Across Agriculture Submission

Productivity Commission

Inquiry into Rural Research and Development Corporations.

June, 2010

Supporting Organisations.

Foreword.

The ability of Australian rural industries to continue to generate substantial export revenue and to be a major source of wealth generation in regional Australia depends heavily on the continued international competitiveness of the sector.

Unlike most other developed nations, Australia does not attempt to enhance the competitiveness of its rural sector by providing subsidies or using trade restrictions. Innovation and associated productivity growth are the main avenues available to rural businesses in Australia to increase their competitiveness, and Australia's rural Research and Development Corporations play a critical role in managing the necessary industry research and development that enables innovation to occur.

The review of rural Research and Development Corporations by the Productivity Commission provides an opportunity for the rural sector and the Australian Governments to examine the structure and performance of the fifteen organisations, many of which were initially established some twenty years ago.

The review is timely, as over recent years there has been increasing evidence that Australian rural sector productivity growth has slowed or stopped, which has major long-term economic implications for the nation.

Given the extended time-lags between research and development investment and subsequent innovation and productivity growth, it is essential that this review takes as its central challenge the need to identify ways to accelerate future productivity growth in Australia's rural industries.

This is the critical issue that all involved in the rural sector in Australia need to recognise and accept as the biggest challenge currently facing Australian rural industries.

This submission.

A range of agricultural sector representative organisations which have a direct interest in rural research and development outcomes and which interact closely with rural Research and Development Corporations wish to provide a combined response from across the agriculture sector to the issues addressed by the Productivity Commission inquiry.

This submission has been prepared by the agricultural organisations representing levy paying producers and processors that provide industry based guidance on research and development investments listed below. These organisations are formally acknowledged by regulation under the PIERD Act (1989), in some industries they are the "prescribed industry bodies" in others the "recognised organisation".

The Almond Board of Australia	Apple and Pear Australia Ltd
Australian Banana Growers Council	Australian Chicken Meat Federation
Australian Forest Growers	Australian Lot Feeders' Association
Livecorp	Australian Mango Industry Association
Australian Mushroom Growers	Australian Nut Industry Council
Australian Passionfruit Industry Association	Australian Macadamia Society
Avocados Australia	Cattle Council of Australia
Cherry Growers of Australia Inc	Cotton Australia Ltd
Citrus Australia Ltd	National Aquaculture Council
Nursery and Garden Industry Australia	Sheepmeat Council of Australia
Strawberries Australia Inc	Summerfruit Australia Ltd
Wool Producers	

Contributing Organisations

Almond Board of Australia

Apple & Pear Australia Ltd.

Australian Banana Growers' Council Inc.

Australian Chicken Meat Federation (ACMF) Inc

AFG Australian Forest Growers

ALFA

amia Australian Mango Industry Association Ltd

A.M.G.A.™ Australian Mushroom Growers Association

ANIC australian nut industry council

Australian Passionfruit Industry Association

Australian Macadamias®

Avocados Australia

Cattle Council of Australia

Cotton Australia Advancing Australian Cotton

Citrus Australia

LiveCorp

National Aquaculture Council

Nursery & Garden Industry Australia

Sheepmeat Council of Australia

Strawberries Australia Inc. The National Strawberry Peak Industry Body

Summerfruit Australia

Woolproducers Australia

Table of Contents

Figures

Tables.

Acronyms

ABARE	Australian Bureau of Agricultural and Resource Economics.
ABS	Australian Bureau of Statistics.
BERD	Business Expenditure on Research and Development
CPI	Consumer Price Index.
CRDC	Cotton Research and Development Corporation.
CRRDCC	Council of Rural Research and Development Corporation Chairs.
CSIRO	Commonwealth Scientific Industrial Research Organisation
EU	European Union
EVAO	Estimated Value of Agricultural Output.
FOR	Field of Research
FAO	Food and Agriculture Organisation of the United Nations.
GATT	General Agreement on Tariffs and Trade.
GERD	Gross Expenditure on Research and Development.
GDP	Gross Domestic Product
GM	Genetically Modified
GPS	Global Positioning System
GVP	Gross Value of Production. Calculated for each sub-sector of agriculture for the purposes of determining the cap on Government R&D funding levels.
IMF	International Monetary Fund.
IOC	Industry Owned Corporation. Refer to RDCs.
MAF	Ministry of Agriculture and Fisheries, New Zealand.
OECD	Organisation for Economic Cooperation and Development.
PIERD	Primary Industries and Energy Research and Development Act. Legislation enacted by the Australian Government in 1989 which established the statutory research and development corporations.
PSE	Producer Support Estimate
R&D	Generally refers to research and development activities including the entire process from experimentation through to adoption by rural producers. Where specific reference is made to official statistics about R&D expenditure, R&D refers only to activities specifically associated with research
RDCs	Rural Research and Development Corporations. These include the statutory corporations (Cotton RDC, Fisheries RDC, Grains RDC, Grape and Wine RDC, Rural Industries RDC, Sugar RDC) and the Industry Owned Corporations (Australian Egg Corporation, Australian Meat Processors Corporation, Australian Pork Limited, Australian Wool Innovation, Dairy Australia, Forest and Wood Products Australia, Horticulture Australia, Livecorp Ltd and Meat and Livestock Australia)
SEO	Socio-economic Outcome
TFP	Total Factor Productivity.
TSE	Total Support Estimate
USDA	United States Department of Agriculture.
WTO	World Trade Organisation.

Executive Summary

The review of rural R&D corporations is being carried out at an important time for Australian rural industries. The sector has experienced important changes and growth over the last two decades, as well as major challenges arising from climatic conditions and emerging competition in international and domestic markets from developing nation agricultural exporters. Productivity growth has been a key factor that has enabled the sector to remain competitive in the face of these challenges. The role of rural RDCs in achieving that productivity growth cannot be exactly estimated, but there is no doubt they have made a major contribution, and are continuing to do so. Their role has become even more important over recent years, as State Governments in particular reduce the level of support they are providing to rural R&D and related rural extension services.

All available evidence provides strong support for continued government funding of rural R&D, because of the substantial spillovers that are generated. Industry spillovers are a major reason why R&D investment in the sector will not be adequate, in the absence of government intervention.

There is comprehensive evidence of the important public good spillovers that arise from successful rural R&D, which justifies public investment. It is not possible to predict the nature or scale of public good spillovers in advance. It is also not possible in most instances to obtain the public benefits in isolation from the industry benefits, because the public benefits arise from changes that occur in businesses within the rural sector. For that reason, the concept that "public good" rural R&D should be funded and managed separately from "industry good" rural R&D should not be supported.

Australian governments have long recognised the need to provide incentives to encourage private-sector R&D investment, and the current government has recently moved to increase incentives for R&D investment and to make those incentives more accessible to firms. The structure of rural industries is such that economy-wide Government R&D investment incentives are not available to the majority of industry participants, and the rural R&D corporation model (either as established under the PIERD Act or as industry-owned corporations) provides a mechanism to incentivize and deliver rural R&D in an efficient and effective manner.

The policy model has proved to be a robust one that meets both industry and government needs, and has been flexibly adapted to the specific requirements of different rural industry sub-sectors. This is important, particularly as rural industries in Australia are quite diverse in structure, geography and in the markets they service. Flexibility will also continue to be important as some rural RDCs will be required to take on expanded roles that include functions such as industry communications, extension, and cross-sectoral coordination as governments reduce the resources they allocate to the rural sector.

Industry contributions, in the form of levy-payer determined compulsory levies, are an equitable way to generate industry funds which overcomes the free-rider problem associated with industry spillovers, while at the same time providing levy-payers with control over the level of funding provided to RDCs.

There is increasing evidence that the current overall level of funding allocated to rural R&D in Australia will not be sufficient to maintain or accelerate sector productivity growth rates, which will be required in order for businesses in the sector to remain internationally competitive, and also to meet future challenges such as climate change, climate change policy, water scarcity, and increased competition from developing nation agricultural exporters.

The lifting of the current 0.5% GVP cap on government matching contributions to industry levy funds is a mechanism that should be used in order to increase funding for rural R&D into the future.

The development of a national Primary Industries Research Development and Extension Framework should also be used as a means of securing increased, long-term commitments from State and Territory governments to maintain and increase the level of resources they provide for rural RD&E, and to standardise rural R&D information systems.

It is likely that private sector investment in rural R&D in Australia will increase in the future, as the reduction in State government regulatory controls over genetically modified crops provides opportunities for the private sector to invest in research with good potential to capture future revenue if the research is successful.

There are a number of reasons why it is unlikely that private sector rural R&D intensity will increase to the same level as is observed in overseas jurisdictions. These include the scale of the Australian market, and the rural R&D infrastructure that major private sector organisations already have in overseas locations. Overseas evidence also highlights that private sector R&D investment is likely to be narrowly focused on the development of plant varieties and agricultural chemicals, which is not surprising given the need for private sector organisations to generate a return on their R&D investments.

There is no evidence to indicate that existing rural RDCs are crowding out private sector rural R&D investment. In fact, to the contrary, there is evidence from both overseas and Australian experience that strong public sector rural R&D investment creates greater opportunities for increased private sector investment, especially in applied research or experimental development associated with bringing new products to market.

The paucity of robust data about R&D funding, the types of R&D being carried out by different participants in the system, the nature and extent of private sector R&D investment, and how the funding and research activities have changed over time is a major weakness of the current system that makes it difficult for both industry and Government to make decisions about the adequacy of the Australian rural R&D system.

A centralised database, similar to the Current Research Information System (CRIS) maintained by the United States Department of Agriculture would provide better data about rural R&D funding and trends, and could be implemented for little cost, once standardised reporting and research categories were agreed. Importantly, such a database should provide information about both the source of, and the expenditure of R&D funds in Australia, something which is badly lacking in the current statistics collected by the Australia Bureau of Statistics.

In the absence of this data, it is very difficult to make informed decisions about the efficiency of current RDCs, and to determine whether there are other structural models (such as a reduced or increased number of corporations) that may be more efficient or effective. There is evidence that RDCs actively collaborate with other public and private sector participants, that RDC funds are used to leverage co-investment, and that RDCs are securing revenue from past successful R&D investments, but the data is not compiled in a consolidated form, nor is it available in a time-series.

Despite the lack of data to inform some key questions, there is no strong evidence available to suggest that RDCs are in need of major reform. In fact, available evidence suggests that Australia's rural R&D system has been performing very well in comparison with other international models, especially when assessed in terms of productivity growth in rural industries. The system continues to deliver valuable industry and community-wide benefits, and should be maintained and strengthened in the future.

* * * * * * * *

1. Introduction

The Australian Government has initiated a review of Australian rural research and development corporation arrangements in Australia. The review is being conducted by the Productivity Commission, which has been asked to review the efficiency and effectiveness of Rural Research and Development Corporations (RDCs) in enhancing the competitiveness and productivity of Australia's rural industries.

The Productivity Commission has released an Issues Paper, which provides some additional discussion of these issues, and poses a number of questions about which the Commission seeks responses.

This response to the Productivity Commission Issues Paper has been prepared by the Australian Farm Institute on behalf of a range of industry organisations which have both a direct and also a strategic interest in rural research and development policies in Australia, in particular to the extent they affect productivity and profitability of businesses within the sectors they represent.

It is recognised that the main focus of the Inquiry by the Productivity Commission is on the RDCs and Industry Owned Corporations (IOCs) which have been established under the Primary Industries and Energy Research and Development Act 1989, or other legislation. However it is not possible to consider rural research and development policy in a small, open economy such as Australia without also considering the international market-place in which Australian rural industries compete, and also without considering in some detail the structure of rural industries in Australia and their evolution over recent decades.

This response to the Productivity Commission's Issues paper is organised broadly in accordance with the structure of that document.

Section two provides an overview of Australian rural industries in a national and global context. It considers the role of rural industries in the national economy, the particular characteristics of rural industries that are different to those of other economic sectors, and the international agricultural and market environment in which Australian rural industries need to compete.

Section three discusses the economic and policy rationale for Australian Government investment in rural research in development. The focus in particular in this section is on the structure and diversity of rural production in Australia, and the implications arising from that for research and development policy. This section also considers economy-wide innovation and research and development policy, and examined how rural research and development policy fits within that framework.

Section four analyses the respective roles of public and private R&D investment in rural industries in Australia, noting some issues surrounding current data sources. This section also examines the extent to which Australia-specific factors may impact on private sector rural R&D investment.

Section five discusses available evidence about the effectiveness of the current RDC model in contributing to the competitiveness of Australian rural industries. This section examines available data about productivity growth in rural industries, noting the challenges associated with attribution of productivity growth to specific factors.

Section six discusses current funding arrangements for RDCs, examining in particular how funding levels for rural research and development compare with those observed internationally, and the extent to which benefits arising from research carried out by the RDCs flow to all industry participants.

Section seven analyses available information about the efficiency and effectiveness of RDCs, noting the roles that the RDCs are required to carry out, and the complexities associated with servicing a diversity of industry structures.

Section eight addresses issues relevant to the mix of research (whether basic, applied etc.) that is commissioned by RDCs, and also the broader question of the extent of coordination of the different institutions that are part of the rural R&D system in Australia.

The final section of the submission provides some general conclusions and recommendations arising from the analysis.

Throughout the submission, the term research and development (R&D) is used to refer generically to the set of processes that include basic and applied research, experimental development, extension and eventual adoption of new technologies and systems in rural industries. For official statistical purposes, rural extension is usually regarded as a separate item, but for all other purposes in this submission the term R&D is assumed to encompass the full process from experiment to adoption.

The organisations supporting this submission are as follows;

1. The Almond Board of Australia
2. Australian Banana Growers Council
3. Australian Forest Growers
4. Livecorp
5. Australian Mushroom Growers
6. Australian Passionfruit Industry Association
7. Avocados Australia
8. Cherry Growers of Australia Inc
9. Citrus Australia Ltd
10. Nursery and Garden Industry Australia
11. Strawberries Australia Inc
12. Wool Producers
13. Apple and Pear Australia Ltd
14. Australian Chicken Meat Federation
15. Australian Lot Feeders' Association
16. Australian Mango Industry Association
17. Australian Nut Industry Council
18. Australian Macadamia Society
19. Cattle Council of Australia
20. Cotton Australia Ltd
21. National Aquaculture Council
22. Sheepmeat Council of Australia
23. Summerfruit Australia Ltd

2. Australian rural industries in a national and global context.

There are many aspects of Australian rural industries that need to be considered in making decisions about the best way to enhance productivity growth through research and development. The industry is not homogeneous, is quite dynamic, is subject to greater risk than most other sectors of the economy, is completely exposed to international competition, and is made up of a large number of small business enterprises. While the Productivity Commission review is closely focused on the management and operations of the RDCs, it is impossible to properly consider how those organisations should operate without examining the nature of the industries that they service.

Australia's rural industries have historically been the source of much of the national wealth generated over the past two hundred years, and remain a vital source of export revenue, employment and economic activity for the nation. For the first half of the twentieth century, rural industries accounted for approximately 25% of the national economy, although this declined in relative terms after World War Two with the development of first the mining and manufacturing industries and more recently the services sector. The relative decline of the rural sector (an economic trend observed in all developed economies) has slowed in recent years, however the agriculture sector in Australia remains relatively large in comparison with agriculture sectors in all OECD countries except for New Zealand (Keogh 2006).

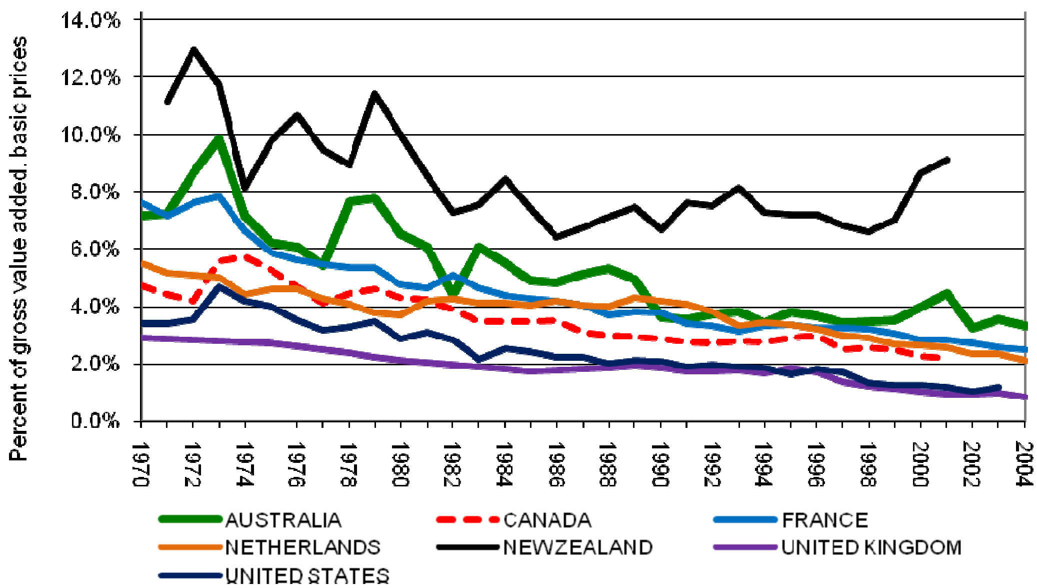


Figure 1 Rural sector as a share of national GDP.
Source: OECD STAN database.

Rural industries make up approximately 3% of Australia's Gross Domestic Product (GDP), compared to mining (around 8%), manufacturing (around 10%), and services (approximately 70%).

The annual gross value of rural production is approximately $45 billion per annum. (ABARE, 2010), and while the sector's relative share of the national economy is declining, the sector has achieved an annual real growth rate of approximately 2.4% on a value added basis over the past fifty years, and annual output growth of almost 6% per annum on a volume basis, despite a 16% reduction in the area of land used for farming over that period. (ABARE, 2009).

Table 1 Gross value of Australian rural production.

	2005-06	2006-07	2007-08	2008-09	2009-10(f)	2010-11(f)
	$m	$m	$m	$m	$m	$m
Grain and oilseeds	8,824	5,113	10,835	10,594	8,949	8,275
Industrial crops	3,181	3,005	2,559	2,555	3,158	3,340
Horticulture	7,342	8,633	8,020	7,894	8,499	9,235
Other crops	1,536	1,683	2,858	1,711	1,695	1,670
Livestock slaughterings	11,960	12,335	12,102	12,979	12,742	12,704
Livestock products	5,836	5,917	7,412	6,293	5,668	5,831
Sub-total - Farm	38,678	36,686	43,786	42,025	40,711	41,054
Forestry	1,673	1,713	1,872	1,747	1,861	1,989
Fisheries	2,166	2,211	2,187	2,121	1,992	2,028
Total Rural	42,517	40,609	47,845	45,893	44,565	45,071

(f) forecast *(Source: ABARE, 2010).*

It should be noted that due to inconsistencies between statistical agencies both within Australia and internationally, slightly different definitions of the rural sector are used. Throughout this submission, the term 'rural sector' is used to refer to the sector of the economy which includes agriculture, fisheries and forestry including nurseries and turf production. The term 'agriculture' is used to refer to farm production not including forestry and fisheries. The term 'broadacre agriculture' refers to the production of livestock and crops on broadacre farms in Australia, and does not include horticulture, vegetables, intensive livestock, dairy, forestry, fisheries or sugar production.

Official statistics understate the significance of the rural sector in the national economy, because growing proportions of the manufacturing and services sectors are associated with value-adding to agricultural, fishing and forestry products. This applies in particular to the food and beverage, retail grocery and the fresh produce sectors. For example, the trend towards increased retail sales of prepared meals rather than basic foods means that additional employment and economic activity is generated for the manufacturing and services sector, rather than for agriculture.

Reinforcing this, research conducted for the Australian Farm Institute by Econtech (Econtech, 2005) identified that the farm sector averaged 3.2% of GDP over six years to 2005, the farm input sector averaged another 0.8% of GDP, and downstream sectors of the economy that relied on farm products as major inputs made up another 8.1% of national GDP. While the results of such an analysis are heavily dependent on assumptions, the conclusion was that more than 12% of national GDP was generated by economic sectors with a strong reliance on agriculture. Similar research by KPMG (KPMG, 2009) for the Australian Food and Grocery Council identified that the food, grocery and fresh produce sectors represent 28% of total Australian manufacturing turnover, and are comparable in size to the Australian mining sector.

A feature of the Australian agriculture sector that is evident from available data is the exposure of the sector to climatic conditions that are generally much more variable than those experienced by agricultural producers in overseas countries. Australia's lack of high mountain ranges (and therefore small annual snow melt to feed rivers) and the low and variable annual rainfall means that irrigation water is limited, and the annual output for the sector is much more variable than is the case for other sectors of the economy.

Using the standard deviation of annual sector output over the period from 1974 to 2003 as a measure of sector volatility, it has been estimated that the agriculture sector is the most volatile sector of the entire economy, experiencing a level of volatility that is more than twice the average of all sectors in the economy (Productivity Commission, 2005). A consequence is that businesses in the sector face higher levels of risk than is the case for businesses in other sectors of the economy. This sector volatility and risk is recognised in a number of Government policy measures such as drought relief and income tax averaging. It also has consequences in relation to risk management strategies adopted by agricultural businesses managers, and is also likely to impact on access to finance and finance costs for businesses involved in the sector.

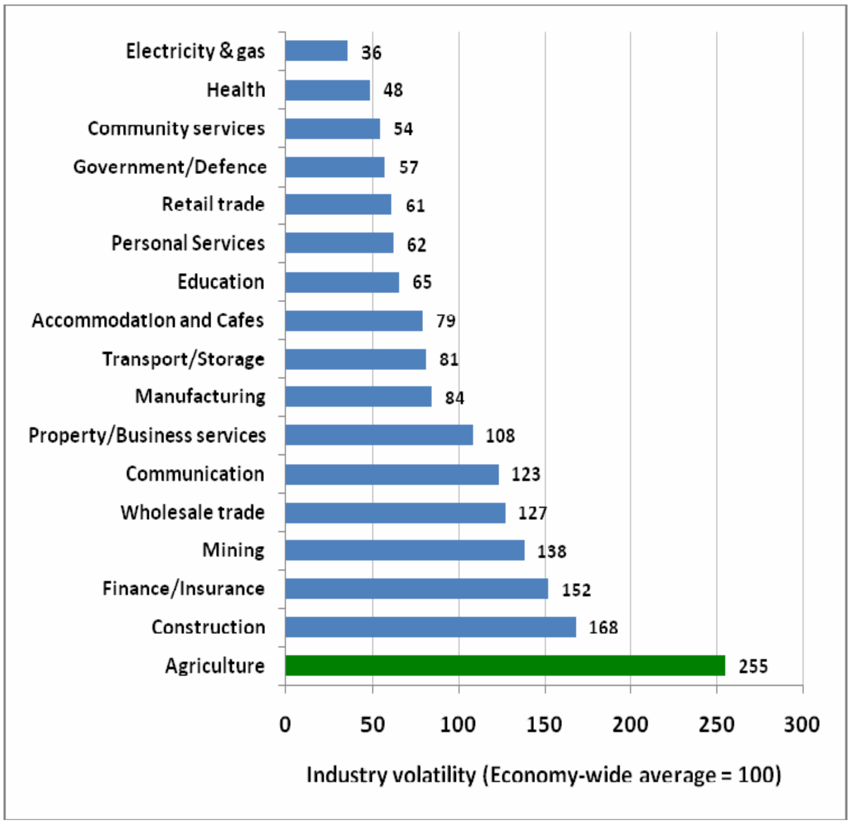


Figure 2 Volatility of sectoral output in the Australian economy.
(Source: Productivity Commission, 2005).

The agriculture, forestry and fishing sectors together directly account for slightly more than 3% of national employment, equivalent to almost twice the level of employment in the mining sector, and a third the level of employment in the manufacturing sector.

Table 2 Australian employment, by major economic sectors.

	2003-04 '000	2004-05 '000	2005-06 '000	2006-07 '000	2007-08 '000	2008-09 '000
Agriculture, forestry and fishing						
agriculture	317	307	300	306	301	318
forestry and logging	9	9	8	8	8	7
commercial fishing	16	14	12	10	14	9
AFF total (including services)	367	357	348	350	353	358
Mining	96	105	129	135	145	167
Manufacturing	1,033	1,051	1,025	1,024	1,056	1,017
Other industries	8,015	8,254	8,568	8,843	9,067	9,199
Total	**9,511**	**9,767**	**10,070**	**10,352**	**10,621**	**10,741**
AFF as % of total	3.9%	3.7%	3.5%	3.4%	3.3%	3.3%

(Source: ABARE, 2009a.)

Within the manufacturing sector, agriculture, forestry and fishing related employment accounts for an additional 280,000 jobs, or a third of all employment in the manufacturing sector. The largest employment sub-sectors within this grouping are meat and dairy processing, and bakery product manufacturing. Importantly, much of this employment is based in regional areas, and in combination with direct employment in agriculture, forestry and fishing, within specific regions represents up to one third of all employment (Econtech, 2005). This data does not include employment in many service sectors associated with these industries – for example the nursery and garden industry, the food service industry, farm advisory and extension services, or the rural-industry related financial services sector.

Table 3 Rural industry related employment in the Manufacturing sector, 2006-07

Manufacturing industry sub-sector	Employment 2006-07
Meat and meat product mfg	58,881
Seafood processing	3,027
Dairy product mfg	18,674
Fruit and vegetable processing	14,323
Oil and fat mfg	1,982
Grain mill and cereal product mfg	7,655
Bakery product mfg	64,466
Sugar and confectionery mfg	16,676
Other food product mfg	20,642
Beverage and tobacco product mfg	33,722
Wool scouring	434
Natural textile mfg	2,275
Leather tanning, fur dressing and leather product mfg	2,643
Log sawmilling and timber dressing	16,032
Pulp, paper and paperboard mfg	5,963
Fertiliser and pesticide mfg	4,782
Agricultural machinery and equipment mfg	7,015
Total	**279,192**

(Source: ABS Statistical publication 8221.0.)

2.1 Australian rural sector exports.

Australia's rural industries have, since the earliest days of European settlement, had a strong export focus. This is a result of Australia's large land area and low population, which has meant that the Australian domestic market for food and fibre has remained relatively static in size, given Australia's high per capita consumption levels for most food and fibre products.

It is currently estimated that approximately two thirds of Australian rural production is exported each year (Productivity Commission, 2005, ABARE and MAF, 2005). Sub-sectors such wheat, wool, sugar, cotton and beef have a high reliance on export markets, with for example, in excess of 95% of wool and cotton production exported each years. The dairy and sheepmeats sub-sectors depend approximately equally on domestic and export markets, while the pigmeat, poultry and horticulture sectors are more dependent on domestic than export markets.

Despite an extended period of drought across southern Australia over recent years and significant disruptions in global markets arising from the global financial crisis, the value of rural sector exports has maintained an upward trend, and further export growth is projected in the coming years. Horticulture (which includes both fruit and vegetables) and livestock exports have both maintained export growth despite reduced global economic activity and consumer spending. A summary of the value of rural sector exports, and future forecasts is provided in Table 4.

Table 4 Value of Australia rural exports by sub-sector.

	2005-06 $m	2006-07 $m	2007-08 $m	2008-09 $m	2009-10 (f) $m	2010-11 (f) $m
Grain and oilseeds	5,308	4,426	5,240	7,890	6,437	6,176
Industrial crops (a)	5,391	5,323	4,155	4,266	4,847	5,225
Horticulture	3,298	3,337	3,632	4,730	4,153	4,079
Meat	5,635	6,008	5,596	6,431	5,759	5,637
Livestock	3,085	3,304	3,348	3,734	3,610	3,867
Wool	2,539	3,065	2,796	2,322	2,297	2,059
Dairy	2,569	2,438	2,763	2,679	1,894	2,029
Forest products	2,140	2,355	2,471	2,343	2,340	2,410
Fisheries products	1,547	1,494	1,342	1,529	1,310	1,378
Total	31,511	31,749	31,343	35,924	32,647	32,861

(f) forecast. (a) Industrial crops include cotton, sugar and wine. (Source: ABARE, 2010.)

The above export data does not provide a complete picture of the role of the rural sector in Australian export performance, because the data generally only includes the value of relatively unprocessed rural products. For example, Australian Bureau of Statistics (ABS) statistics indicate approximately 10% of the value of annual output from the food processing sector is exported each year. The inclusion of more processed food and fibre products in export data indicates that the rural sector accounts for approximately 20% of Australian goods and services exports annually (Productivity Commission, 2005).

Australian rural products are subject to import competition in domestic markets, with horticulture, dairy, fisheries, pork, forestry and oilseed product imports all growing steadily in value over recent years. The value of both rural exports and rural imports into Australia over recent years highlights the extent to which the sector is fully exposed to international competition from the farm sectors of both developed and developing nations.

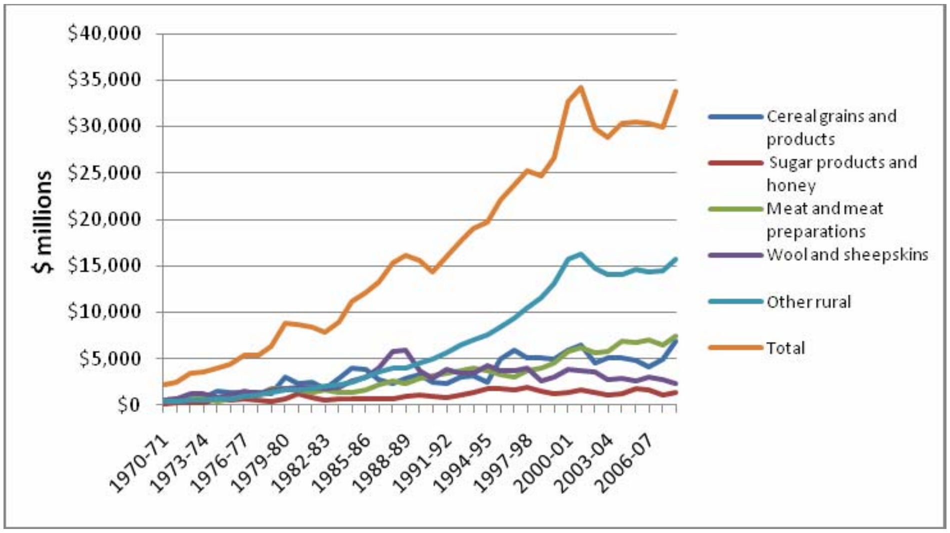


Figure 3 Trends in the value of rural exports over time.

On a balance of payments basis at current prices. 'Other rural' includes other farm, forest and fisheries products. Also includes wine, paper and paperboard, and tuna transhipped at sea or captured under joint venture agreements, which are not included in rural exports by the ABS. *(Source: ABARE 2009a)*

Australia accounts for a relatively small proportion of global agricultural output (approximately 1.04% on a value basis), however is more significant as a source of global agricultural exports (approximately 3.5% of value), and even more significant as a source of net agricultural exports (value of agricultural exports minus value of agricultural imports), being ranked fourth in the world in 2006 behind Brazil, the Netherlands and Argentina (FAO, 2009). It is likely that Australian net agricultural exports have increased since that time, given improved seasonal conditions since 2006.

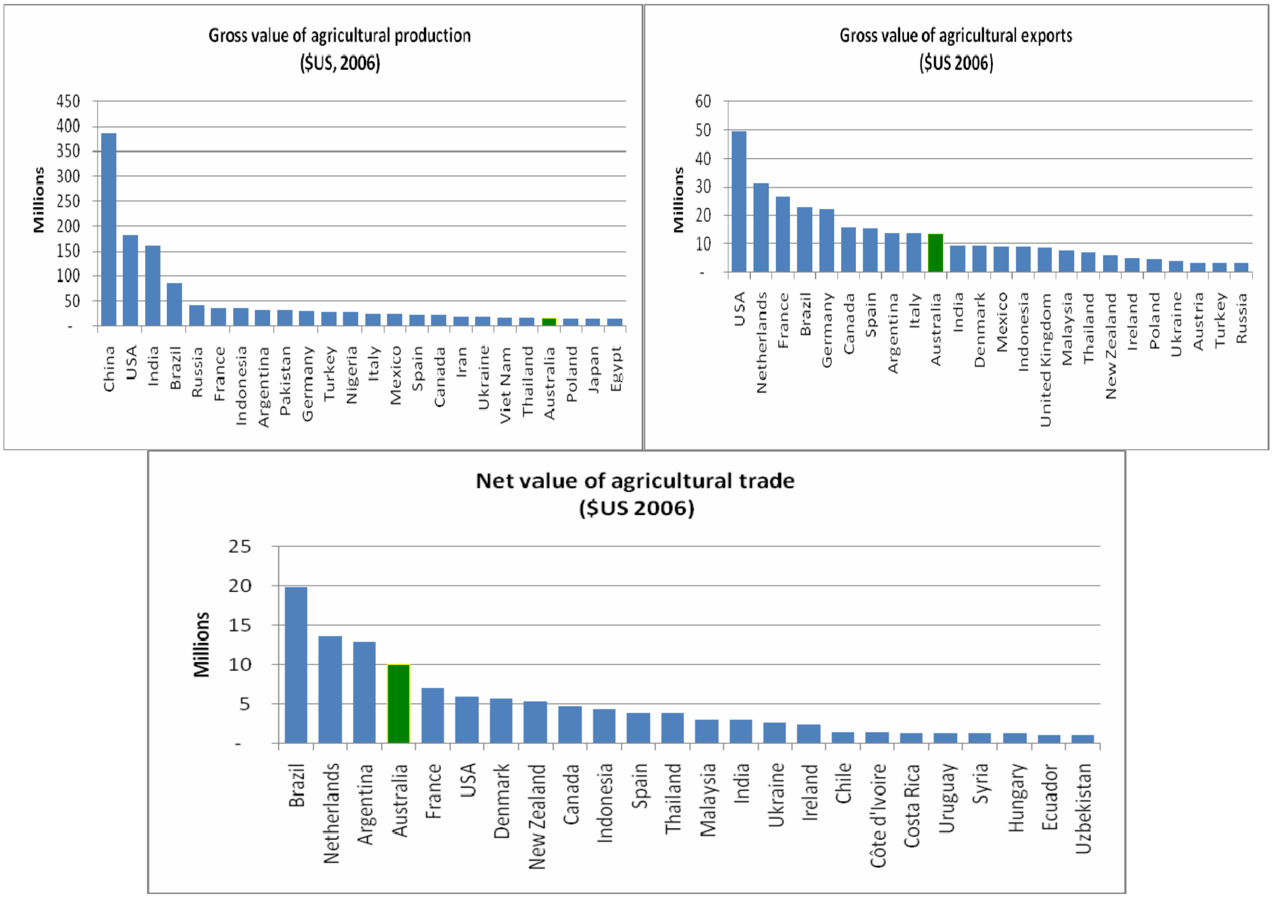


Figure 4 Australia's role in global agricultural trade.
(Source: FAO, 2009)

Australia’s role as a major net agricultural exporting nation is significant, given developments that have occurred in international agricultural markets over recent years, and projections of future developments. Concerns about the future ability of global agriculture to produce sufficient food for a growing world population have re-emerged over recent years, and were heightened by the global commodity price spike which occurred in 2008. The sudden fall in agricultural commodity prices post the financial crash in the last quarter of 2008 reduced these fears to some degree, although many respected forecasters, including the World Bank and the Food and Agriculture Organisation of the United Nations (FAO) continue to highlight the struggle that global agriculture will face in increasing output to meet projected future demand.

Reinforcing this, long-term global agricultural price trends all show that the long downward trend in real agricultural prices that commenced in the 1960s appeared to bottom out in the early 2000s, and agriculture and food prices since that time have been trending upwards. While there are a number of factors contributing to this change, increased grain demand associated with grain-based biofuels and the emergence of China as a major net agricultural importer post that nation’s accession to the WTO in 2001, appear to be major contributors. Fluctuations in the exchange rate of the Australian dollar tend to mask these trends in domestic markets, but long-term international price data maintained by the International Monetary Fund (IMF) (see Fig 5) shows the change in price trends, which has persisted despite the disruptions of the 2008 financial crisis.

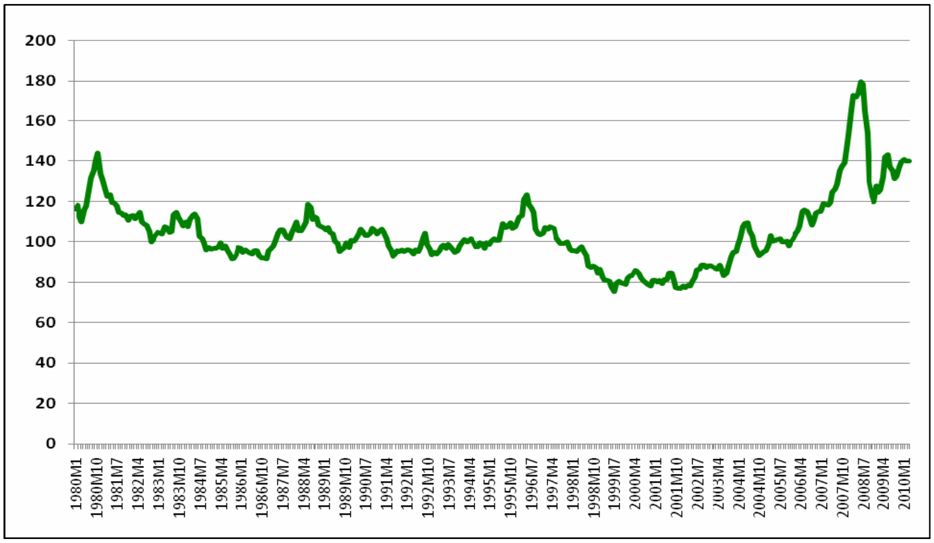


Figure 5 IMF commodity food price index.

(Source: IMF, 2010. Includes cereals, vegetable oils, meat, seafood, bananas, sugar and orange prices.)

The trend towards higher real prices for agricultural commodities and in particular food products is also evident at a domestic level in Australia, with food prices generally having increased at a greater rate that the consumer price index since around 2000. It is notable that those food items in particular where the raw agricultural products are internationally traded (such as beef, dairy, lamb and cereals) have increased in price more quickly than the CPI. While drought and reduced livestock numbers are obviously contributing to higher prices for some products, the graph highlights the extent to which Australian and international food prices are linked.

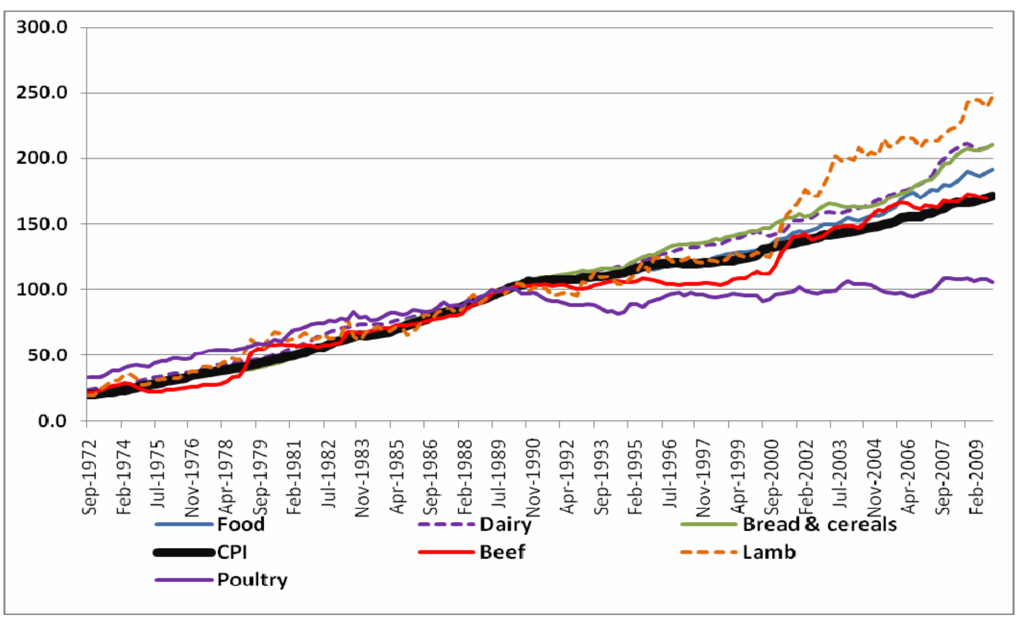


Figure 6 Trends in the Australian CPI and component indices since 1972

(Source: ABS Statistical publication 6401.0)

Capturing benefits from rural productivity growth.

The preceding graph provides a good example of the transient nature of industry benefit-capture from rural productivity growth, and also of the broad community benefits that quickly arise from rural productivity gains. A specific example is developments in the chicken meat sector over the last four decades.

Over the last forty years in Australia, the average length of time taken to grow chickens to slaughter weight has decreased by almost 40%, and the amount of feed required to produce a kilogram of chicken meat has declined by about the same amount. However, the benefits of these gains have quickly been captured by Australian consumers, as the average real price of chicken meat ($2008) has declined from $9.32 in 1970 to $4.89 in 2010. Based on current average national consumption of 37.7 kg per capita, this represents a benefit of $167 per person per annum, or a national benefit for consumers of $3.67 billion for the 2010 year alone.

(Source: Australian Chicken Meat Federation. Accessible at www.chicken.org.au)

2.2 International agricultural trade distortions

That Australian agriculture has consistently been able to achieve a high level of agricultural exports is a considerable achievement, given the impediments that exist to international trade in agricultural products, and the competitive distortions created by overseas governments through domestic agricultural policies.

There are a number of unique features of agricultural trade that need to be identified in order to understand not only its importance to international trade reform, but also the difficulties surrounding its liberalization. Despite considerable effort over more than half a century, the General Agreement on Tariffs and Trade (GATT), has been unable to limit the use of quantitative import restrictions on agricultural products. The original aim of the GATT was to reduce the protection of domestic industries to only one measure (Sanson 2005), however even at its inception, this principle was ignored. In 1966, for example, Switzerland entered the GATT only on the basis that agriculture was exempt from GATT norms.

In the Uruguay Round under the GATT, a start was made on bringing agriculture under normal trade rules, through the Agriculture Agreement which came into force in 1995. The long-term objective of the Agreement on Agriculture was 'to establish a fair and market-oriented agricultural trading system', but also to focus on setting up an ongoing process of reform (McMahon 2006). This ongoing reform process is under the Doha Development Agenda under the World Trade Organisation, which has had limited success.

The Agriculture Agreement distinguished between three areas of distortion for agricultural trade: market access (tariffs and tariff-rate quotas), export subsidies and domestic support. Of these, it was estimated in 2005 that 90% of the benefits of agricultural trade reform would arise from a reduction in trade barriers, and 10% from reducing farm subsidies (Anderson and Martin 2005).

Despite many changes under the Uruguay Round, rates of protection on different products even within the same country are highly dispersed, even though the aim of the Agriculture Agreement was to reduce tariffs across the board. This can be seen in the following table, where rates for five product groups are shown, and the countries listed have at least one product line within that group with a bound tariff rate higher than the number shown (Williams 2009).

Table 5 Tariff peak rates for agricultural products.

Cereals: >500% - Egypt, Japan, Switzerland, Norway, South Africa, South Korea >150% - US, Canada, Turkey, Mexico >100% - EC, India
Dairy: >400% - Japan, Switzerland, Norway >200% - EC, Canada >100% - US, India
Animal Products: >400% - Japan, Canada, Switzerland, Norway >200% - EC, Turkey, Mexico >100% - India, South Africa
Fats and Oils: >400% - Japan, Korea >200% - Canada, Switzerland, Norway, Mexico, India >100% - US
Sugar: >400% - Switzerland >200% - Norway, South Korea, Mexico >100% - US, EC, Japan, Turkey, India, South Africa

Compiled from WTO, World Tariff Profiles, 2006.

A further indication of the restrictions imposed on agricultural trade is the average bound tariffs applied to agricultural imports by a range of countries. In their market access schedules under the GATT, WTO members set out 'bound' tariff rate; and GATT Article II prohibits members from charging customs duties in excess of the amount bound in their schedule. As can be observed from Table 6, Australia has the lowest level of bound agricultural tariffs of virtually any nation involved in international agricultural trade, and is one of only three nations with tariffs for agricultural products that are lower than those for non-agricultural products.

Table 6 Simple average bound tariff rates for nations with involvement in agricultural trade.

Country/territory	Agricultural products	Non-agricultural products
Australia	3.3	11.0
Brazil	35.5	30.8
Canada	14.5	5.3
Chile	26.0	25.0
China	15.8	9.1
Colombia	91.8	35.4
European Communities	15.9	3.9
India	114.2	34.7
Indonesia	47.1	35.6
Japan	24.0	2.5
Mexico	44.2	34.9
New Zealand	5.7	10.6
South Africa	41.2	15.7
Thailand	42.7	25.6
Ukraine	11.1	5.0
United States	4.8	3.3
Viet Nam	18.5	10.4

Source: WTO trade and tariff data, 2009

Export subsidies were subject to a simple prohibition in the GATT Agreement on Agriculture, however agricultural products were differentiated and the process of bringing export subsidies on non-agricultural and agricultural products under the same rules was supposed to be achieved in future rounds of negotiations; - specifically the Doha Development Agenda – which has been limited in its success. In practice, most of the export subsidies on agriculture being paid in the entire world are being paid by the European Union. In 1995 the EU accounted for 89% of the export subsidies being paid by all WTO Members (Swinbank 2005).

2.3 International government support measures for agriculture.

The third area under the Agricultural Agreement that was recognised as distorting agricultural trade was domestic support subsidies. Policymakers around the globe acknowledge that a reduction in government interference and distortionary support for agriculture has the potential to assist in solving problems such as developing nation poverty, global food insecurity, and environmental degradation.

For the last twenty years, the Organisation for Economic Cooperation and Development (OECD) has maintained a program that monitors the agricultural policies of developed, and more recently developing nations, the outcome of which are annual publications that provide an enormous amount of detail on the specific policies adopted by various nations. These reports also convert this information into some index measures of farm support levels, to enable comparisons to be made between nations and over time.

The main index measure of farm support provided by the OECD is termed the ‘Producer Support Estimate’ (PSE). According to the OECD, the PSE estimates the value of annual monetary transfers to farmers from three broad categories of policy measures that:

1. *Maintain domestic prices for farm goods at levels higher (and occasionally lower) than those at the country's border (market price support (MPS) estimation).*
2. *Provide payments to farmers based on, for example, the quantity of a commodity produced, the amount of inputs used, the number of animals kept, the area farmed, an historical (fixed) reference period, or farmers' revenue or income (budgetary payments).*
3. *Provide implicit budgetary support through tax or fee reductions that lower farm input costs, for example for investment credit, energy, and water (budgetary revenue foregone estimation).*

The PSE measure used by the OECD is not just a measure of budgetary outlays to the sector, but it also includes an estimate of the extent to which trade barriers (for example) result in agricultural commodity prices that are higher than those prevailing in international markets. When a nation's PSE estimate is expressed as a percentage of gross farm receipts (including government payments to farmers) it provides an estimate of the per cent of annual farm incomes within the nation that are effectively provided by government support measures.

In more recent years, the OECD has extended its analysis to some agriculturally important developing nations, as these nations have emerged as major players in global agricultural markets. Figure 7 shows national PSE estimates for the nations included in the two recent OECD reports using 2007 data for developing nations, and 2008 data for developed nations.

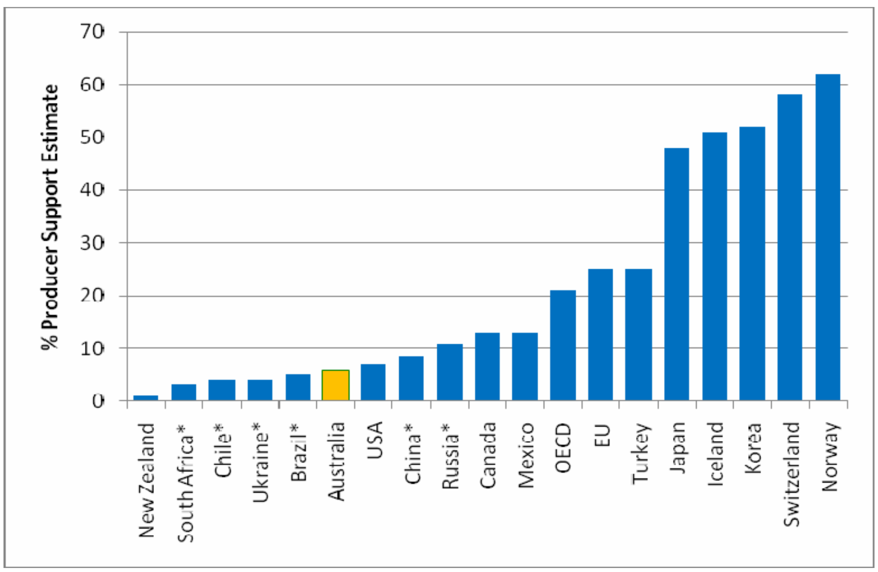


Figure 7 OECD estimates of farm support levels
(Source: OECD, 2009)

As can be observed, New Zealand is the only developed nation with a lower level of government support for its agriculture sector than Australia, and a number of developing nations that are major competitors for Australian farmers are also estimated to receive similar or higher levels of government support.

There are a number of factors that require consideration when examining these results. The first is that as a consequence of recent drought years, estimated support levels for Australian farmers have trended upwards over the last few years. This has occurred due to the increase in drought exceptional circumstances payments made to Australian farmers in response to repeated poor seasons, but also because drought has depressed the total value of farm receipts, therefore the PSE calculation utilises a smaller denominator than would otherwise be anticipated.

At the same time, estimates of farm support measures (in PSE terms) have apparently declined quite considerably in both the USA and the EU since around 2001. This appears to be as a result of some policy changes in the EU that have resulted in farm payments being 'decoupled' from farm production, and therefore classified in a different way. In both the USA and the EU, the apparent decline is also a consequence of generally higher farm commodity prices since that time, which has meant that price support measures for specific commodities have not been triggered; and therefore payments have not been made to farmers under these measures.

An important element in both USA and EU farm policy over the past decade has been an increase in payments to farmers for voluntary land retirement (USA), or for the provision of environmental services (EU). These payments are recorded as part of the PSE support measure, and while less market distorting than other forms of farm support, provide a significant additional element of farm income that is independent of seasons and markets. Concerning the lack of such programs in Australia and New Zealand, the OECD report diplomatically notes '*Some OECD countries (Australia, New Zealand) rely mostly on regulations to address environmental issues in agriculture.'*

The OECD report notes that the current relatively lower levels of agricultural support measures in both the USA and the EU are partly as a consequence of limited policy reform, and partly a result of higher commodity prices. A period of lower agricultural commodity prices would be expected to trigger a return to higher levels of measured support. This is especially the case in the USA where the most recent Farm Bill did not include any fundamental policy changes. The reintroduction of dairy export subsidies in both the USA and the EU as a consequence of lower dairy prices (a change that occurred after the OECD figures were compiled) is a reminder that what currently appears to be a reduction in farm support measures in both these locations may only be a temporary phenomenon.

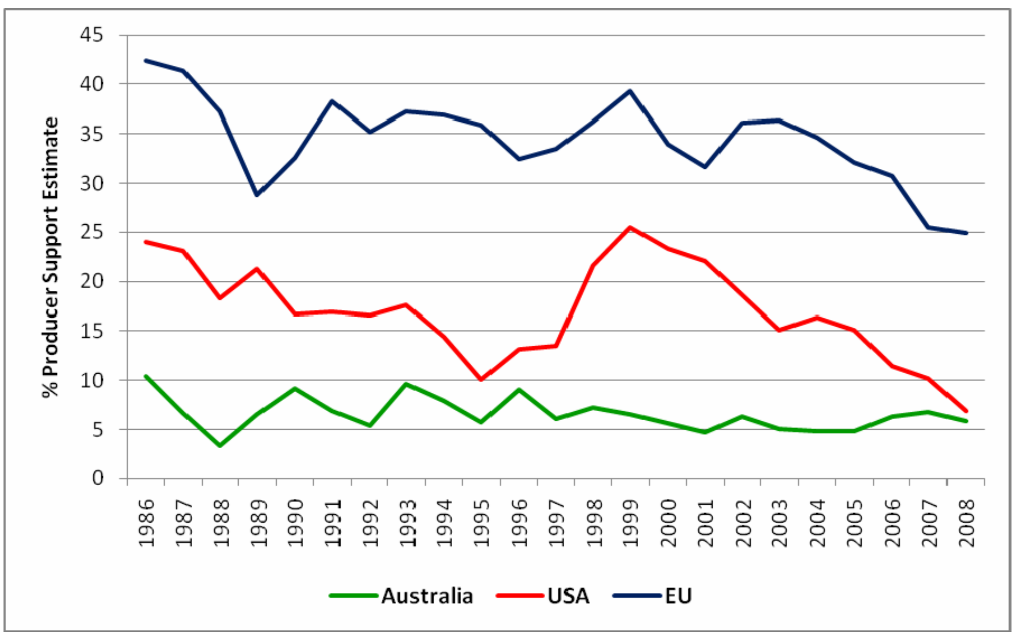


Figure 8 OECD estimates of trends in Government farm support measures.
(Source: OECD, 2009)

Another measure of government support for the farm sector that is compiled and published by the OECD is termed the Total Support Estimate (TSE). In addition to the support measures included in the PSE measure, this estimate includes government expenditure on items such as agricultural research and development, agricultural education, quarantine and inspection services, agricultural infrastructure, and agricultural marketing and promotion expenditure.

As Figure 9 shows, the level of expenditure by USA and EU governments on these items is much higher than is the case in Australia, and while the total expenditure as a proportion of gross farm production in the USA and the EU has declined since 2000, this is a reflection of an increase in the value of agricultural output as a consequence of higher agricultural commodity prices, rather than a reduction in total agriculture sector expenditure. It is noteworthy that these declines in support levels for both the USA and the EU have not been triggered as a consequence of any significant changes in farm support policies.

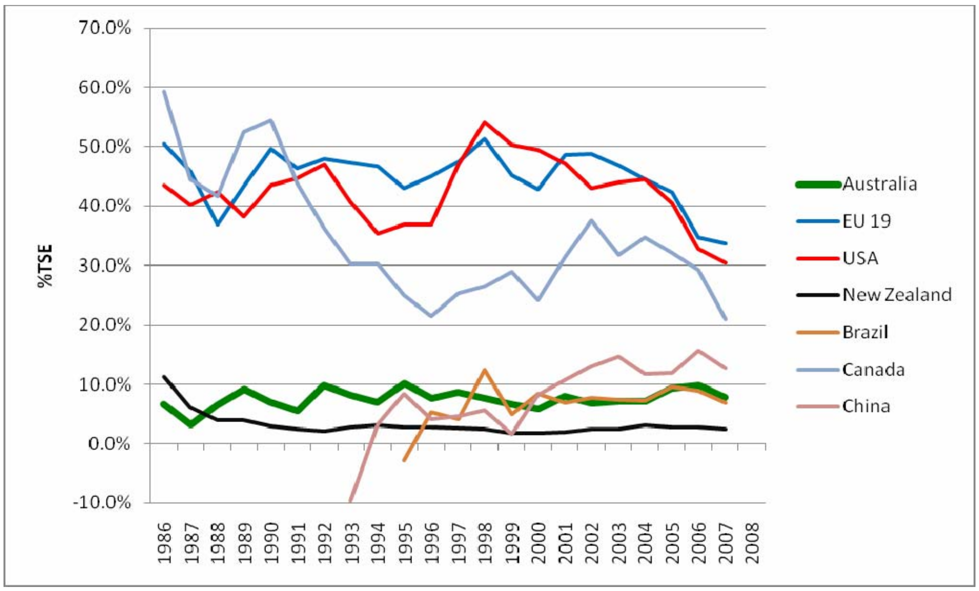


Figure 9 OECD estimates of trends in total Government farm-sector expenditure.
(Source: OECD, 2009)

On the Australian figures, the OECD report notes that the total support provided to agriculture as a percentage of total national GDP has declined from 0.4 per cent in 1986–88 to 0.3 per cent in 2006–08, a level which is one of the lowest in the OECD, and around one-third of the OECD average.

Not included in estimates of farm subsidies in either the USA or the EU is the indirect effect of biofuel mandates on agricultural commodity prices. In the USA (and Canada) the main focus has been on the production of ethanol utilising corn or wheat, while in the EU the focus has been on the production of biodiesel from a number of different feedstocks, including oilseeds.

The overall impact of these policies on farm incomes is not easy to calculate, due to complex interactions through other sub-sectors of agriculture both domestically and internationally. Corn, wheat and oilseed producers in both North America and the EU have benefited from higher prices, with a recent study projecting that prices of corn, vegetable oils and wheat will be 45 per cent, 17 per cent and 9 per cent higher respectively as a result of biofuels policies (Fridfinnson and Rude, 2009).

On the other hand, as a result of these policies livestock feed costs have increased and are projected to result in reduced output and profitability for farmers in those sub-sectors of agriculture.

The impact of these biofuels policies also extends internationally, because these policy measures mean lower availability of grain and oilseed exports from North America and the EU, and therefore higher prices in international markets. These biofuels policies are also attractive from a government budget perspective in both the EU and the USA, in that the resulting higher grain and oilseed prices mean that agricultural commodity price support thresholds are breached less often, and there is less need for direct payments to be made to farmers under these policy measures.

2.4 Australian farm support measures.

A detailed analysis of the specific items that make up the estimated total level of government support to Australian agriculture highlights that a relatively small number of specific items make up the total amount of support provided to the sector. The following table summarises the main items.

Table 7 OECD estimates of Australian Government farm support measures.

Item	2008 estimate ($ millions)	% of PSE total
Drought support		
EC Interest subsidy	$524	19.8
EC relief payments	$237	8.9
Fuel Tax Credit	$869	32.8
Dairy Industry restructure	$203	7.7
State Government Services		
Advisory services	$120	4.5
Disease and pest control	$129	4.9
Training services	$23	0.8
Farm Management Deposit Scheme	$96	3.6
Livestock valuation – natural increase	$92	3.5
Income tax averaging	$55	2.1
Environmental programs (State)	$65	2.5
Other small programs	$238	8.9
Producer Support Estimate	**$2,651**	**100**

As might be anticipated, drought support measures (both interest rate subsidy payments and relief payments) constitute the biggest item of farmer support, making up 28.7 % of the total. The amount of support under these items was significantly less in 2008 than in 2007, as drought conditions moderated and specific regional areas became ineligible for these measures.

Perhaps the most surprising inclusion in estimates of support to agriculture is the ‘Fuel Tax Credit’ item, which makes up almost 33 % of the estimated support. Since 2006, the fuel tax credit scheme has been available to all business users of fuel, and more particularly to all users of fuel for off-road purposes. The fact that it is widely available to eligible business in all sectors of the economy means that the measure is not an agriculture-specific measure, and should not be included in any assessment of the level of support provided to Australian farmers.

The removal of this item from the calculation of Australian farm support would result in a calculated PSE of 4.26 %, rather than the 5.85 % reported for 2008.

The 2008 estimate of Australian farm support measures also contains several other line items for which the calculation methodology is not evident, and it is therefore difficult to determine whether or not the reported figure is justified.

The 'Livestock valuation – natural increase' item presumably refers to the arrangement whereby for taxation purposes, natural increases in livestock numbers can be valued a number of different ways, including the use of nominal values. It is difficult to understand how this arrangement could be classified as a farm support measure, as irrespective of the valuation system used, the tax will either be paid when the livestock are first recognised in farm accounts, or when they are eventually sold.

It is also questionable whether the line item 'Income tax averaging' should be considered as a farm support measure. The Australian Tax Office explains '*Tax averaging enables you to even out your income and tax payable over a maximum of five years, to allow for good and bad years. This ensures that you do not pay more tax over a number of years than taxpayers on comparable but steady incomes.'* Tax averaging means that farmers pay less tax in high income years, but pay more tax in low income years, and the net result is tax payments that are equivalent to those of others in the community on a similar average income. Why this is considered to be a support measure for the farm sector is unclear, as is the method of calculating the value of this measure to the farm sector.

The removal of these three items from the estimation of farm support levels for Australia would result in a calculated PSE of 3.9 %, rather than the 5.85 % that is reported. It is understood that the OECD has confirmed that at least some of these adjustments will be made in the final estimate for 2008 that is pending.

Future Australian farm support levels are likely to be further reduced due to the cessation of the dairy industry restructure scheme, and the winding back of drought support payments as seasonal conditions improve. This means that the estimated level of government support for Australian agriculture in 2009 could be very close to the level reported for New Zealand, and will confirm that Australian (and New Zealand) farmers receive the lowest level of government support of virtually any farmers around the world.

2.5 Australian rural industry structure.

The Australian rural sector, unlike the manufacturing or services sectors, is dominated by small-scale enterprises. According to the Australian Bureau of Statistics (ABS) there were 120,677 businesses predominantly engaged in rural production (rural includes livestock, crop, fruit, vegetable, nut, flower, nursery and turf production) and a further 15,055 businesses predominantly engaged in other industries which also carried out some rural production, making a total of 135,996 businesses engaged in rural activities in 2008-09. For the ABS, a business is counted as a farm business if it has a minimum estimated annual value of agricultural output (EVAO) valued in excess of $5,000.

According to the ABS data, approximately 50% of these businesses have an annual EVAO of less than $100,000 per annum, while less than 5% have an EVAO of more than $1 million per annum. The size and distribution of businesses varies between different commodities, with intensive livestock (pork and poultry) and dairy having a much greater proportion of businesses with an EVAO greater than $500,000, and broadacre livestock, horse and some of the nursery sub-sectors being dominated by businesses having an EVAO of less than $100,000.

The distribution of farms by EVAO categories for all farms, and for each of the main farm commodity groupings is displayed in Figure 10.

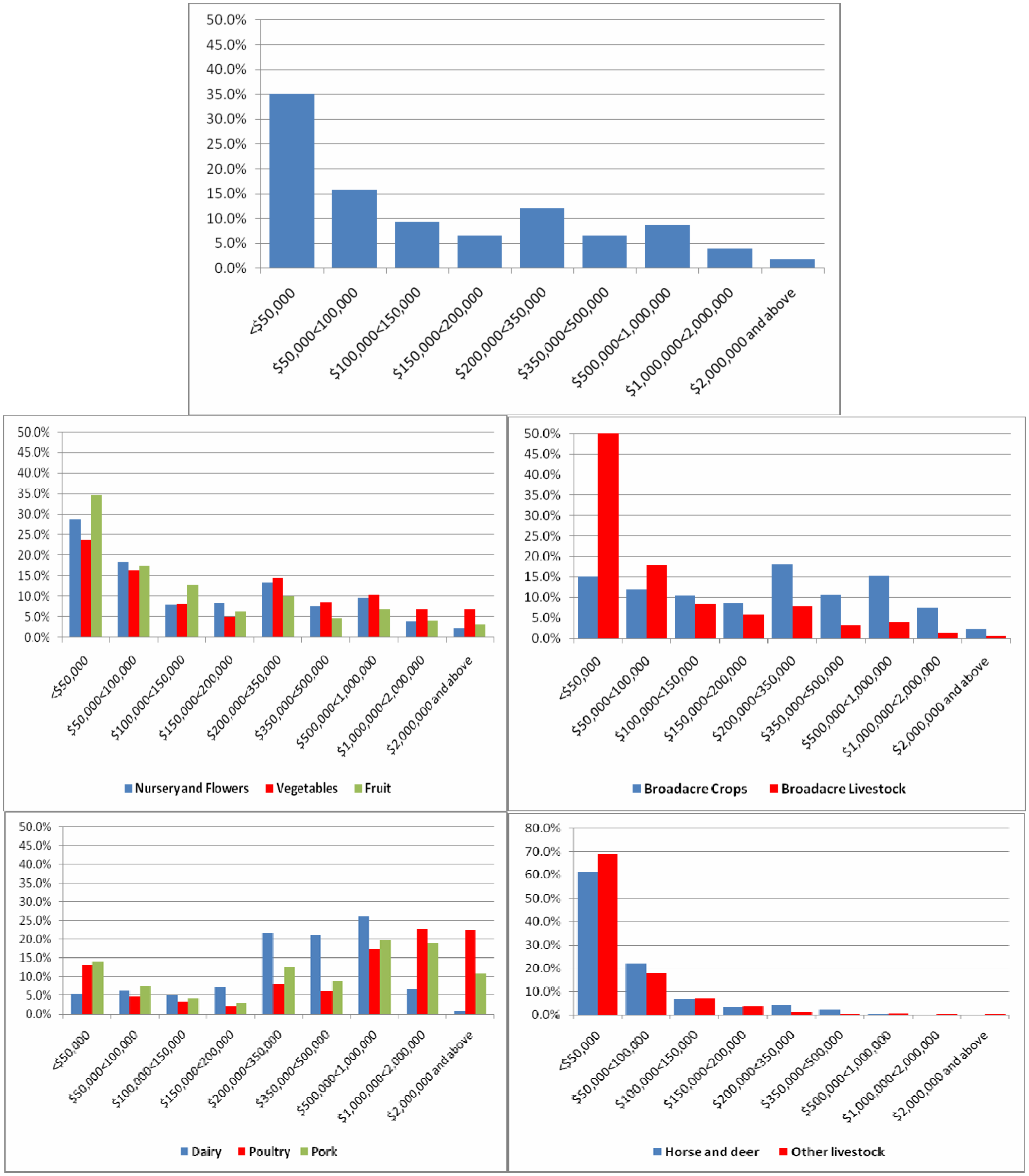


Figure 10 Distribution of farm business EVAO by commodity grouping (2008-09).
(Source: ABS Statistical publication 7121.0

A number of changes have been occurring in the structure of rural industries over the past two decades. Farm businesses have been reducing in number, and increasing in size. The extent to which this is occurring varies by commodity sector, however there is incomplete coverage of all commodities in relevant statistical data to provide a full picture.

The overall number of businesses engaged in rural industries in Australia has been decreasing by approximately 1.1% per annum since the mid 1950s, a trend that is evident in agriculture sectors worldwide, and not just in Australia. A key factor driving this trend is the development of greater mechanisation and production technology, which enables increased farm output with reduced labour inputs. Unfortunately, statistics associated with these trends do not provide a clear picture, because both government agencies involved in their collection (ABARE and the ABS) have changed definitions, thresholds and collection method on a number of occasions, resulting in incomplete data or data series that are not comparable.

The ABS collects data from all agricultural businesses with more than $5,000 of EVAO, although changed collection methods in 2005-06, with the result being a sudden apparent increase of approximately 20,000 in farm business numbers in that year. ABARE collects data via an annual survey of a sample of broadacre and dairy farm businesses, but does not regularly collect data from horticulture, intensive livestock, sugar, nursery industries or other smaller livestock and cropping industries. In addition, ABARE has on a number of occasions adjusted the minimum threshold applicable to farms included in surveys, with resulting changes in estimates arising from those surveys.

Bearing these qualifications in mind, the following figures provide some indication of the major structural changes that have been occurring in Australian rural industries over recent decades.

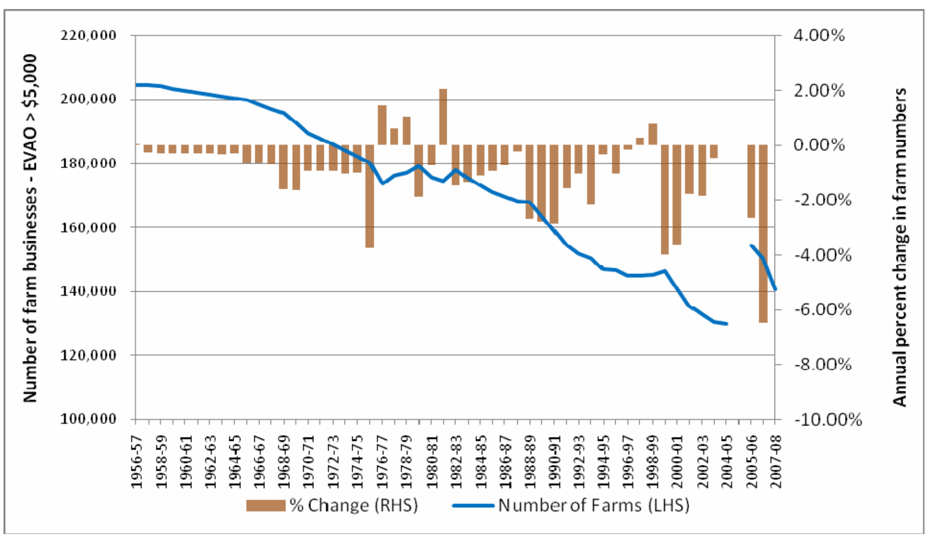


Figure 11 Change in the number of farms in Australia since 1956

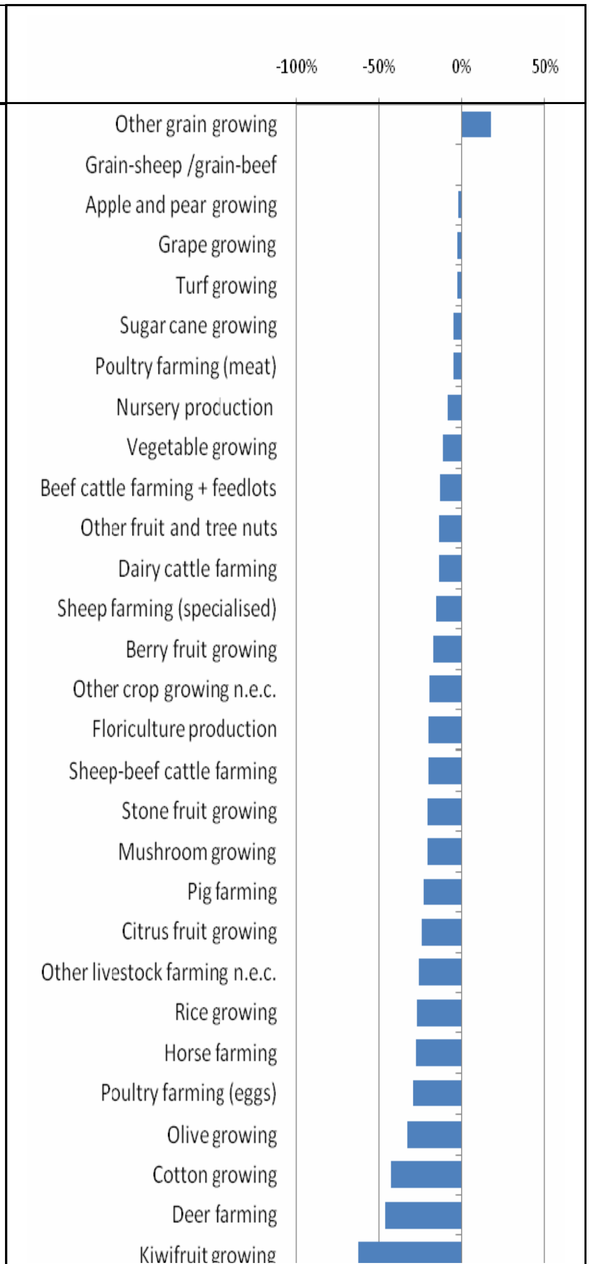
NOTE: A change occurred in statistics collection methodology in 2005-06. The apparent increase is a result of the changed methodology, and does not reflect an actual increase in farm numbers.

(Source: ABS Statistical publication 7121.0, various years)

It is noteworthy that annual reductions in farm numbers appear to have accelerated in recent years. This is to be expected, given the prolonged drought and difficult market conditions for some sub-sectors. Changes in the number of farm businesses within each sub-sector over the last three years are shown in the following table. The data is subject to some questions, as industry levy-payer numbers are in some cases different from the data presented in the table.

Table 8 Changes in Australian broadacre farm populations since 2006-7

2006-7	2007-8	2008-9	% change
11,165	13,723	13,110	17%
13,782	13,059	13,778	0%
743	896	725	-2%
6,091	6,062	5,926	-3%
291	366	283	-3%
3,968	3,758	3,762	-5%
807	862	765	-5%
1,121	804	1,029	-8%
4,953	4,429	4,403	-11%
45,230	41,640	39,426	-13%
3,333	3,837	2,873	-14%
8,993	8,792	7,749	-14%
12,285	1,148	10,368	-16%
549	390	453	-17%
2,401	836	1,921	-20%
767	775	611	-20%
8,443	7,226	6,690	-21%
1,215	981	959	-21%
109	120	86	-21%
892	642	682	-24%
1,384	1,230	1,041	-25%
1,006	616	743	-26%
145	46	105	-28%
3,102	1,697	2,231	-28%
440	417	309	-30%
400	259	267	-33%
482	294	276	-43%
170	138	91	-46%
40	65	15	-63%
134,354	**125,108**	**120,677**	**-10%**



(Source: ABS Statistical publication 7121.0, various years.)

As would be anticipated given the lack of water available for irrigation, the biggest reductions in farm numbers over the three years have been in sub-sectors heavily dependent on irrigation water. It should be noted that in the case of both rice and cotton farms, these are often multiple-enterprise farms and being annual crops, the farm businesses are likely to have simply chosen not to grow crops in years when water was not available. It would be anticipated that the numbers of farm businesses categorised as rice or cotton farms will increase once irrigation water is again available.

A notable feature of the Australian rural sector in comparison with that of nations such as the USA is the relatively high proportion of multiple-enterprise farm businesses in Australia. It was estimated in 2001 that 61% of Australian rural businesses involved multiple enterprises, and that these businesses accounted for approximately 70% of the total value of agricultural output (Synapse Research and Bob Hudson Consulting 2005). Multiple enterprises are assumed to be operated as a means of risk management and also due to the complementarity of different enterprises, although there does not appear to be data available to confirm this. There has, however, been some recent discussion on the implications of multiple enterprise businesses in relation to decision-making and productivity (Kingwell 2010).

Changes that have occurred in the number of farms in different size categories, and the relative share of gross farm production associated with each of those groups can be observed in Figure 12.

Utilising ABARE annual farm survey data from 1990 to 2009, the figures show firstly, changes in the proportion of broadacre farm businesses in each farm size category, bearing in mind that all farm income data for each of the years has been adjusted to 2008-09 dollars. It is evident from this graph that growth has occurred in the proportion of farms in the $400,000 and above gross income category, and the proportion of farms in the ‘less than $100,000 gross income category has decreased. The trend lines are somewhat erratic, because the number of farms that meet the different gross revenue thresholds each year changes with seasonal conditions and commodity prices.

Over the same period, the proportion of total gross farm output attributable to large-scale farms has increased substantially, rising from around 30% in 1990 to around 70% at present. This means the 20% of farms in the $400,000 + gross revenue category now account for 70% of gross production, while the 40% of broadacre farms in the $100,000 and less gross revenue category now account for just 6% of gross broadacre farm production.

Available statistics also highlight that there has been an increased reliance on off-farm wages, especially for small-scale broadacre farms which have gross output of less than $100,000. As displayed in Figure 12, on average broadacre farms businesses with less than $100,000 of annual farm output have steadily increased reliance on off-farm wages, to the extent that in some recent years, off-farm wages made up more than 100% of gross income, because the farm businesses actually incurred a cash loss.

As would be anticipated, larger farms rely less on off-farm wages, however the general trend for all except the largest farm businesses has been an increased reliance on off-farm wages. This statistic has large implications, because it identifies that over 40% of all farm businesses now rely on off-farm wages to sustain the farm business. The owners of these farm businesses will obviously have different motivations, and may not be seeking to maximise farm profit or increase productivity to the extent that a business operator fully reliant on farm income would. It means that ‘average’ industry statistics which include data arising from this group of farms may be very misleading. Farm owners in this group are on average probably working more hours per week off-farm than on-farm, which has implications for a broad range of rural policy issues, and especially in relation to rural extension services, and technology uptake and productivity growth rates.

While similar statistics are not routinely collected for non-broadacre rural businesses, anecdotal evidence is that, in particular the same situation would also apply for smaller-scale horticultural and nursery businesses, especially those located in close proximity to urban centres, and also to smaller-scale sugar farms.

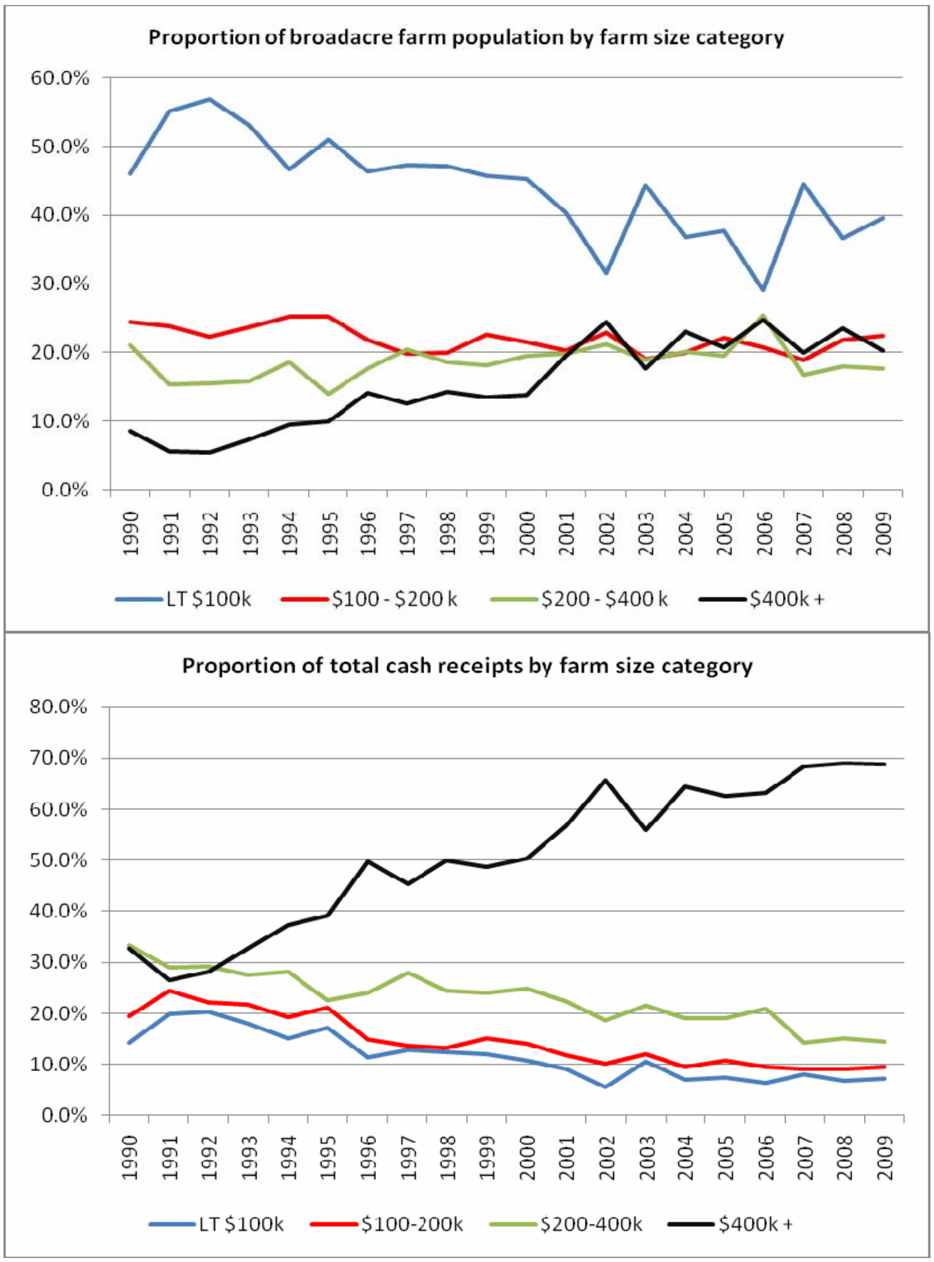


Figure 12 Changes in Australian broadacre farm populations since 1990

(Source: ABARE Agsurf database, 2010.)

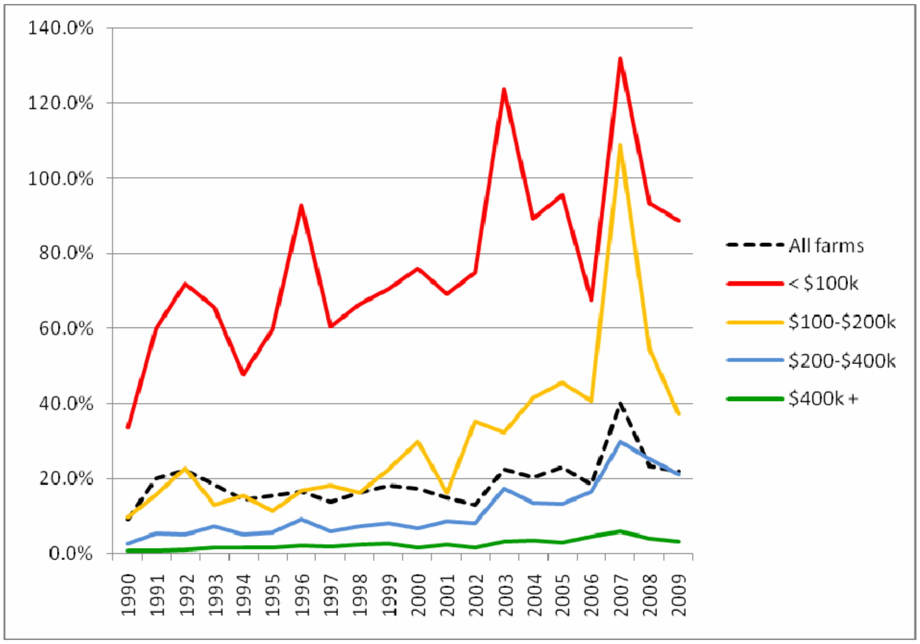


Figure 13 Off-farm wages as a percentage of total net cash income.

Total net cash income is equal to total farm cash income plus income from off-farm wages, minus total cash costs. Off-farm wages represents more than 100% of total net cash income in years when farm businesses incur a cash operating loss. *(Source: ABARE Agsurf database, 2010)*

Average rates of return on investment (as defined by ABARE) for farm businesses have typically been low, however there is a large degree of variation between enterprises and commodities. Average rates of return (inclusive of capital appreciation) fell dramatically with the cessation of the wool industry Reserve Price Scheme in 1991, and remained low for the balance of the 1990s. Rates of return recovered after 2000 with stronger commodity prices, although have since declined - probably as a result of the prolonged drought that has been experienced in some areas since 2003.

When disaggregated by farm turnover, it is apparent that rates of return for larger-scale farms have been much higher than those of small-scale farms, and that for much of the 2000's, returns for wheat and other grains have been higher than returns for livestock industries. This has changed in recent years and reported returns are generally comparable between commodities, although it would be expected that drought impacts would be greater on cropping enterprises than on livestock enterprises, and this may explain the relatively lower rates of return for crop enterprises over recent years.

The above rates or return data are aggregated for all farms within a particular category, but do not provide an accurate picture of the variation in rates of return for farm businesses within those groups. ABARE data, anecdotal evidence and information arising from farm benchmarking groups highlight that the leading 25% of farm businesses, for example, consistently generate returns on investments that are much higher than aggregate industry averages (Hooper et. al. 2002).

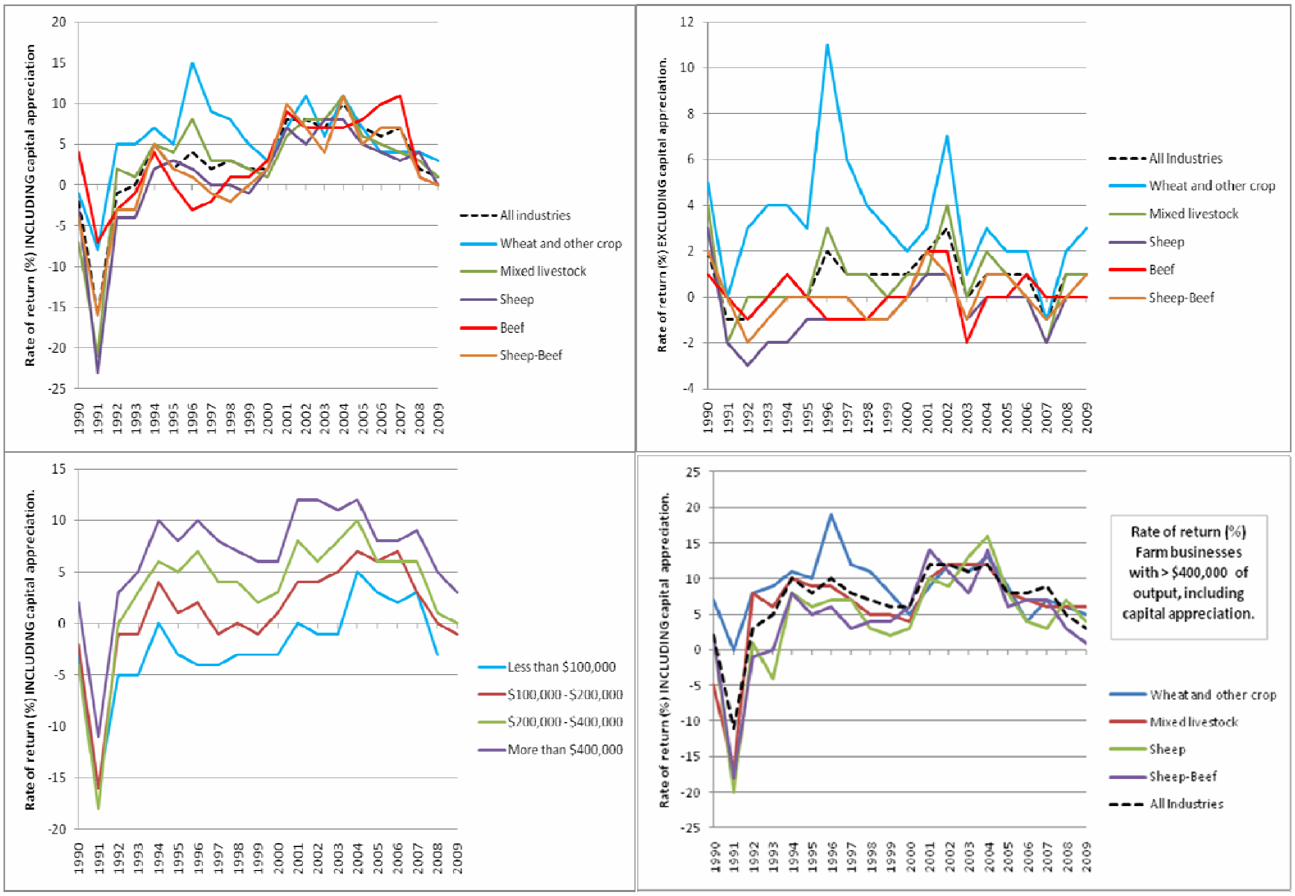


Figure 14 Average rates of return for broadacre farm enterprises, 1990 - 2009
(Source: ABARE Agsurf database, 2010.)

More detailed analysis of the structure of the Australian rural sector, and the changes that are occurring in the sector have been carried out over recent years. These include work by the Productivity Commission (*Trends in Australian Agriculture, Productivity Commission, 2005)*, by ABARE (*Agriculture in Australia; Past, Present, Future, ABARE 2006)*, by the Australian Farm Institute (*Australian Farm Sector Demography: Analysis of Current Trends and Future Farm Policy Implications, Australian Farm Institute, 2005)* and Land and Water Australia (*Australia's farmers: Past, Present and Future, Land and Water Australia, 2005)*. These all highlight different aspects of the sector, and provide a useful reference point in considering potential policy changes that will affect the sector.

2.6 Rural R&D policy implications.

A number of points emerge from the preceding brief analysis that are of importance in considering future arrangements for rural research and development in Australia.

The first is that businesses in the Australian rural sector are not homogenous in terms of scale, demography, enterprise mix and the geographic and climatic conditions under which they operate. It is also evident that businesses in the sector experience constant change, driven by a range of climatic and market factors. A consequence of this is that there cannot be a one-size-fits–all policy model available that can be applied across the entire rural sector with respect to research and development policy or structures.

A second point to emerge is that despite the relatively small proportion that the rural sector makes up of national GDP, the sector is quite significant in terms of its impact in regional economic activity, and in the manufacturing and service sectors. Food manufacturing, in particular, accounts for significant regional and urban employment and economic activity, yet is strongly dependent on agricultural production for inputs. The continuing competitiveness of these downstream sectors is dependent on the competitiveness of the rural sector.

The above data also highlights the volatility of rural sector output, which is linked to climatic and market volatility. The result is that rural businesses face a higher-level of business risk than businesses in most other sectors of the economy, and this has implications when it comes to investment in, or the adoption of new technologies, a process that often involves taking on additional business risk.

A further implication of the risk exposure of Australian rural businesses is the predominance of multiple-enterprise rather than single enterprise businesses. It is likely that multiple-enterprise businesses predominate because they provide added opportunity for risk management and complementarity, however this means that decision-making is more complex. A decision to adopt new technology or an innovation will have implications for all the enterprises on a farm – not just the specific enterprise the innovation is associated with.

An issue that the above analysis reinforces is that the Australian rural sector receives minimal levels of government support or trade protection, in comparison with the rural sectors of virtually all the nations (both developed and developing) with which Australian rural sector exports compete. This means that successful Australian rural businesses need to remain at the cutting-edge in terms of efficiency, and hence to maximise rates of productivity growth. Australian rural R&D policy should not be, and is not seen as a substitute for more direct farm support measures. However, the fact that Australian farmers are required to compete in distorted international markets for agricultural products has implications for research and development policy, in that it is even more critical that such policies work effectively in Australia than is the case for rural sectors in other, more protected nations.

Finally, there is evidence emerging that some of the long-term negative price trends that the rural sector in Australia has experienced over the last fifty years may be changing. International commentators believe accelerating global demand, driven by population growth, dietary changes and biofuel refining, will create increased market opportunities for rural exporters in the future. This creates the potential for increased growth in rural exports, but also makes likely the growth of international demand for associated rural service industries as international governments and private investors move to expand rural production.

These all have implications for the design of a rural R&D system to service the sector. Firstly, the scale of the industry and its economic significance means that it is important for national wealth generation that the rural sector remains competitive, and continues to be successful in securing export markets. This requires continued and strong investment in R&D, which is widely recognised as an important component of industry innovation systems and productivity growth.

However, national innovation policy measures that governments have adopted more generally to incentivize R&D and innovation are not accessible to the vast majority of rural businesses, because they are too small in scale. In addition, even if rural businesses had sufficient resources available to be able to justify direct R&D investment of the scale required, the ability of an individual rural business to capture most of the benefits of successful R&D investment is quite limited, particularly over time, because of the large spillovers inevitably associated with rural innovation.

As a consequence, underinvestment in rural R&D will almost certainly arise in the absence of government intervention, and the community will also be at a disadvantage, as public-good spillovers are an important outcome of successful R&D investment. This rationale is accepted by governments in relation to the general economy, and is the reasons that governments have adopted specific policy measures that create incentives for greater investment in R&D, even for those sectors of the economy that are dominated by very large scale businesses.

The ability of Governments to successfully directly intervene in rural R&D is, however, limited by the diversity and dynamism that is present within the rural sector. For example, one alternative for intervention in rural R&D could be the creation of a single rural research and development agency, operating within the Department of Agriculture, Fisheries and Forestry. This single agency would be required to manage R&D portfolios on behalf of a wide variety of different commodity sectors, but would invariably be constrained to a standardised model of operation for all those sectors. In order to successfully meet sector needs, the personnel working in the agency would need to gain a specialised knowledge of the particular commodity sector they interacted with, but this would be unlikely to occur due to the relatively high staff turnover rates and non-specialisation that is a feature of the Commonwealth public service. It is not conceivable that a single government agency would be able to secure the strong identification and engagement with rural producers that is currently the case for RDCs. It is also inevitable that an agency such as this would become subject to political interference, which would result in an inevitable reduction in effectiveness and efficiency. In addition, it is likely that bureaucratic processes would constrain the ability of the agency to respond to strategic industry changes, or to manage intellectual property issues in a manner that met the needs of potential private sector investors.

There is general acceptance by rural producers that collective investment in R&D will bring benefits to businesses, and therefore a willingness to share the cost of R&D. However, it is doubtful if industry participants would be willing to simply contribute funds to a monolithic industry R&D structure, over which they have little or no control, and which would inevitably be seen as just another arm of government.

Rural R&D corporations therefore provide a good model whereby industry and governments share in the cost of R&D, and also the benefits. Industry interaction with, and ultimately control over the resources available to R&D corporations (through levy votes) means the system is responsive to industry needs, and delivers research outcomes in a professional manner that benefits all industry participants, as well as the wider community. RDCs are able to attract and retain staff with specialist knowledge and experience in rural industries, and implement communication and extension strategies that vary depending on the nature of the sector they serve.

It is difficult to envisage an alternate model that could achieve the same outcomes with the same or increased industry engagement and ownership.

3. Economic and policy rationale for Australian Government rural R&D investment.

There are a number of different policy rationales advanced in support of government intervention to encourage R&D in the economy, not just in the rural sector. These have been canvassed in detail by Governments over many years, and were most recently re-examined by the Cutler Review (Cutler 2008), initiated by the Australian government. That review revisited the case for government intervention to increase investment in R&D (in all sectors of the economy), and concluded that such policies remain as valid at present as they have been in the past. As the review report noted;

The case (for government intervention) *rests largely on those properties of information and ideas which are central to all forms of innovation.*

- *Knowledge is non-rival. An idea, unlike a consumer good or service, has to be produced only once and it can then be used many times without detracting from its value.*
- *Knowledge is cumulative. The current stock of knowledge provides the fertile ground from which further research develops new knowledge.*
- *Knowledge is reproducible at negligible cost. With recent developments of computer and communication technologies, digitised knowledge can be reproduced and transmitted at close to zero cost.*
- *Knowledge is only partially excludable. Inspection of patent applications and reverse engineering can reveal most of the information in product innovations.*
- *Knowledge is an intangible asset. It is not a tangible asset that can be recovered by an investor in the way that a building or a machine can be recovered.*
- *The generation of new knowledge involves fundamental uncertainty. Most investments involve risk which is quantifiable, but by definition the generation of new knowledge takes us beyond what we know and can quantify into the area which economists refer to as irreducible uncertainty.*

In combination, these factor dictate that private businesses will under-invest in R&D, because of the high risk involved, and the difficulty private businesses face in attempting to capture the benefits of successful R&D investment. The review concluded "*the case is strong for public intervention to provide support for the development of innovative capacity and to aid the diffusion of innovations."* Innovation, in turn, leads to increased productivity and the generation of greater wealth for members of the community.

In responding to the review, the Australian government (Carr 2009) expressed strong support for Government intervention to increase the level of Australian investment in R&D. The Minister noted;

> *Australia's recent innovation performance has been uneven, and we have failed to keep pace with the rest of the world. In the last eight years, Australia has slipped from fifth to eighteenth in the World Economic Forum's Global Competitiveness Index. Our multi-factor productivity grew 1.4 per cent a year on average between 1982–83 and 1995–96. Growth has averaged only 0.9 per cent a year since then, which is no better than we achieved in the 1960s. Since 2003–04, our productivity has actually declined.*
>
> *The reasons for this are not hard to find. Commonwealth spending on science and innovation has fallen 22 per cent as a share of GDP since 1993–94. Business spending on research and*

> *development collapsed in the late 1990s, and while it has grown since then, we still lag many of the countries we compete with. The proportion of Australian firms introducing innovations has been stuck at one in three for years. A decade of policy neglect has hurt Australia's innovation performance, making us less productive and competitive, and reducing our ability to meet the needs and aspirations of Australian families and communities.*

The response by the Government to the Cutler review has reaffirmed Australian Government R&D policies that have been in place since the mid 1980s. Australian government intervention in national R&D has involved three broad approaches. The first is the direct funding of scientific research through organisations such as the CSIRO. The second is through the provision of tax concessions to large businesses investing in R&D. The third is via joint government and industry investment in rural R&D, a policy implemented in recognition of the marked differences between the rural sector and other sectors of the economy.

While government science agencies such as the CSIRO have existed for over fifty years, the tax and rural R&D policies have their genesis in the mid to late 1980s when it was recognised that Australia's future prosperity would depend on increased national competitiveness. The R&D tax concession was introduced by Minister John Button in 1985, and the Primary Industries and Energy Research and Development Act which established rural research and development corporations was introduced by Minister John Kerin in 1989. While there have been some changes to these policies over the intervening years (most notably to the R&D tax concession arrangements) these policies which provide incentives for eligible R&D investment have formed the mainstay of Australian government efforts to stimulate R&D investment, and thereby to achieve increased innovation and national productivity growth.

The industry R&D Tax Concession (which has essentially been accessible to large private-sector organisations) and the rural RDC arrangements (whereby the Australian government matches rural industry funding up to 0.5% of the gross value of production (GVP)) are broadly similar in terms of the level of financial incentive they provide for businesses (either collectively in the case of the rural sector, or individually in the case of other sectors) to invest in R&D.

The industry R&D Tax Concession (which will be modified and become a Tax Credit scheme in 2011) is essentially targeted at large businesses, with the 7,754 companies registering for the concession in 2007-08 collectively spending $14.2 billion on eligible R&D investment at an average of $1.83 million per company. (Australian Government, 2010) According to the Government, the Tax Credit Scheme to be introduced in mid-2010 will provide even more generous R&D incentives, with the proposed measures providing the equivalent of up to a 150% tax concession for eligible R&D expenditure. This concession is accessible to any Australian businesses undertaking eligible R&D activities. There is no requirement to demonstrate that there will be public good arising from the R&D, nor is there a requirement to comply with national research priorities, or to seek Ministerial approval before embarking on the R&D.

As the earlier data on the structure of the rural sector highlighted, few rural sector businesses are of sufficient scale to be able to invest in R&D, let alone at the level of investment that would make it viable for them to seek access to the R&D tax concession.

Total Australian government support (either as outlays or as revenue foregone through the R&D tax concession) for R&D was estimated to be $7.2 billion in 2008-09 (Australian Government, 2010), of which $2 billion was for the Higher Education sector, $1.7 billion was for government science agencies, $1.4 billion was for the industry R&D tax concession, and approximately $238 million was expenditure on rural RDCs or other rural-related research facilities.

3.1 Key rationale in support of public rural R&D investment.

For Australia's rural sector, which is dominated by small businesses which operate in volatile markets and which face a relatively high levels of risk and low levels of profitability compared to businesses in other sectors of the economy, there are perhaps six main factors that require consideration in R&D policy formulation aimed at increasing innovation and productivity in the sector.

1. **Individual rural businesses cannot capture most of the benefits associated with successful rural R&D investment, meaning aggregate sector investment in R&D will be low, reducing regional and national economic wealth unless strong incentives are provided or government investment occurs.**

As is evident from earlier analysis, the rural sector in Australia consists primarily of small businesses. The average total cash receipts for all broadacre farms with output in excess of $40,000 per annum in 2009 was $336,600, and less than 5% of all businesses had gross output in excess of $1 million. Given the relatively low rates of return of these businesses, and the fact that it is difficult to capture (through intellectual property ownership or branding) the benefits of successful research in rural industries (even if it could be sustained financially by a farm business), there is little or no realistic opportunity for most of these businesses to invest in R&D to the extent and for the length of time that it would normally require to generate outcomes that would make the investment profitable for the individual business. This applies in particular to more basic research, but given costs and timeframes involved, even to research associated with near-commercial innovations.

Rather than individual farm businesses, however, it might be anticipated that rural service organisations such as chemical or fertiliser manufacturers, plant or animal breeding companies or machinery and equipment manufacturers would conduct R&D, and subsequently market the resulting technology to generate a return on that investment. However, much R&D in rural industries is directed at issues which, even if the R&D is successful, it is quite difficult if not impossible to secure ownership of rights to, and to be able to subsequently protect those rights. In addition, the biological processes which are the subject of much research are highly complex and often involve the human food chain, which necessitates comprehensive and expensive compliance and food safety testing before products can be released.

An added disincentive for investment in agricultural R&D in Australia arises as a consequence of the export-oriented nature of the sector and the relatively small scale of the sector in global terms (as noted earlier). Australian agricultural products are marketed into a wide range of international markets, all of which have specific biosecurity and food safety compliance requirements for imported products. Even if a novel chemical, for example, was developed through unique Australian R&D, the developer would need to obtain widespread international registration for its use, at costs that are reported to run into hundreds of millions of dollars per product, before it could be marketed to Australian rural producers for use on products destined for export.

These factors in combination create major disincentives for even large organisations to invest in rural R&D in Australia, except in specific areas where robust intellectual property rights can be secured. Such situations may include the development of specific plant varieties, or local applications for agricultural chemicals that have been developed internationally. Even in these cases, a large amount of investment in applied R&D will be required to understand the performance of the variety or product under different climatic and geographical situations before it is released, even in a relatively small market like Australia.

A relevant example in this regard is the development of GM cotton varieties in Australia. Even though the original genetic traits were developed internationally by Monsanto, extensive research had to be conducted by the CSIRO in Australia in order to integrate those traits into cotton varieties that were suited to Australian conditions. In the absence of this public investment, GM cotton varieties almost certainly would not have been released in Australia.

It is noteworthy that even in the case of other sectors of the economy (such as mining and manufacturing) where much larger businesses are involved and where R&D would be directed at processes and technologies for which intellectual property rights capture would appear to be more straightforward, the government maintains substantial incentives for firms to undertake R&D, because of the benefits innovation and productivity growth bring to the wider economy.

In the case of agriculture, the processes being researched are largely biological, are difficult to secure intellectual property rights over, and many of the inputs into production systems are highly variable and subject to constant change. This dictates that there is an even greater need to provide incentives or to support R&D than is the case in the rest of the economy.

2. **There are multiple positive public good spillovers arising from successful agricultural research and development, which cannot be captured by individuals or the sector, and which provide social and environmental benefits both within Australia and internationally.**

An important aspect of rural sector innovation and productivity growth that has long been recognised is the associated public-good spillovers that are frequently generated. At a very simple level, this is evidenced by the fact that the volume of national agricultural output has grown by an average of 6% per year over the past fifty years, while the area of land used for agriculture has shrunk by 16% over the same period. This means that the Australian community has been able to set aside some 83 million hectares of land for conservation purposes, while still enjoying the economic benefits generated by a growing rural sector.

The examples of spillover public-good benefits arising from successful rural innovation are numerous, and often much more complex than just being able to retire land for conservation purposes. A relevant example in this regard is the introduction of GM cotton varieties during the 1990s. Prior to the introduction of GM cotton varieties, the cotton industry needed to use large amounts of pesticides to control insect pests in crops. It was not uncommon for a single cotton crop to be sprayed up to 15 times during a growing season. Despite the best efforts of the industry, this heavy use of pesticides had negative impacts on human health in the communities associated with the industry, and also resulted in pesticide residues in waterways, and in other agricultural products produced in the region. A result was a number of incidents of contamination of beef with chlorflurazuron and endosulfan, which resulted in the temporary closure of export markets with a major negative economic impact on the rural sector during the 1990s.

The subsequent development of GM cotton varieties has resulted in an up to 80% reduction in pesticide use in cotton production (CSIRO, 2010), a dramatic reduction in pesticide residues in cotton catchment waterways, and a virtual cessation of incidents of communities being affected by spray drift. In addition, the Australian beef industry has been able to consolidate its position as a preferred supplier of safe and natural product to the highly discerning Japanese and Korean beef industries. At the same time, the cotton industry has been able to continue to generate strong economic benefits for regional NSW and Queensland, as well as generating important export earnings.

A similar example exists in respect of the adoption of minimum tillage in the broadacre cropping sector in Australia. From virtually no use of minimum tillage in 1980 (D'Emden et al 2006) to almost 70% use for broadacre cropping in 2008 (ABS Statistics publication No. 4627.0, 2009) the adoption of minimum tillage in Australian crop production has produced multiple industry and community benefits. The industry benefits include a significant reduction in fuel use and machinery costs (Sijtsma et al 1998), an increase in crop planting flexibility, soil fertility and condition benefits (Tullberg et al 2003), (Rahman et al 2007), an increase in yields per millimetre of growing season rainfall, and the ability to better integrate cropping and pasture rotations. From a community perspective, the advantages include reduced water and wind erosion (Silburn et al 2007), leading to reduced siltation of waterways, and reduced runoff into environmental assets such as the Great Barrier Reef or major inland waterways.

Public good spillovers from rural research

Recently released research (Burney, Davis and Lobell, 2010) has highlighted the very important public good spillovers that frequently arise from successful agricultural R&D. The researchers examined changes in crop yields over the last forty years, and the implications of those changes for greenhouse gas emissions from agriculture. Their conclusion was that the increased intensification of crop production (via increased yields) has delivered a major benefit in the form of reduced greenhouse gas emissions. The Executive Summary of the research stated;

As efforts to mitigate climate change increase, there is a need to identify cost-effective ways to avoid emissions of greenhouse gases (GHGs). Agriculture is rightly recognized as a source of considerable emissions, with concomitant opportunities for mitigation. Although future agricultural productivity is critical, as it will shape emissions from conversion of native landscapes to food and biofuel crops, investment in agricultural research is rarely mentioned as a mitigation strategy. Here we estimate the net effect on GHG emissions of historical agricultural intensification between 1961 and 2005. We find that while emissions from factors such as fertilizer production and application have increased, the net effect of higher yields has avoided emissions of up to 161 gigatons of carbon (GtC) (590 GtCO2e) since 1961. We estimate that each dollar invested in agricultural yields has resulted in 68 fewer kgC (249 kgCO2e) emissions relative to 1961 technology ($14.74/tC, or $4/tCO2e), avoiding 3.6 GtC (13.1 GtCO2e) per year. Our analysis indicates that investment in yield improvements compares favorably with other commonly proposed mitigation strategies. Further yield improvements should therefore be prominent among efforts to reduce future GHG emissions.

In concluding, the researchers argued that research to increase crop yields will deliver very important public benefits. Their concluding comments were;

The global population is expected to reach 8.9 billion by 2050, with food demand expected to rise by 70%. Even if yield gains over the next four decades are smaller than those of the previous four decades, the potential to avoid future emissions may be larger and more cost-effective than the 161 GtC of emissions avoided thus far, given that current cropland expansion often occurs in tropical forests and that the remaining forests are carbon-rich relative to many cleared forests. Improvement of crop yields should therefore be prominent among a portfolio of strategies to reduce global greenhouse gas emissions.

There are a large number of other examples available in virtually all sub-sectors of rural industries where successful R&D resulting in productivity growth has also created significant public good spillovers, ranging from more nutritious and higher quality products, through to improved human health, reduced and less dangerous pesticide residues, more efficient water utilisation, better standards of animal welfare, reduced smell and dust, and reduced water contamination. In addition, enhanced agricultural productivity is undoubtedly part of the reason that 50,200 Australian farmers were able to report that by 2007-08 they had set aside a total of 9.1 million hectares of farm land for conservation purposes. (ABS Statistical publication 4627.0, 2009).

An important issue in relation to these public good spillovers is that in the main they cannot be achieved in isolation from the industry benefit arising from the successful application of an R&D outcome or series of R&D outcomes. They are a consequence of successful innovation and the resulting productivity growth, but it is difficult if not impossible to predict the full extent of these spillovers in advance, or to attempt to achieve them in isolation.

This is because while R&D by its very nature targets a very specific and controlled aspect of a rural production system and tests the effect of a particular change, it is not always a straightforward process to simply adopt this change into a complex farming system.

Farming systems, by their very nature, involve the management of numerous interactions between biological processes and the environment. Changing one part of a system often has consequences for other parts of the system, and farm business managers need to make decisions about potential innovations against a background of constantly changing market, climatic and policy settings.

As a simple example, the adoption of minimum tillage systems which involve the utilisation of herbicides to kill in-crop weeds can also result in a post-harvest stubble that contains less herbage for grazing livestock, and results in added pasture re-establishment costs at the end of a cropping phase. For a farm business that relies heavily on livestock income, this may be a disadvantage that would discourage the adoption of a minimum tillage system, whereas pasture re-establishment may not be a consideration for a cropping specialist. A livestock specialist may also delay changing to minimum tillage because the benefits may not justify the added capital costs associated with purchasing new tillage equipment that will only be used to crop a small area each year. A specialist cropping enterprise, on the other hand, may find that a quick change to minimum tillage is justified.

This uncertainty in both the timing and the nature of adoption of successful R&D outcomes means that an undue emphasis on the pursuit of spillover benefits – either in selecting specific projects for research funding, or in developing overall rural R&D policies, is likely to produce poor outcomes from a rural productivity perspective. This, in turn, will mean that the projected public-good spillover benefits will not be realised, because they are dependent on the adoption of an innovation and not something that can be obtained in isolation.

It is noteworthy that the achievement of public-good spillover benefits is not a precondition of the R&D incentive that is provided to the non-rural sector, in the form of the R&D tax concession. This is sensible policy, and leaves businesses free to make their own choices about the R&D that has the best potential to enhance their productivity and competitiveness. There is no strong argument why decision-making at a sub-sector level for rural R&D investment should be any differently constrained or directed.

3. Risks and time-lags associated with R&D investment make such investment unviable for many businesses.

Rural R&D investment invariably involves a high level of risk, in comparison with other investments that may be available for a rural service provider or a rural business. There are also typically extended time-lags between a novel discovery, its development to a commercial stage, and its subsequent adoption in rural production and the generation of a return on the R&D investment.

Various estimates have been made of the time function associated with successful rural R&D, although most of these consider adoption rates, and do not encompass the full length of the cycle from basic research to commercialisation and adoption. Research into the time-lags and risks associated with rural R&D has been carried out by US researchers, using the rich supply of data available from rural research activities over many decades in the USA. One group of US researchers noted;

> "*Many researchers underestimate the time lags between initial research investment and ultimate economic impacts. Research takes a long time to affect production, and then it affects production for a long time. The dynamic structure linking research spending and productivity involves a confluence of processes—including the creation and destruction of knowledge stocks and the adoption and disadoption of innovations over space and time—each of which has its own complex dynamics. That science is a cumulative process, in which today's new ideas are derived from the accumulated stock of past ideas, influences the nature of the research-productivity relationship as well. It makes the creation of knowledge unlike other production processes."*(Alston, Pardy and Ruttan, 2008)

The history of the development of genetically modified Bt crop varieties provides a relevant example. The *Bacillus thuringiensis* (Bt) bacterium was initially discovered in 1901, and by 1938 it was being used by European farmers as an insect sprays in crops, and was field tested as an insect spray in the USA in 1958. By the 1980s, commercial interest in Bt grew as alternatives to synthetic pesticides were sought. The use of Bt toxin genes in genetically modified plants for pest control became an established field of research in the mid-1980s. From the mid-1990s, plants genetically modified to express the Bt toxin have become increasingly common, and are now grown widely in the USA and other countries (MAF, 2002). The first genetically modified crop grown in Australia used the BT gene and was planted in 1996. Since that time, its use has expanded to the extent that GM cotton varieties containing the Bt gene now account for 90% of the cotton grown in Australia. It is important to note that the GM cotton varieties grown in Australia arose as a result of a partnership between the CSIRO and Monsanto, and utilised cotton varieties that had been developed by the CSIRO for Australian conditions. This brief history highlights the extended timeframes and the accumulation of knowledge stocks over time that is a critical element of rural innovation.

A stylized representation of the investment timeframe associated with successful rural R&D is shown in figure 17. It highlights that there may be a lag of fifteen years before R&D investment starts to generate a positive cashflow, although some researchers suggest that the time-lags can be much greater. Some Australian research into this question suggests a 35 year timeframe might be a more appropriate model.

The adoption rates of new wheat varieties in NSW (Fig 16) provide some support for this, especially as the graph only depicts adoption rates, and not the time period over which investment occurred prior to the release of the particular variety. It would be anticipated there might be 5-10 years of variety development and trials, prior to a variety being released.

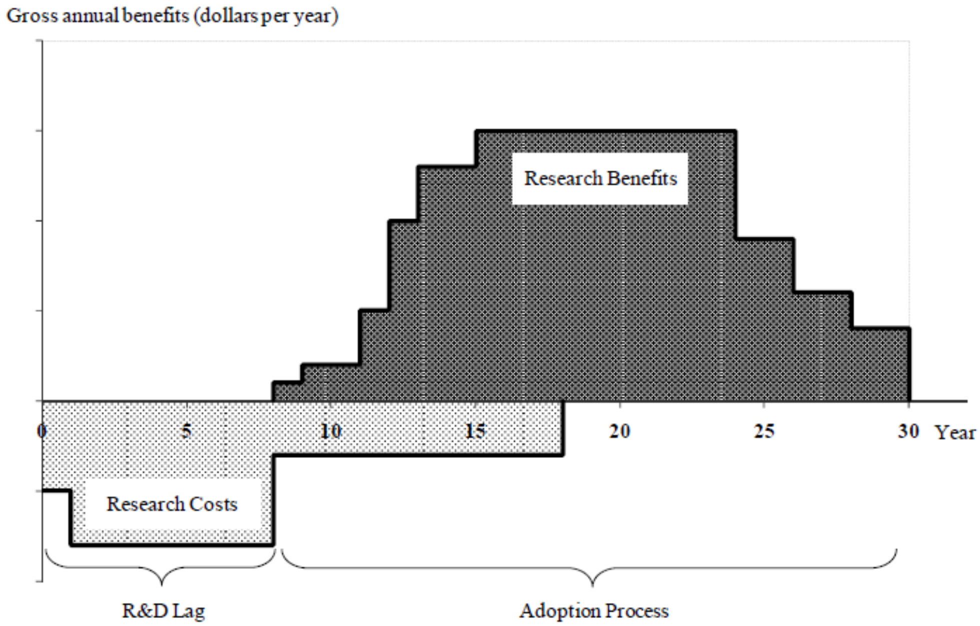


Figure 15 Stylised depiction of time-lags associated with rural R&D investment

(Source: Alston, Pardy and Ruttan, 2008)

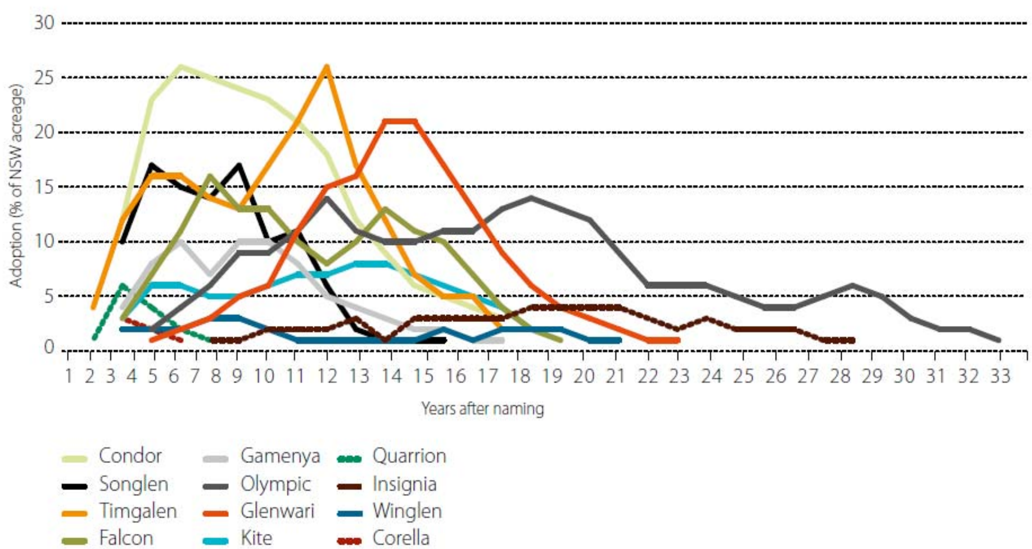


Figure 16 Adoption rates for wheat varieties in NSW

(Source: ABARE 2009b, citing Fitzsimmons, 1991)

While the stylized (and actual) depictions investment timeframes and time-lags associated with rural R&D investment are useful in understanding the challenges investors face, they do not provide a picture of the risks associated with rural R&D investment. Investment in R&D by its very nature is highly speculative, and that is one of the main reasons governments provide incentives for such investments. Risks include not only that the specific technology will be unsuccessful, but there are also a range of regulatory risks associated with issues such as biosecurity and food safety that need to be considered. Sovereign risk is also an issue, with investors in GM crop technology in Australia over recent decades having discovered, for example, that State governments have a tendency to implement regulations on the use of specific technologies without warning, and for indefinite periods. There is also risk associated with the non-uniform production systems and environmental variations associated with production areas. As has been noted;

> *The atomistic structure of much of agriculture means that the attenuation of incentives to innovate is more pronounced than in other industries that are more concentrated in their industrial structure. On the other hand, unlike most innovations in manufacturing, food processing, or transportation, agricultural technology has a degree of site specificity because of the biological nature of agricultural production, in which appropriate technologies vary with changes in climate, soil types, topography, latitude, altitude, and distance from markets. The site-specific aspect circumscribes the potential for knowledge spillovers and the associated market failures that are exacerbated by the small-scale, competitive, atomistic industrial structure of agriculture.* (Alston, Pardy and Ruttan, 2008)

For small businesses operating on narrow margins, or even for large businesses operating in a globally-small market such as Australia, the risks and time-lags associated with R&D investment are undoubtedly a major disincentive, and mean that there will be under-investment in rural R&D in the absence of strong incentives.

4. **Some rural R&D investment is associated with the resolution of large-scale natural resource challenges, which would not be resolved without such investment, but which produce limited direct rural industry benefit.**

Over recent decades, in addition to R&D investment into very specific aspects of agricultural production systems, there has been concerted research efforts associated with cross-sectoral industry issues, arising from which there is little or no incentive for R&D investment at either the firm or the commodity sector level. Examples of issues for which major sector-wide research efforts have been mounted include water quality and dryland salinity, vegetation and biodiversity conservation, water use in agriculture, the impact of climate change on agriculture, and mitigation of agricultural greenhouse gas emissions.

Typically, each of these programs has involved the allocation of major new funding by the Commonwealth government, by the Commonwealth and State governments in partnership, or by both levels of government and industry (via resources allocated by RDCs).

These are all issues that have the potential to have a significant impact on rural sector productivity over the longer-term, but which require large research investments over an extended period, with much of the research effort directed at collecting basic information and monitoring long-term trends.

It is arguable that R&D investment into these issues should be the sole responsibility of Commonwealth and State governments, given the broad community benefit that will potentially arise from the research. There is also a danger that diversion of industry R&D investments to these issues will mean that industries have reduced resources available to invest in productivity-enhancing research, and that the result will be an effective reduction in rural R&D investment, with a consequent slowing in rural productivity growth.

It is noteworthy that despite the very important R&D investment incentives provided to businesses in other sectors of the economy by broad government R&D tax concessions, there is no similar requirement to contribute to R&D into these large, long-term public good issues imposed on businesses taking advantage of those tax concessions.

At the very least, the requirement that is placed on rural RDCs to invest in these initiatives (a requirement that appears to be increasing as State Governments progressively reduce funding for rural research and development at the State level) provides a strong justification for public funding of RDCs.

5. **Australia's engagement in global markets necessitates considerable 'compliance' R&D investment to ensure Australian produce retains international market access.**

The recent Beale Inquiry into Australia's biosecurity systems and the subsequent response by the Commonwealth government has again reinforced that biosecurity is an issue that incorporates both industry and public good. As the report arising from that inquiry noted;

> *The task of managing Australia's complex biosecurity regime has never been easy. In recent years, it has become even more challenging, principally for the following reasons:*
>
> - *globalisation, which is integrating the world economy and increasing the volume and range of products traded internationally;*
> - *population spread into new habitats and increasingly intensive agriculture, which increases the risk of zoonoses (that is, animal diseases capable of transmission to human populations) and complicates the ability to contain, and increases the impact of, a pest or disease incursion;*
> - *growth in tourism, passenger and cargo movements, which increases the risks of exotic pest and disease incursions despite the best efforts of border security;*
> - *the potential risk of agri-terrorism involving animal rights extremists or political terrorist organisations;*
> - *increasing global movements of genetic material as farmers endeavour to increase productivity, which places particular demands on pre- and post-border biosecurity services;*
> - *climate change, which adds to the spread of pests and diseases (expanding range or habitats, changing migratory bird patterns, and weather events supporting the spread of disease vectors);*
> - *an emerging shortage of highly qualified plant and animal pest and disease professionals—partly associated with 'baby boomer' retirements and partly the result of competing career alternatives;*
> - *physical constraints for border interception activities, especially at major passenger airports; and*
> - *financial constraints, as governments allocate scarce revenue among many competing demands.*

In responding, the Australian government acknowledged that Australia depends on trade, and this brings with it unavoidable risks. The government acknowledged that managing these risks, and managing the possible outbreak of a pest or disease is becoming more challenging, due to factors such as climate change, intensification of agriculture and urbanisation.

R&D investment into agricultural diseases and pests is important in maintaining Australia's biosecurity status for agricultural trade purposes, but also to minimise the risk of pests or disease imposing a major economic cost on the nation (as was experienced with outbreaks of Newcastle disease in the poultry industry from 1999 to 2002) and as would be the case in the event that a major outbreak of Avian Influenza.

Given the significant public good associated with maintaining international market access for Australian agricultural products, and the associated public good associated with Australia's high biosecurity status, a strong argument exists for continued public funding to be made available for R&D in support of these two areas.

6. **The maintenance of core R&D infrastructure and personnel provides a 'fire brigade' which can be activated in the event of biosecurity and other disease challenges, and which also provides the basis of a rural services export industry.**

In earlier times, Australian State Governments maintained a strong agricultural research and extension capability through State Departments of Agriculture or Primary Industries. Not only did the staff within these agencies provide a direct service to rural industries, but these Departments also served as an important training-ground for agricultural science, veterinarian and agricultural economics graduates. Subsequent to their periods with State Governments, many of these personnel moved on to roles in the private sector as service providers and advisors to rural businesses.

The progressive reduction in resources provided by State governments to these agencies has meant that there is a greater reliance by them on project funding provided by the RDCs to maintain staff positions and research facilities.

The supply of skilled and qualified rural industry personnel is important not only to maintain rural productivity, but also because those personnel form the basis of an export services sector for overseas nations seeking to improve their agricultural performance. Just as the success of the Australian mining industry has spawned a rapidly growing mining services export sector, so Australia appears to have an opportunity to develop a much stronger rural services export sector. Such exports bring important national economic and diplomatic benefits and also help to maintain a well-trained professional workforce to service the rural sector and to respond in the event of major disease or other natural disasters. There is a strong argument to support public funding allocations to rural R&D corporations for this purpose.

3.2 Policy implications.

The preceding six issues provide a very strong justification for public investment in rural R&D. This is by no means an exhaustive list, as it deals only with the benefits that accrue to the community or to industry, and does not include the role that spillovers from Australian rural R&D play in international agricultural productivity growth, which is of major importance in hunger and poverty alleviation internationally.

Perhaps the most important issue in relation to rural R&D investment is the spillovers that arise, and which cannot be captured by an individual or an organisation in isolation. The size of the spillovers, and the eventual wide distribution of benefits to industry and the community over time make underinvestment in rural R&D inevitable, in the absence of public intervention. While measures such as Intellectual Property Rights (IPRs) and Plant Variety Rights (PVRs) and international agreements on trade in IPRs have created some opportunity for private benefit capture, this is not the case for outcomes associated with a broad range of rural R&D activities. This applies in particular to those associated with natural resource management, and therefore the argument in favour of continued Government intervention and public investment remains very strong.

4. The respective roles of the public and the private sector in rural R&D in Australia.

The key to understanding the respective roles of the public and private sectors in rural R&D in Australia is to understand the sources of investment in rural R&D, although unfortunately, this is not a simple task.

Some caution is needed in relation to the available data, published by the ABS. The published data segregates R&D expenditure by field of research, and by socio-economic outcome. The "Field of Research" (FOR) categorisation essentially disaggregates data based on the type of research being carried out, whereas the "Socio-economic Outcome" (SEO) categorisation is based on the outcome the research is attempting to achieve. For the purposes of rural-sector R&D, the appropriate Field of Research categorisation is "Agriculture, veterinary and environmental sciences". Alternatively, if relying on Socio-economic Outcome categorisation, the appropriate categories are "Plant production and plant primary products", and "Animal production and animal primary products".

It is also important to understand that the categorisation of research under either of these two (SEO or FAR) depends on the survey respondent, so there is a degree of subjectivity in the assessment.

However, the most significant aspect of this data is that it does not provide information about the source of funding for research. It simply provides an indication of the value of rural R&D that is performed by each sector each year. Public-sector expenditure on rural R&D may arise due to funding provided by the private-sector or rural R&D corporations, and private sector expenditure may arise due to public sector co-investment. The data is therefore not suitable as a means of determining how much the public or private-sectors currently invest in rural R&D, nor whether the private sector is increasing or decreasing investment in rural R&D, relative to other sectors.

There have been various estimates made of the total annual investment in rural R&D in Australia. Most recently, ABARE (ABARE 2009b) and Core (Core 2009) have estimated that total expenditure was approximately $1.7 billion in 2006-07. This figure is based on ABS data (ABS Statistical publication 8112.0, 2008), and is the ABS estimate for total expenditure on R&D in agriculture, veterinary and environmental science, based on the "Field of Research" categorisation. It includes investment by the private, public and higher education sectors. Up to and including 1998-99, this data series published by the ABS only included expenditure on R&D classified as "Agricultural science". From 2001, the category was expanded to include veterinary and environmental science. This change coincided with a 19% increase in estimated R&D expenditure, although it is not possible to discern from the ABS data, nor has the ABS estimated how much of this increase was due to the changed categorisation, rather than an actual increase in expenditure.

Alternatively, using Socio-economic outcome (SEO) categorisation, the total value of annual rural R&D carried out (plant production and plant primary products, and animal production and animal primary products) was $1,184 million in 2006-7, having increased from $726 million in 1992-3. Of this, The Commonwealth and State governments accounted for $643 million in 2006-07. This estimate is substantially lower than the FOR estimates by the ABS referred to earlier.

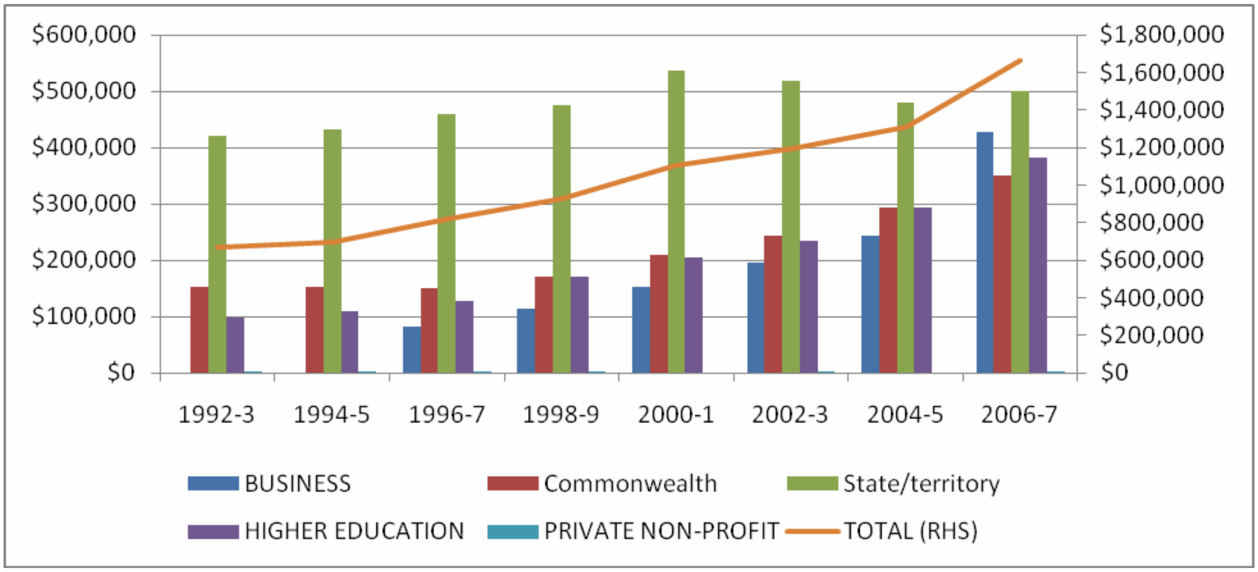


Figure 17 Expenditure on agricultural, veterinary and environmental sciences R&D.
(Source: ABS Statistical publication 8112.0)

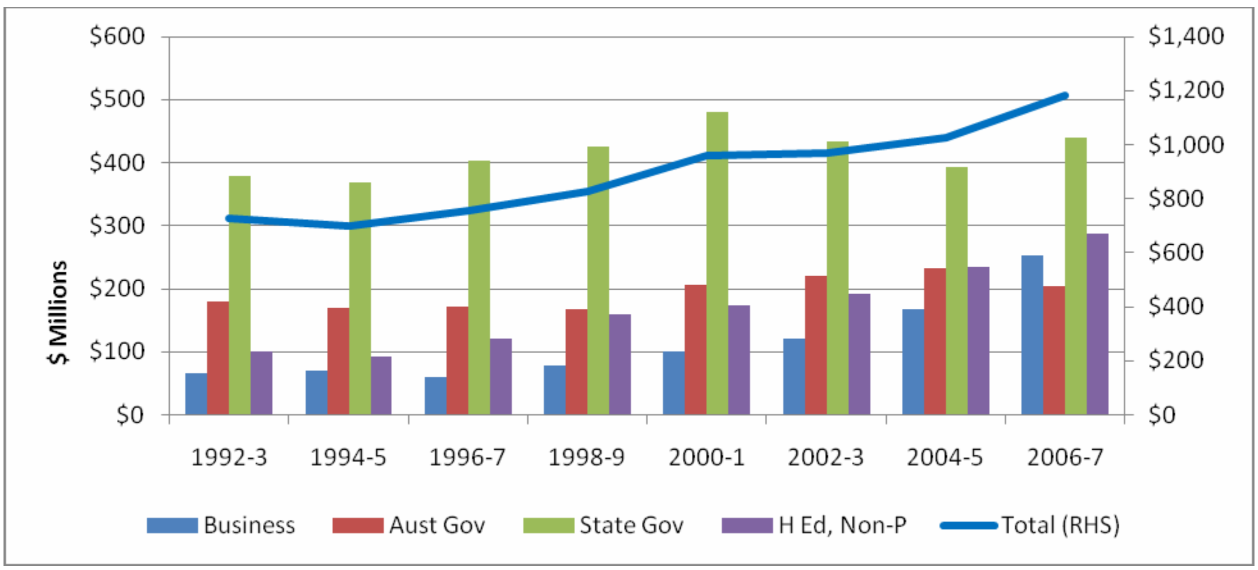


Figure 18 Expenditure on plant and animal production R&D.
(Source: ABS Statistical publication 8112.0)

There are several reasons to believe the SEO categorisation represents the more accurate estimate of expenditure on productivity-enhancing rural R&D. Firstly, respondents are required to use the SEO categorisation to describe what the R&D is aiming to achieve, as distinct from the particular science being used for the research which is the subject of the FOR categorisation. As a simple example, a researcher using veterinary science to test the effect of human cosmetic products on the skin of an animal would, under the FOR categorisation, include this R&D expenditure in the agriculture, veterinary and environmental sciences category. However, under the SEO categorisation, this research would not be included in the plant and animal production category, but under a category such as human health, which more accurately reflects the intent of the R&D expenditure.

A second reason the SEO categorisation seems likely to more accurately reflect productivity-enhancing rural R&D expenditure is that since 2001, the FOR and SEO R&D expenditure estimates produced by the ABS have begun to diverge by an increasing amount, as can be observed in the following graph.

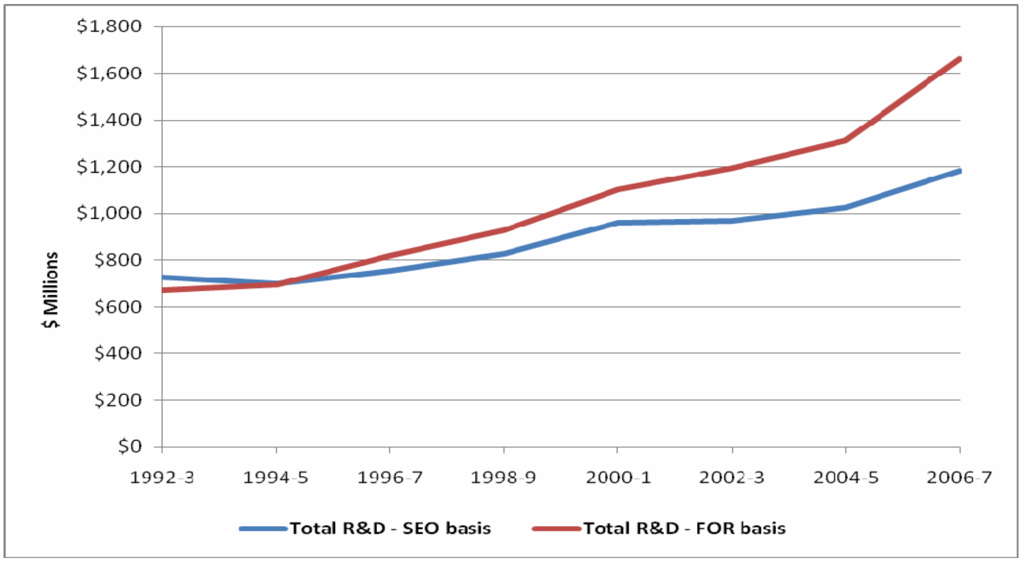


Figure 19 ABS estimates of total annual rural R&D expenditure.
(Source: ABS Statistical publication 8112.0)

A likely cause of the growing divergence is the inclusion of environmental and veterinary sciences within the same category as agricultural science, commencing from the 2001 survey. It is probable that increased R&D expenditure on environmental sciences (on issues such as climate change and greenhouse gas emissions) may explain the growing differences between the two estimates since that time.

An estimate of public-sector (rather than total) agricultural R&D expenditure from the 1950s to the present day has been made by Mullen (Mullen, 2010) utilising a combination of ABS data and data from publicly-available financial reports produced by State government agencies. Mullen estimates that total public sector expenditure on Australian agricultural R&D in 2006-07 was $884 million (2007 dollars). This estimate excludes R&D expenditure in fisheries and forestry, and focuses on expenditure associated with farm production research. This estimate differs slightly from the ABS SEO estimate for public-sector rural R&D expenditure ($930 million), with the difference probably arising from the exclusion of fishery and forestry R&D expenditure from the Mullen estimate.

Based on the SEO data, business accounted for approximately 20% of total rural R&D expenditure in 2006-07, although as noted, it is not clear what the source of funds was for this expenditure. It is likely that some of the funding for this originated from government or rural RDCs, but that the majority was direct R&D investment by private-sector businesses.

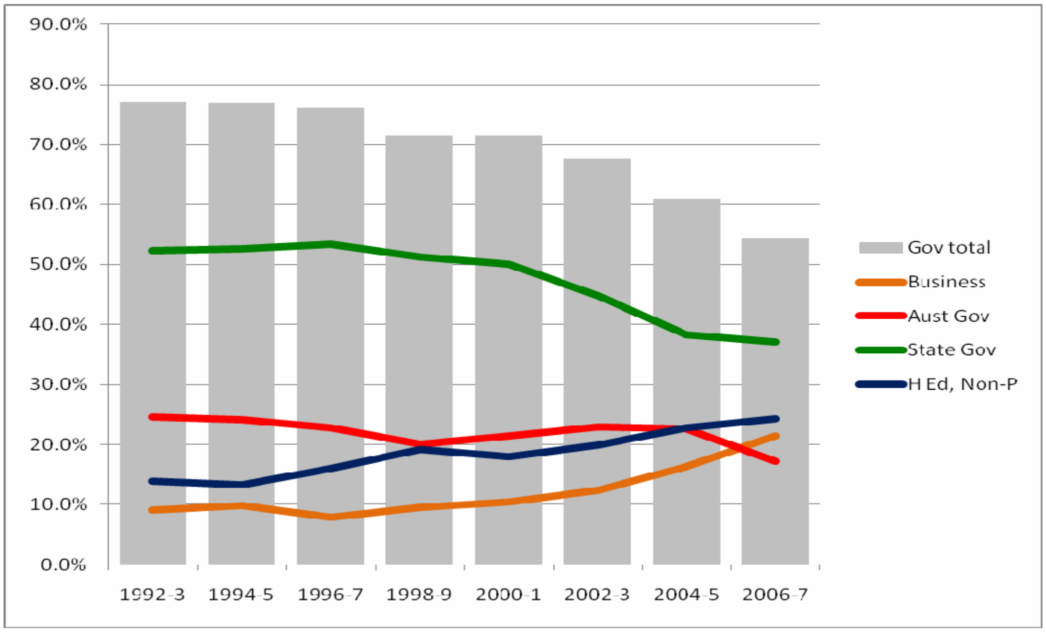


Figure 20 Changes in rural R&D expenditure (SOE categories) by different sectors.
(Source: ABS Statistical publication 8112.0)

State governments have performed progressively less of the total annual rural R&D carried out, declining from 52% in 1992 to 37% in 2006-07 (Mullen, 2010). The largest declines in rural R&D expenditure since 2001 have been by the NSW and Queensland governments, although the Victorian government has also reduced expenditure to some degree. As noted earlier, these figures represent gross expenditure rather than net expenditure, with some of this expenditure undoubtedly associated with funding sourced from rural RDCs. There have also been announcements by some State governments over the last two years (notably Victoria) of specific increases in expenditure, and by others (notably NSW) of further reductions in rural R&D expenditure.

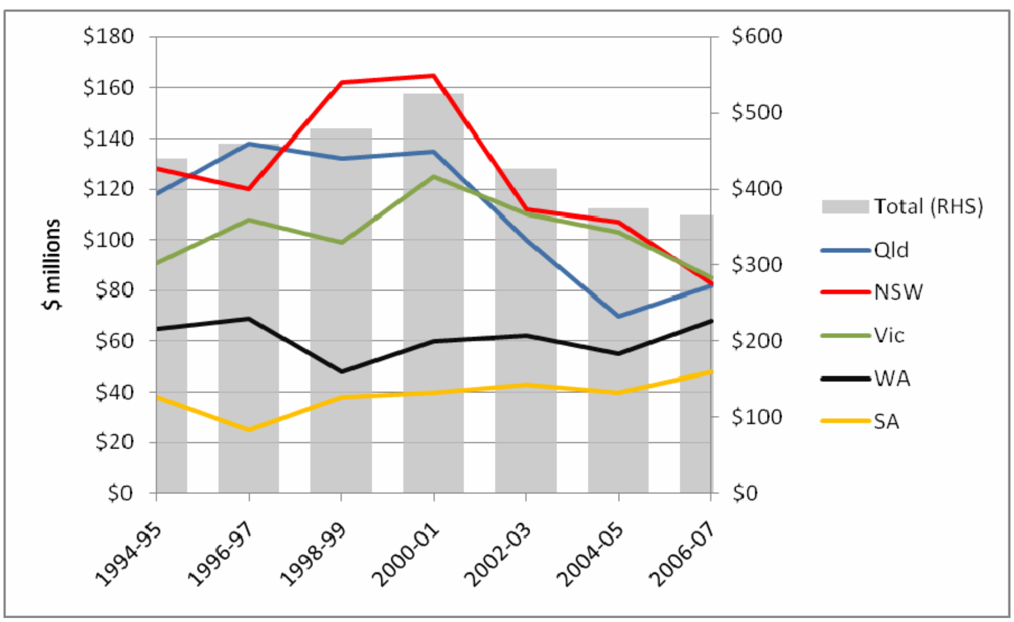


Figure 21 Rural R&D expenditure by State governments.
(Source: Mullen, 2010)

Public and private investment in agricultural R&D in the USA

There has traditionally been a much greater proportion of private-sector investment in agricultural R&D in the USA than is the case in Australia. Available data indicates that by 2000, private-sector R&D investment was greater than public-sector investment, and growth in private-sector investment was the main reason for growth in overall agricultural investment in the USA. It is noteworthy, however, that private-sector R&D investment has traditionally been approximately half the total US R&D investment, and that private-sector investment has increased despite steady public-sector investment levels, suggesting that 'crowding out' by the public-sector may not be factor in private-sector investment decisions.

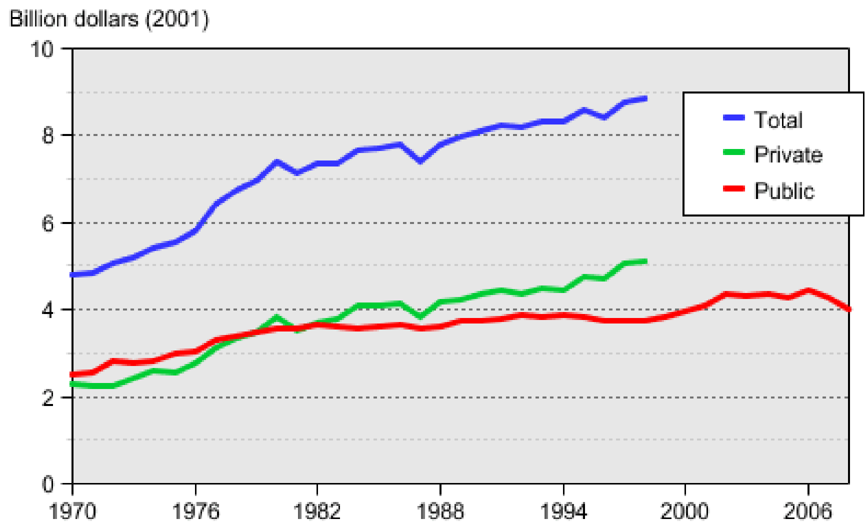


Figure 23 Public and private investment in agricultural R&D, USA.

(Source: USDA Agricultural research and productivity briefing room. www.ers.usda.gov)

Not surprisingly, the R&D investment priorities of the public and the private-sector in the USA are dramatically different. Private-sector investment is focused on plant breeding, agricultural chemicals, machinery and food products, although food production R&D investment has declined as a proportion of total investment. Public-sector investment is more broadly focused on plant and animal systems, and natural resource and the environment.

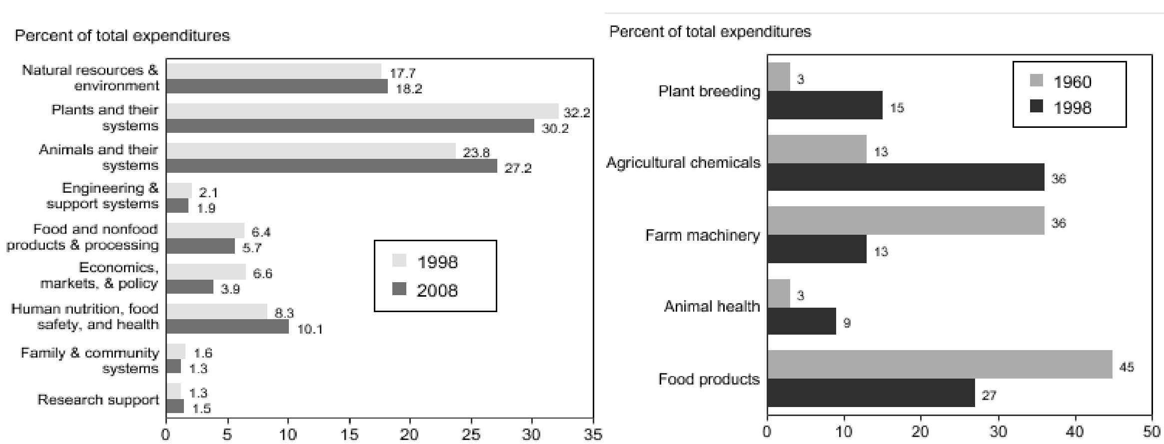


Figure 23 Allocation of public (left) and private-sector (right) agricultural R&D funds.

(Source: USDA Agricultural research and productivity briefing room. www.ers.usda.gov)

As already noted, however, this data simply provides information about the organisations that are carrying out rural R&D, but does not identify the source of funding for that research. ABARE (ABARE 2009a) has recently attempted to identify the source of rural R&D funding in Australia (as distinct from the providers of research services, and their summary is provided in the following figure. The information is derived from ABS data. It should be noted that the data refers to expenditure on the basis of the Field of Research categorisation, which includes environmental, veterinary and agricultural sciences, and is based on the type of science being utilised, not the objective of the research.

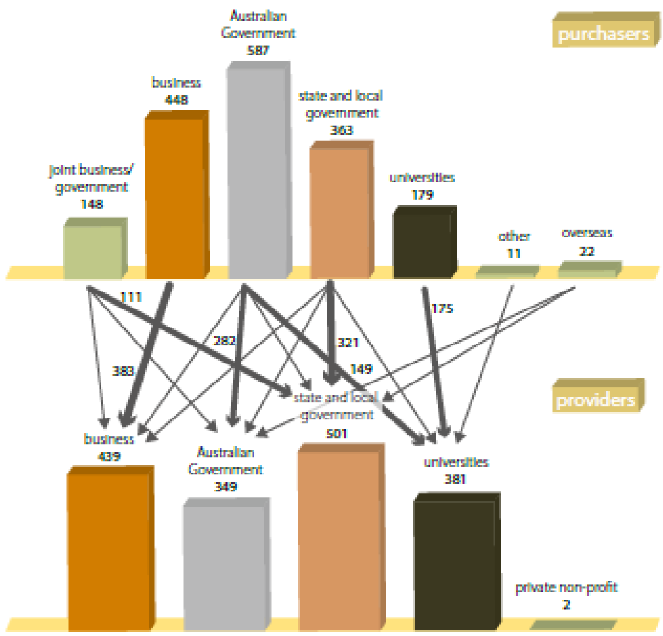


Figure 24 Purchasers and providers of rural R&D in Australia (FOR categorisation).
(Source: ABARE, 2009b based on ABS data.)

Some information about rural R&D funding is available for the Australian government, and the rural RDCs. Australian government investment in rural R&D includes that associated with the CSIRO, as well as the Cooperative Research Centre program, and a number of other small programs.

The Annual Report of the CSIRO (CSIRO 2009) identifies that the CSIRO agribusiness group accounted for $255.8 million in gross expenditure, although not all of the research by that group was rural research. Offsetting this, the CSIRO received $36.5 million in revenue from Rural RDCs, and an additional $38 million in Cooperative Research Centre funding, some of which would have originated from rural RDCs. In addition, the CSIRO food futures flagship expended $46.4 million on R&D, much of which would appear to be classified as rural research.

The Australian Government also expended $180 million on Co-operative Research Centres in 2008-09, of which approximately $50m would appear to be classified as rural research. Taken in combination, these figures indicate that the Australian government was the source of approximately $300 million of expenditure on rural-related R&D in 2008-09, in addition to the funding provided to the rural RDCs.

The budget papers of the Commonwealth Department of Innovation, Industry, Science and Research record that expenditure on rural RDCs and other rural programs in 2008-09 was approximately $240 million, bringing the total Australian government expenditure for rural R&D in 2008-09 to an estimated $540 million.

State Government expenditure is less certain due to complex reporting systems, although based on the data reported by Mullen (Mullen 2010) would have been approximately $350 million. Some of this undoubtedly originated from rural RDCs and other Australian government programs.

Taken together, Australian government, State government and rural RDC expenditure in combination on rural R&D appears to have been approximately $1.1 billion in 2008-09. This compares with the ABS estimate of approximately $1.2 billion in total expenditure in 2006-07, including business and higher education expenditure. Clearly, there is either a considerable overlap in the reported data from the Australian and State governments, or the ABS total investment estimate is too low. Irrespective of the uncertainty associated with official statistics, the expenditure data confirms that governments and RDCs dominate as the source of rural R&D funding in Australia.

It has been noted that the level of private sector investment in rural R&D in Australia is low in comparison with the levels of private sector investment observed in other developed nations (Pardy et al 2006). While definitive information about the reasons for this is not available, anecdotal information suggests that there are a number of factors contributing to this. These include;

- Australia represents a small and somewhat unique market, being only 1% of global agricultural output. This makes investment in long-term, risky rural R&D in Australia (and particularly more basic R&D) difficult to justify on potential future revenue grounds for multi-national businesses.
- Apart from beef, wheat, barley and sugar, Australian rural commodity sub-sectors are very small by global standards, meaning it is more likely that new technologies introduced in these small sub-sectors will be the result of international spill-ins, facilitated by Australia applied research, rather than arising from Australian-based research.
- Australian agricultural production is primarily destined for export markets, which means that even if, for example, a unique new pesticide active ingredient was developed from Australian research, it would still need to be registered for use in all major international markets (at considerable cost) before it could be used on Australian farms. This makes it uneconomic for businesses to consider the development of uniquely Australian products.
- Major multi-national organisations involved in the livestock and crop industries have very large research facilities and infrastructure located in places such as Europe and North America. The bulk of their R&D efforts occur in these facilities, rather than in Australia. Australia tends to be looked on as a potential minor market for new products, rather than as a location to develop new products. There is also some concern expressed about both the cost and the regulatory constraints imposed on research activities in Australia.
- Much of the growth in private-sector rural R&D investment over the past decade globally has been associated with the development of genetically-modified crops. Up until quite recently, Australian State governments maintained moratoriums on the release of such crop varieties, and this - plus the investment uncertainty that it created - undoubtedly deterred private-sector rural R&D investment into these crops in Australia.

- Anecdotal evidence suggests that much of the private-sector rural R&D investment that occurs in Australia is associated with product registration and residue testing requirements, and even for these purposes private-sector organisations commonly seek contributions from rural RDCs to defray some of the costs and to make product registration economically viable.
- In the case of experimental development research associated with out-of-patent chemicals, under Australian law the data generated is publicly available and can be used by any chemical retailer to register a brand-name product. While there are reasons for this, it acts as a disincentive for private-sector experimental development research on such compounds, necessitating public investment in order that the industry can retain access to the chemical.
- As noted earlier, the majority of Australian farm businesses are multiple-enterprise, meaning that not only do new technologies need to be effective, but they also need to be able to be integrated into complex farm management systems. This probably creates a greater risk of slow or limited adoption which undoubtedly deters private sector investment in rural R&D.

Taken together, these factors mean that rural R&D investment in Australia will continue to be dominated by Government and compulsory industry contributions, rather than by private sector investment. This is not to say that the private sector will be restricted to current investment levels, as it is likely that the de-regulation of the use of genetically-modified crops will create an increased opportunity for private sector investment over coming years, and there has also been some growth in the privately-funded plant breeding industry in recent years.

In relation to private sector rural R&D investment, it is noteworthy that despite substantial growth in rural R&D expenditure by the private sector in the USA, it has been observed that productivity growth rates for US agriculture have slowed. (Alston, Babcock and Pardy, 2010). They observed that "*Over the most recent 10 to 20 years of our data, the annual rate of productivity growth (*of US agriculture*) was less than half the rate that has been sustained for most of the twentieth century.*" This confirms the views of other authors (Tokgoz, 2006) that private-sector R&D investment can be complementary to public-sector investment, but is not a substitute for it. This is because private sector investment will invariably be narrowly focused on a specific, proprietary technology, rather than on broader, sector-wide issues with significant spillover potential.

Research is currently underway to gain a better understanding of the nature of private-sector investment in rural R&D in Australia, and the results of this research should further clarify some issues with respect to the future role of the private-sector in rural R&D activities in Australia.

4.1 Implications for the Australian rural R&D system.

While data is somewhat limited in relation to the respective roles played by different research providers in delivering rural R&D in Australia, it seems that the roles are largely as would be expected. Commonwealth Government science agencies and the Higher Education sector have a more dominant role in basic research, while State Government agencies and the private sector have a stronger presence in applied research and experimental development, as well as rural extension. It is apparent from available data that State government investment levels have declined significantly over recent decades. There is evidence that growth has been occurring in private sector involvement in rural R&D over recent years, although the current level of private sector investment in Australia appears to be between 15 and 20% of total investment, which is quite low by international standards. The average reported for the OECD data (Pardy et al 2006) is 54%, although there are some questions about the accuracy of the data used to compile these figures.

There are reasons to doubt whether the private-sector will ever reach the level of significance in terms of share of rural R&D investment in Australia that it has in major overseas nations, and these relate to the scale of the Australian market, the relative uniqueness of many Australian rural production systems, and the deadweight costs associated with having new technologies registered for international use. However, governments and the rural RDCs have an important role to play in leveraging greater private-sector investment in rural R&D in Australia.

The development of the national Primary Industries Research Development and Extension framework (DAFF, 2010) is a welcome and overdue initiative that has the potential to ensure that there is a greater degree of cooperation and coordination in the Australian rural R&D system, and that the respective roles of different participants are widely understood. It is noted that the private sector (for example major animal health or agricultural chemical companies) have not been involved in the framework development. This is appropriate given that the framework essentially details the need for R&D and the roles of providers, but it will be important to engage the private-sector as part of implementing the framework.

The two issues where Government policy can encourage greater private-sector investment in rural R&D are incentives that are provided in the economy for R&D investment, and regulations surrounding the use of new technologies. The Commonwealth has recently instituted changes to its R&D tax concessions, and the changes, which include lowering expenditure thresholds, seem likely to encourage more private-sector investment by businesses involved in the rural sector, although it is still too early to be sure of the impact of the changes.

Regulations surrounding the use of new technologies in agriculture – specifically those associated with the use of GM crops – are the responsibility of State Governments, and there is no doubt that the policy changes by State Governments, and the lack of coordination of those policies over recent years has had a negative impact on private sector R&D investment.

Rural RDCs also have an important role to play in encouraging greater private sector R&D investment. Co-contributions from rural RDCs can provide very important leverage to encourage greater private sector R&D investment, and there are numerous examples of such projects listed by different RDCs. While care is obviously needed to ensure that RDC contributions are not unnecessarily subsidizing private sector costs, it seems quite clear that in the absence of such leverage, private sector investment levels in rural R&D in Australia would be considerably lower, and Australian farmers would not have access to some chemicals that are very important for some commodities.

A vexed issue for the different participants in the rural R&D system is the question of access to royalties and intellectual property rights. There are a number of examples where RDC funds have been used to pay for research carried out by Commonwealth Government agencies, following which the government agencies have secured the flow of royalty payments, rather than the RDC. There are also a number of RDCs that have been able secure revenue flows through commercialisation agreements. These arrangements require careful management, because they obviously create the potential for RDCs and Government agency researchers to become too focused on R&D activities that have commercialisation potential, rather than on R&D that can bring maximum benefit to the industry.

An issue of growing importance in relation to the different roles played by organisations involved in providing rural R&D is the rural extension system that communicates information about new technologies to farmers and encourages their adoption. While State Government agencies previously had a major role in rural extension, this is changing quickly as the States reduce rural sector funding and personnel.

In some industries, notably the cropping industries, the private sector is filling the extension role, although for the system to work well rural RDCs need to establish good communication systems with private-sector farm advisors, and this imposes additional costs on RDCs.

In the livestock and horticulture industries where the use of private-sector advisory services by farmers is much less common, RDCs are being required to expand the amount of resources devoted to communications with farmers, and this imposes a constraint on resources available for investment in other areas of rural R&D.

The rural extension system plays a critical role in encouraging the adoption of new technologies, and is therefore a fundamental element in terms of the success of a national rural R&D system. The withdrawal or downscaling of rural extension services by State Governments will impact on adoption rates and ultimately productivity growth in the rural sector, and appears to be happening in an ad hoc and politically-driven manner, rather than as a consequence of long-term planning and analysis of industry needs. While a counter argument is that private sector advisory services will replace public extension services and be more effective, this is not likely to occur evenly across all commodity sectors or geographical locations, and private-sector advisory services still need access to robust information in order to remain effective.

A dilemma for RDCs in this regard is that the more they assume responsibility for the extension of research outcomes to farm advisors and farmers, the more they give licence to State government agencies to withdraw from this role. However, if the RDCs fail to take on this role, the effectiveness of the R&D system will undoubtedly be jeopardized.

Rather than allowing rural extension services to wither in an ad hoc manner, there is a need for industry (including RDCs) and Government to consider the best ways to ensure that rural extension does not become the weak link in the national rural R&D system, limiting future rural productivity growth. The development of the national Primary Industries Research, Development and Extension Framework (DAFF, 2010) is a useful step, however the statement of intent associated with the framework provides no details or imposes no requirements in relation to resourcing rural extension services. While it is understood that the framework is still undergoing development, the lack of focus on the future of rural extension systems appears to be a major shortcoming that could have negative implications in future for Australia's rural industries.

5. The effectiveness of the current RDC model.

In the absence of substantial government support measures for agriculture and faced with full exposure to international competition, the main means by which the Australian agriculture sector has been able to remain profitable has been to achieve sustained increases in farm productivity – effectively producing more units of output per unit of input. There are many factors that contribute to productivity growth, and have enabled the agriculture sector output to continue expanding, despite constraints on the availability of land and water for agriculture in Australia. The most important of these are all products of R&D, and include developments such as improved plant and animal genetics, improved pest and disease management and fertiliser technologies, and very large advances that have been made in farm machinery sophistication and efficiency. Economy-wide factors such as improvements in transport and communications efficiency and improved education and health standards have also contributed to the productivity gains that have been made.

Figure 25 shows changes in the volume and value of agricultural output by Australian farms over the period since 1960. The data highlight the strong output growth that has occurred during the 1990s, in particular in crop production, and the very significant impact that drought periods have on agricultural output. The period from 2003 to 2007, for example, has been one during which most major crop production regions of Australia have at some stage experienced the lowest levels of rainfall ever recorded over a twelve month period. This has resulted in a substantial decline in crop production, which is anticipated to recover strongly given a return to more average rainfall conditions.

Recent relatively high agricultural commodity prices have somewhat compensated for the reduced volume of agricultural production as a consequence of drought, and have enable the gross value of Australian agricultural production to be maintained over recent years despite the difficult climatic conditions that have been experienced.

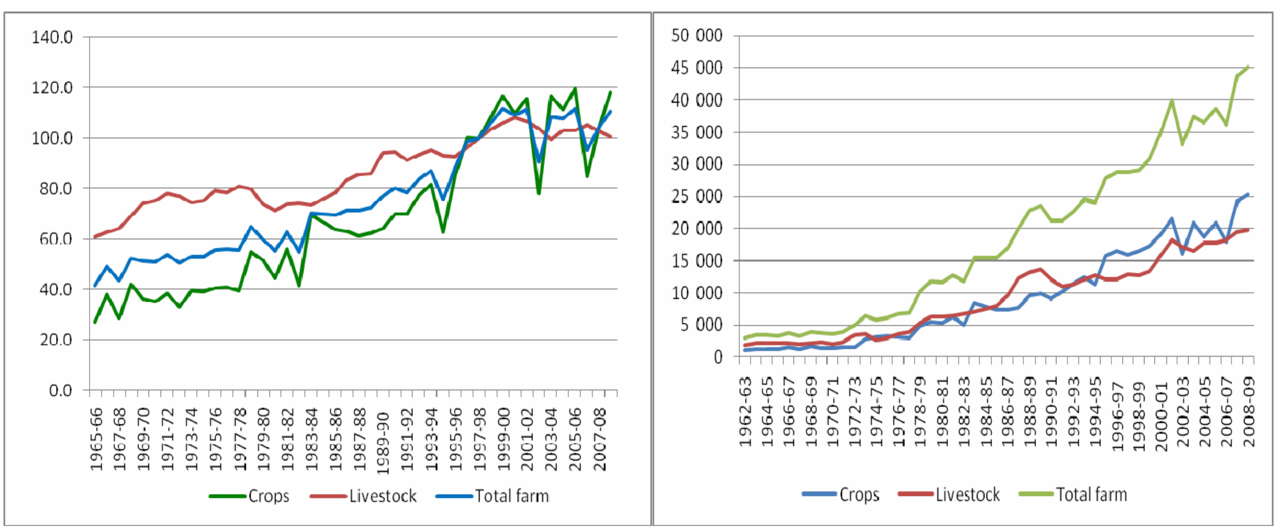


Figure 25 Volume (left) and value (right) of farm production, Australia.
(Source: ABARE 2009a)

The data also identify that rates of output growth in plant industries has been considerably greater (although more variable) than that achieved for the animal industries. This reflects growth in both the horticulture and the cropping sectors since the mid 1990s, and also reflects changes in commodity sectors such as the sheep industry where the flock size has decreased by a large amount.

Output growth is only one component of agricultural productivity growth - outputs can be increased simply by increasing farm inputs such as water or fertiliser. A more comprehensive measure of farm productivity is Total Factor Productivity (TFP), which takes account of changes in both farm inputs and farm outputs. Several studies have been conducted into changes in TFP in the Australian agriculture sector over recent decades, and further research is being carried out to identify the specific sources of identified productivity changes.

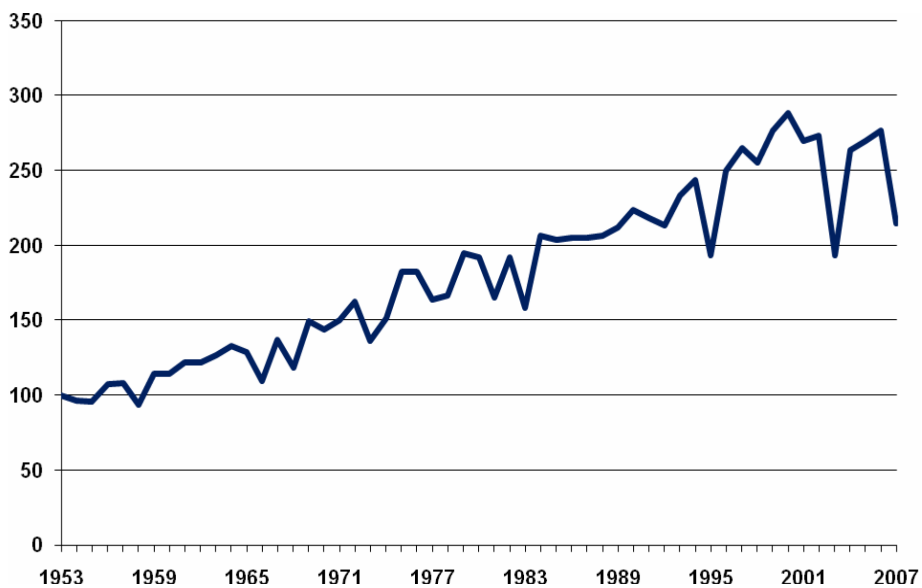


Figure 26 Trends in Australian broadacre farm productivity.
(Source: Mullen, 2010)

Of note in the above figure is the sustained level of productivity growth that was maintained over the period from 1960 to 2000, and the apparent acceleration in productivity growth that was achieved during the 1990s. Also of note is the trends observed over the period since 2000, during which there is some evidence of a slowing in productivity growth rates. The trend since 2000 has been the subject of detailed analysis, because it has coincided with a series of drought years that have obviously impacted on farm output, and hence productivity growth. The analysis has identified that there has been a significant change in productivity growth trends since 2000, that the change cannot be explained by climate alone, and that the stagnation in public R&D investment has also contributed to the slowdown. (Mullen, 2010, Sheng at al 2010, Nossal and Sheng, 2010).

The analysis is, of necessity, limited to the broadacre and cropping sectors for which there is sufficient data available at a detailed level. For other rural sub-sectors, there is not sufficient detailed information available to allow similar analyses.

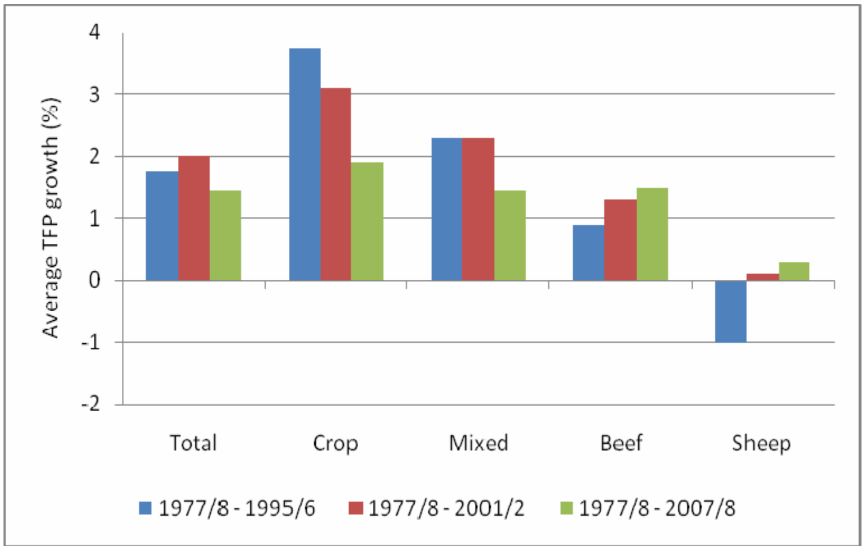


Figure 27 Changes in broadacre TFP growth rates over time.
(Source: Nossal and Sheng, 2010)

The extent to which seasonal conditions have contributed to the observed productivity slowdown are currently the subject of further analysis by ABARE. While a definitive answer will take some time to obtain, it has been observed that even if seasonal conditions are a major factor, the trends observed are indicative of what could be experienced in the future under climate change. This highlights that Australian agriculture, and in particular the cropping sector will need to accelerate productivity growth above the long-term trend rate in order to sustain or increase output in future, and this will require sustained additional investment in R&D to achieve.

A comprehensive review of rates of change of farm TFP (both in Australia and internationally) was carried out by the Australian Farm Institute (Mullen and Crean, 2007). That research identified that TFP growth rates in Australian agriculture have averaged 2.5% per annum over fifty years, although at different times the rate of growth had slowed or accelerated. During the 1990s, for example, TFP growth rates in agriculture were found to have averaged close to 4% per annum, the fastest rate of productivity growth of any sector in the Australian economy with the exception of the communications sector.

The research also highlighted that rates of productivity growth in Australian agriculture compare more than favourably with those observed for other nations, (see Table 9) although the calculated results depend greatly on the nature of the data used in the calculations. The research also notes that calculated agricultural TFP growth rates can vary depending on the period over which data is included.

Table 9 Estimates of Total Factor Productivity growth rates for agriculture in selected nations.

Country	Author	Period	TFP growth (%)
Australia	Mullen and Cox 1996	1953–1994	2.50
	Knopke et al. 2000	1978–1999	2.60
	Knopke et al. 1995	1978–1994	2.60
	Productivity Commission 2005	1975–2004	2.80
United States	Ahearn 1998	1948–1994	1.94
	Acquaye et al. 2003	1949–1991	1.90
	Gopinath et al. 1997	1949–1991	2.30
	Ball et al. 2004b	1960–1999	1.71
	Karagiannis & Mergos 2000	1948–1994	1.99
United Kingdom	Barnes 2002	1948–1995	1.93
	Thirtle et al. 2004	1953–2000	1.26
	Amadi et al. 2000	1953–1995	1.81
	Schimmelpfennig and Thirtle 1999	1973–1993	1.60
South Africa	Schimmelpfennig et al. 2000	1947–1997	1.30
	Thirtle et al. 1993	1947–1991	1.30
China	Carter et al. 2003	1978–1996	1.60 [a]
	Fan 1997	1952–1995	1.51
	Hsu et al. 2003	1984–1999	-0.10
Canada	Baldwin and Harchaoui 2002	1981–2000	3.40 [b]
	Stewart et al. 2006	1940–2004	1.56

[a] Results based on analyses of productivity growth in Jiangsu Province using household level data. The authors also investigated the importance of different data sets in estimating productivity levels in China. They raised concerns about more aggregated data sets, which when used indicated TFP growth in Chinese agriculture of 5.40% over the period 1978–96.

[b] Derived from productivity data reported in Baldwin & Harchaoui (2002).

(Source: Mullen and Crean, 2007)

The researchers identified limitations in comparing international agriculture-sector TFP in isolation from TFP changes in national economies. The reason for this is that if TFP growth in the rest of a national economy is strong, goods and services used as inputs in farming are being produced more efficiently, and farmers are able to take advantage of that and increase TFP without changes occurring on farm.

Comparing the ratio of agriculture and non-agriculture TFP growth rates provides a more complete way of measuring agricultural TFP growth. Using this ratio as a means of international comparison, Australian agricultural TFP growth rates very highly. Australian agriculture sector TFP was estimated to have increased at 3.6 times the rate of TFP growth in the rest of the national economy over the period from 1970 to 1987. Only the USA and UK agriculture sectors increased TFP relative to national TFP growth at a faster rate over that period.

5.1 Rates of productivity growth within sub-sectors of agriculture.

Aggregate, sector-wide TFP growth rates provide a useful indicator of overall progress but do not provide much information about the sources of TFP growth nor the factors contributing to any changes observed. More detailed analysis is available of estimated TFP growth rates within sub-sectors of agriculture. For Australian agriculture, such analyses are made more complex due to the fact that the vast majority of farm businesses are involved in producing two or more commodities, and there are often complementarities between commodities (for example legumes used for livestock grazing also increase soil nitrogen that can be utilised during a cropping phase). They are also made more complex because TFP estimates vary over time due to the impact of seasonal conditions and commodity prices.

Table 10 provides a summary of the results of a number of different studies carried out to determine rates of TFP growth within sub-sectors or commodity groupings of Australian agriculture.

Table 10 Estimates of Total Factor Productivity in sub-sectors of Australian agriculture.

Authors	Period[a]	Annual Input Growth (%)	Annual Output Growth (%)	Productivity Growth (%)
Males et al. 1990	1978–89			
• All agriculture				2.0
• All Broadacre		1.4	3.6	2.2
• Crops		-1.8	3.7	5.5
• Sheep		1.3	1.5	0.2
Zeitsch and Lawrence 1993	1983–94			
• Sheep				≈ 1.0
Mullen and Cox 1995	1953–94	0.1	2.6	2.5
Knopke et al. 1995	1978–94			
• All broadacre		0.2	2.9	2.7
• Crops		0.4	5.0	4.6
• Sheep		0.5	1.5	1.0
• Beef		0.3	1.9	1.6
• Sheep-Beef		-2.1	0	2.1
Knopke et al. 2000	1978–99			
• Grains industry		0.7	3.3	2.6
• Crops		1.3	4.8	3.6
• Sheep		0.6	1.2	0.6
• Beef		0.3	2.4	2.1
• Sheep-Beef		-0.9	0.4	1.4
ABARE 2004	1989–2002			
• All broadacre				
• Crops				1.8
• Beef				2.1
• Beef – crops				2.4
ABARE 2006	1989–2004			
• All broadacre		-0.9	1.3	2.2
• Crops		7.7	10.1	2.4
• Sheep		-5.4	-5.0	0.4
• Beef		-0.3	2.2	2.5
Kokic, Davidson and Rodriguez 2006	1989–2004			
• Grains industry				1.9
• Crops				1.8

[a] The observation period in the table is in calendar year form, but refers to the last half of the financial year.

(Source: Mullen and Crean, 2007)

Several points emerge from this table. Firstly, it is evident that TFP rates for crop enterprises are generally higher than for livestock enterprises, especially during the 1990s. TFP growth for cropping enterprises during this period appears to have arisen as a result of reduced growth in inputs coincidental with rapid growth in outputs. Secondly, there is some indication that TFP growth rates during more recent periods have slowed, although this is possibly related to the sequence of drought years that have been experienced since 2003 in many regions of the grain belt.

A lack of consistent, long-run data sets limits the opportunity to examine TFP changes at the level of individual farm commodities, however, an examination of detailed production data for individual commodities over the last four decades provides some indication of the changes that have occurred.

5.1.1. Wheat

Wheat is Australia's predominant cereal crop, and has been grown in Australia since the time of European settlement. Its production has been greatly advanced through successful plant breeding over almost 100 years, by Australian advances in tillage equipment (the "Stump-Jump plough") and, more recently, important technological advances in fertiliser management, minimum tillage, the development of high-capacity planting and harvesting technology and the use of GPS technology and precision mapping systems. Changes in wheat production and yields over the past three decades are displayed in Figure 28.

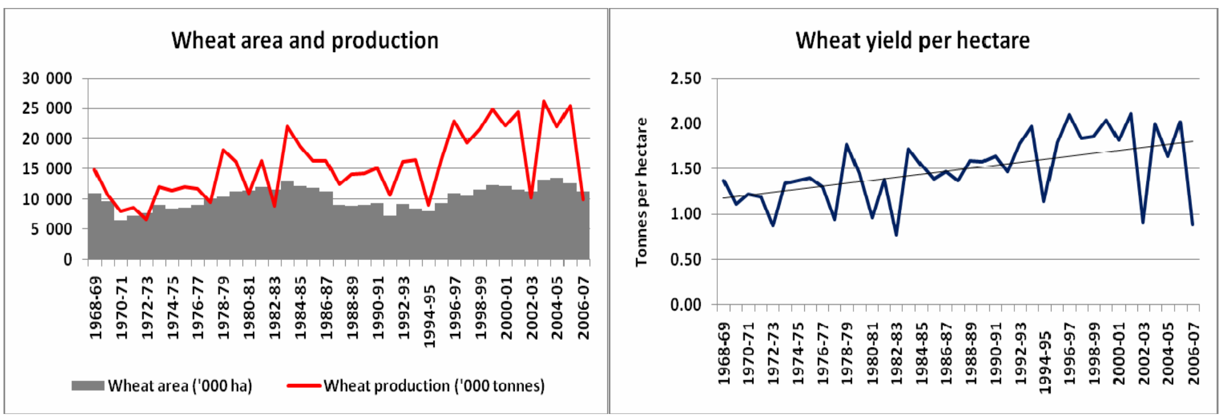


Figure 28 Wheat areas, yield and production, Australia

(Source: ABARE 2009a)

The figures highlight that the area sown to wheat annually has not increased since 1983, but that wheat production has trended upwards, now exceeding 25 million tonnes in years when seasonal conditions are favourable. Production has increased as a result of average national yields steadily increasing over the long-term, despite short-term fluctuations caused by droughts. There is some evidence of a substantial increase in average yields occurring throughout the 1990s decade. During this period many mixed-enterprise farms reduced their reliance on sheep production, in response to sustained low wool prices, and increased the area of their farms sown to wheat, a change evident in the graphs. There was also widespread adoption of minimum tillage technologies during this period, which has enabled farmers to take better advantage of available rainfall while reducing fuel use and preventing soil degradation.

The use of GPS guidance and mapping technology has increased over the past decade, with this technology enhancing farmers' ability to map crop yields within paddocks, and to apply fertilisers at variable rates depending on need. GPS guidance systems also enable farmers to reduce fertiliser and chemical waste by avoiding overlapping during application. This is a particular advantage in areas where farmers have relatively large areas under crop. It is evident from statistics that farm consolidation has been greatest in cropping regions, with farmers able to take advantage of high-capacity sowing and harvesting equipment to minimise labour inputs. Specialist harvesting, spraying and sowing contractors are now common in cropping regions, and this has assisted farmers to reduce investment in machinery while still managing large areas of crop production. The emergence of commercial agronomists and crop advisory services has also probably enhanced cropping efficiency. Available statistics do not enable the relative contribution of each of these factors to enhanced crop productivity to be precisely estimated.

5.1.2 Beef

Beef cattle have been reared in Australia for the past two hundred and twenty years. Beef production occurs in all regions, and beef cattle production occurs on more farms than any other enterprise. Specialist beef production is more common in higher-rainfall zones of southern Australia and in the tropical regions of northern Australia. Trends in beef production over the past four decades are shown in Figure 29.

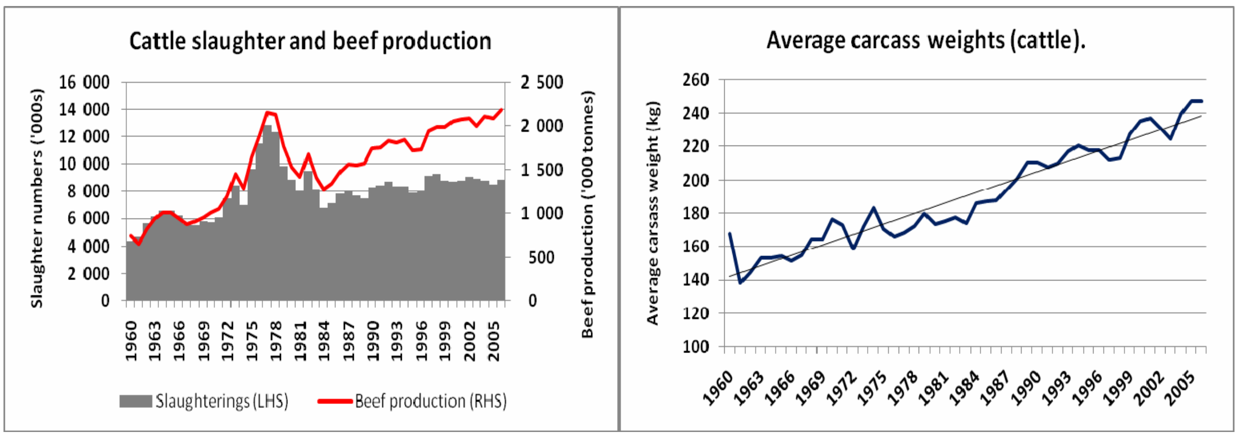


Figure 29 Beef production and carcass weights, Australia.
(Source: ABARE 2009b)

Grain finishing ('lot feeding') of cattle is an important part of the beef industry, now representing around 30% of the cattle slaughter. However, the majority of Australian beef cattle are still grown on pastures. Beef cattle numbers fluctuate depending on seasonal conditions and the relative returns available from beef and other farm commodities.

There have been substantial gains in productivity in the beef industry in Australia over recent decades (relative to other broadacre livestock industries) as a result of the introduction of new genetics, in particular *Bos indicus* breeds that are better adapted to northern Australia. Crossbreeding (with resulting hybrid vigour) has also been important in increasing cattle growth rates, as has genetic selection based on objective measures of performance.

Available statistics appear to indicate that rates of productivity (indicated by average carcass weights) increased more rapidly in the period following the large decline in the beef industry during the late 1970s. The lack of beef profitability during the late 1970s perhaps created added pressure on beef producers to increase productivity, resulting in the apparent surge during the 1980s and 1990s.

More intense cattle management systems have been introduced by southern beef producers over recent decades, with artificial breeding and pregnancy testing becoming increasingly common. There have also been advances in cattle health management, due to the introduction of new parasiticides, and in supplementary feeding.

Pasture management is also a very important element in beef production. The progressive introduction of improved pasture species, greater reliance on perennial pastures and advances in fertiliser and soil management have all undoubtedly contributed to enhanced beef industry productivity.

5.1.3 Wool and sheepmeats

The Australian sheep industry has been through some dramatic changes over recent decades. During the nineteenth and the first half of the twentieth century, wool was the mainstay of the rural economy and a major source of national export income. The invention of synthetic fibres during World War Two and their subsequent development introduced competition into fibre markets, and wool has struggled to remain competitive. Prior to 1991, Australian wool was marketed under a reserve price system which resulted in the creation of a large stockpile of wool. This system was abandoned in 1991, lowering wool prices and resulting in a sustained period of depressed prices as the stockpile was sold. Over recent years, relatively high prices for sheep-meats have resulted in a changed emphasis for sheep producers, with reduced numbers of sheep, and a greater emphasis on meat rather than wool production.

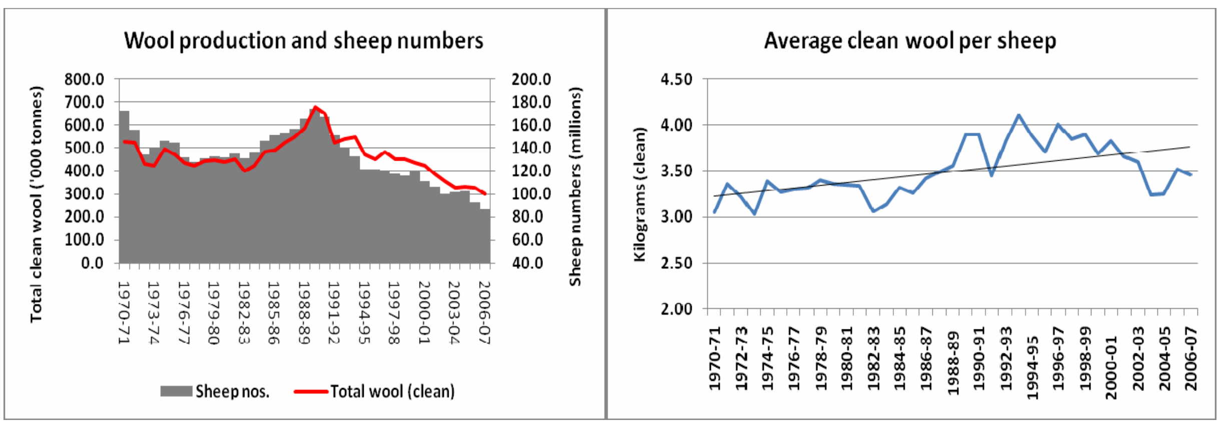


Figure 30 Wool production, sheep numbers and wool per head, Australia.
(Source: ABARE 2009b)

Wool production per head has increased marginally over recent decades, although droughts have depressed production. Specialist woolgrowers have been selecting sheep producing finer wool, which is higher priced, although fine woolled sheep generally produce less wool. Productivity gains in the wool industry have arisen from improved pasture management, selection of sheep with superior genetics, improved animal health and parasite management and general improvements in farm efficiency.

Despite the overall decline in sheep numbers, lamb meat production has been steadily increasing since the mid 1990s as a result of improved sheepmeat prices and lower wool prices. In previous decades the lamb industry was a 'by-product' of the wool industry, whereas in recent years the number of specialist lamb producers have been increasing, new sheep breeds have been introduced with superior meat production characteristics, and lamb output has been growing.

Lamb production is also increasingly oriented towards export markets, with the USA and China emerging over the past decade as important markets. This export orientation has, in turn, created a greater focus on heavier carcass weights, and improved genetics and pasture feeding systems have been utilised to achieve this change. Sheep genetic selection on the basis of objective measurement, and the utilisation of hybrid vigour associated with cross-breeding have also been important elements of the productivity gains made in the lamb industry over recent years.

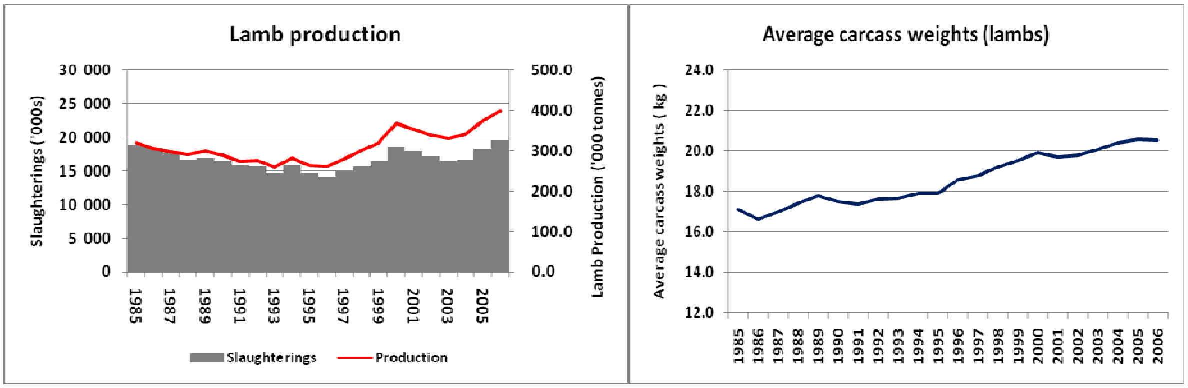


Figure 31 Lamb production and average slaughter weights, Australia.
(Source: ABARE 2009b)

5.1.4 Dairy

The Australian dairy industry has experienced considerable change in its recent history. In the immediate post-war years the industry had a predominantly domestic focus, with state-government regulated marketing arrangements and a large number of small co-operative dairy processors. This has changed significantly. The industry now exports approximately half its total production. The dairy processing sector has undergone significant rationalisation, and dairy marketing has been deregulated. The dairy industry negotiated with governments a significant deregulation 'package' that provided financial support to those farmers leaving the industry, and extra payments to farmers to assist them adjust to lower prices. At the time of deregulation in 2000, milk prices were approximately 28c/litre, whereas these have now increased somewhat, helping to restore farm profitability.

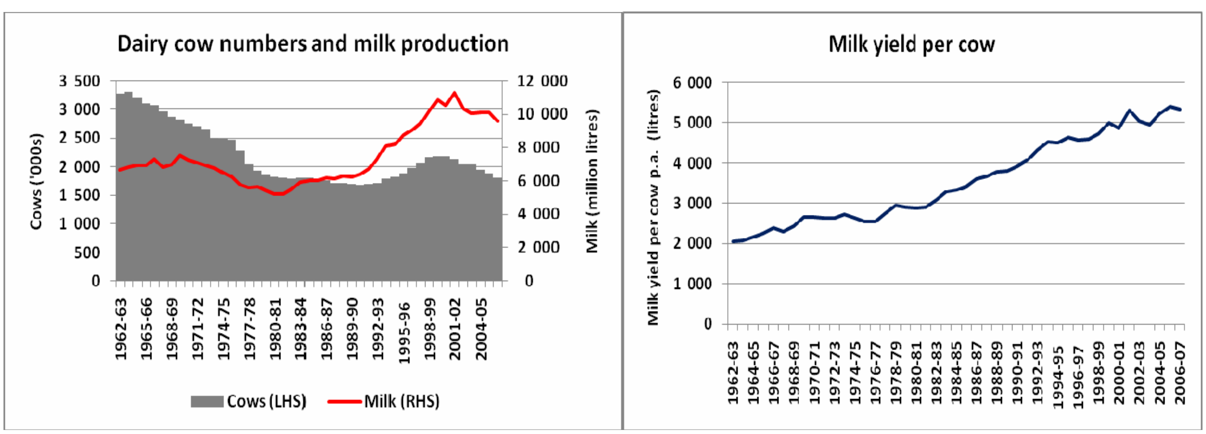


Figure 32 Dairy cow numbers, milk production, and yield per cow, Australia.
(Source: ABARE 2009b)

Dairy production in Australia is predominantly based on pasture, although in recent years there has been some development of large, intensive production systems based almost entirely on grain and fodder feeding. Many dairy farms in southern Australia rely on irrigation, and a lack of irrigation water in recent years, combined with historically high prices for grain and fodder, has resulted in a reduction in dairy cow numbers.
Productivity gains in the dairy industry have arisen from widespread adoption of artificial breeding technologies and genetic selection based on objective measurement. There has also been widespread use of international genetic material. Technologies have also been adopted to improve the efficiency of utilisation of water use on irrigated pastures. Improved pasture species have been planted and more intensive management of herd health has also been adopted.

Dairy processing companies have also increased production of branded dairy products and now rely less on generic products such as milk powder or bulk cheddar. This has, in turn, enabled them to pay higher prices to dairy farmers supplying milk, which has facilitated greater on-farm investment to increase farm and herd productivity.

5.1.5 Oilseeds

Canola is the dominant oilseed produced in Australia, accounting for almost 80% of the total area sown to oilseeds. Other oilseeds produced include sunflowers, safflower and soybeans. Canola is predominantly grown in the grain belt of southern Australia, commonly in rotation with cereal crops. It plays an important role as a 'break' crop, disrupting the buildup of soil-borne cereal crop diseases. Canola is less drought tolerant than cereals and thus canola production declines markedly during drought periods, as can be observed in Figure 33.

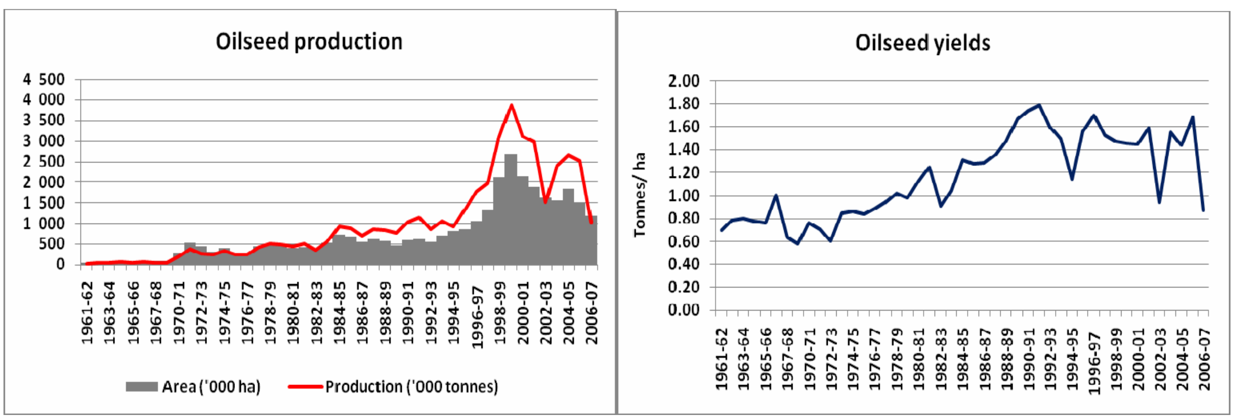


Figure 33 Oilseed production and yields, Australia.
(Source: ABARE 2009b)

Oilseed yields increased markedly in the period from the early 1970s to the mid-1990s, as management systems were developed for canola subsequent to its introduction in the early 1960s. Yields appear to have plateaued since that time, although severe droughts in 2003 and 2006, combined with generally drier conditions over that period and the need to grow lower yielding triazine tolerant varieties to counteract wild radish have undoubtedly had a negative impact on yields. Genetically-modified (GM) canola varieties were banned in Australia until the 2008 season, after which they have been allowed to be grown in a number of states. The introduction of GM canola varieties may create an opportunity for a further increase in oilseed productivity, due to their reduced reliance on chemical inputs.

5.1.6 Cotton

Attempts were made to grow cotton in Australia virtually from the first days of European settlement, but without great success. More success was achieved with new varieties and modern technology after 1960. Production of the crop expanded rapidly, when new areas of irrigation were opened up and modern machinery made the cultivation of large areas feasible. Cotton is predominantly grown under irrigation in Australia, with annual production levels subject to large fluctuations, depending on the availability of water for irrigation.

GM cotton varieties have been grown in Australia for more than a decade and have been very important in enabling reduced chemical use in cotton growing with increasing crop yields.

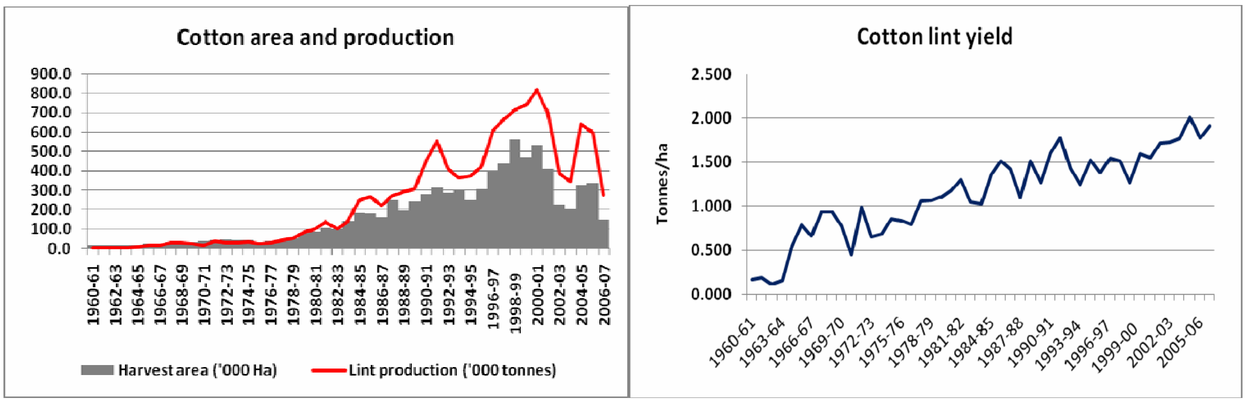


Figure 34 Cotton production and yields, Australia.

(Source: ABARE 2009b)

In normal seasons, average cotton yields in Australia are the highest recorded in the world, being approximately double the yields per hectare recorded in most other cotton-growing nations. Part of the reason for the high productivity growth in the cotton industry is the close interaction that exists between cotton farmers and industry researchers. The cotton industry also exists in a relatively compact geographical area, enabling good industry communications and exchange of ideas.

The large capital investment required to establish and manage a cotton farm has also meant that only farmers with substantial capital and a strong technical orientation are likely to be involved in the industry, and this undoubtedly helps to ensure farmers aggressively pursue enhanced productivity.

5.1.7 Sugar.

Sugar production is largely confined to coastal regions in the northern half of the east coast of Australia, although some sugar is now also grown in north-west Western Australia.

The sugar industry has experienced significant change, with Australian marketing arrangements being effectively deregulated in January 2006. Australian sugar growers are now fully exposed to international competition and, despite being efficient producers, need to compete in international markets against sugar produced with high levels of subsidies and behind trade barriers. As a result, sugar production in Australia fluctuates from year to year as international markets change.

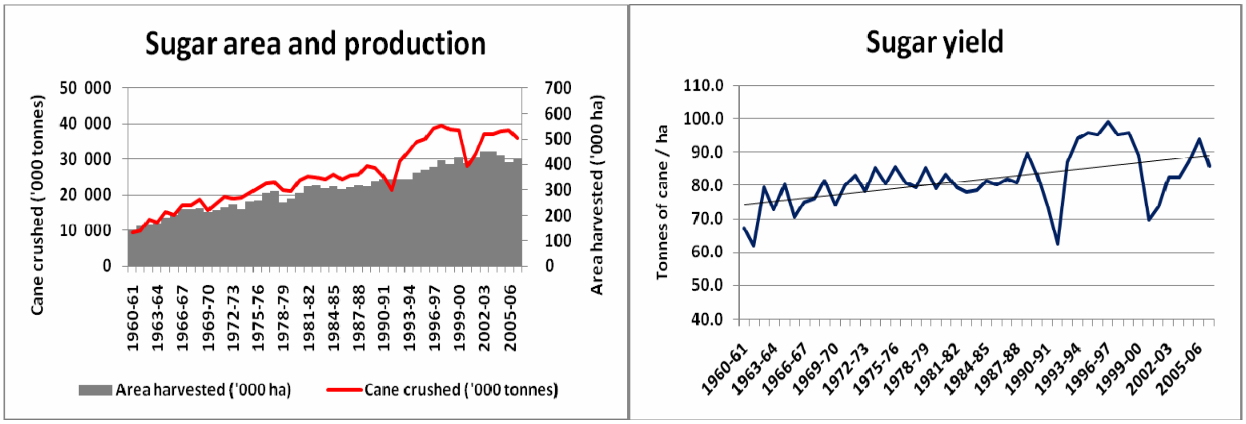


Figure 35 Sugar production and yields, Australia.

(Source: ABARE 2009b)

As is the case for other cropping sectors, strong productivity growth has been achieved through the establishment of close linkages between researchers and producers and the introduction of new technologies and management practices throughout the industry. GPS technology is now used in the industry which is highly mechanized. Improved soil and fertiliser management systems have also been introduced over recent years.

5.1.8 Horticultural industries.

The horticultural sub-sectors of Australian agriculture have historically been domestically-oriented, small-scale, and fragmented. This has changed over the past decade as growth has occurred in exports of some horticultural exports, and some large-scale vertically-integrated businesses have emerged in some sub-sectors. The amenity horticulture sub-sectors (including nurseries and turf production) have also grown substantially over recent decades. Together, these sub-sectors represented an average of approximately $10 billion in total output over the three years from 2006 to 2008, an average of almost 25% of the total value of Australian agricultural output.

Unfortunately, there is limited statistical data available about these sub-sectors of agriculture, as farms in these sub-sectors are not included in ABARE surveys, and there are a large number of separate commodities represented within this sub-sector, which makes accurate data collection difficult. For that reason, data on productivity changes within these sub-sectors is not available.

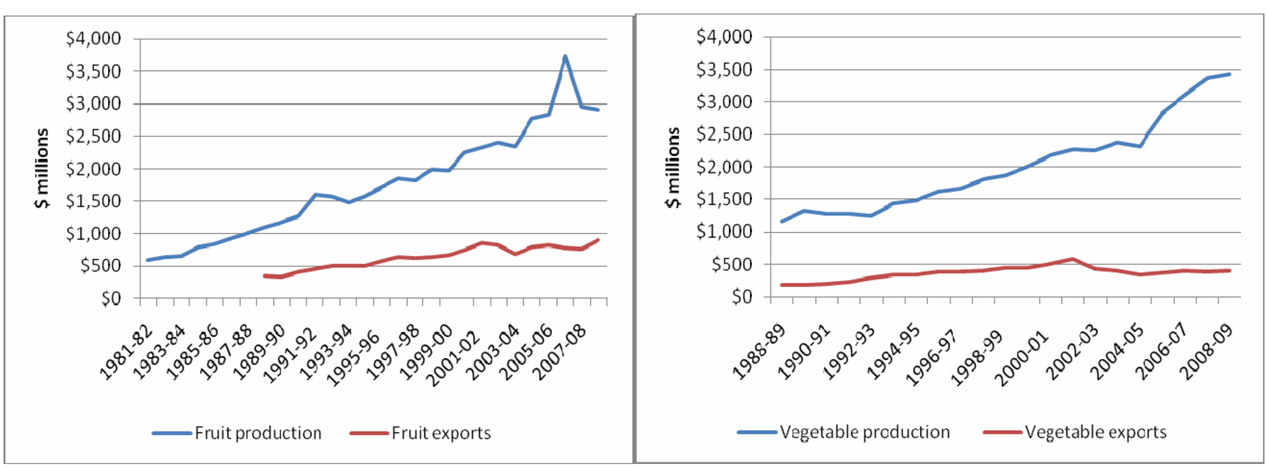


Figure 36 Value of Australian fruit and vegetable production and exports.

(Source: ABARE 2009b)

5.1.9 General conclusions and policy implications.

Comparisons of productivity growth rates between the rural sector and the rest of the Australian economy confirm that productivity growth rates in the rural sector have been the second highest in the Australian economy, with only the communications sector having a higher rate of productivity growth over the period from 1985 to 2006 (ABS, 2007). The following table and graph summarises the sector productivity growth rates calculated by the ABS.

Table 11 Annual percentage change in multi-factor productivity by economic sector.

	1985-86 to 1990-91	1990-91 to 1995-96	1995-96 to 2000-01	2000-01 to 2005-06	1985-86 to 2005-06
Communication services	4.7	4.7	2.2	2.7	**3.6**
Agriculture, forestry, fishing	2.3	1.8	5.3	2.5	**3.0**
Finance and insurance	3.1	2.0	2.0	0.2	**1.8**
Transport and storage	0.7	2.9	1.7	1.6	**1.7**
Wholesale trade	-1.8	3.9	2.9	1.3	**1.5**
Electricity, gas and water	6.0	2.6	0.5	-3.2	**1.4**
Retail trade	-1.0	1.1	2.2	0.7	**0.7**
Manufacturing	0.9	0.5	1.1	0.4	**0.7**
Construction	-1.8	0.2	-	4.5	**0.7**
Mining	3.5	2.3	1.1	-5.9	**0.2**
Accommodation, cafes, restaurants	-3.8	-	1.4	2.5	**-**
Cultural, recreating services	-0.9	-2.2	0.8	-0.2	**-0.6**
Market sector	**0.8**	**1.6**	**1.6**	**0.8**	**1.2**

(Source: ABS Statistical publication 5260)

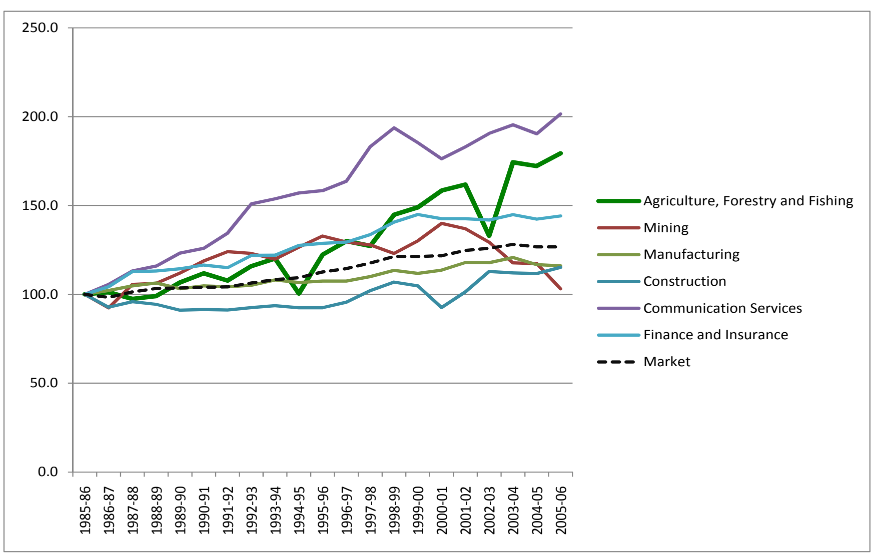


Figure 37 Multifactor productivity indexes for Australian economic sectors.
(Base year is 1985-86. Source; ABS Statistical publication 5260, 2007)

While it is acknowledged that rural R&D is not the sole contributor to rural productivity growth, these and other similar results identify that productivity growth in the rural sector in Australia has been higher than that observed for most other sectors, and considerably above the average observed for the entire economy. This provides good evidence that the innovation system in the rural sector has been performing as well as, if not better than the systems in most other economic sectors in Australia.

When Australian rural productivity growth rates are compared with those observed in other nations (see Table 8), the conclusion is that the rates of productivity growth observed in the rural sector in Australia have been amongst the highest observed for any national rural sector in a developed nation. (Mullen and Crean, 2007, Alston, Babcock and Pardy, 2010). In addition, comparisons of rural sector productivity growth relative to economy-wide rates of productivity growth also identify that the relative productivity performance of the Australian rural sector is comparable with the best performances observed internationally. (Mullen and Crean, 2007). This is important, as it provides a comparison between national rural sector productivity growth rates, taking into account the benefit the respective national rural sectors obtain from national productivity growth.

These results provide good evidence that the rural R&D system in Australia has performed well. While the rural R&D systems comprises a number of participants and not just the RDCs, the significant role the RDCs have in the system means that the evidence is that the current RDC model has been effective in improving the competitiveness of Australian rural industries.

The recent apparent slowing of rural productivity growth rates in Australia over the period since 2000 is a matter of concern, especially because it has important long term implications. While it may be argued that this trend suggests that the RDCs may no longer be as effective as they once were, the more likely cause of this is the stagnant, and in some cases declining government investment in rural R&D, in combination with seasonal conditions which have clearly impacted crop sector output. Irrespective of whether the slowing in productivity growth is a result of stagnant R&D investment rates, poor seasonal conditions or a combination of both, it provides strong evidence that there is a need for increased levels of investment in rural R&D in Australia.

An apparent slowdown in rural R&D productivity growth has also been observed in other developed nations, coinciding with either stagnation or a decline in the levels of public sector investment in rural R&D. As was noted in a recent major review of this issue;

> *"The compilation of country-specific studies reported in Alston et al. (2000) reveals a strong association between lagged research and development (R&D) spending and agricultural productivity improvements. We suspect that a substantial share of past agricultural productivity growth resulted from agricultural R&D. Consistent with that view, and the fact that research affects agricultural productivity with a long lag, we also suspect that the reduced growth in productivity observed during the past decade or two may be attributable in significant part to a slowdown in the rate of growth in spending on agricultural R&D a decade or two previously."* (Alston et al 2010)

This has implications for Australian R&D policies, as it means that it is likely (in the absence of a major change in rural R&D investment policies internationally) that international spill-ins are likely to slow, and Australian will need to rely to an even greater degree in the future on the success of the national rural R&D system, which is dependent to a large degree on the level of resources available to the system, and in particular the RDCs.

6. The appropriateness of current funding levels and arrangements

It is apparent from the extensive published research into the links between rural R&D and rural productivity growth that there are no firm 'rules of thumb' about how much rural R&D investment is required to obtain optimum rates of productivity growth, or indeed the 'dose-response' relationship between rural R&D investment and rural productivity growth. This uncertainty arises because the outcomes of R&D activities are just one of a large number of different factors that contribute to rural productivity growth. It is also evident that there is a considerable time-lag between changes in R&D investment levels and associated responses in rural productivity growth rates, and this further adds to the uncertainty. This is important, as robust data about R&D investment levels and rural productivity growth generally is only available over the past fifty years for a limited number of nations, so there is not a great deal of evidence available about rural productivity responses to changes in R&D investment levels.

Judgments about how much rural R&D investment is needed tend to be made on the basis of either a comparison with investment levels in other nations, or on an assessment of the returns that are available from extra rural R&D investment.

6.1 International comparisons.

In considering what should be the R&D investment level in the Australian agriculture sector, it is useful to reference levels of R&D investment globally, and for all sectors rather than just agriculture. Two measures of R&D investment intensity are used internationally; Gross Expenditure on R&D (GERD) which includes both government and business expenditure, and Business Expenditure on R&D (BERD), which only includes R&D expenditure by the private sector. For international comparison purposes, both are expressed as a proportion of national GDP.

Within the OECD, the average GERD ratio for 2006-07 was 2.26%, and Australia was ranked 10th highest with a GERD ratio of 2.01%. Leading nations include Sweden (3.73%), Finland (3.45%), Japan (3.39%) and the USA (2.62%). National levels of business investment in R&D (BERD) are always lower, and the average BERD ratio for OECD countries was 1.59% for 2007-08, with Australia ranked 14th with a BERD ratio of 1.27%. Leading nations include Japan (2.63%), Sweden (2.66%) and the USA (1.93%) (OECD, 2008)

Amongst developed nations, the intensity of R&D investment in agriculture is generally much higher than the intensity of R&D expenditure in the economy as a whole. For developed nations, the average gross expenditure (Government and private sector) on agricultural R&D expressed as a ratio of agricultural GDP was 5.16% in 2000 (Pardy et al 2006) of which the private sector accounted for 54.3% of total expenditure. Government R&D investment intensity averaged 2.36% in 2000, a figure that remained largely unchanged from 1990. Developing nations had a much lower average Government agricultural R&D investment intensity (approximately 0.5%) in 2000, although the developing nation rate was growing quickly, whereas public investment levels for developed nations tended to be static.

Private sector investment levels in agricultural R&D have increased quite substantially over the past two decades, although there is some question about whether international statistics identifying the organisations carrying out agricultural R&D also reflect the source of investment for that R&D. That qualification noted, the 'privately performed' share of agricultural R&D in OECD countries grew steadily from 43.6% in 1981 to 54.3% in 2000 (Pardy et al, 2006), and was equivalent to an R&D investment intensity of 2.8%.

Australian public agricultural R&D investment intensity is currently estimated to be approximately 3% (Mullen, 2010), although this data excludes public R&D investment in forestry and fisheries. Australian public investment levels grew rapidly in the post-war years, peaking at almost 5% from the mid 1970s to the mid 1980s, but have since stagnated and then declined as public agricultural R&D investment levels have declined in both nominal and real terms.

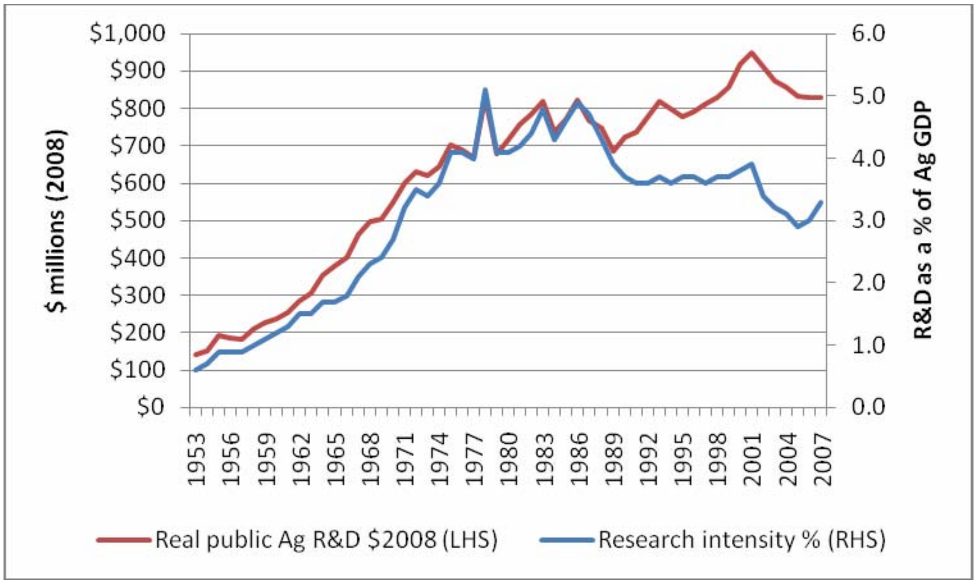


Figure 38 Real public agricultural R&D investment levels and investment intensity.
(Source: Mullen, 2010).

Based on estimates noted earlier, if private sector rural R&D investment is added to public sector investment, it is likely that gross national expenditure (both public and private) on agricultural R&D in Australia at present is equivalent to approximately 3.7 - 4% of rural GDP, a level which seems to be generally in agreement with recent analysis by ABARE (ABARE, 2009a). This estimate indicates that rural R&D investment intensity in Australia is below the OECD average level reported by Pardy et. al. in 2000, although the OECD average is likely to have changed since that time. Australian public-sector investment levels appear to be slightly higher than the OECD average, while private sector investment levels are considerably lower. In comparison with the USA, however, both private and public sector rural R&D investment levels in Australia are significantly lower.

6.2 Rural R&D investment returns.

From the perspective of Australian governments, the critical question in making decisions about the level of public funding that should be allocated to rural R&D should be "*what is the return the community generates from investing in rural R&D compared to returns available from other public investments?*" Implicit in this question is not only that public investment in rural R&D should generate positive investment returns, but also that the returns available from rural R&D investment should be better than the returns available from other investments. It would be naïve to think that governments make decisions based solely on objective analysis without any consideration of political implications, but nevertheless consideration of available investment returns should at least be an important factor in government decision-making.

Assessing the returns available from investment in rural R&D is not a simple task. Any analysis is complicated by the fact that R&D is inherently risky, that knowledge accumulation can result in innovations not foreseen at the time of the research, that innovations can develop from new knowledge generated either within or outside the industry, and that there is commonly a multi-decadal time lag between the discovery of new knowledge and the adoption of innovations arising from that knowledge. As discussed earlier, successful rural R&D also commonly generates spillover benefits that extend well beyond the agriculture sector, and attributing a value to these spillover benefits is not easy. As a simple example, the pioneers of human in-vitro fertilization in Australia were agricultural researchers, but the spillover benefits of their early research would be almost impossible to place a value on.

There have been a range of different studies conducted both in Australia and internationally to calculate the returns that are generated from investment in rural R&D. A summary of the results of these studies was reported by Mullen (Mullen and Crean 2007), and is displayed in the following table.

Table 12 Estimations of rates of return to agricultural R&D investment.

Researchers	Period investigated	Details	Results
Scobie *et. al.* 1991	Prior to 1990s	Returns to research expenditure in the Australian wool industry	Average national IRR of 9.5%. IRR to woolgrowers of 25%
Mullen and Cox 1995	1953-1988	Returns to public research expenditure in Australian broadacre agriculture.	Returns between 15% (35 year research lag) and 40% (16 year research lag)
Mullen and Strappazzon 1996	1953-1994	Returns to public investment in Australian broadacre agriculture research.	Returns between 18% (35 year research lag) and 39% (16 year research lag) p.a.
Cox *et. al.* 1997	1953 - 1994	Returns to public investment in Australian broadacre agriculture research.	Marginal IRR to research and extension expenditure of 12-20%
Alston *et. al* 2000	1953 - 2000	Meta-Analysis of reported rates of return to agricultural R&D investment for 292 studies published internationally.	Median return of 48.0% p.a. for research, 62.9% p.a. for extension, and 37% p.a. for returns to research and extension combined.
Shanks and Zheng 2006 (Productivity Comm.)	1970s - 2004	Rates of return to public R&D investment in Australian agriculture.	24% - 32% rate of return p.a. depending on assumptions.
Wang (2006)	1953 - 2003	Returns to public investment in Australian broadacre agriculture research.	IRR of 11% to 35% per annum
Mullen, 2007	1918-2003	Rates of return to Australian research and extension expenditure under different scenarios.	IRRs of between 14 and 17%

Importantly, the conclusion from the review of these studies is that there is no evidence that the rates of return from agricultural research have, or are likely to decline over time.

More recently, a specific initiative has been undertaken by the Council of Rural Research and Development Corporation Chairs (CRDCC) to evaluate investment returns arising from Australian research projects funded by RDCs (Council of Rural Research and Development Corporation Chairs, 2008, 2010). This work has involved, firstly, the development of an agreed project evaluation methodology, and secondly the use of that methodology to evaluate a sample of projects that have been funded and managed by the RDCs. The 2008 evaluation of 32 randomly selected projects estimated that the average rate of return for each dollar invested was approximately $11, with the benefits being shared approximately equally by the industry and the community.

A second round of analysis examined a further 59 randomly selected research programs, and concluded that over a twenty five year timescale, returns to investment were $10.51 for every dollar invested. This research also identified that investment returns were quick to be realised, with 60% of projects showing a positive net present value return by five years and 77% showing a positive net return after ten years.

The research report noted that it was not possible to evaluate environmental and social benefits arising from many of the projects, and the estimated rates of return therefore underestimate the full set of benefits derived from the research.

6.3 Funding arrangements of RDCs

An important element in the funding of rural R&D in Australia is the payment of compulsory levies by rural producers, more particularly in the agricultural sub-sectors. The payment of compulsory levies has long been an issue of contention in Australian agriculture, although historically the contention has focused mostly on the payment of levies for promotion and marketing purposes, rather than on R&D levies. While there are arguments for and against compulsory R&D levies, there is strong support (as expressed in levy ballots) amongst rural producers for their continuation. This is particularly so given the industry good outcomes generated by levy-funded R&D.

Opportunities exist within the different RDCs for producers and producer groups to voluntarily contribute additional revenue to specific research projects, and also for downstream sectors of the industry to become co-contributors to research through contributions to Donor Companies or through other arrangements. Financial reports of RDCs highlight that these other sources of revenue are significant, and provide an indication of the industry-wide support for R& D investment. In the absence of compulsory R&D levies, the large industry and public-good spillovers arising from rural R&D would create major ‘free rider’ inequities, and create disincentives to R&D investment which would disadvantage the entire sector over the longer term.

6.4 Conclusions.

Both the analysis of levels of Australian and international agricultural R&D investment intensity, and the rates of return to agricultural R&D investment indicate that current agricultural R&D investment levels in Australia are lower than optimal, and have been declining since the late 1980s. Given the long time-lags involved between R&D investment and productivity growth, this has the potential to reduce Australian agricultural competitiveness over the longer term, if current levels of investment persist into the future.

The rates of return estimates across a range of R&D projects indicate that government investment in rural R&D is as good, if not a better investment than many of the alternative investment options that are available to governments. This is particularly so given the long-term cumulative nature of benefits derived from rural R&D investment, and the fact that the calculated investment returns from rural R&D do not include the value of many environmental and social benefits that arise. These benefits arise initially in regional Australia and are therefore useful as an indirect means of addressing regional disadvantage, but are also enjoyed more generally by the entire population in the form of cheaper and better quality food and fibre, and improved environmental outcomes in relation to air and water quality, and biodiversity conservation outcomes.

Of particular concern in relation to funding levels is the steady decline in resources allocated to rural R&D by state governments. State government agencies have traditionally played a strong role in agricultural research and also in agricultural extension, which is obviously of great importance in ensuring successful agricultural R&D is translated into innovation and productivity growth. It has been apparent for some years that the progressive downgrading of state government agricultural extension activities has longer term implications for the efficient operation of the Australian agricultural R&D system. In some sub-sectors – in particular in the cropping industries – extension activities are being taken up by the private sector, either as part of the service provided by agricultural input suppliers, or by commercial providers operating on a fee-for-service basis. Commercial providers are also providing these services to operators of large-scale, vertically-integrated horticultural and intensive livestock businesses, but it seems that medium to small-scale broadacre farm businesses, the majority of horticulture businesses and most businesses in the livestock sector in particular have not adopted this approach. The reduction of state government research and extension services has placed added demands on rural RDCs, and a number of them have now undertaken specific initiatives (such as regional structures and increased interaction with professional farm advisors) as a response. This, of course, has implications in terms of the availability of RDC resources for research activities.

A perennial question in relation to government co-contributions to RDCs has been whether or not the matching dollar-for-dollar government contribution is justifiable in terms of the mix of industry and community benefits arising from rural R&D. Certainly, at an individual project level the share of benefits for industry and the wider community will vary. In some instances, it appears that more than half the benefits are captured by industry, while in other cases, public benefits have been estimated to be more than five times the benefits captured by industry (Radhakrishnan et al, 2009). Even in the instances where most of the short-term benefits accrue to industry, over time these benefits are usually transferred to consumers in the form of lower prices. It is noteworthy that the analysis carried out by the CRRDCC identified that, over a portfolio of projects, the estimated benefits were almost equally distributed between the industry and the community. This supports the pragmatic notion that a 50:50 funding split for rural RDCs between industry and government remains appropriate, in the absence of strong evidence that it should be varied in either direction.

An option to enable levels of investment in rural R&D in Australia to increase into the future is the removal of the 0.5% Gross Value of Production cap that applies to matching funds contributed by government to RDC funding. This would allow rural industries to evaluate, and if agreement can be reached, to increase industry R&D investment levels, while at the same time ensuring that the wider community contributes to the benefits that are likely to be gained as a consequence.

7. The efficiency and effectiveness of the RDC model and scope for improvements.

The RDC model that has developed and evolved in Australia is somewhat unique, and is also not a single model, but one which varies between industry sub-sectors. This flexibility is important, because the structure of commodity sub-sectors within agriculture means that a ‘one-size-fits-all’ approach to the delivery of research and development services will not necessarily meet industry needs. That noted, it should be a high priority of RDCs to ensure that the services they provide are delivered in the most efficient and effective manner possible, and that levy-payers have access to objective and transparent information about the efficiency and effectiveness of the organisations they fund. Information about the efficiency and effectiveness of RDCs does, however, need to be considered in the context of the differences between the sub-sectors of agriculture they service.

A simple example is the difference between the sectors serviced by Horticulture Australia Limited, and the Cotton Research and Development Corporation.

Horticulture Australia services an industry that is distributed geographically across the entire nation from northern Australia to southern Tasmania, and which consists of thirty eight distinct commodity production groups. Some of these are quite large, while others are relatively small. The businesses supply a wide range of different markets, from local fresh domestic consumption to processing and export markets. The demographics of the businesses within the commodity groupings also varies considerably, with some of the largest and some of the smallest farm businesses being involved, and a relatively even distribution across the entire rural business-size spectrum.

The Cotton Research and Development Corporation, on the other hand, services approximately 1,000 cotton growers, the majority of whom are located within a relatively small geographic region in northern NSW and southern Queensland. The nature of the cotton industry is such that it consists of farm businesses that are relatively large in scale, have a high level of investment in machinery and technology, and these businesses also operate in close association with downstream participants in the industry, such as cotton gins. The industry is also almost exclusively focused on export markets.

The challenge of developing industry research priorities, commissioning research, managing research projects to successful conclusion, and then extending the results of that research to growers is dramatically different for the two organisations. Cotton businesses generally utilise professional advisory services, so these advisors provide a communication pathway for the CRDC to extend research outcomes to growers. The relatively limited geographical distribution of cotton production also makes other forms of extension, such as field days and valley meetings, a viable and effective means of communicating with growers.

Horticulture producers, on the other hand, do not utilise advisors to the same degree, and the industry has therefore had to rely on state government extension services or RDC staff to communicate with producers. The gradual disappearance of state government extension officers, and the relatively specialised nature of many horticulture sub-sectors makes communication with industry participants a particular challenge, and an added cost for Horticulture Australia.

Horticulture Australia, in managing a research portfolio for a large number of organisations – some of which are relatively small in size – also faces the added challenge of potentially administering a much larger number of research projects, many of which may be relatively small due to the limited resources available to a specific group of commodity producers on whose behalf the project is being administered. Experience suggests that each research project, irrespective of size, will involve relatively fixed deadweight costs for an administering organisation, and a portfolio with relatively more small projects will therefore inevitably be more expensive to administer than one with a smaller number of large projects.

As a consequence, Horticulture Australia faces a distinctly different set of challenges in servicing its levy-payers than does the Cotton Research and Development Corporation.

A similar situation also applies for other RDCs, with each one facing a different set of industry demographics and industry production challenges. Those servicing the livestock industries, in particular, inevitably need to commission projects that are more expensive and take longer to complete, simply because of the extra regulatory and management requirements associated with research involving animals, compared to plant research..

Added complexities will also inevitably be associated with cross-sectoral research projects that may involve a mix of private sector, RDC and government participation. State government research agencies, in particular, invariably have contract negotiation and approval processes that involve processes within multiple sections of an organisation, and experience has shown that projects involving these can take a much longer period of time to finalise, at greater overhead cost. The result is that RDCs involved in collaborative projects will invariably incur a greater proportion of administrative costs than will be the case for projects with only a single organisation involved.

A conclusion from these observations is that there is some danger in using simple measures such as the ratio of administration costs to research project expenditure as a measure of the efficiency of each of the RDCs. There may also be perverse outcomes associated with the use of these measures, if for example, an organisation could improve its apparent efficiency by reducing the resources (and costs) associated with industry communication and extension. The end result could well be a very efficient research organisation that is very ineffective at getting industry to uptake innovations and increase its productivity.

A preferred approach to ensure all RDCs constantly strive to improve their efficiency and effectiveness is the development of an agreed set of indicators that are capable of providing performance measures of the full range of functions that are carried out by each RDC, ranging from industry consultation on research priorities through project management and extension of information to industry. The compilation and publication of these measures could become an important tool to improve RDC efficiency and effectiveness, not so much by comparing measures between organisations, but by comparing an organisation’s performance over time.

8. The appropriate mix of research, and the role of different institutions.

An important role for the Board of an RDC is the implementation of a balanced portfolio of research, which includes projects that will deliver benefits within a relatively short timeframe, and which also includes projects that it is expected will deliver benefits over a longer timeframe, but which will take a longer period to get to 'market'. Official categorisation systems for research usually include four categories of research types. These are Pure Basic, Strategic Basic, Allied Research and Experimental Development. The definitions of each of these are as follows;

- ***Pure basic research*** is experimental and theoretical work undertaken to acquire new knowledge without looking for long term benefits other than the advancement of knowledge.
- ***Strategic basic research*** is experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the solution of recognised practical problems.
- ***Applied research*** is original work undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives.
- ***Experimental development*** is systematic work, using existing knowledge gained from research or practical experience that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

At a national level, ABS statistics identify that about 10% of research expenditure economy-wide is categorised as involving pure basic research, with the Higher Education sector being the main provider of this research. (Fig 39)

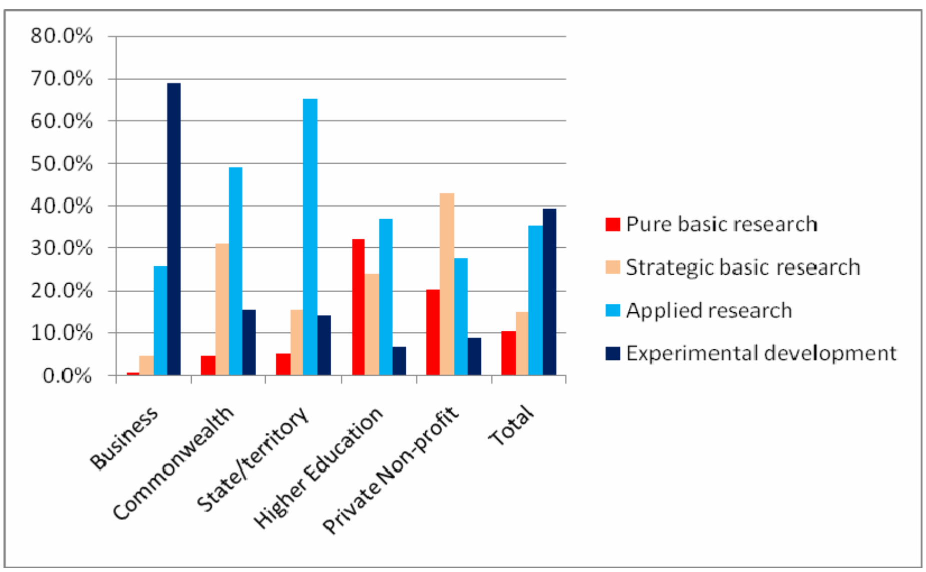


Figure 39 Types of research carried out by Australian research providers
(Source: ABS Statistical publication 8112.0. Averaged over the period between 1992-3 and 2006-7)

Approximately 15% of research carried out is strategic basic research, 35% is applied research and 40% is experimental development. Business research investment overwhelmingly involves research classified as experimental development, whereas the Commonwealth and State Governments tend to have a greater proportion of their research classified as either strategic basic or applied research.

It should be noted that these statistics are economy-wide, and there does not appear to be similar information available that is specific to the rural sector.

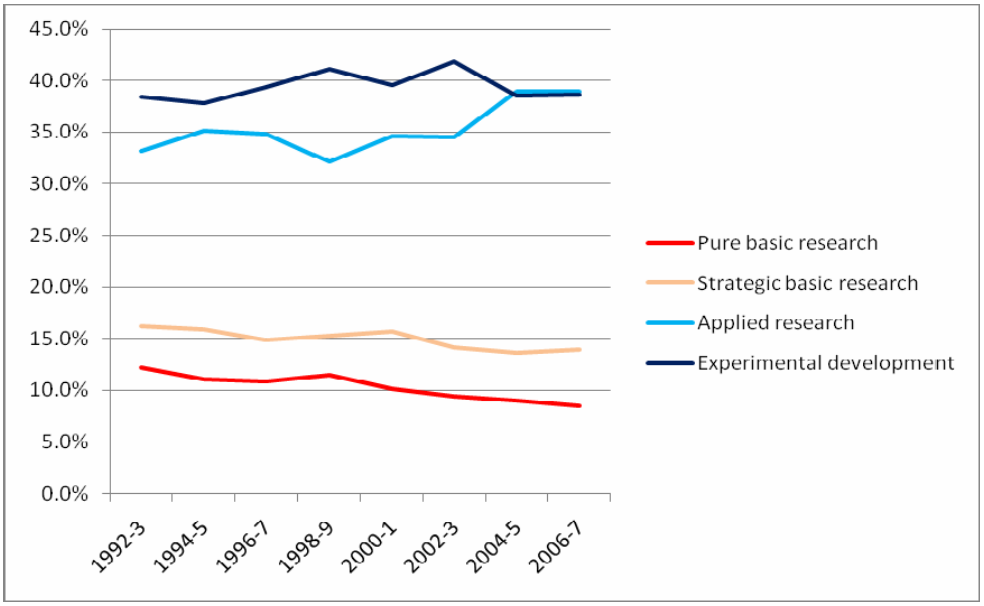


Figure 40 Changes in the Type of Research mix over time, Australia.
(Source: ABS Statistical publication 8112.0)

At the national level, there has been a reduction in the proportion of pure basic and strategic basic research being carried out over time, and an increase in the proportion of applied research. These trends are probably a reflection of the increased importance of private or business investment in total Australian R&D expenditure. Again, these trends are for R&D in the economy as a whole, and not specific to rural R&D.

There has been some debate on the best agricultural R&D portfolio mix in the USA over a number of years. Based on available statistics (National Science Foundation, 2010) the 2009 USDA agency R&D portfolio consists of 41% basic research projects, 51% applied research projects, and 8% experimental development projects. The largest allocation of funds was to the USDA's own Agricultural Research Service, which was identified as predominantly carrying out basic research. It should be noted that the USDA is responsible for around 28% of total US public agricultural research expenditure, with the balance carried out at State-level institutions.

A comparison of investment returns from different projects carried out some years ago (Fox et al 1987) in the USA did not reach any firm conclusions about whether basic or applied research projects delivered better returns over the long-term, and concluded that there are risks in moving a R&D portfolio too far in either direction.

In relation to rural R&D in Australia, it is likely that the portfolio mix, and the changes in that mix over time would broadly reflect trends observed economy-wide, although there is not data available to support that contention. Similarly, rural RDCs do not generally report their research activities in terms of the type of research being carried out, and it is therefore difficult to make a judgment about whether R&D portfolios of the RDCs contain a balance of both applied and basic research projects.

In saying this, it should be noted that there is no necessarily 'correct' mix of research that an organisation should undertake, and it may well be that Australia is not internationally competitive in conducting basic rural research, for example. However, if this is the case it will mean that it is even more important that applied research and experimental development investment occurs in Australia, given the commodity and geographic diversity of Australian rural industries.

In relation to the respective roles of different institutions, it is probable that Universities and Australian Government agencies such as the CSIRO would be involved in more basic research activities, whereas the State Government agencies and the private sector would be involved in applied research or experimental development. Unfortunately, there is a lack of comprehensive data on the rural R&D system in Australia, (not just on the type of research being carried out) which makes judgments about the appropriateness of the research mix impossible to make. The establishment and maintenance of a single comprehensive data collection about rural R&D in Australia would greatly assist decision-making on these issues, and is recommended as an important tool in better coordinating and managing rural R&D.

The structure of some RDCs, whereby Board are periodically subject to election by levy-payers, potentially creates pressure for Board to bias the RDC portfolio towards applied research and experimental development, in order to be able to quickly generate benefits for levy-payers. At the same time, however, the Board election process makes the RDCs accountable to levy-payers, and establishes a degree of engagement and ownership by farmers. As a means of managing the tension between the demand for quick returns and the need for some long term projects, RDC Board should provide levy-payers with objective information about the makeup of the RDC portfolio, and the rationale employed to arrive at that position. It is also important, given the role played by RDCs, that Board selection process ensure there is a good balance of industry knowledge and research and development experience represented around the board table.

9. General conclusions and recommendations.

Much of the focus of the review of RDCs is on operational issues, which vary between different organisations, and require considerable detailed information in order to be able to respond to in an objective manner. Underlying this review, however, is the more general issue of the future competitiveness of Australia's rural industries, and the contribution that investment in R&D can make to enhancing that competitiveness in the future. All the available evidence points to a need to accelerate productivity growth in the rural sector in order for the sector to remain competitive, and also to the strong relationship that exists between R&D investment levels over the longer term and rates of productivity growth.

There are two suggested mechanisms that arise from this review that will enable increased investment in rural R&D in the future. The first is to lift the current cap on matching government contributions to rural R&D from 0.5% of GVP. As it stands, the cap acts as a disincentive to further investment, as industry groups are well aware that research investment in excess of this level will not attract matching government funding, but will still generate the same public good spillovers that arise from rural R&D in general. In effect, the wider community becomes a 'free-rider' if commodity sub-sector elects to exceed the 0.5% GVP threshold.

A second mechanism aimed at securing continued support for R&D from State Governments is to utilise the current discussions about a National Primary Industries Research Development and Extension Framework to lock-in commitments from State Governments to rural R&D over the longer term, via an intergovernmental agreement. If this does not occur, it seems inevitable that a number of State Governments will continue to reduce the level of expenditure they allocate to rural R&D, and will continue to rely more and more on RDCs and the Commonwealth to provide rural R&D investment in Australia.

A related issue is the increased demands that are being placed on RDCs to demonstrate that their research investments are generating substantial public good in the form of environmental or greenhouse emission outcomes, or other more general benefits to the wider community. There is a real danger that a focus on public good outcomes will diminish the industry productivity outcomes from RDC investment, especially in circumstances where the total pool of funds available for investment is limited. As is noted in this submission, there are not similar public good outcome requirements imposed on business R&D investment that is eligible for the R&D tax concession, because that would have the potential to distort the decision-making processes of businesses and limit their future profitability. The same rational should apply to RDC investment decisions. This is not to argue that RDC Boards should ignore public good outcomes in their decision-making, nor is it to argue that public good outcomes should be ignored in post-research evaluations of investment returns. However, too much focus on potential public-good outcomes at the investment decision-making stage will have the same effect as a reduction in overall investment.

The review has highlighted that the statistics associated with rural R&D in Australia are not as comprehensive or standardised as is the case in other nations, and this is a particular weakness that needs to be addressed. Again, the development of a National Primary Industries Research Development and Extension Framework provides an opportunity to develop standardised reporting systems to make information about the entire public-sector, and potentially the private-sector contribution to rural R&D in Australia much more transparent and accessible.

10. References

ABARE and MAF 2006, *Agricultural Economies of Australia and New Zealand: Past, Present, Future.* ABARE, Canberra.

ABARE 2009a, *Australian Commodity Statistics.* ABARE, Canberra.

ABARE 2009b. Promoting productivity in the agriculture and food sector value chain: issues for R&D investment. ABARE and BRS report for the Rural R&D Council, December 2009.

ABARE, 2010. *Australian Commodities,* March 2010.

ABS, 2009. 4627.0 Land Management and Farming in Australia 2007-08.

ACIL Tasman Pty Ltd, *AWI Performance Review2003 to 2006.* ACIL Tasman Pty Ltd. August 2006.

Adlas, J., and Achoth, L. *Is the Green Revolution Vanishing? Empirical Evidence from TFP Analysis for Rice*. Prepared for presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006

Agricultural Science and Technology Indicators Initiative. International Food Policy Research Institute. Washington, D.C. October 26, 2001

Agriculture and Agri-food, Canada, 2009 *An Overview of the Canadian Agriculture and Agri-Food System*. Agriculture and Agri-food, Canada August 2009

Alene, A. D.2009 *Productivity Growth and the Effects of R&D in African Agriculture*. Presentation at the International Association of Agricultural Economists Conference, Beijing, China, 16–22 August, 2009

Alfranca, O. and. Huffman, W. E., 2003 *Aggregate Private R&D Investments in Agriculture: The Role of Incentives, Public Policies, and Institutions*. *Economic Development and Cultural Change.* The University of Chicago. 2003

Alston, J. M., Babcock, B. A., and Pardey, P. G, 2010 *The Shifting Patterns of Agricultural Production and Productivity Worldwide.* The Midwest Agribusiness Trade Research and Information Center. Iowa State University, Ames, Iowa, 2010

Alston, J. M., Beddow, J. M., and Pardey, P. G, 2009. *Mendel Versus Malthus: Research, Productivity and Food Prices in the Long Run.* University of Minnesota, College of Food, Agricultural and National Resource Sciences, January 2009.

Alston, J. M., Pardey, P. G, and Ruttan, V. W. 2008 *Research Lags Revisited: Concepts and Evidence from U.S Agriculture.* University of Minnesota, College of Food, Agricultural and National Resource Sciences, December 2008.

Amanor-Boadu, V. and Zereyesus, Y. A. 2007 *Producers as Investors in Agricultural Research: Searching for Alternative Funding Strategies in Land-Grant Universities.* Presentation at the American Agricultural Economics Association Annual Meeting, Portland, July 29-August 1, 2007

Anderson K and Martin W (eds), 2005 *Agricultural Trade Reform and the Doha Development Agenda* (World Bank & Palmgrave Macmillian, 2005)

Arfini, F., Cernicchiaro, S., and Mancini, M. C. 2007 *Private Innovation and Public Innovation: Who Leads and Who Follows?* Presentation at the 1st International European Forum on Innovation and System Dynamics in Food Networks. Officially endorsed by the European Association of Agricultural Economists (EAAE), Innsbruck-Igls, Austria. February 15-17, 2007

Australian Government 2005. *Australia's farmers: past, present and future.* Land & Water Australia, June 2005

Australian Government, 2010. Department of Innovation, Industry, Science and Research. R&D Tax concession fact sheet. Accessible at http://www.innovation.gov.au/Section/AboutDIISR/FactSheets/Pages/RDTaxConcessionBERDFactSheet.aspx

Australian Government 2010b. *Australian Innovation System Report 2010.* Department of Innovation, Industry, Science and Research, 2010.

Australian Government. 2007 *New Elements of the R&D Tax Concession: Evaluation Report.* June 2007.

Australian Government: The Treasury, 2009. *The New Research and Development Tax Incentive* . Consultation paper, October 2009.

Australian Tax Office, 2010. *Tax averaging for primary producers*, accessible at: http://www.ato.gov.au/businesses/content.asp?doc=/content/33445.htm

Binenbaum, E., Mullen, J., and Tao Wang, C. 2008 *Has the Return on Australian Public Investment in Agricultural Research Declined?* Paper to be presented at the 2008 AARES conference in Canberra

Boehlje, M., Broring, S., and Roucan-Kane, M. 2009 *Innovation in the Food and Agricultural Industries: A Complex Adaptive System*. Dept. of Agricultural Economics. Purdue University. December 2009

Burnley J, Davis S, Lobell D. 2010 *Greenhouse gas mitigation by agricultural intensification.* Proceedings, National Academy of the Sciences, June 15, 2010.

Byerlee, D. and Dubin, H. J. 2009 *Crop Improvement in the CGIAR as a Global Success Story of Open Access and International Collaboration.* Paper presented at the International Conference on the Microbial Commons, Ghent, Belgium, June 12-13th, 2009

Carr, 2009. *Innovation powering ideas: An innovation agenda for the 21st Century.* Government response to the Cutler Review. Commonwealth of Australia. 2009.

Carew, R. 2006 *Private R&D Investment and Productivity Growth in a Panel of Food Manufacturing Industries*. Pacific Agri-food Research Centre, Agriculture and Agri-food Canada. Summerland, British Columbia. May, 2006.

Carrigan, G., Chudleigh, F., and Wilson, T. 2008 *Evaluating Research, Development and Extension: Practical insights from the Queensland Department of Primary Industries and Fisheries*. Paper presented at the 52nd Annual Conference of the Australian Agricultural and Resource Economics Society, Canberra, Australia, February 5th-8th, 2008.

Carroll, J., Greene, S., O'Donoghue, C., Newman, C. and Thorne, F.2009 *Productivity and the Determinants of Efficiency in Irish Agriculture (1996-2006).* The 83rd Annual Conference of the Agricultural Economics Society. Dublin. 30th March to 1st April 2009

Cooke, B. and Robles, M. 2009 *Recent Food Prices Movements: A Time Series Analysis*. International Food Policy Research Institute. Markets, Trade and Institutions Division. December 2009.

Cotton Economics Research Institute. 2007 *Guide To Foreign Crop Subsidies and Tariffs*. Department of Agricultural and Applied Economics, Texas Tech University. February 2007.

Council of Rural Research and Development Corporation Chairs, 2008. *Measuring economic, environmental and social returns from Rural Research and Development Corporations' investment.* Accessible at www.ruralrdc.com.au

Crowe, B., Linder, B., and Llewelly, R. 2006 *The benefits and beneficiaries of "public" investment in herbicide use research and development*. Presentation at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-28, 2006

CSIRO, 2010. Cotton breeding fact sheet. Accessible at http://www.csiro.au/science/Cotton-breeding.html

Cutler, 2008. *Venturous Australia.* Report of a review of the national innovation system. Commonwealth of Australia, 2008.

DAFF, 2010. Department of Agriculture Fisheries and Forestry 2010. Accessible at http://www.daff.gov.au/agriculture-food/innovation

Davidson, Prof. S., 2006 *Back to Basics: Why government funding of science is a waste of our money*. Public Affairs. *IPA Backgrounder*, Sept 2006, Vol. 18/4

D'Emden F H, Llewellyn R S, Burton M P. 2006. *Adoption of conservation tillage in Australian cropping regions: an application of duration analysis.* Technological Forecasting and Social Change. Vol 73.

Econtech 2005, *Australia's Farm-Dependent Economy: Analysis of the Role of Agriculture in the Australian Economy.* Australian Farm Institute, Surry Hills. Australia.

Ekboir, J. 2009 *The CGIAR at a Crossroads: Assessing the role of international agricultural research in poverty alleviation from an innovation systems perspective*. ILAC Working Paper 9, Rome, Institutional Learning and Change Initiative.

Ekboir, J. M., Dutrénit, M. V., Vargas, A. T., and Vera-Cruz, A. O. 2009 *Successful Organizational Learning in the Management of Agricultural Research and Innovation: The Mexican Produce Foundations.* International Food Policy Research Institute, 2009.

FAO 2009. Agstat database. Accessible at www.fao.org

Fox G Evenson R and Ruttan W 1987. *Balancing basic and applied science: the case of agricultural research.* Bioscience. Vol 37 (7). American Institute of Biological Sciences.

Fridfinnson B & Rude J 2009, '*The effects of biofuels policies on global commodity trade flows',* CATPRN Trade Policy Brief 2009-01, University of Alberta, accessible at: www.catrade.org

Fuglie, K O., and Heisey P W.2007 *Economic Returns to Public Agricultural Research.* EB-10, U.S. Dept. of Agriculture, Economic Research Service. September 2007.

Fuglie, K. O., MacDonald, J. M., and Ball, E. 2007 *Productivity Growth in U.S. Agriculture*. United States Department of Agriculture. Economic Research Service. Economic Brief Number 9. 2007.

Global Harvest Initiative, 2009. *Accelerating Productivity Growth: The 21st Century Global Agriculture Challenge: A White Paper on Agricultural Policy.* Global Harvest Initiative

Gray, R., Malla, S., and Tran, K. 2005 *Pecuniary, Non-Pecuniary, and Downstream Research Spillovers: The Case of Canola.* prepared for presentation at the XIth Congress of the European Association of Agricultural Economists, 'The Future of Rural Europe in the Global Agri-Food System', Copenhagen, Denmark, August 24-27, 2005

Griffith, G., Parnell, P., and McKiernan, B. 2006 *The Economic, Environmental and Social Benefits to NSW from Investment in the CRC for Beef Genetic Technologies.* NSW Department of Primary Industries 2006

Hall, A., Mytelka, L., and Oyeyinka, B. 2005 *Innovation systems: Implications for agricultural policy and practice.* ILAC Brief 2, July 2005.

Hartwich, F., Gottret, M. V., Babu, S., and Tola, J. 2007 *Building Public–Private Partnerships for Agricultural Innovation in Latin America: Lessons from Capacity Strengthening.* International Service for National Agricultural Research Division. May 2007.

Headey, D., Malaiyandi, S., and Fan, S. 2009 *Navigating the Perfect Storm: Reflections on the Food, Energy, and Financial Crises*. International Food Policy Research Institute. Development Strategy and Governance Division. August 2009.

Hooper S, Martin P, Love G, Fisher B 2002 *Farm size and Productivity: Where are the trends taking us?* Australian Commodities. Vol 9, No 3, September 2002.

Huffman, W. E. 2009 *Measuring Public Agricultural Research Capital and Its Contribution to State Agricultural Productivity.* Iowa State University Department of Economics. November 2009.

Huffman, W. E., and Just, R. E. 1998 *The Organisation of Agricultural Research in Western Developed Countries.* Iowa State University, Staff Paper No. 303. August, 1998.

James, J. S., Pardey, P. G., and Alston, J. M. 2008 *Agricultural R&D Policy: A Tragedy of the International Commons.* University of Minnesota, College of Food, Agricultural and National Resource Sciences. September 2008.

Kaye-Blake, W., and Saunders, C. 2006 *Estimated Contribution of Four Biotechnologies to New Zealand Agriculture.* Agribusiness and Economics Research Unit, Lincoln University, 2006.

Keogh M 2006, *"In Australia's services-dominated economy, should policymakers take any notice of agriculture?"* Paper presented to Australian Agriculture and Resource Economists Society Annual Conference, February 2006.

King, J. L. 2009 *Multinational Technology Diffusion in Agriculture.* USDA Economic Research Service. Presentation at the Agricultural & Applied Economics Association's 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, WI, July 26-28, 2009.

Kingwell R. 2010 *Managing complexity in modern farming.* Presidential address to the Australian Agricultural and Resource Economics Society Annual Conference, February 2010.

KPMG 2009, *State of the Industry 2009.* Report prepared for the Australian Food and Grocery Council, Canberra. Australia.

Labarthe, P. and Laurent, C. 2009 *Transformations of agricultural extension services in the EU: Towards a lack of adequate knowledge for small-scale farms.* EAAE-IAAE Seminar "Small Farms: decline or persistence". University of Kent, Canterbury, UK. 26th-27th June 2009

Liebenberg, F., Pardey, P. G., and Kahn, M. 2010 *South African Agricultural Research and Development: A Century of Change.* University of Minnesota, College of Food, Agricultural and Natural Resource Sciences. January 2010.

Lohmar, B., F. Gale, F. Tuan, and J. Hansen. 2009 *China's Ongoing Agricultural Modernization: Challenges Remain After 30 Years of Reform*, Economic Information Bulletin No. 51, U.S. Department of Agriculture, Economic Research Service, April 2009.

MAF 2002. Ministry of Agriculture and Fisheries, New Zealand. "Towards a Strategy for Using Bt toxins in New Zealand. MAF Technical Paper 2002/20. Accessible at http://www.maf.govt.nz/mafnet/rural-nz/research-and-development/biotechnology/using-bt-toxins-in-new-zealand/

MAF, 2009. *Funding primary sector and food research and innovation.* MoRST/MAF Joint Briefing, NZ Ministry of Agriculture, Forestry and Fishing.

McCalla, A. F., and Revoredo, C. L. 2001 *Prospects for Global Food Security. A Critical Appraisal of Past Projections and Predictions. Food, Agriculture, and the Environment Discussion Paper 35.* International Food Policy Research Institute. October 2001.

McMahon, J. A., 2006, *The WTO Agreement on Agriculture – A commentary,* Oxford University Press, New York, p 14.

Meat and Livestock Australia 2009.*Building the Australian prime lamb industry: The Industry Impact.* Meat and Livestock Australia.

Moss, C. B. 2006 *Valuing State-Level Funding for Research: Results for Florida.* Journal of Agricultural and Applied Economics. Southern Agricultural Economics Association. April 2006.

Moutinho, N., Machado, F. S., and Silva, E. 2003 *An International Comparison of Productivity Change in Agriculture and the Economy as a Whole: A Stochastic Production Frontier Finite Mixture Model Approach.* CETE − Centro de Estudos de Economia Industrial, June 2003.

Mullen J D 2007. *Productivity growth and the returns from public investment in Australian broadacre agriculture.* Australian Journal of Agriculture and Resource Economics. Vol 51.

Mullen J D and Cox T L 1996. *Measuring productivity growth in Australian Broadacre Agriculture.* Australian Journal of Agricultural Economics. Vol 40 (3)

Mullen J D and Crean J, 2007. *Productivity growth in Australian Agriculture: Trends, Sources, Performance.* Australian Farm Institute.

Mullen J D, 2010. *Trends in Investment in Agricultural R&D in Australia and its Potential Contribution to Productivity.* Australasian Agribusiness Review. Vol. 18, 2010.

Naseem, A., Were Omamo, S., and Spielman, D. J. 2006 *The Private Sector in Agricultural R&D: Policies and Institutions to Foster its Growth in Developing Countries*. International Service for National Agricultural Research, August 2006.

National Research Council, 2001. *Publicly Funded Agricultural Research and the Changing Structure of U.S. Agriculture.* Committee to Review the Role of Publicly Funded Agricultural Research on the Structure of U.S. Agriculture (Washington, DC: National Academy Press).

National Science Foundation, 2010. Science Resources Statistics FY 2009. Accessible at http://www.nsf.gov/statistics/nsf10305/content.cfm?pub_id=3966&id=2

Nossal K and Sheng Y 2010. *Productivity growth: Trends, drivers and opportunities for broadacre and dairy industries.* Australian Commodities 17(1) March 2010.

OECD 2009, *Agricultural Policies in Emerging Economies: Monitoring and Evaluation 2009*, accessible at: www.oecd.org

OECD 2009, *Agricultural policies in OECD countries: Monitoring and evaluation*, accessible at: www.oecd.org

OECD, 2008. Main Science and Technology Indicators, Vol 2008/1. Available at www.oecd.org

OECD, 2005. *Agricultural Policy Reform in China.* Policy Brief, October 2005.

Pal Singh, R., Brennan, J. P., Lacy, J., Steel, F. 2008 *An Assessment of the Economic, Environmental and Social Impacts of the Ricecheck Program.* Economic Research Report Number 28. NSW Department of Primary Industries. December 2008.

Pardey, P.G. and N.M. Beintema. 2001 *Slow Magic: Agricultural R&D a Century after Mendel*. Washington, D.C.: IFPRI Food Policy Report, 2001.

Pardey, P. G., Beintema, N., Dehmer, S., and Wood, S. 2006 *Agricultural Research. A Growing Global Divide?* Agricultural Science and Technology Indicators Initiative. International Food Policy Research Institute, Washington,D.C. August 2006

Pfeiffer, L. M., 2003 *Agricultural Productivity Growth in the Andean Community.* American Journal of Agriculture Economics (December 2003, Volume 85, Issue 5),

Pingali, P. 2009 *Global agriculture R&D and the changing aid architecture.* Presented at the 27th International Association of Agricultural Economists Conference. Beijing, China. 2009

Plastina, A. S., and Fulginiti, L. E. 2007 *Rate of Return to Public Agricultural Research in 48 U.S States.* Presentation at the American Agricultural Economics Association Annual Meeting, Portland, OR, July 29-August 1, 2007

Pray, C. E. and Fuglie, K. 2001 *Private Investment in Agricultural Research and International Technology Transfer in Asia.* United States Department of Agriculture. Agricultural Economic Report No. 805. November 2001.

Productivity Commission 2005. *Trends in Australian Agriculture.* Research Paper, Productivity Commission, Canberra.

Productivity Commission 2007*, Public Support for Science and Innovation*, Research Report, Productivity Commission, Canberra.

Productivity Commission 2009, *Trade & Assistance Review 2007-08*, Annual Report Series, Productivity Commission, Canberra.

Radhakrishnan M, Islam N, Ward G 2009. *Measuring the benefit from R&D investment beyond the farm gate: the case of the WA wine industry*. Contributed paper - Australian Agricultural and Resource Economics Society Annual Conference, Feb 2009.

Rada, N. E., Buccola, S. T., and Fugile, K. O. 2009 *Brazil's Rising Agricultural Productivity and World Competitiveness.* Presentation at the Agricultural & Applied Economics Association 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, Wisconsin, July 26-29, 2009

Rahman L., Chan K.Y., Heenan D.P., 2007 Impact of tillage, stubble management and crop rotation on nematode populations in a long-term field experiment, Soil and Tillage Research, Volume 95, Issues 1-2, September 2007, Pages 110-119, ISSN 0167-1987

Rausser, G. C., Simon, L. K., and Stevens, R. 2008 *Public Vs. Private Good Research at Land-Grant Universities.* Department of Agricultural & Resource Economics, UCB, 2008

Roberts, I., Haseltine, C. and Maliyasena, 2009 A. *Factors affecting Australian agricultural export.* ABARE, March 2009.

Roucan-Kane M, Ubilava D, Xu P. 2007 E*ffects of Firm-Specific Factors on R&D Expenditures of Agribuisiness Companies***.** Working Paper #07-04. July 2007. Dept. of Agricultural Economics. Purdue University.

Ruttan, V. W., 2002 *Productivity Growth in World Agriculture: Sources and Constraints***.** *Journal of Economic Perspectives—Volume 16, Number 4—Fall 2002—Pages 161–184*

Sanson, M., 2005, *Essential International Trade Law,* 2nd Ed., Cavendish Australia, Sydney, p 12.

Scobie, G. M., and Hall, J. 2006 *The Role of R&D in Productivity Growth: The Case of Agriculture in New Zealand: 1927 to 2001.* New Zealand Treasury Working Paper 06/01. March 2006.

Sijtsma C. H., Campbell A. J., McLaughlin N. B. and Carter M. R., 1998. Comparative tillage costs for crop rotations utilizing minimum tillage on a farm scale. Soil and Tillage Research Volume 49, Issue 3, 2 December 1998, Pages 223-231

Sheng Y Mullen J and Zhao S 2010. *Has growth in Australian broadacre agriculture slowed?* Paper presented at Australian Agricultural and Resource Economics Society Conference, Feb 2010.

Silburn D M, Freebairn D M, Rattray D J 2007. *Tillage and the environment in sub-tropical Australia – Tradeoffs and challenges.* Soil and Tillage Research. Vol 97 (2) Dec 2007.

Simpson, S., and Dargusch, P. 2010 *Classifying public benefit in Australian agricultural research. Australasian Agribusiness Review, February 2010, Vol.18*

Sparger, J. A., Heisey, P., Alwang, J., and Norton, G. 2010 *Is the Share of Agricultural Maintenance Research Rising*? Presentation at the Agricultural & Applied Economics Association 2010. AAEA, CAES, & WAEA Joint Annual Meeting, Denver, Colorado, July 25-27, 2010

Spielman, D. J., Hartwich, F., and Von Grebmer, K. 2007 *Sharing Science, Building Bridges, and Enhancing Impact: Public–Private Partnerships in the CGIAR.* International Service for National Agricultural Research Division And Communications Division, June 2007.

Spriggs, J., Farquharson, B., and Martin, B. 2010 *On the Impact Assessment of ACIAR (Australian Centre for International Agricultural Research) Projects.* P*aper for the 54th Annual AARES Conference, Adelaide 10-12. February 2010*

Srinivasan, C. S., and Crost, B. 2007 *Plant Varieties, Intellectual Property Rights and Innovation in Uk Agriculture.* Paper for the Agricultural Economics Society Annual Conference, Reading. 2007

Stads, G., Faylon, P. S., and Buendia, L. J. 2007 *Agricultural R&D in the Phillipines: Policy Investments and Institutional Profile.* ASTI Country Report, May 2007

Sun, L., Ball, E., Fulginiti, L., and Plastina, A. 2009 *Impact of local public goods on agricultural productivity growth in the U.S.* Presentation at the Agricultural & Applied Economics Association's 2009 AAEA & ACCI Joint Annual Meeting, Milwaukee, WI, July 26-28, 2009

Suphannachart, W., and Warr, P. 2009 *Research and Productivity in Thai Agriculture*. The Australian National University, Canberra, Australia. September 2009

Swinbank A, 2005 "The Evolving Common Agricultural Policy, Pressure for Reform and Implications for Trade Policy *Farm Policy Journal*, Vol 2 No 2 May Quarter 2005

Texas Tech University. 2009 *Crop Subsidies in Foreign Countires: Different Paths to Common Goals (Updated).* Cotton Economics Research Institute Department of Agricultural and Applied Economics. March 2009.

Thomas G.A., Dalal R.C., Standley J., 2007 No-till effects on organic matter, pH, cation exchange capacity and nutrient distribution in a Luvisol in the semi-arid subtropics, Soil and Tillage Research, Volume 94, Issue 2, June 2007

Tokgoz, S. *Private Agricultural R&D in the United States*. 2006 Journal of Agricultural and Resource Economics 3 1 (2):212-238. Western Agricultural Economics Association. 2006.

Tullberg J, Yule DF and McGarry D 2003 "On Track" to sustainable cropping systems for Australia. In 'Proceedings of the 16th International Soil Tillage Research Organisation conference'. University of Queensland, Brisbane.

Valdes, C.,2006 *Brazil's Booming Agriculture Faces Obstacles.* Amber Waves, Volume 4(5) 2006.

Van der Mensbrugghe, D., Osorio-Rodarte, I., Burns, A., and Baffes, J. 2009 *Macroeconomic Environment, Commodity Markets: A longer term outlook.* Expert Meeting on How to feed the World in 2050, Food and Agriculture Organization of the United Nations Economic and Social Development Department. October 2009.

Vere, D.T., Griffith, G.R. and Silvester, L. 2005, *Australian Sheep Industry CRC: Economic Evaluations of Scientific Research Programs*, Economic Research Report No. 27, NSW Department of Primary Industries, Orange, December.

Von Braun, J., Fan, S., Meinzen-Dick, R., Rosegrant, M., and Nin Pratt, A. 2008 *International Agricultural Research for Food Security, Poverty Reduction, and the Environment: What to Expect from Scaling Up CGIAR Investments and "Best Bet" Programs.* International Food Policy Research Institute, 2008.

World Tariff Profiles 2009. World Trade Organisation. 2009.

Xia, Y., and Yuan, Y. 2005 *Privatization of Agricultural Biotechnology Research in U.S. Universities.* Presentation at the American Agricultural Economics Association Annual Meetings, July 24-27, 2005, Providence, Rhode Island.

Zobbe, H. 2002 *On the Foundation of Agricultural Policy Research in the United States*. Purdue University, Department of Agricultural Economics. Staff Paper 02-08. December 2002.