, and do not necessarily represent the whole grains industry, the responses gathered identify some regional differences as well as variations in perspectives between growers and consultants.

Toowoomba growers workshop

What has driven productivity growth in the past?

- More efficient water use
- Minimum tillage
- New practices for managing pests and disease
- Precision agriculture, including yield mapping and controlled traffic farming
- Use of crop rotations

Why has productivity growth slowed?

- Limited water availability
- Inability to access new capital
- Human behaviour and a lack of motivation to increase productivity
- Fewer new varieties coming onto the market
- Drought has stalled investment decision-making

Where might future productivity gains come from?

- Improved weed and pest control
- Research into optimal farming systems
- Improved extension to facilitate uptake of innovations
- New varieties to overcome production constraints
- Improved intellectual property rights

Priority areas for:

management	new varieties	environment	other
• increase mechanisation (e.g. driverless technologies) • succession planning • better record keeping	• resistance to pests and disease • higher yields • nutrient efficiency	• improve weather forecasts • reduce herbicide loads	• improve access to new technology • better intellectual property rights • value non-production aspects of farming/ time

Toowoomba consultants workshop

What has driven productivity growth in the past?

- Improved soil health from use of crop rotations, reduced tillage, increased organic matter and disease management
- Improved water use efficiency
- Technological progress in information technology and GPS
- Increased farm scale
- Working together to share information and equipment

Why has productivity growth slowed?

- Knowledge gaps are constraining the uptake and efficient use of new technology
- Communication links between researchers and management is breaking down
- Infrastructure constraints, particularly transport and storage
- Ageing of farmer population
- Human capital constraints

Where might future productivity gains come from?

- Better extension of existing information—utilise consultants
- Disease control
- Understanding nitrogen and water management
- Adapt existing technology to new environments/problems
- Improve skills

Priority areas for:

management	new varieties	environment	other
• increase adoption of the most efficient farming systems • improve extension of skills and knowledge • utilise contract services	• better suited to regional conditions • traits valued by customers	• better soil health • improve water use efficiency	• improve links between research organisations • attract skilled researchers

Dubbo growers workshop

What has driven productivity growth in the past?

- Zero-till has improved water holding capacity and soil health
- Increasing scale
- Good management
- Larger extension system
- Higher soil fertility

Why has productivity growth slowed?

- Ageing farm population and lack of interest in innovating
- Low rainfall
- Declining soil health
- Fewer genetic gains
- Risk aversion and reduced input applications

Where might future productivity gains come from?

- Better computer technologies including GPS
- Improved access and extension of new and existing technologies
- Agronomy services and advice
- Water use efficiency
- Understanding landscape and biological processes

Priority areas for:

management	new varieties	environment	other
• improve management skills and timeliness • better use of inputs to reflect productive capacity	• better access to soil phosphorus • higher yields • frost tolerance	• more research into soils • improve weather forecasting • fertiliser efficiency	• viable break crops • improve communication of research findings • improve dissemination of technologies

Dubbo consultants workshop

What has driven productivity growth in the past?

- Zero-till
- Use of fertilisers
- Information flows
- Better management and planning systems
- Internet

Why has productivity growth slowed?

- Over-application of fertilisers and other inputs
- Limited water availability
- Lack of new technologies with large gains
- Farms disaggregating
- Overcapitalistion

Where might future productivity gains come from?

- More farms switching to zero-till
- Use of crop rotations
- Precision farming and GPS
- New technologies
- Use of break crops

Priority areas for:

management	new varieties	environment	other
• succession planning • use of contract services • improve decision-making and investment frameworks	• fewer varieties of higher quality • improve marketability	• more research into soil health • better testing capabilities for nitrogen and phosphorus • improve seasonal forecasting	• more research and extension staff • economic analysis of production systems • more data on the effects of technologies and practices

Perth growers workshop

What has driven productivity growth in the past?

- No-till farming
- Advances in equipment and machinery
- Increased operating scale
- Use of liquid nitrogen
- Higher yielding varieties

Why has productivity growth slowed?

- Reduced motivation because of off-farm incomes
- Low confidence from drought leading to sub-optimal farming decisions
- Shift away from rotational farming and break crops
- Inconsistent use of soil ameliorants
- Fewer opportunities for expanding into pasture country

Where might future productivity gains come from?

- GPS technologies, zone management and yield mapping
- Increase flow of knowledge to farmers
- New varieties
- Improved soil science and use of nutrients
- Using rotations

Priority areas for:

management	new varieties	environment	other
• improve decision-making • better use of current technologies and knowledge • improve confidence and innovativeness	• higher frost, drought and salt tolerance • higher yield • legumes suited to dry areas	• improve weather forecasts • improve soil knowledge and management • better weed management	• less restrictive plant breeding rights • more on-farm trials • research and extension into farming systems

Perth consultants workshop

What has driven productivity growth in the past?

- Less risk aversion in farmers
- Advances in machinery
- Use of most fertile land
- Higher nutrient availability
- Ability to sow earlier with minimum till technology

Why has productivity growth slowed?

- Risk aversion and conservative input use
- Higher incidence of frost
- Fewer genetic and technological gains
- Weed resistance
- Expansion of cropping into marginal areas

Where might future productivity gains come from?

- More widespread adoption of zero-till
- Diversification
- Improved understanding and training in sophisticated farming systems
- New varieties
- Variable rate technology

Priority areas for:

management	new varieties	environment	other
• better timing, management and business skills • optimising input use	• adaptable to a variety of soil types • frost and salt tolerance	• improve weather forecasts • non-chemical herbicides • increase knowledge of soil biology/type	• better understanding of variable rate technology • more basic research • better communication from research organisations

Adelaide growers workshop

What has driven productivity growth in the past?

- Minimum tillage
- Improved pest and disease resistance
- Better chemicals
- Increase in private agronomy services
- Increased farm size

Why has productivity growth slowed?

- Subsoil constraints, especially acidity
- Misinformation and poor decision-making
- Increasing weed resistance
- Lack of skilled labour
- Risk aversion leading to sub-optimal decisions

Where might future productivity gains come from?

- Improved water use efficiency
- Increased uptake of variable rate technology
- Use of crop rotations
- New varieties
- Increasing soil carbon

Priority areas for:

management	new varieties	environment	other
• training in business and management skills • better software required for data analysis • attention to detail in production systems	• nitrogen fixing varieties • frost, drought and disease resistance • crop for wet, acid soils • viable legume crop	• effective tool for measuring carbon • phosphorus recycling	• attracting young people to agriculture

Adelaide consultants workshop

What has driven productivity growth in the past?

- No-till farming allowing timely sowing
- Improved disease control
- Developments in machinery capacity
- Increased use of fertilisers and chemicals
- Expanded cropping areas

Why has productivity growth slowed?

- Ageing of farming population
- Reduced labour availability
- Poor seasons
- Suboptimal input applications to reduce risk
- Increasing herbicide resistance

Where might future productivity gains come from?

- Better use of soil moisture
- Advancing skills of agronomists
- Greater uptake of new and existing technologies
- Improved management of on-farm variability
- Use of crop rotations

Priority areas for:

management	new varieties	environment	other
• training in whole farm business analysis • variable rate technology • improve computer skills	• frost tolerant crops • profitable legume crop	• maintain groundcover after legume crops • improve water use efficiency • understand soil health • integrate pest	• more economic analysis of management systems variety data • broaden consultant and farmer connections • research into adoption process

Horsham growers workshop

What has driven productivity growth in the past?

- New varieties, especially legumes
- Minimum tillage
- Increased nitrogen fertiliser
- Increased farmer skills resulting in higher intensity of cropping
- Early sowing

Why has productivity growth slowed?

- Poor seasonal conditions
- Expansion of cropping areas slowed
- Now fine-tuning production systems rather than making big changes
- Reduced prevalence of lentil crops
- Research has not been suitably targeted

Where might future productivity gains come from?

- Greater ability to react to changing seasons
- Precision agriculture
- Non-chemical control of pests and diseases
- More effective extension
- Education about farming systems

Priority areas for:

management	new varieties	environment	other
• resistance of pests and disease • education	• adaptability to varying climate • low-rainfall legumes • improve water and nutrient use efficiency	• improve weather forecasts	• target research to most innovative producers • economic analysis of production systems

Horsham consultants workshop

What has driven productivity growth in the past?

- Crop rotations, particularly the availability of legumes
- Increased use of nitrogen fertiliser
- Falling price of wool
- Increased use of consultants
- Better varieties

Why has productivity growth slowed?

- Falling R&D, slower innovation
- Adjustment to drier seasonal conditions
- Overcapitalisation
- Increased debt servicing costs
- Exceptional circumstances payments

Where might future productivity gains come from?

- Education to facilitate uptake of innovations and to develop new knowledge
- Greater investment in R&D
- Develop a high value break crop
- Improve extension through better communication
- Attract and retain skilled people in the industry

Priority areas for:

management	new varieties	environment	other
• land use decisions • management skills • computer technology	• herbicide tolerance • higher yields	• seasonal conditions • climate change	• exceptional circumstances • variable rate technology • inter-row sowing and rotations

Melbourne combined growers and consultants workshop

What has driven productivity growth in the past?

- New varieties targeting higher yields
- Advances in chemicals and fertilisers
- Direct drilling
- Use of break crops
- Rainfall patterns

Why has productivity growth slowed?

- Changing seasonal conditions
- Slow uptake of new technologies
- Labour constraints
- Fewer extension services
- Fewer genetic gains

Where might future productivity gains come from?

- Improved extension of new technologies
- Increased use of consultants
- Use of GPS
- Increased use of contractors
- Controlled traffic farming

Priority areas for:

management	new varieties	environment	other
• uptake of new technologies • improve management skills	• higher yields • marketable varieties • stress tolerance (heat and frost)	• more accurate forecasts • better testing of soil nutrients	• education and training opportunities • attract young people

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CRC Plant Biosecurity

CSIRO (Commonwealth Scientific and Industrial Research Organisation)

Dairy Australia

Department of Primary Industries, Victoria

DN Harris and Associates

European Commission

Fisheries Research and Development Corporation

Fisheries Resources Research Fund

Forest and Wood Products Australia

Grains Research and Development Corporation

Grape and Wine Research and Development Corporation

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