Australian
Farm Institute

research report

Enhancing Private-Sector Investment in Agricultural Research Development and Extension (R,D&E) in Australia

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Enhancing Private-Sector Investment in Agricultural Research Development and Extension (R,D&E) in Australia

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the Cotton Research and Development Corporation

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Australian Government
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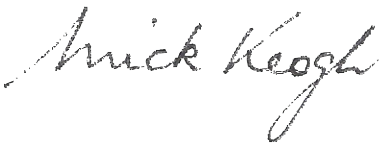
Foreword

The role of public-sector agricultural research, development and extension (R,D&E) investment as a starting point for innovation and productivity growth in agriculture is well understood, with numerous international studies highlighting the linkages between long-term publicly-funded agricultural R,D&E investment and agricultural productivity growth. Less well understood, however, are the linkages between private-sector agricultural R,D&E investment and agricultural productivity growth. This arises in part because of the shorter history of private-sector agricultural R,D&E investment, but also due to the lack of clarity surrounding the motivations for, and the nature and extent of private-sector investment. Further complicating this lack of clarity is the multinational nature of much private-sector agricultural R,D&E investment, with many of the investment decisions made in the context of global market opportunities, rather than national agriculture sector priorities.

For a relatively small and agriculturally unique market such as Australia, the engagement of the private sector in agricultural R,D&E investment is essential in order to maximise national agricultural R,D&E efforts, but also challenging due to the lack of information about such investment. The research reported here had the objective of developing a better information base about private-sector agricultural R,D&E investment in Australia, in order to find ways to incentivise such investment, with the longer-term goal of optimising national agricultural productivity growth.



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December 2017

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Executive Summary

The research reported here aimed to obtain a better understanding of role of the private sector in agricultural research, development and extension (R,D&E) in Australia, with a particular focus on those factors or policies that are likely to enhance the role of the private sector in agricultural R,D&E.

The Australian Farm Institute previously conducted research into private-sector investment in agricultural R,D&E in Australia in 2011. The focus of the previous research was on quantifying investment by the private sector, and obtaining a better understanding of the nature of that investment.

Understanding where and how investment in agricultural R,D&E is occurring, from both public and private sources, is important for the formation of good public policy and for strategy development for private entities. This data is needed to ensure that critical capacity is retained in vital research areas and that appropriate collaborative efforts are identified to maximise the effectiveness of research and development (R&D) investment. The opaque nature of R&D classifications for statistical purposes and the poorly defined boundaries between food processing (and other industrial processes) and production within the food and agriculture supply chain continue to frustrate efforts to understand investment trends and potential areas requiring additional investment.

In the absence of reliable disaggregated data to inform investment trends, this research took a more qualitative approach through guided interviews and an industry survey in order to understand influencing factors in decision-making for investment in agricultural R,D&E. The interview and survey questions included such topics as:

- the likelihood of increased or decreased investment in R,D&E
- factors influencing increased or decreased investment in R,D&E
- the importance of financial incentives (such as tax concessions) for investing in R,D&E
- the quality of research providers
- factors influencing partnerships with research providers.

A consistent response, from the organisations surveyed, was that the quality of science and research service provision provided in Australia is high and is not an impediment to investment. Beyond this commonality however, there were diverse views and attitudes towards increasing or decreasing investment in agricultural R,D&E.

Financial incentives such as R&D tax concessions were an important consideration for smaller companies without large R&D budgets. For larger companies, especially multinationals, external financial incentives were welcomed but were a secondary factor in investment decisions. The most important financial considerations for these companies were related to market size, and global opportunity and applicability of the research. As businesses investing in R&D continue to consolidate, the market size they need to justify product development also becomes larger. The unique nature of much of Australia's agricultural production environment means that there are many small markets for specific research outcomes, which may be incompatible with the business objectives of large multinational research investors.

For these markets to be serviced adequately, the necessity for effective partnerships between publicly-funded research organisations working on Australian focused issues and commercial organisations with path to market delivery process and commercialisation procedures becomes

paramount. Unfortunately, while many private research investors had participated in collaborative ventures with publicly-funded organisations, the experience of doing so was not always positive. In fact, the inability to form effective collaborative relationships was a reason many interview and survey participants are either not increasing or potentially decreasing investment in agricultural R,D&E in Australia.

A common factor for the organisations which raised collaborative partnerships as an issue, was the mismatch of commercialisation culture, administrative inefficiencies and different expectations around intellectual property management.

For smaller organisations which did not have the in-house capacity to perform research themselves but were willing to invest in external research service provision, a factor limiting investment was the ability to locate appropriate research expertise and capacity to invest in.

For all organisations, the cost and uncertainty of regulatory compliance was raised as a significant disincentive for investment.

Investment by the private sector in agricultural R,D&E in Australia is increasingly important if overall research intensity is to be maintained. Better data, detailing where investment is occurring, will help to direct public funds to ensure critical capacity is maintained. Private-sector investment can also be enhanced through a range of measures aimed at forming better research collaborations and commercialisation processes as well as reducing the cost of regulatory compliance.

The recommendations arising from the research were as follows:

Recommendation 1:

A more descriptive methodology should be developed by the agriculture sector in conjunction with the ABS for categorising agricultural R,D&E expenditure to better inform industry strategy and investment decisions.

Recommendation 2:

Participation in programs which attempt to match innovation and commercialisation culture between public and privately-funded organisations should be incentivised. This would include such things as industry-based research or work placement programs as well as student internships.

Recommendation 3:

The current Australian Government R&D tax incentive should be maintained with the eligibility criteria made more transparent and the application process streamlined.

Recommendation 4:

Australian governments should commit to sustain and ideally increase the availability of public funding for agricultural R&D and associated infrastructure in Australia, acknowledging the importance of a robust public-sector agricultural R&D system as a major factor to incentivise increased agricultural R&D investment by the private sector.

Recommendation 5:

The Australian Government, in conjunction with the CSIRO and the Council of Rural RDCs should develop a framework for a standardised database to be used to record details of agricultural research projects currently underway or completed in Australia, and once established it should be a condition of public funding that recipient research organisations record and maintain information about all research projects on that database.

Recommendation 6:

Australian regulatory approval procedures should recognise and use the results from approved international approval processes to reduce the cost of compliance for developing products for the Australian market.

Recommendation 7:

Australian Government agricultural R&D agencies should develop and actively encourage collaborative partnerships with large agribusiness companies in order to leverage the expertise and resources of these organisations in seeking opportunities to enhance Australian agricultural innovation and productivity.

Recommendation 8:

Australian Government agricultural R&D agencies and universities should develop and implement regular and effective engagement and collaboration with relevant private-sector farm advisors, recognising these now constitute the major communications pathway by which Australian farmers become aware of, and consider the adoption of new innovations.

1. Introduction

Relatively low levels of government intervention, combined with the necessity of competing in open domestic and export markets and the need to manage farm businesses in a highly variable climate, has resulted in an agriculture sector in Australia that is considered to be innovative and adaptive. Farmers have long held the view that a critical element in stimulating innovation and maintaining relatively high levels of productivity growth in the sector, has been sustained investment in agricultural R,D&E.

Farm sector productivity growth has, at times, been higher than the rate of productivity growth of any other sector in the national economy, suggesting that agricultural R,D&E investment has delivered valuable industry and national benefits (Productivity Commission 2005). However, in recent years, the rate of growth in Australian agricultural productivity has declined considerably (Organisation for Economic Cooperation and Development [OECD] 2016a), and there is growing concern that the reduction in real levels of investment in agricultural R,D&E that have occurred over the past two decades in Australia are a key factor in this decline.

Historically, much of the focus on agricultural R,D&E investment in Australia has been on investments being made by various government and public-sector agencies, including the Australian Government (investing in the CSIRO, universities and matching funding for rural research and development corporations), state and territory governments (investing in research funding for state agricultural agencies), and the rural research and development corporations (investing levy funds contributed by farmers).

The contribution of government and public-sector investment in agricultural R,D&E in Australian is extensively documented and regarded as critical to the sustainability, productivity and image of Australian agriculture in the global market (Hunt et al. 2012; Mullen & Keogh 2013; National Farmers' Federation 2017; NSW Department of Primary Industries 2014).

However, over the past decade there has been an increasing focus globally and within Australia on the role of the private sector in agricultural R,D&E investment. This has arisen due to a number of factors, including the development of intellectual property (IP) rights which enable private-sector R,D&E investors to capture benefits arising from that investment, and the gradual decline in real terms of the value of public-sector agricultural R,D&E investment.

Information about private-sector investments in agricultural R,D&E in Australia is quite limited. The Australian Farm Institute published a research report in 2011 (Keogh & Potard 2011) that reported on the results of an industry survey which aimed to quantify levels of investment, and the nature of investments by the private sector. The Australian Bureau of Statistics (ABS) also collects and reports some information on this subject, as a sub-set of a much broader collection of statistics about investment in R&D in different sectors of the economy.

During the course of the earlier Australian Farm Institute research, numerous comments were made by private-sector agricultural R,D&E managers about factors that impacted on private-sector agricultural R,D&E investment decisions in

Australia. This highlighted that equally as important as the need to better understand levels of private-sector agricultural R,D&E investment was the need to gain a better understanding of the various factors that may either encourage or discourage private-sector investment in agricultural R,D&E in Australia.

The aim of the research reported here was to identify and evaluate the factors affecting private-sector agricultural R,D&E investment decisions. By better understanding these factors, the opportunity exists to encourage increased investment, and also to ensure that R,D&E investment by the public and the private sectors remains complementary, rather than competitive. Intuitively, Australian agriculture is likely to achieve maximum benefits from R,D&E investments where there is complementarity between the public and the private sector in investing in agricultural R,D&E.

Objectives

The objectives of the research reported here were as follows:

1. To obtain a clear understanding of current levels of investment in agricultural R,D&E by the private sector in Australia, including by farm businesses, farmer groups, agricultural input and service suppliers, and agricultural technology suppliers.
2. To develop a comprehensive understanding of the factors that act as barriers to increased private-sector agricultural R,D&E investment, including both industry and policy-related factors.
3. To identify and propose policy measures or initiatives that will assist in increasing the level of private-sector agricultural R,D&E investment in Australia in the future.

Report Structure

Chapters 1 and 2 of this report review available literature on both national and international investment in private- and public-sector R,D&E.

Chapters 3 and 4 provide the details of structured interviews conducted with 20 senior agribusiness leaders, and a wider industry survey of private-sector organisations in Australia which was designed to obtain information about the level and nature of agricultural R,D&E investment as well as decision-making factors associated with those investments.

Chapter 5 provides some discussion and analysis of findings from the survey and interviews, and proposes policy measures or initiatives that will assist in increasing the level of private-sector agricultural R,D&E investment in Australia in the future.

2. Review of Literature

There is a large body of international and Australian research examining the impact of agricultural R,D&E investment on farm innovation and farm sector productivity growth. The conclusion, almost universally, is that continuing high rates of return on agricultural R,D&E investments reaffirms that benefits continue to be generated by such investments, and that they should at least be maintained, if not increased.

The above results notwithstanding, inconsistencies in terms used to describe and categorise agricultural R,D&E internationally have frustrated attempts to better quantify the cost and impact of such activities. The lack of consistency regarding definitions of 'agricultural' R,D&E, has resulted in inconsistent analysis of private- and public-sector agricultural investments and trends. This also makes understanding the nature of funding mechanisms, generated outputs, and quantification of realised values difficult (Schroeder et al. 2009).

A further difficulty in obtaining accurate data about agricultural R,D&E investment is cross-sectoral information transfer and technology utilisation, which blurs the distinction between agricultural and non-agricultural R,D&E investment within a nation (Walter, Nutley & Davies 2003). The significance of these issues has been recognised and documented for decades and continues to be a regular topic of discussion within the agricultural sector.

Defining Agricultural R,D&E

There is a suite of official statistical data published regarding the level of Australian and international R,D&E investment, however flaws in the methodology of data collection means that the validity of this information is often questioned. Due to the accepted issues associated with data collection and interpretation, many nations are encouraging adoption of the *Frascati Manual* (OECD 2002) developed by the Organisation for Economic and Co-operative Development (OECD) to introduce standard methodologies to data collection and description.

The OECD is an information forum formed by the governments of its 35 member-countries. It promotes collaboration and sharing of information to understand the drivers of economic, social and environmental change, and measures productivity and flow of global trade and investment. The OECD attempts to provide a contextual picture of R,D&E in a national and global context by supplying relatively comprehensive and up-to-date datasets using information obtained through the measurement of global productivity and trade. The data submitted to the OECD is subject to peer review and collated based on a framework and guidelines detailed in the *Frascati Manual* which is provided as a reference of consistent definitions for contributors to follow.

Australian data on R,D&E are compiled by the Australian Bureau of Statistics (ABS) per the Australian and New Zealand Standard Research Classification (ANZSRC). The ANZSRC is jointly produced by the ABS and Statistics New Zealand (Stats NZ) and therefore, the definition, scope and classification of R,D&E activities contained in ANZSRC largely follow international standards structured in the *Frascati Manual*.

The ANZSRC defines R,D&E as 'creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications'.

There are at least three different ways of further categorising investment in R&D, and allocating it to different sectors of the economy. The first is by 'Type of Activity' (TOA), which involves categorising research as either Basic, Applied or Experimental Development. A second possible categorisation is by 'Field of Research' which is based on the nature of the science being used for the research. A third categorisation is 'Socio-Economic Objective' which involves categorisation of the research on the basis of the outcomes that are being sought.

There can be some confusion created by these different categorisation systems, and careful interpretation is needed. For example, research to test a new drug for use in treating human disease could involve agricultural science as the Field of Research (testing the drug on sheep) but the Socio-Economic Objective of that research would be to improve human health.

As a general rule, the categorisation of research by Socio-Economic Objective provides the most accurate picture of R,D&E investment on the basis of the outcomes being sought and hence the sector and businesses most likely to benefit from that research if it proves successful.

As Australia's primary statistical agency, the ABS attempts to ensure correct and consistent data interpretation and reporting by applying consistent processing methodologies, and attributes the underlying reliability of their data to the nature in which data providers self-classify R,D&E expenditure based on their interpretation of OECD or ABS definitions. The challenge of assessing the accuracy and reliability of information obtained remains a factor in the processing, collection and categorisation of data.

Global Investment in R,D&E

Based on available comparable international statistics, the level of government and business investment in research and development that occurs in the Australian economy is similar to levels observed in other OECD nations. This is evident from the data displayed in Table 1, which provides a summary of data compiled by the OECD, detailing aggregate national R&D investment levels.

The table shows that Gross Expenditure on R&D (GERD) as a proportion of GDP in Australia was approximately 2.1% in 2013/14, an intensity that is higher than that of New Zealand, Canada, China or the United Kingdom (UK), although below that of the United States (US), France and Japan. A similar picture emerges for business investment in research and development (BERD), with investment intensity by Australian businesses on average above that of New Zealand, Canada and the UK, but below that observed in the US, France, Japan and China.

Table 1: National R,D&E investment indicators (all industries).

Millions of the national currency – 2013/2014	Australia A$	NZ NZ$	US US$	Canada C$	UK £	France €	Japan J¥	China C¥
Gross domestic expenditure on R,D&E – GERD	33,472	2,685	477,708	31,972	28,900	47,480.452	16,680,069	1,184,659
Business enterprise R,D&E expenditure – BERD	18,849	1,246	340,728	16,032	18,400	30,708.072	12,691,655	912,187.43
GERD as a per cent of National GDP	2.12%	1.20%	2.74%	1.70%	1.67%	2.24%	3.59%	2.05%
Percentage of R,D&E expenditure by private business	56%	46%	65–71%	52%	64%	65%	76%	77%
BERD as a per cent of national GDP	1.19%	0.54%	1.94%	0.85%	1.10%	1.44%	2.79	1.58

Source: OECD Statistics database (2016b).

The Australian public sector accounted for approximately 44% of gross domestic expenditure on R,D&E (GERD), a proportion that was greater than that of the government sector of the US (35%), less than that of Canada (48%), and relatively comparable with governments of other developed nations (ABS 2016; OECD 2016b; Statistics Canada 2015; United States Census Bureau [USCB] 2016).

Investment in Agricultural R,D&E

Agricultural R&D investment is typically a relatively small subset of total national R&D investment by governments. Traditionally government investment in agricultural R,D&E was seen as a key part of national economic development while agriculture was a dominant sector of a national economy, however as nations developed and diversified their economies, the importance accorded to agricultural R,D&E as a government spending priority tended to decline.

Figure 1 provides estimates of government expenditure on agricultural R,D&E as a proportion of the gross value of agricultural output by nation. It highlights that most national governments have an agricultural R,D&E investment intensity in the range of 1.5–2%, which is higher than the R&D investment intensity of governments in non-agricultural sectors, as evidenced in Table 1.

The data is most easily comparable on a R&D investment intensity basis (dollars of expenditure per dollar of agricultural output) although this can be deceptive, given that a decline in agricultural output (for example due to drought) can create the impression of increasing R,D&E investment intensity, and vice versa.

For example, Figure 1 gives the impression of increasing investment intensity in agricultural R,D&E during the first half of the 2000s in Australia, when a significant and extended drought negatively impacted Australian agricultural output. Available expenditure data indicates static or declining real annual investment in agricultural R,D&E in Australia over this period.

While there is a tendency to consider national agricultural R,D&E investment in isolation, globalised agricultural trade has the effect of creating international spill overs, such that investments in one nation invariably results in at

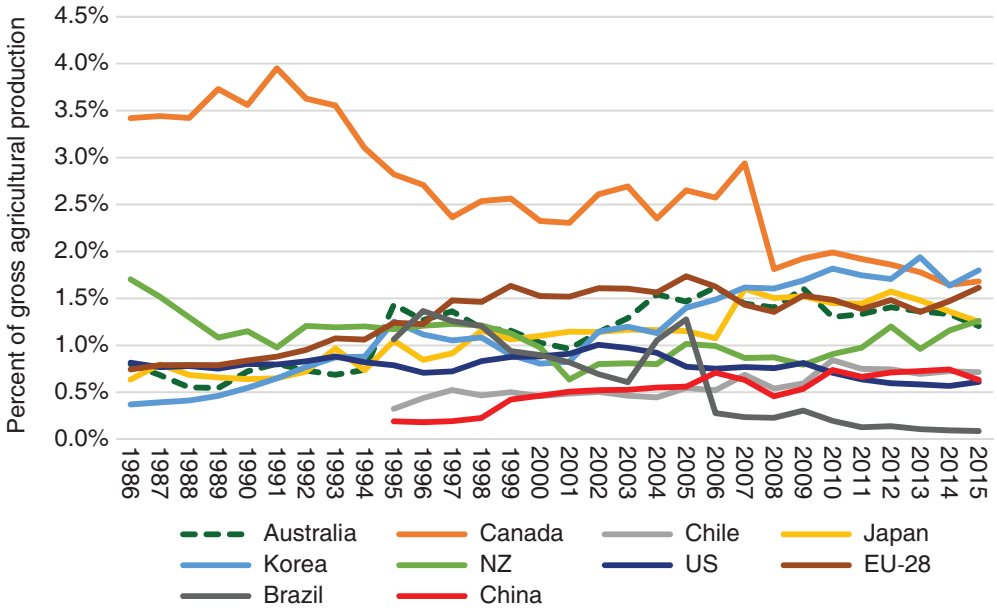

Figure 1: Government expenditure on agricultural R,D&E compared to agricultural output.

Source: OECD (2016a).

least some spill over benefits accruing to other nations, and to private sector businesses.

As a result, public investment in agricultural R,D&E has the potential to incentivise private-sector businesses to invest in R,D&E through a combination of providing new areas of technological opportunities, knowledge spill overs and competition effects (Shanks & Zheng 2006).

Unfortunately, comparable data is not as readily available for private-sector investment in agricultural R,D&E, either internationally or in Australia. Data that is available indicates a general trend of increasing private-sector investment in agricultural R,D&E, especially in developed nations such as the US (Fuglie 2016; Pray & Fuglie 2015; Fuglie & Toole 2014).

At the same time, the share of global agricultural R,D&E investment accounted for by developed nations (both public and private sector) has declined as emerging middle-income nations account for an increasing share of global agricultural output and agricultural R,D&E investment (Pardy et al. 2016). Globally, it was estimated that 52.5% of agricultural R,D&E investment in developed nations was by private firms in 2011, an increase from 42.4% in 1980 (Pardy et al. 2016). The same trend was observed for developing nations, with the private sector accounting for 36.8% of agricultural R,D&E investment in 2011, up from 19.0% in 1980.

As is the case more generally with R,D&E investment data, some caution is needed due to differences in definitions. This is demonstrated in Figure 2, which displays trends in real levels of investment in agricultural R,D&E in the US by the public and private sectors.

Total private-sector investment in R,D&E appears to have grown very rapidly after 2005 and is now more than double public-sector investment levels. However, the data highlights that approximately 50% of private-sector investment is in food manufacturing rather than agriculture.

Considered from the perspective of levels of investment in productivity enhancement in the agriculture sector, the US data indicates that private-sector investment now exceeds public-sector investment, and has done so since 2010, but not to the extent that combined food and agriculture data indicates.

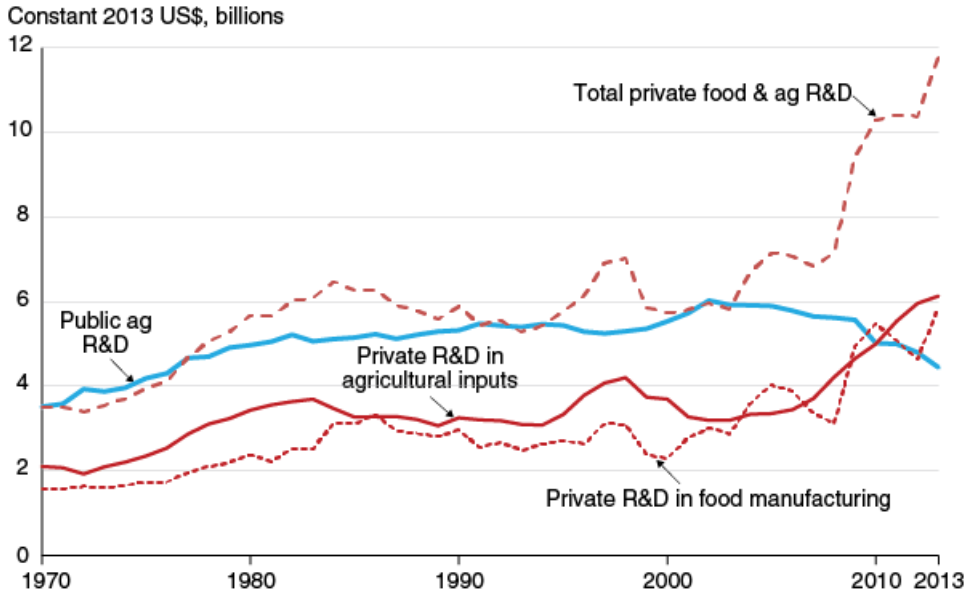

Figure 2: Public- and private-sector investment in agricultural R,D&E, US.

Source: Clancy et al. (2016).

National Agricultural R,D&E Systems

Comparable nation-level data on both public- and private-sector investment in agricultural R,D&E is not readily available, however it is useful to understand some of the differences in national agricultural R,D&E systems as part of considering factors that may impact on investment decisions by the private sector. The following section provides a brief description of the national agricultural R,D&E systems in a number of different nations, with a focus on programs or measures aimed at facilitating R,D&E investment by the private sector.

New Zealand

New Zealand, like Australia, has very low levels of government intervention in its agricultural sector, and investment in agricultural R,D&E is in fact the only direct intervention by government in the agricultural sector. Agriculture directly makes up approximately 5% of the New Zealand economy (relatively high for a developed nation) and of that, dairy accounts for about half of total agricultural output. Downstream processing of primary products makes up a further 4.1% of GDP, emphasising the importance of the primary sector to the New Zealand economy (Falloon 2012).

In 2014, New Zealand's gross expenditure on research and development (GERD) was NZ$2,685 million with the private sector accounting for NZ$1,246 million, an increase in NZ$53 million from 2012. Of the total, 16% was spent on primary industries research, which was second only to manufacturing (18%) in sectoral importance. While New Zealand's GERD has increased overall, investment in agricultural R,D&E has declined since 2012. Primary industries accounted for 34% of government expenditure on primary industries R&D in 2010 (Falloon 2012).

Structurally, the New Zealand agricultural R,D&E system consists of three key 'Crown Research Institutes' which are state-owned enterprises governed by their own Act and managed by an independent board. Agresearch focuses on the pastoral industries; Plant and Food Research is focused on horticulture, food and seafood; while Scion focuses on forestry. There are also two other Crown Research Institutes (Landcare Research and National Institute of Water and Atmospheric Research) that focus on natural resource research areas of some relevance to agriculture.

Agricultural research is also performed at New Zealand's eight universities, two of which in particular (Lincoln and Massey) dominate agricultural education and research.

New Zealand's dominant dairy processor, Fonterra, is also considered to make a significant contribution to dairy research, extending from the farm right through the supply chain in market destinations.

Funding for agricultural research is obtained from direct government, and from farmer levy payments collected by industry research corporations (similar to Australian rural research and development corporations). Farmers vote on levies every six years, and if supported become compulsory for all industry participants.

The New Zealand Government invests in agricultural R,D&E through a range of programs and initiatives managed by the Ministry of Primary Industries. The New Zealand Government invests around NZ$30 million annually into research and development focused on improving agricultural productivity and profitability in its NZ$3 billion industry (NZTE 2017). Government funding and levies are used for research activities, with product development and extension considered to be the responsibility of the private sector.

The programs currently offered by the New Zealand Government, administered in conjunction with the Minister for Primary Industries, include:

- Primary Growth Partnership (PGP)
- Sustainable Farming Fund
- Irrigation Acceleration Fund
- The New Zealand Agricultural Greenhouse Gas Research Centre
- The New Zealand Fund for Global Partnerships in Livestock Emissions Research

- The ICT-AGRI
- The Sustainable Land Management and Climate Change Research Programme
- The Sustainable Land Management (SLM) Hill Country Erosion Programme.

Additionally, there are grant initiatives available for application such as:

- Technology development grants:
    - Targeted at medium to large research-intensive firms if they are able to show that their activities result in spill over effects and wider benefits to New Zealand. The government will contribute grant funding equal to 20% of the firm's expected R&D expenditure for a period of three years (up to a maximum of NZ$0.24 million per annum).
    - To be eligible claimants must: have an R&D intensity level of 3% (measured as a ratio of R&D expenditure to revenue) over a three-year period; revenues of NZ$3 million or greater per annum; ability to demonstrate strong R&D management capabilities; R&D program likely to generate significant benefits for the community through high-value products and services.
- **Technology transfer vouchers:** Aimed at assisting smaller firms without resources to perform R&D in-house, by giving them a voucher for up to 50% of an eligible R&D projects costs, to be redeemed at an accredited research organisation.
- **Project funding:** Available for companies undertaking R&D projects to develop new technology products, processes or services. Funding is generally granted on a 50/50 co-funding basis.
- **Capability funding:** Aimed to fund the employment of students on fellowships or internships, and to engage world-class experts to build R&D capability.

Small start-ups can often incur high up-front costs that are a barrier to investment in R&D. To address this issue, the New Zealand Government introduced the 'R&D loss tax credit' in 2016 which, as described by Inland Revenue (2015), is aimed at allowing start-up companies with an R&D focus to 'cash out' their tax losses caused by qualifying R&D expenditure. The research and development (R&D) loss tax credit allows business losses from eligible expenditure associated with R&D to be cashed out instead of being carried forward.

For income years beginning on or after 1 April 2015, firms may be able to 'cash out' (have refunded) up to 28% of any tax losses associated with eligible R&D activity if the company is resident in New Zealand. The R&D loss tax credit can be repaid by paying future income tax (ie by trading into profit), and/or R&D repayment tax following a loss recovery event.

The continuing success of New Zealand agriculture depends on the sector remaining globally competitive, and agricultural R&D is considered to be a key input to this process. The clear delineation of the role of government and the private sector is considered important in optimising the performance of the agricultural R&D system in New Zealand.

United States

The United States (US) is one of the world's largest producers, consumers, exporters and importers of agricultural commodities. The US Government has traditionally maintained relatively high levels of intervention in the agriculture sector (compared to those in Australia and New Zealand), although during recent decades the focus has shifted to risk management, biofuel mandates and incentives for natural resource management activities as indirect farm income support measures, and away from the historic direct production subsidies that prevailed in the 1970s.

Structural arrangements associated with the public-sector agricultural R,D&E system in the US date back over 150 years. Public agricultural research performers include the Land Grant Universities, State Agricultural Experimental Stations and the

Agricultural Research Service (the research division of the USDA). These are funded through a mix of government and non-government sources, as shown in Figure 3.

Funding sources include the US Government, state governments, industry (through levy arrangements including check-off levies) and the private sector. As noted earlier, available statistics detailing funding arrangements rely on varying definitions (with the major variation being whether food processing research is included with agricultural research), and hence some caution is needed in comparing data between the US and other nations. That caution noted, Figure 3 provides a breakdown of funding sources and providers of research services to the agriculture sector in the US in 2013.

The United States Department of Agriculture (USDA), is the US federal executive department responsible for developing and executing federal laws related to farming, agriculture, forestry, and food. Funds from the USDA and other federal agencies support 50–60% of agricultural R&D at state institutions, and state-level appropriations support roughly another third. Non-government sources including research contracts from private firms, technology licensing fees and foundation grants provide the remaining 20% of research funding for these state institutions. Research activities are generally overseen by the USDA Cooperative Research and Development Agreements, commercialisation programs that enable private-public sharing of resources, including staff and intellectual property (IP) associated with publicly-funded institutions (US Food and Drug Administration 2015)

Out of a total of US$16.3 billion spent on food and agricultural R&D in 2013, funding from the Federal Government accounted for US$2.8 billion (17.2%), and the states accounted for an additional US$1.0 billion (6.1%). By comparison, non-government sources – mostly the private business sector but also including foundations and farmer organisations – contributed US$12.4 billion (76.3%) (Clancy, Fuglie & Heisey 2016).

Originally, federal funding for Land Grant Universities and State Agricultural Experimental Stations was predominantly in the form of 'formula funding' under which arrangements the states received a fixed share of federal funding, which state governments were required to match. From 1977 onwards, there has been an increased focus on competitive funding – whereby the universities and state agricultural experimental stations compete for funding on the basis of competitive research proposals. By 2014, competitive and formula funding were approximately equal, as the federal government has progressively introduced competition in order to generate a more efficient and effective research system (OECD 2016b).

There has been some analysis of the factors that have contributed to the relatively high levels of investment in agricultural R&D in the US (OECD 2016c). There is no definitive answer on which are the most important factors, but there is general agreement on those factors likely to be important. They include:

- The US has the least restrictive product market regulatory regimes in the OECD, with no state ownership of agricultural businesses and few restrictions on capital moving in or out of the sector.
- The US has a relatively 'light' regulatory regime associated with land and water resources, and a strong reliance on incentives rather than regulations to achieve environmental outcomes.
- The US has a strong national biosecurity regime, which has assisted US agriculture to maintain high levels of pest and disease freedom.
- The US has a Coordinated Framework for the regulation of Biotechnology, which provides a single, national regulatory regime, and which is focused on the potential impact of the modified crop on human or animal health and safety, and not the technology used to produce the crop.
- There is a well-developed and deep financial system associated with the agriculture sector that provides multiple avenues to obtain finance. (OECD 2016c)

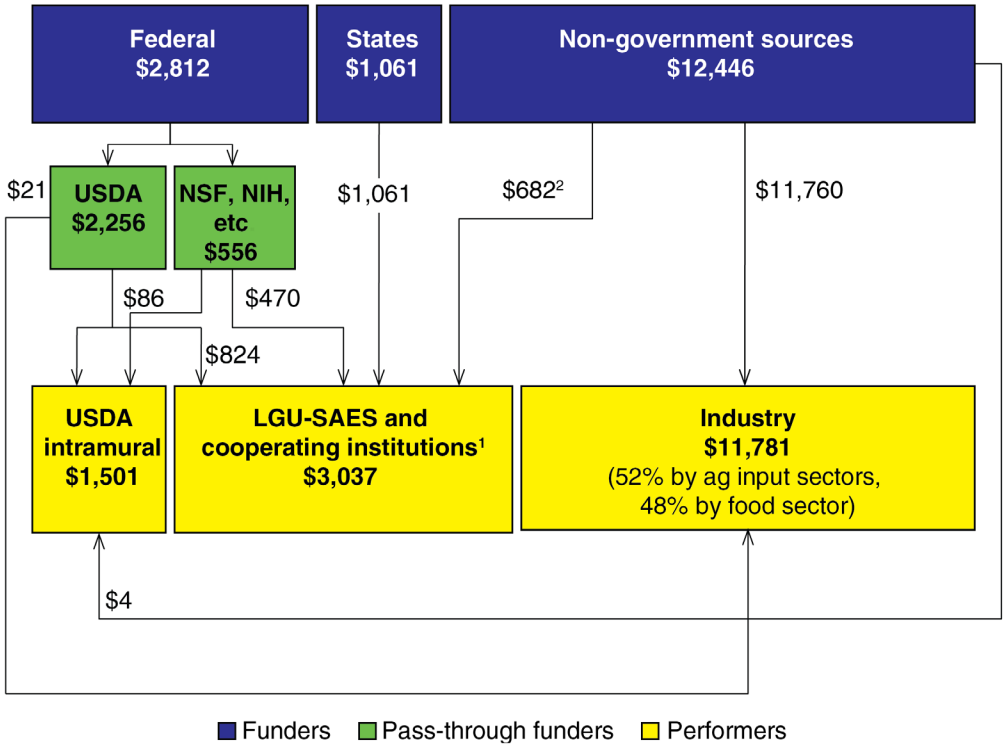

Figure 3: Funding sources and research providers in the US agricultural R,D&E system (US$ millions).

1. LGU-SAES and cooperation institutions: The 1862 and 1890 Land Grant Universities and State Agricultural Experiment Stations (LGU-SAES) Cooperationg Institutions include veterinary schools, forestry schools, and other US colleges and universities receiving agricultural research funding from the USDA. Data based on 2013 state-level reporting. Note that state reporting standards changed in 2010.

2. Non-government contributions to LGU-SAES (US$682 million) consist of (i) research grants and contracts from private companies; (ii) research grants from commdity groups, philanthropic foundations, individuals and otehr organisations; and (iii) revenue and fees from the sale of products, services and technology licences.

Source: Clancy et al. (2016), from USDA, Economic Resesrch Service.

Undoubtedly, the fact that the US agricultural sector is one of the largest in the world, and is very open to trade are both important factors which foster investment in agricultural R&D by the private sector. It is also noteworthy that the main production sectors of US agriculture (corn, soy and cotton in the cropping sectors and pork, poultry, beef and dairy in the livestock sectors) are all relatively intensive and require high levels of inputs, and are all very significant globally. This means technology developed in the US market also has a readily available global market, and can be profitably exported.

The ability to secure 'ownership' rights over intellectual property is also considered to be an important factor that has encouraged private-sector investment in agricultural R&D in the US. Table 2 (over page) highlights that protection for private intellectual property has existed in various forms for many years, a factor that undoubtedly provides private-sector agricultural R&D investors with greater confidence that they will be able to profit from successful investment.

A further factor to note is the observation that, rather than public-sector investment in agricultural R&D 'crowding out' investment by the private sector as some have argued (Productivity Commission 2011), US researchers believe the opposite is the case (Fuglie & Toole 2014). They concluded on a close analysis of the nature of agricultural R&D investment by the public and private sectors in the US that activities were largely complementary, and that every $1 of public-sector investment stimulates a further $0.70 of private-sector investment in agricultural R&D.

Table 2: Intellectual property rights protection for agricultural innovations, US.

Type	Year available	Length of protection	Eligibility criteria	Limitations
Trade Secrecy	Grew out of common law beginning in 1837	Indefinite	– Economically valuable information not generally known – Firms make reasonable efforts to maintain secrecy	– Reverse engineering is not protected – Independent invention is not protected – State-level enabling legislation is not uniform across country
Plant Patents	1930	20 years	– Asexual plants – At least one distinguishing characteristic – Non-obvious – Not sold ot released in US more than one year prior to application	– Tubers are not eligible
Plant Variety Certificates	1970 (with 1990 amendments)	25 years for trees and vines 20 years otherwise	– Sexually reproducing plants and tubers – New – Distinct – Uniform – Stable	– Farmers may save seeds that result from growing for reuse (but not resale) – Researchers may use for breeding and other bona fide research
Utility Patents	1790 (extended to plants and animals in 1980)	20 years	– 'Anything made by man under the sun' – Novel – Useful – Non-obvious	– Must disclose invention so that someone skilled in the relevant arts can replicate

Source: OECD Working Party on Agricultural Policies and Markets (2016).

It seems logical that an important factor in the avoidance of crowding out by the public sector in the US is the Current Research Information System (CRIS) maintained by the USDA.

CRIS provides documentation and reporting for ongoing agricultural, food science, human nutrition, and forestry research, education and extension activities for the USDA; with a focus on the National Institute of Food and Agriculture (NIFA) grant programs. Projects are conducted or sponsored by USDA research agencies, state agricultural experiment stations, land-grant universities, other cooperating state institutions, and participants in NIFA-administered grant programs, including Small Business Innovation Research and Agriculture and Food Research Initiative.

CRIS is a searchable database which provides information about individual projects, and data that can be disaggregated by research topic, research provider, funding source and a number of other categories. From the perspective of a potential private-sector investor in agricultural R,D&E, the availability of this comprehensive dataset would be of great benefit in identifying researchers with expertise in specific areas, and also past and current research projects of relevance.

Finally, the OECD Working Group (2016c) noted the continuing public-sector investment in agricultural extension in the US, via the Co-Operative Extension Service, and the relatively strong national coordination of public-sector agricultural R&D investment exercised by the USDA are both likely to be important factors which

contribute to the overall efficiency and effectiveness of the US agricultural R&D system.

Canada

Agriculture and food processing accounted for some 6.6% of Canadian GDP in 2014 (AIC 2017), and it was estimated that approximately 58% of the value of Canadian agricultural production was exported, making Canada the world's fifth largest agricultural exporter. More than 50% of Canadian agricultural exports were to the US in 2014 and were valued at C$26.5 billion, while agricultural imports from the US in the same year were valued at C$24.2 billion (Agriculture and Agri-food Canada 2016a).

The system of government in Canada is not dissimilar to that in Australia, with responsibilities shared between the Federal Government and state/provincial governments, particularly in relation to the agriculture sector. Canadian agricultural R,D&E activities are shared among Agriculture Canada and other federal agencies, provincial departments of agriculture, provincial research councils, university faculties of agriculture and veterinary medicine and private industry (Agriculture and Agri-food Canada 2016a).

In 2015/16, total Canadian Federal Government expenditure on agricultural R,D&E was estimated to be C$705 million, while expenditure by provincial governments was estimated to be C$440 million. In both cases, these figures represent a continuation of long-term downward trends in real public-sector investment in agricultural R,D&E in Canada. This trend has been evident since 2007, prior to which Canada typically maintained relatively high levels of public-sector investment in agricultural R,D&E, as is evident from Figure 1.

For the same period, private-sector expenditure on agricultural R&D was estimated to be C$73 million. (AIC 2017). Over the same period, private-sector investment in food processing R&D was estimated to be C$126 million, meaning that total private-sector investment in agriculture and food R&D was approximately C$200 million, or about 15% of the total public- and private-sector investment.

These data show that private-sector investment in food and agriculture R&D in Canada is relatively much less significant than is the case in the US or Australia. It seems likely that this may be related to the proximity of Canada to the US and level of agricultural trade between the two nations. There is likely to be a high level of spill overs of the results of successful agricultural R&D between the US and Canada.

The largest public research agency is Agriculture Canada, whom conduct approximately 50% of all agricultural research. The balance of research is conducted by universities.

The Government of Canada employs a tactical suite of R,D&E support options, including funding through single project or collaborative R&D grants, advisory services, networking and linkages, and industry partnership facilities and services. There are two major national committees formed by representatives of federal governments, universities and other research organisations that regulate the provision of services through these options. The Canadian Agricultural Services Co-ordinating Committee coordinates research, extension and education services, as well as assesses immediate and future research needs and assists in the development of proposals. The Canadian Agricultural Research Council advises the government on the state of agricultural research in Canada (Agriculture and Agri-food Canada 2016b).

According to the OECD data for 2013, 86% of Canadian Federal Government support for private R&D is delivered through tax credits. Canadian controlled private firms receive a 35% refundable tax credit on eligible R&D expenditures up to C$3 million. R&D expenditures above the C$3 million threshold receive a 15% non-refundable or partially refundable tax credit.

In addition to fiscal incentives available to the private sector, significant infrastructure and support facilities exist, the most renowned of which is the Agriculture and Agri-food Canada, Central Experimental Farms which extends to over 40 research establishments across Canada.

Intellectual Property protection in Canada consists of both patent protection and a Plant Breeders Rights system. The private sector has been the main contributor of agriculture-related patents over the last 15 years, accounting for 58% of the total, followed by universities (26%) and Federal Government agencies (12%). Over this period, Canada's share of global agricultural patents has generally declined. The use of Plant Breeders Rights has increased in recent years, subsequent to Canada updating its legislation in 2015 (AIC 2017).

Canada maintains a public agricultural extension system, predominantly delivered by industry associations and commodity groups, although the involvement of the private sector in these activities is steadily increasing.

United Kingdom

The United Kingdom (UK) agriculture and food sector contributed approximately 6.6% of UK GDP in 2016 and was valued at £109 billion, although the direct contribution of agriculture (farmgate value) was estimated to be approximately 0.5%. Total food and agricultural exports were valued at £18.5 billion, while imports were valued at £40.1 billion, highlighting the extent to which the UK is a net importer of food and agricultural products.

The UK agricultural R,D&E system is complex, in part due to the fact that the UK consists of four separate countries (England, Northern Ireland, Scotland and Wales), each of which has separate agricultural administrations and significant devolved powers. Science funding is provided by the UK Government via seven research councils, which allocate funding primarily to universities. Funding is also allocated to research institutes, four of which have an agricultural focus, and a further two of which are embedded within universities. These include institutes such as Rothamsted, Pirbright, John Innes Centre, East Malling Research, James Hutton Institute (JHI) and Moredun.

A major change occurred in agricultural research funding in the UK in the wake of the global financial crisis in 2008–09. The UK Government withdrew from direct funding of agricultural research, and the primary source of public-sector funds became the research councils. This led to a rationalisation of agriculture-related research institutes to the current six. The UK Government also announced initiatives designed to stimulate private-sector investment, including funding for collaborative R&D through the 'Agri-Tech Strategy'. Essentially these initiatives make available a contestable pool of funding over a five-year period, with eligibility limited to industry-led research collaborations.

Data on agricultural R&D funding by UK Governments are patchy, with one estimate being that in 2012, it totalled approximately £370 million, although trends in annual funding since that time are unclear. Available information indicates that there has been a substantial reduction in the availability of public funding for agricultural R&D since the global financial crisis in 2008–09.

In addition to government funding, industry levies are also collected by the Agriculture and Horticulture Development Board (ADHB) on behalf of six commodity sectors covering about 70% of UK agricultural output. The commodities which collect levies from farmers are Pig meat in England, Milk in Great Britain (GB), Beef and lamb in England, Commercial horticulture in GB, Cereals and oilseeds in the UK and Potatoes in GB. Total funding available is estimated to be approximately £60 million annually, which is used to fund R,D&E activities on a competitive basis.

Private-sector expenditure on R&D relevant to agriculture, hunting, forestry and fishing has been estimated at approximately £140 million per annum (Fowler et al. 2014) although it is unclear whether this includes industry-levy funds. Again, data relating to this is patchy.

The UK Government provides a number of incentives for private-sector investment in R&D, although these are not specific to the agriculture sector and apply in general for all businesses.

The UK offers distinct R&D tax incentives for large, and small and medium enterprises (SMEs). SMEs are defined as those with a turnover of under £100 million or a balance sheet under £86 million.

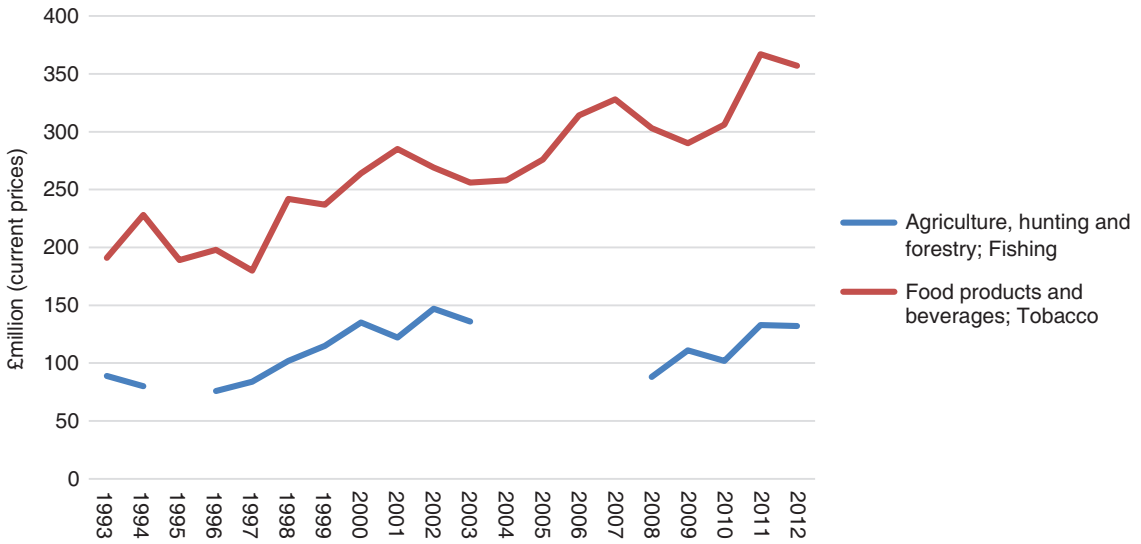

Figure 4: Business R&D spending in food and agriculture, UK.

Source: Fowler et al. (2014).

SMEs can deduct 230% of eligible R&D expenditure from their normal taxable profit. For large corporations, the deduction is equal to 130% of R&D expenditure. The corporation tax in the UK is 20% of company profits. There is also a provision which allows companies running losses to either carry tax relief forward or convert profit deductions into tax credits at 14.5%. Table 3 depicts an example presented by the UK Government.

Table 3: Converting R&D tax relief on expenditure of £20,000 to a tax credit payment.

Calculation step	Amount
R&D expenditure	£20,000
R&D enhancement	£20,000 × 130% = £26,000
Normal taxable profit	£6,000
Trading loss (after R&D tax relief)	£20,000
R&D expenditure qualifying for conversion to credits	£20,000
Potential tax credit	£20,000 × 14.5% = £2900
Payable tax credit	£2,900
Losses available to carry forward or back	Nil

Accounting period commencing 1 April 2015 and ending 31 March 2016.

Source: HM Revenue & Customs (2015).

Under the R&D expenditure credit scheme (RDEC), some claims may be eligible to subcontractors of R&D activities conducted on behalf of large companies. Some SMEs may also be eligible to claim tax credits under this scheme.

The 2014 review of the UK agricultural R&D system conducted as part of a broader European Union (EU) review of agricultural R&D systems in EU-member nations concluded:

> The main trends in investment in agricultural research in the UK giver cause for concern. This is because, as far as can be ascertained from limited available data, the decline in public sector funding, despite incentives to do so, is not yet being offset by increased private sector activity. (Fowler et al. 2014)

Of additional concern to those involved in the UK system is the UK Government's overall target for reductions in public-sector expenditure which indicates that less than half the projected 2018 reduction has been achieved (meaning further public-sector science funding cuts are likely), and the proposed UK exit from the EU, which will result in current subsidies being received by UK farmers from the EU having to be sourced from UK taxpayers (given the UK Government has vowed to maintain these). The funding pressure associated with post-Brexit support for UK agriculture is likely

to impose additional pressure on public funding of agricultural R&D in the UK.

France

France is the world's sixth largest agricultural producer and EU's leading agricultural power, accounting for about one-third of all agricultural land within the EU, and approximately 18% of the total value of EU agricultural production. Despite the food and agriculture sector declining in relative terms, it still accounts for more than 3% of national GDP and almost 6% of national employment.

An important feature of the agriculture sector in France is the relatively sophisticated and diversified agricultural R,D&E system that operates, involving government, industry and the private sector all operating in close partnership. The structural arrangements are detailed graphically in Figure 5, and there are some important elements to note.

First, the Ministry of Agriculture has a strong strategic role, including in relation to agricultural education (from schools to universities) but also in relation to research through policy setting and funding. University agricultural education is delivered as postgraduate degrees, there being no actual agricultural faculties within French universities. Postgraduate agricultural education is delivered by 21 colleges, most of which are not affiliated with universities, but all of which are under the supervision of the Minister of Agriculture.

Second, there are two very important public research institutes (National Institute of Agronomic Research [INRA] and National Institute of Science and Technology for Agriculture [IRSTEA]), both of which are directly supervised by the Minister of Agriculture. Some sense of the scale of these can be gleaned from the fact that INRA has an annual budget of €870 million, and 8300 scientists working in 17 research centres spread throughout France. The organisation is the largest agricultural research organisation in Europe, and the second largest in the world. IRSTEA has an annual budget of €116 million and 1200 scientists on its staff, working in 24 research units.

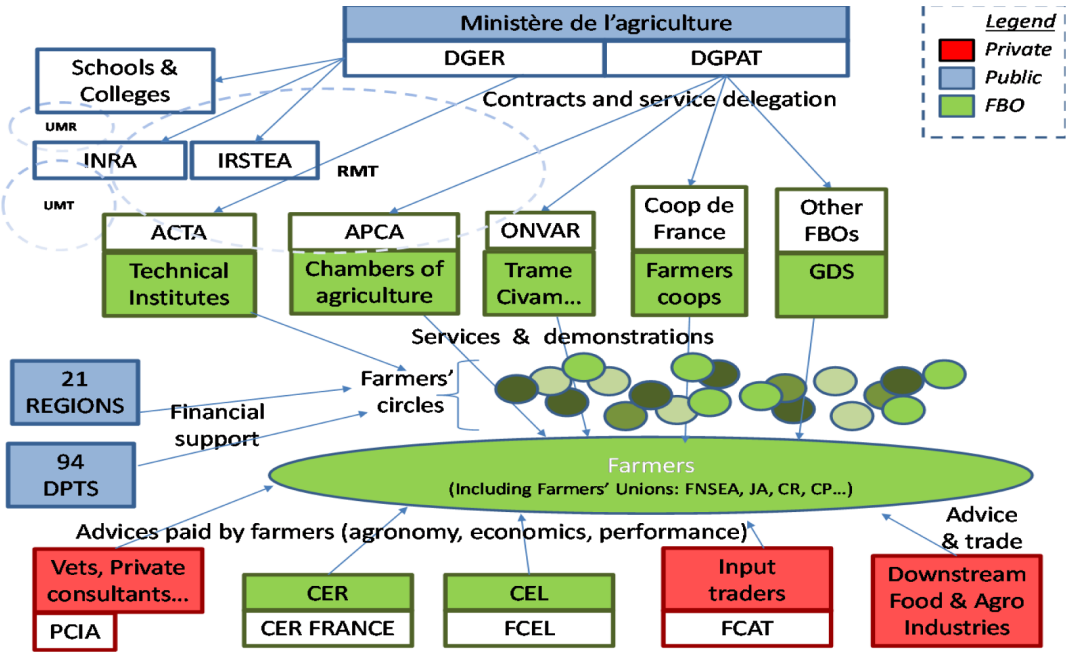

Figure 5: The agricultural innovation and knowledge system of France.

Source: Labarthe (2014).

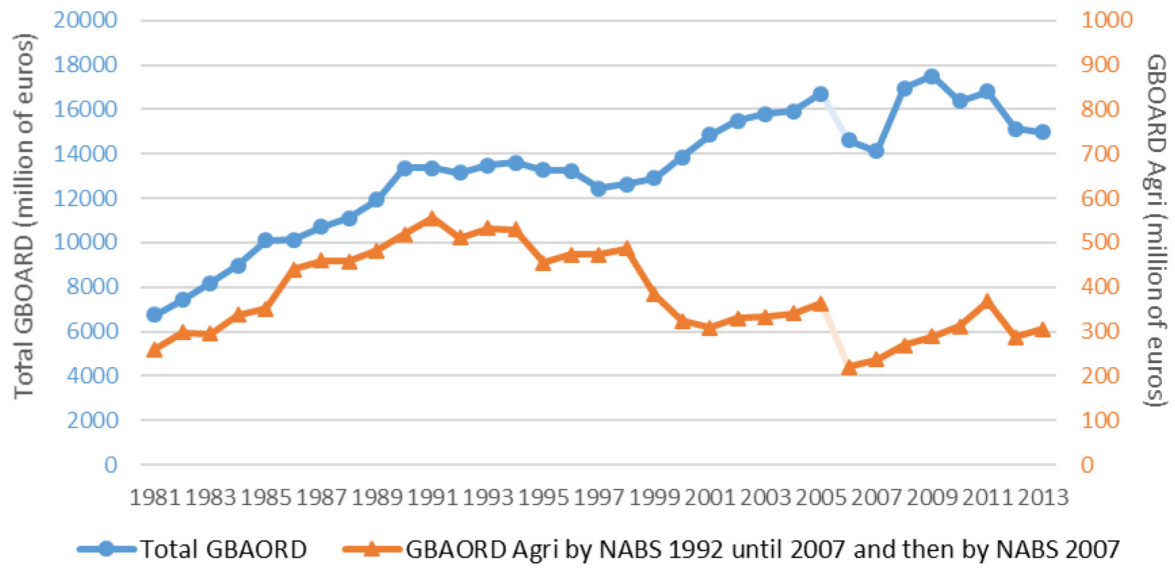

Figure 6: Government budget allocations or outlays for R&D, France.

Source: Chartier, Doghmi & van den Broek (2014).

In addition to the two main Institutes, research is also conducted by a network of agricultural technical institutes (ACTA) and other similar technical institutes.

A further important feature of the French agricultural R,D&E system is the role of Chambers of Agriculture, which are established in each of the regions of France. These are publicly-funded organisations governed by elected farmer boards which are responsible for agricultural extension in France, in conjunction with approximately 30 'technical' institutes. The funding for these is derived from a tax on the turnover of agricultural holdings (0.19% for turnover up to €370,000 and 0.05% for turnover above that level). The total revenue available from this source annually for this purpose has been between €110 million and €150 million, over the past decade.

Unfortunately, a lack of available data means it is not possible to calculate the total public-sector investment in agricultural R,D&E in France. As a recent review of French agricultural R,D&E system noted:

> This review reveals that despite important efforts devoted every year to collect data related to research investments, it is not possible to monitor adequately the expenditures in the agricultural sector because expenses in the public sector are not collected.
>
> (Chartier, Doghmi, & van den Broek 2014)

There is some broad general data published for total French Government outlays for R&D annually, and the amount allocated to agriculture (excluding food), but the data suffers from the fact that the categorisation system was changed in 2005, making the long-term trend difficult to discern. Certainly since 2005, there has been an upward trend in French Government outlays for agricultural R&D. This data does not include outlays by regional authorities.

There is also data published on expenditure by businesses on R&D, with this segregated into agriculture and food processing. It shows a generally increasing trend in nominal expenditure in both agricultural and food processing R&D, and indicates that business investment in agricultural R&D may exceed French Government investment amounts, bearing in mind the qualifications about the completeness of the data. It appears likely the business investment data is derived from business tax returns, and would not include levies paid by farmers, for example.

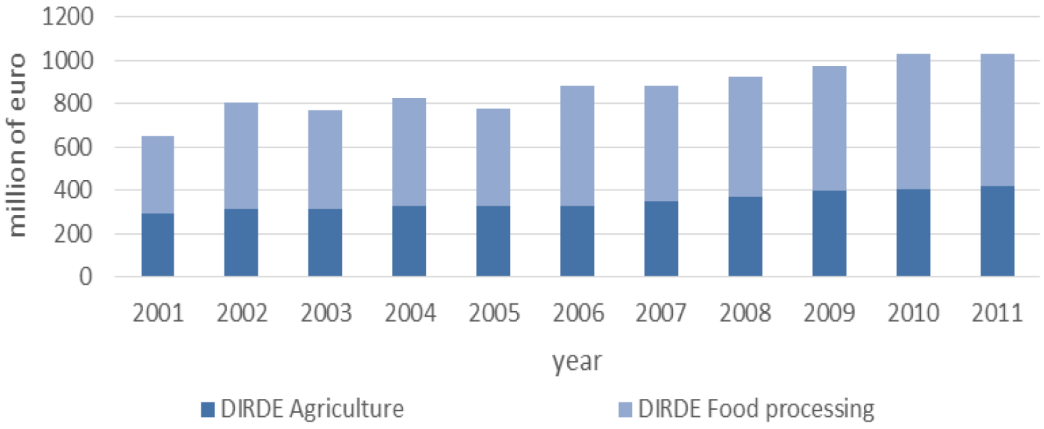

Figure 7: Business expenditure on agricultural R&D, France.

Source: Chartier, Doghmi & van den Broek (2014).

French private-sector research expenditure in the agriculture, forestry and fish sector represents approximately 40% of total business expenditure at €418 million and the 'manufacturing of food, drinks and tobacco' sector 60% at €607 million (Chartier, Doghmi & van den Broek 2014).

More generally throughout the French economy, the level of investment in R&D appears to be consistent with that observed throughout Europe. Figures for general expenditure on R&D (GERD) and business expenditure on R&D (BERD) for France in 2013 closely reflect EU averages, at 2.24% and 1.44% GDP, respectively.

Since 2011 there has been an overall trend to increasing R,D&E expenditure in the EU. Many nations have already met 2020 targets for GERD as a percentage of GDP with Finland, Sweden and Denmark leading the way at greater than 3%.

France is renowned for having one of the most developed and diversified national research systems in the EU and the world. France has 71 innovation clusters or 'competitiveness poles' that bring together universities, private companies and research centres, as well as new technology research institutions benefiting from public/private joint investments. In comparison with the US research system, where a significant proportion of research is conducted by universities, agronomic research in France is mainly conducted by the large research institutions.

In addition to institutional support, the French Government offers research tax credits (Crédit Impôt Recherche – CIR) to offset R&D expenditures undertaken by both domestic and foreign firms operating in France, regardless of size or business sector, covering both R&D spending and innovation expenses incurred by small and medium-sized enterprises. The French Government provides tax credits to support up to 30% of a firm's first €100 million in R&D costs, and an additional 5% in credits above this threshold. Additionally, since 2013, an 'innovation tax credit' is available that reduces the cost of innovation expenditure by 20% up to €400,000. The research tax credit and innovation schemes are set until 2017.

There are similarities between the US and France in the relationship that appears to exist between public- and private-sector investment in agricultural R&D. Both nations have retained relatively consistent levels of public-sector investment in agricultural R&D, and foster close interaction between the public and the private sectors. This, in turn, appears to have resulted in relatively consistent levels of investment in agricultural R&D by the private sector, possibly facilitated

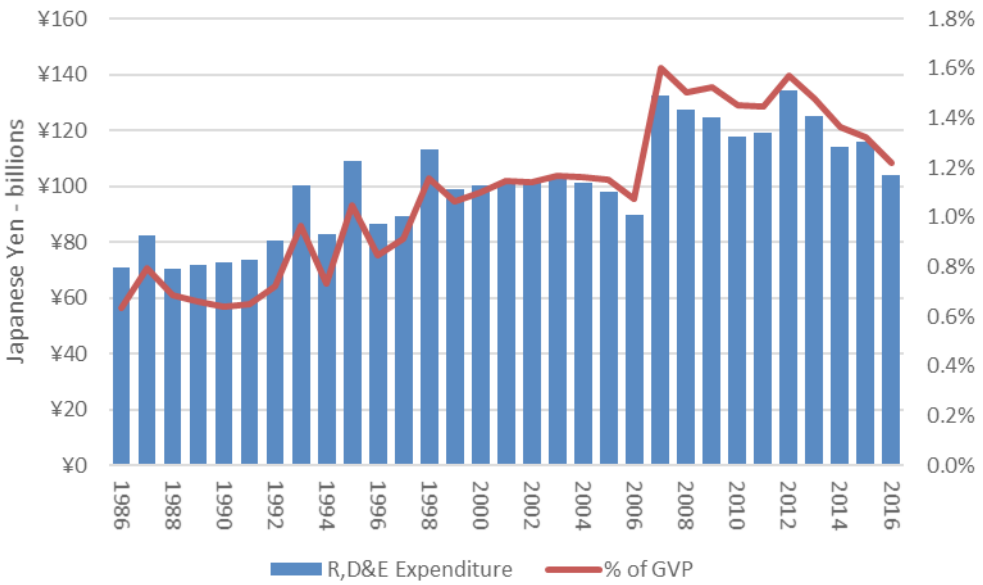

Figure 8: Japanese investment in agricultural R,D&E.

Source: OECD (2016).

by the ready availability of trained technical staff graduating from universities, and the relatively strong level of investment that is maintained in public agricultural R&D infrastructure.

Japan

Japan is not normally considered to be globally significant in agriculture, despite being the world's ninth largest producer in volume terms. From the perspective of a net agricultural exporting nation such as Australia, the main interest in Japan is the size of the market for Australian agricultural exports, rather than developments within its agriculture sector.

Japanese agriculture has traditionally faced major challenges arising from the very small scale of Japanese farms, its very rigid and highly regulated agricultural policy settings, and the challenge presented by an ageing farm workforce.

However, food security has always been a high priority for Japanese Governments, and that, coupled with efforts to reform and revitalise the Japanese economy, resulted in the Japanese Government increasing its commitment to the agriculture sector in the wake of the global food crisis of 2007–08. It substantially increased expenditure on agricultural R,D&E for an extended period, and while annual investment levels have subsequently fallen back almost to pre-2008 levels, agricultural R,D&E investment intensity has been maintained at levels that are comparable with many other developed nations (see Figure 1).

Most publicly-funded research is conducted by institutes under the jurisdiction of the Ministry of Agriculture, Forestry and Fisheries (MAFF), and generally fall under the Agriculture, Forestry and Fisheries Research Council (AFFRC). The MAFF sets quality standards for food products, supervises commodity markets and food sales, and undertakes land reclamation and land improvement projects.

There are many operational research organisations and facilities in Japan, the most renowned including:

- National Agriculture and Food Research Organisation (NARO) – An independent administrative agency and the largest R&D organisation addressing agriculture, food and rural communities in Japan. In 2014, NARO had

an annual budget of 58.2 billion yen (US$582 million). It has 14 research institutes and centres with specialist fields and missions across Japan.

- National Institute of Agro-biological Sciences (NIAS) – Known for collaboration with overseas institutions and universities.
- National Institute for Agro-environmental Sciences (NIAES) established in 1983, became an independent administrative institution in 2001. Dedicated to basic research into agriculture and environment.
- Japan International Research Centre for Agricultural Sciences (JIRCAS).
- The Norinchukin Research Institute Co Ltd.

Japan and Israel have also signed a memorandum of understanding for agricultural research cooperation in April 2017. The agreement between Israel's Volcani Centre and Japan's NARO, calls for collaborative research projects in the fields of water technology, environmental protection, agricultural sustainability and plant sciences (Udasin 2017). This is the latest in a string of international agreements in science and innovation, and highlights that part of the future strategy for agricultural R,D&E in Japan involves a process of active engagement with leading global agricultural R,D&E institutes.

Observations arising from international models

The preceding reviews of a selection of national agricultural R,D&E systems is not a comprehensive survey, but does provide some valuable observations about the interactions between national publicly-funded agricultural R,D&E systems, and private-sector agricultural R,D&E activities.

The first is the almost universal dearth of robust statistics that provide an accurate perspective of trends in both sectors – either in terms of expenditure, or in relation to the nature of the research being undertaken. This deficiency is less pronounced in the US and France, but even in those locations the details and extent of private-sector involvement in agricultural R,D&E is difficult to determine. The CRIS database maintained by the USDA is a notable exception, providing both public- and private-sector investors in agricultural R,D&E with a robust information base that seems likely to reduce the risk of unnecessary duplication of research activities, while at the same time helping private-sector investors to identify research expertise and resources.

While noting the deficiencies in available data, there is no strong evidence that the maintenance of a relatively well-resourced public-sector agricultural R,D&E system results in 'crowding out' of the private sector. In fact, it seems likely that the opposite is more likely to be the case, in that nations like the US and France that have maintained relatively stable levels of investment in public-sector R,D&E also appear to have relatively strong private-sector agricultural R,D&E sectors.

A further observation is that national governments have adopted a number of measures to incentivise private-sector investment in agricultural R,D&E, which range from active encouragement through direct grants, to a more passive approach based on tax incentives. It is not obvious that one particular approach is more successful than others, and the previously mentioned dearth of objective data makes these initiatives difficult to judge from an effectiveness perspective. That noted, continued growth in private-sector investment is probably a good indicator that the measures adopted are having the desired effect.

The Australian Agricultural R,D&E System

The Australian agricultural R,D&E system is composed of a complex network of participants which includes farmers (through levy contributions), the Australian Government, state and territory governments, rural research and development corporations (RDCs), the CSIRO, universities and private-sector agribusinesses, as depicted in Figure 9.

The Australian Government has established national R&D priorities, applicable to the entire national economy. The funding and programs provided for

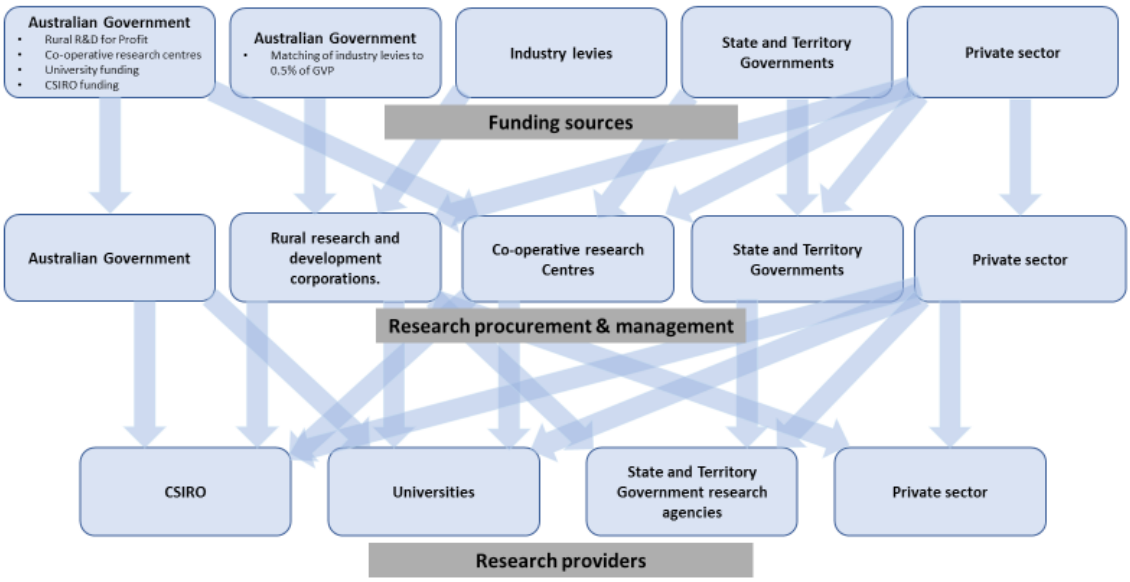

Figure 9: The Australian agricultural R,D&E system.

the agricultural sector are for R&D activities that are broadly aligned with these national priorities.

The agricultural sector has established detailed R,D&E strategies for the sector, through the development of the national primary industries R,D&E framework. Under the Framework 14 sectoral (commodity) strategies have been developed and endorsed. A further seven cross-sectoral strategies have also been developed for implementation covering animal biosecurity, animal welfare, plant biosecurity, climate change, soils, water use in agriculture, and food and nutrition.

The Rural RDCs, along with the Australian, state and territory governments, CSIRO, the Bureau of Meteorology and universities are jointly implementing the framework to improve coordination and collaboration across the rural innovation system (Council of Rural RDCs 2017).

The Australian Government, through the 'Rural R&D for Profit' program, is currently providing funding to incentivise organisations and agencies to implement cross-sectoral R&D programs, some of which give effect to these national agricultural R,D&E strategies. This funding partially addresses a criticism of the national R,D&E strategies which was that, while well-meaning, there were no resources or administrative structures to ensure their implementation.

Funding for agricultural R,D&E in Australia is obtained from a range of different sources, including the Australian Government, state and territory governments, industry levies and from the private sector. The specific amounts of funding provided by each of these is difficult to accurately determine, because of the previously mentioned uncertainties associated with the categorisation of different programs, and the complex institutional arrangements which create the risk of 'double-counting' some funding. Outside of the agricultural R,D&E system, the Australian Government also provides funding to the Australian Research Council – which is the main body which allocates public funding to universities for research – and some of this is allocated to agriculture-related R&D activities by university researchers.

The above qualifications noted, Table 4 provides an estimate of the various sources of funding that are utilised for agricultural R,D&E in Australia. Table 4 refers only to funding allocated to agricultural R,D&E activities (as per OECD definition) and excludes environmental research not directly related to agriculture, and post-farm processing R&D.

Table 4: Australian agricultural R,D&E funding.

Funding source	Estimated amount ($ millions) 2014–15
Australian Government – Rural R&D for Profit	$25
Australian Government – matching agricultural R&D levies	$250
Australian Government – cooperative research centres	$50
Australian Government – CSIRO core funding	$250
Australian Government – university grants/ARC	$130
Total Australian Government	**$705**
State and territory governments – agricultural R,D&E	$250
Total state and territory governments	**$250**
Industry – agricultural R,D&E levies	$250
Private sector – agribusiness R,D&E investment	$620
Total – industry and private sector	**$870**
Total – Australia	**$1825**

These estimates are derived from a number of different sources, including the annual report of the Department of Agriculture and Water Resources, the Australian Bureau of Statistics, and the Productivity Commission. They are necessarily approximations, due to the limitations of reporting systems, and the difficulty associated with disaggregating block grants to the CSIRO or universities for specific agricultural R,D&E programs. The data also differs from the comparative data reported by the OECD, in that the OECD data refers to funding specifically allocated to the agricultural sector, but does not include funding for universities that is subsequently used for agricultural R,D&E, and appears to understate funding for a number of other items, which may be due to differing cut-off dates for reporting periods.

Those qualifications noted, the data that Australian governments report to the OECD each year does provide a consistent data series which provides a perspective on funding trends through time, as can be observed in Figure 10. It shows that in real terms, public-sector agricultural R,D&E funding in Australia has remained largely unchanged over the past 20 years. The significant increase observed over the 2002–04 period was almost entirely due to additional funding provided to the CSIRO.

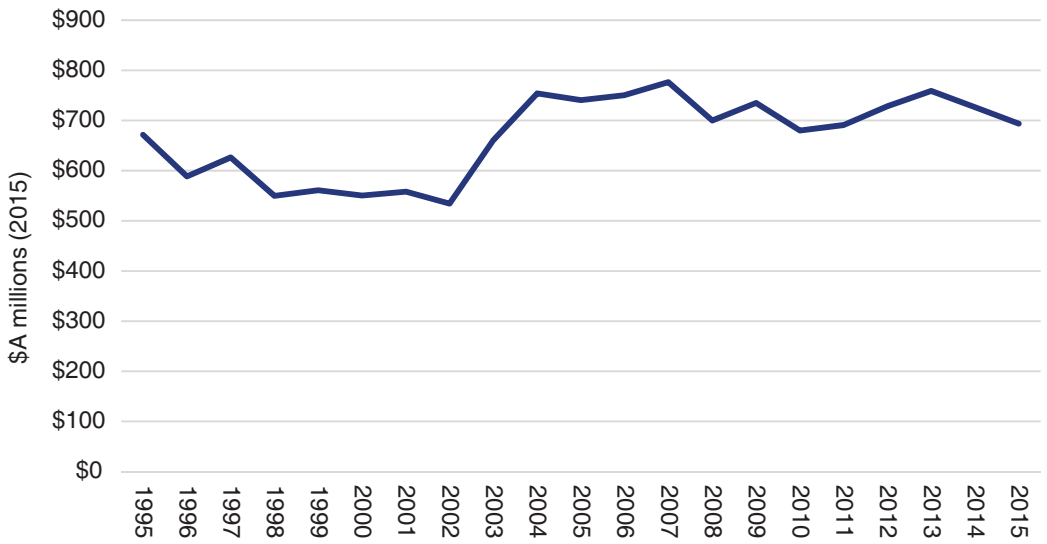

Figure 10: Trends in real government expenditure on agricultural R,D&E, Australia.

Source: OECD.

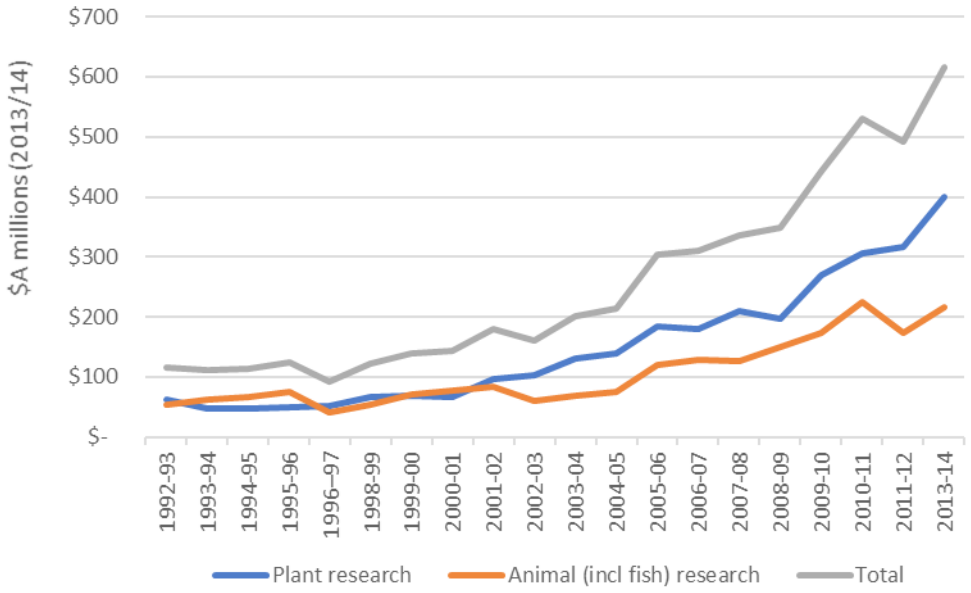

Figure 11: Private-sector investment in agricultural R,D&E, Australia.

Source: ABS.

Private-sector investment in agricultural R,D&E in Australia is currently estimated to be approximately $616 million per annum (ABS 2017). The level of annual investment has increased quite steadily since around 1990, which coincides with the establishment of the current rural RDC system via the enactment of the *Primary Industries and Energy Research and Development Act* (PIERD Act) in 1989. The growth in private-sector R&D investment appears to have been strongest in plant-related research, which is unsurprising given the introduction of genetically modified crops in 1996 which created a greater opportunity for private-sector companies to secure investment returns from successful R&D projects. Many of the previously government-owned plant breeding corporations have also been privatised over this period, which has also created greater opportunities for private-sector agricultural R&D investment. The lower rates of growth in livestock R&D investment is possibly related to the predominance of broadacre livestock production in Australia, in contrast to the prominence of intensive livestock production systems in many northern hemisphere and Asian nations. Intensive livestock production systems (such as pork, poultry and dairy) provide much greater opportunities for private-sector investors to capture the benefits of successful R&D, due to the relatively high level of inputs and control that can be exercised by farm managers in comparison with more extensive pasture-based livestock production systems.

The data displayed in Figures 10 and 11 show that the private sector accounts for approximately 33% of total investment in agricultural R,D&E in Australia, or 48% if compulsory industry levies are also included as part of the contribution by the private sector. The latter figure is proportionally less than the level of investment by the private sector in agricultural R,D&E in the US, although the rate of growth of private-sector investment in Australian agricultural R,D&E is comparable with the growth which has been observed in the US (see Figure 2).

The funding available for agricultural R,D&E in Australia is allocated and managed by both government and industry organisations, including the rural research and development corporations, a number of cooperative research centres that have an agricultural focus, and private-sector organisations that manage their own research programs. These organisations typically develop detailed R,D&E programs, and then tender out specific projects competitively to research providers. Projects are

typically funded for periods of from three to five years, although CRCs are normally funded for at least seven years, and some major research programs have longer-term funding arrangements in place.

Organisations that receive Australian Government funding for agricultural R,D&E include CSIRO, various CRCs and the RDC network (which uses capital procured from producers via statutory or voluntary levies, as well as funding provided by the government). State and territory government funding is also provided as part of a range of other programs, much of which is directed at in-house research conducted in state or territory institutes or experimental stations, and related extension activities.

Public-sector agricultural R,D&E

Public-sector contributions via funding, principle investigation and/or in the commissioning of R,D&E, are an integral component of Australian agriculture and research sectors. However, due to the vast number of stakeholders and the challenge of capturing the benefits of R,D&E, describing the impact of public-sector involvement is often difficult.

Currently, the public sector, namely Australian governments, aim to encourage R&D by providing direct support via project specific grants, infrastructure or services, as well as indirect support by fiscal incentives. The primary R,D&E interventions made by the Australian public sector are outlined in the following sections:

Research and development tax incentive

The first Australian research and development tax concession was introduced in 1985–86 as a mechanism for reorienting Australian firms and changing the attitudes and priorities of management towards innovation in the wake of industry policy shifts from protectionism to integration. Now termed the research and development tax incentive it is jointly administered by the Australian Tax Office (ATO) and AusIndustry, and is designed to encourage Australian industry investment in R,D&E by offering a refundable tax offset for eligible activities (Commonwealth of Australia 2015).

The R&D tax incentive (the incentive) is the largest component of Australian Government support for innovation. In 2013–14, approximately 13,700 entities generated $19.5 billion of R,D&E at an estimated cost of $3 billion to the government (Ferris, Finkel & Fraser 2016). Under the incentive, refundable tax offsets are provided to entities engaged in R,D&E. A 43.5% offset is available for eligible entities with an aggregated turnover of less than $20 million per annum, and a 38.5% offset for all other eligible entities with the potential carry forward unused offset amounts to future income years. The rate of the R,D&E tax offset is reduced to the company tax rate for that portion of an entity's notional R,D&E deductions that exceed $100 million for an income year.

The incentive is aimed at improving competitiveness and productivity across the Australian economy by encouraging industry, both large and small, to conduct R,D&E by providing a predictable, less complex innovation dividend. In addition to this incentive, in May 2015, the government launched the 'Boosting Commercial Returns from Research' strategy aimed at improving business and research sector collaboration, supporting economic growth and enhancing Australia's competitiveness into the future.

Agricultural levy system

The Department of Agriculture and Water Resources is responsible for the collection, administration and disbursement of levies and charges on behalf of Australian agricultural industries. Since the introduction of the first compulsory levy in 1936, substantial changes to the system have occurred, with levies now imposed on approximately 68 rural commodities and products across several industries, from fishery to horticulture, forestry, livestock, grains, fibre and dairy.

Levies are imposed on primary producers by government at the request of industry to collectively fund research and development, marketing, biosecurity and residue testing programs. Upon collection, levy contributions are appropriated to the relevant research and development corporation and other government programs such as Animal Health

Australia, Plant Health Australia and the National Residue Survey, minus the cost of collection, to fund initiatives that benefit levy paying industries.

Research and development corporations

There are 15 research and development corporations (RDCs) responsible for planning, investment, and overseeing R,D&E activities to deliver improvements in production, sustainability and profitability across agriculture, forestry and fishery industries. RDCs are industry service bodies and, with the exception of Australian Pork Limited, are not industry representative bodies. The RDCs, except for Sugar Research Australia, do not own or manage research facilities or undertake research and development activities themselves. RDCs partner with, and leverage off the activities of other participants in Australia's rural innovation system. The RDCs are funded primarily by statutory R,D&E levies on various commodities, and receive matched funding from the Australian Government.

Cooperative research centres

Cooperative research centres (CRCs) are partnerships between research funders, research providers and end users and are formed to undertake R,D&E in specific areas with an emphasis on applied R,D&E. CRC partners can include private-sector organisations (small, medium, and large enterprises), industry associations, universities and government research agencies such as CSIRO, and other end users. CRCs receive funding through the Department of Innovation, Industry, Science and Research portfolio, which must be matched by participants' cash and in-kind contributions, and undertake research and development aimed at producing outcomes of direct positive socioeconomic impacts.

The CRCs program is a competitive, merit based grant scheme that supports collaborative research partnerships between industry, government, researchers and the community, and is open for medium- to long-term support via 'CRC grants', or short-term support via 'CRC project grants.'

CRC grants are directed at solving industry problems and delivering tangible outcomes by improving competitiveness, productivity and sustainability, as well as the delivery of outcomes according to government priorities and the fostering of quality research through collaboration partnerships between industry entities and research organisations. A CRC must have at least one Australian industry organisation and one Australian research organisation.

Current agriculture-related CRC (and their funding expiry dates) are as follows:

- CRC for High Integrity Australian Pork (2019)
- CRC for Sheep Industry Innovation (2019)
- Invasive Animals CRC (2017)
- Plant Biosecurity CRC (2018)
- Poultry CRC (2017)

Recently announced new agriculture-related CRCs that have secured funding in the latest CRC selection round (and their funding expiry date) include:

- CRC for High Performance Soils (2027)
- CRC for Honey Bee Products (2022)
- Food Agility CRC (2027)

Industry growth centres

Industry growth centres (IGCs) are the collective term for industry-led initiatives currently established in six industry sectors of competitive strength and strategic priority including food and agribusiness. IGCs have the primary function of driving innovation, productivity and competitiveness by focusing on areas of competitive strength and strategic priority. The initiative attempts to facilitate national action against key issues such as collaboration, commercialisation, international engagement, skills and regulation reform. The initiative is ongoing, with $250 million in Australian Government funding allocated for four years from 2016/17 to 2019/20.

The IGC responsible for agriculture is Food Innovation Australia Ltd (FIAL), which

has developed a 10-year strategy 'Sector Competitiveness Plan' with the food and agribusiness sector that identifies priority areas for research and regulatory issues. The plan outlines the perceived actions needed to ensure that Australia's food and agribusiness sector is best placed to respond to the increase in global demand for food, and to maintain global competitiveness through increased productivity.

In addition to direct research initiatives, FIAL conduct 'collaborative circles' workshops in conjunction with the Hargraves Institute. These workshops bring together a range of businesses to facilitate collaborations aimed at overcoming technical challenges (supply chain issues, processing problems, export barriers) and achieve immediate solutions to benefit both large and small businesses.

Private-sector R,D&E

Australian private-sector contributions to agricultural R,D&E are primarily delivered through industry-owned providers, private-research providers, large farming operations and agricultural input and processing companies.

Private-sector R,D&E is generally conducted to develop or adapt modern technology and processes aimed at reducing production costs or increasing the value of goods and commodities. In the absence of external incentives these firms invest in R,D&E at corresponding levels to expected financial returns. This type of investment behaviour is commonly associated with a business' ability to appropriate private benefit, and the potential implications this imposes on other businesses (Shanks & Zheng 2006).

An important consideration is the accrual of benefits in the form of knowledge spill overs through information exchange between firms, employees and public information, including any intellectual property (IP) not covered by patent.

The primary sources of private funding for private-sector rural R,D&E include industry levy payments to RDCs, R&D tax incentives, industry-owned research institutions, state-based research organisations, large commercial farming companies, and chemical, fertiliser and other agricultural supply companies. In addition to the private-sectors utilisation of a number of publicly provided incentives, firms also often consider the implications of availability and accessibility of appropriate resources, skills and knowledge, market influences, and internal or external support mechanisms. Furthermore, R,D&E activities and investment are subject to other considerations such as IP rights and end-point royalties.

Intellectual property rights

IP is proprietary knowledge, or a productive new idea created by an individual. IP can exist in the form of an invention, trademark, design, brand or the application of an idea (IP Australia 2017). The primary laws that apply to protecting IP in Australian agriculture are plant breeder's rights, patents laws, trademarks and designs. IP rights are designed to provide an incentive to invest in innovation, and are regarded as crucial for economic development. The protection and exploitation of IP is delivered through the right to exclude others from using an innovation in exchange for the full public disclosure of the invention, brand name, design, or new plant species.

Despite government programs that facilitate knowledge transfer about IP to Australian businesses, processes for obtaining, maintaining and challenging the four IP rights administered by IP Australia are complex and may create additional regulatory effort. Compliance costs and administrative procedures and processes associated with meeting regulatory requirements can be disproportionate to business size.

Patents

A patent is a right that is granted for any device, substance, method or process that is new, inventive and useful and is granted on the basis of technical human intervention that distinguishes it from a simple discovery.

If successful, a patent confers to its owner exclusive, legally enforceable rights to sell, make,

use, offer to sell or import an innovation within an allocated country. Once secured, patents can be used to prevent others from exploiting inventions; or can be licensed or sold to generate income and allow the invention to be used in other contexts. Plant material eligible for patent include GM or non-GM plants, plant genetic machinery; reproductive materials, methods or new inventions used during production; and products or progeny produced by the plant. The discovery of biological material, such as a new plant variety, is not patentable.

Plant breeder's rights

Plant breeder's rights (PBR) are a form of IP, like patents and trademarks, that provide exclusive commercial rights for a registered plant variety or design. PBR protection covers the propagating material of the protected variety and that of essentially derived and dependent varieties, and can extend to the harvested material and products derived from the harvested material if the registrant has not had an opportunity to exercise their rights to the propagating material.

The PBR scheme protects plant breeders and facilitates a commercial monopoly for the duration of the registration period (20–25 years depending on the species) and subsequently encourages plant breeding and innovation both during, and after the lapse of the protection period, following the release and free accessibility of new plant varieties.

End-point royalties

An end-point royalty (EPR) is a mechanism of value capture used by plant breeding companies to recover their return on investment. It is a risk sharing mechanism, whereby the grower of the crop pays a royalty based on production rather than a set fee for the relevant variety. A significant level of investment is required to develop and commercialise new varieties, with a path to market potentially taking up to 12 years. The continual investment made by plant breeding organisations (both privately and publicly funded) is supported by returns generated from the EPR system. As EPR return is linked to production level, the return on investment received by plant breeding organisations provides an incentive to develop the most productive and highest value varieties, which in turn ensures the Australian grains industry continues to receive the highest quality varieties into the future.

Agricultural Extension

The transfer of information and knowledge to and between farmers is a crucial component of production and sustainability. The activities by which information is conveyed and adopted by farmers is the foundation of extension. While often included by default in discussions about R,D&E systems, extension systems can have an important impact on innovation adoption rates, and hence merit more detailed consideration.

Historically, rural industry extension services in Australia were provided by state and territory government primary industries departments. However, in recent years the funding and delivery of extension has changed considerably, with state and territory governments reducing direct provision of extension services. In response, there has been an increase in the number of private agronomists providing these services, as well as grower groups and some joint public and private investment (eg the Dairy Extension Centre is a partnership between the Victorian Department of Primary Industries and Dairy Australia).

Extension in Australia

In the decades following World War II, up until the early 1990s, Australian agricultural development was a public policy priority. The extent of R,D&E, and the number of agricultural institutions participating in related activities, grew both in terms of scale and professional expertise (Hunt et al. 2014; Naseem, Spielman & Omamo 2010). This growth occurred simultaneously with the expansion of state and territory government extension services.

However structural reforms in the 1980s resulting in the retraction of financial entitlements and support by government for agricultural production encouraged rural industries to begin to invest in their own R,D&E as opposed to relying solely on

state governments or the Commonwealth. Some of the structural reforms included the establishment of the RDCs, industry centres of excellence in research, and CRCs. These structures recognised the need to combine the professionalism, knowledge, skills and experience of individuals from both public and private sectors to identify, manage and resolve priority issues in Australian agriculture (Hunt et al. 2012). While these initiatives reflected an increased dedication to agriculture and related research, Vanclay (1994) predicted major changes in agricultural extension, and at the time, identified the major drivers of this change as:

- Fiscal limits – reduced availability of government funding.
- Effectiveness uncertainty – extension practices not working. Farmers fail to adopt many recommended practices, particularly in the area of environmental management.
- Legitimation questioning – negative comments about extension services.
- Theoretical foundation – Australian extension agencies reject traditional model but have no cohesive, coherent, or widely accepted alternative.

These issues still exist today, with the struggle to achieve high adoption rates attributed to the inability to convey clear value propositions to farmers. It is also difficult to assess the impact of extension services as the indicators (eg adoption of technology and farm productivity) are also influenced by many other factors that have compounding affects.

The many initiatives and developments considered in this report have continued to support the Australian agricultural R&D system, however there has been less attention paid to extension services even though there has been a major decline in public extension systems over the past decade.

Prior to the establishment of the national framework for primary industries R,D&E; Stone (2010) discussed the future importance of the private sector in addressing the requirements for extension services in Australia due to the change in organisation structures and decline in state and territory government agricultural extension services. Stone proposed that the future of extension in Australia would be characterised by joint relationships between state agencies, the R&D sector, and agribusinesses. The primary basis for such relationships could potentially involve a joint culture of information supply by agencies, and the subsequent synthesis of that information by agribusiness into information products and packages. This mechanism could provide outcomes that are jointly badged and delivered on a 1:1 and small group basis, and facilitate feedback from agribusiness to state agencies and R,D&E providers on producer R,D&E needs.

In the period since that time, state and territory governments have successively reduced the resources available for agricultural extension, and farmers have responded by adopting fee-for-service advisory services provided by agribusiness – either as a stand-alone advisory service, or as a support service associated with farm inputs such as fertilisers and chemicals. The development of private-sector farm advisory services has been most pronounced for the grains and cropping sectors, the dairy industry, and intensive horticulture and livestock sectors.

This has presented a challenge for rural RDCs, in that it has removed the main channel they previously utilised to facilitate two-way communication between researchers and farmers. There has been a variety of responses, which can be summarised as:

- RDCs developing their own regional network to connect with farmers and farm advisors (eg Dairy Australia), or
- RDCs funding private-sector farm advisors for specific industry extension activities (eg Meat & Livestock Australia).

There is no clear evidence about which of these, or any alternative approach, is likely to be more successful. Other developments that confound the extension question include the development of digital agriculture technologies, and the (almost) universal availability of mobile phones and internet

access, which have dramatically changed the way that people in general, and farmers in particular access and exchange information.

International comparison of extension systems

Like Australia, many European countries established agricultural extension services, only to be met during the 1990s with constraints in the form of restricted government budgets, lack of experienced personnel, and competition with vested interests (Daku et al. 2005). The subsequent growth of private-sector farm advisory services in many EU countries has resulted in a transformation from public extension systems to private fee-for-service advisory services.

While there have been limited studies that have investigated the impact of EU extension services systems on agriculture and the broader economy, most authors argue that ongoing reforms in the sector contribute to important benefits, such as increased efficiency, flexibility and accountability of the providers. While environmental and social dimensions cannot be completely isolated from agriculture as a production focused dimension, literature also illustrates concern over the impact of privatised extension on sustainability related issues such as natural resource management.

In a comparative study of agricultural extension services in six European countries (France, Germany, Greece, the Netherlands, Spain and UK), Laurent, Cerf and Labarthe (2006) identified the negative implications associated with the link between technical support for agriculture and market regulation. A key driver in the decline of extension services identified by the study was the reduction in technical interaction between beneficiaries and their colleagues following the development of consultancy as fee-for-service. This behaviour, while providing a benefit through productive advantage, was observed to reduce the diverse nature of new knowledge.

The privatisation of agricultural services ultimately became a concern for competitive advantage between producers and agencies, and as such, restricted the diffusion of knowledge through the industry. Similarly, Daku et al. (2005) identified demand and supply-side factors that affect the profitability of the service, and the factors that arise from the public-good nature of extension output, externalities, and moral hazards that affect the appropriation of returns of the service as the primary reason for this.

As well as the decline in free extension services, where such services existed across Europe, Laurent, Cerf and Labarthe (2006) noted the distinct differences in national and regional trends within the countries analysed. These differences were attributed to the political and institutional history of each country (the weight of co-management in France, the environmentalist lobby in the UK, etc), the role of agriculture in that history, and the funding capacities of each. For example, in the UK, since the environment is considered a ‘public good’, extension services related to environmental aspects of agriculture receive government assistance, however producers are required to pay for consultancy that concerns production. Issues identified in the EU system also highlight the reduction in support for agricultural extension services, despite the environmental and social dimensions that accompany it.

3. Perspectives of Private-Sector Agricultural R,D&E Funders

The preceding sections of this report have provided a brief overview of the nature of, and changes that have occurred in agricultural R,D&E systems in Australia and in other locations. A very obvious trend in all jurisdictions is the increasing importance of the private sector in investment in agricultural R,D&E.

The limited available statistical data provides some indication of trends in private-sector investment in agricultural R,D&E, and the various policies and programs implemented by governments to incentivise private-sector investment presumably have some impact, although to what extent is uncertain.

In order to better understand the factors that either encourage or discourage private-sector investment in agricultural R,D&E in Australia, structured interviews were conducted with either the chief executives or research directors of 20 Australian agribusinesses that currently, or have previously invested in agricultural R,D&E projects. The companies included in the interview process were selected to ensure that a range of company sizes, from large multinational to small Australian-based, were included in the sample. The interview population was also selected to ensure that it included agribusinesses involved in a broad range of different farm commodities.

The interviews were conducted on the basis of anonymity so that frank and open opinions could be expressed. Interview questions were sent in advance to the participants and then followed up with telephone calls to record the answers and any further discussion that may have been relevant.

The following section provides a tabulation of the interviewees responses to each of the interview questions. Because the information being sought was largely qualitative, to the greatest extent possible all responses have been included in the tabulation. For a number of reasons, the interviewees have been allocated to one of three categories – these being:

1. Large multinationals with an Australian-based business
2. Australian companies with an international partnership
3. Australian companies only involved in the Australian domestic market.

In each of the tables below, that provide responses from interviewees, the responses have been allocated to one of these three categories based on the nature of the company represented by the interviewee. Not all interviewees answered all questions, with some declining on the basis of the information being confidential. For that reason, the company numbers allocated to separate responses are not constant throughout the tables, but are simply used to differentiate individual responses.

SECTION I: Company Information

Twenty companies were interviewed for this project. The companies were selected to cover as broad a range as possible across sectors, company size and research fields.

The companies had head offices and research facilities that were located across Australia and in several countries internationally.

Product lines produced by the companies interviewed included animal health and veterinary products, animal genetics, seed varieties for a range of grain and fibre crops, fertilisers, pesticides, machinery, technology and services.

Most Australian agricultural sectors were serviced by the companies interviewed including grains, cotton, sugar, horticulture, red meat, wool, dairy, forestry, wine, and poultry.

SECTION II: Current Agricultural R&D Activities

Approximately how many staff does the company employ in R&D?

(Anonymised responses are shown to provide range. Some businesses declined to answer citing commercially sensitive information.)

	Internationally	Within Australia
Multinational		
Company 1	5,000	60
Company 2	12,500	–
Company 3	1,000	–
Company 4	124	1
Company 5	1,600	20
Company 6	Many thousands	1,000*
Company 7	–	12
Australian with international partnership		
Company 1	–	2
Company 2	–	45
Australian		
Company 1	–	18
Company 2	–	1.2
Company 3	–	2
Company 4	–	10
Company 5	–	13
Company 6	–	65
Company 7	–	34
Company 8	–	60
Company 9	–	2

* The company representative stated that all their staff were involved in R&D activities as part of their roles, although not full-time.

Approximate company R&D expenditure annually

	Internationally	Nationally
Multinational		
Company 1	€1 billion	$ 1.5 million
Company 2	$364 million	–
Company 3	$35 million	$150,000
Company 4	$350 million	–
Company 5	$700 million	$1.5 million
Australian with international partnership		
Company 1		$0–$500K
Australian		
Company 1		$5 million
Company 2		$1.3 million
Company 3		$0–500,000
Company 4		$6–8 million
Company 5		$150,000
Company 6		$3 million
Company 7		$800,000

Anticipated future trends in R&D expenditure by your company (next five years):

Multinational
Increase
Stable
Increase
Increase/stable
Increase
Increase
Australian with international partnership
Increase
Increase
Australian
Increase
Stable
Stable
Decrease
Increase
Increase
Increase
Increase
Stable

Does your company operate its own research facilities (laboratories, research stations), or outsource its R&D activities (or a combination of both)?

Multinational
Own
Combination
Own
Own
Combination
Own
Australian with international partnership
Combination
Combination
Australian
Own
Own
Combination
Outsource
Combination
Own
Combination
Combination

Location of major R&D activities? (either own facilities or commissioned R&D)

R&D activities were located in all states of Australia, both regionally and in major cities.

Internationally, countries with R&D activities feeding into Australian product development included: US, China, Brazil, EU, India, Korea and Japan.

Can you provide an approximate percentage breakdown of the type of R&D conducted by your organisation (both in Australia and internationally) using the following R&D categories provided by the Australian Bureau of Statistics (ABS)?

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 practical 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, which is directed to producing new materials, products, devices, policies, behaviours or outlooks; to installing new processes, systems and services; or to improving substantially those already produced or installed.

	Pure basic	Strategic basic	Applied	Experimental development
Multinational				
Company 1	–	–	–	100
Company 2	15	10	35	40
Company 3	25	25	35	15
Company 4	10	20	30	40
Company 5	–	–	Y	Y
Company 6	25	–	–	75
Australian with international partnership				
Company 1	–	–	100	–
Company 2	–	5	5	90
Australian				
Company 1	–	–	75	25
Company 2	10	10	40	40
Company 3	–	–	–	100
Company 4	–	–	–	100
Company 5	–	5	25	70
Company 6	15	25	35	25
Company 7	10	25	10	5

Approximately how much of the R&D conducted by your organisation in Australia is:

	By your organisation for own purpose	In collaboration with another company (non-government)	In collaboration with government or R,D&E agencies
Multinational			
Company 1	40	40	20
Company 2	15	50	35
Company 3	80	10	10
Company 4	50–95	5–50	
Australian with international partnership			
Company 1	40	20	40
Company 2	90	5	5
Australian			
Company 1	60	15	30–40
Company 2	80	20	75
Company 3	100 (mainly)	50 (private) 35 (university)	15
Company 4	100	–	–
Company 5	100	–	–
Company 6	10	60	30
Company 7	20	–	80

SECTION III: R&D Collaboration

Have you collaborated with government research agencies in Australia (state DPIs, CSIRO, universities)?

Multinational

- Mainly with government and universities. Universities and government entities do not orient well to collaboration with commercial entities – particularly multinationals.
- No. Focus has been on primary production but will take time to build ability to understand collaboration opportunities.
- Yes, collaborate with QAFFI.
- Yes.
- Yes, with all these parties.
- CSIRO. Rice Institute. UNE farm assist.
- Yes.

Australian with international partnership

- Yes.
- Yes.

Australian

- Fee-for-service in product trialling, so yes but not necessarily in a partnership aimed at commercialisation or research development.
- Yes.
- UNE, Adelaide Uni, CSIRO, Elizabeth Macarthur Agricultural Institute, MLA.
- Universities, RDC's CSIRO, pretty much worked with everyone.
- Mainly QDAF, UQ Gatton. Some NT Government.
- Yes, Cotton Australia, CRDC.

What is your company's opinion of the effectiveness of R&D collaboration with government research agencies in Australia?

Multinational

- Researchers rewarded for publishing papers. Essential interests are different to a company that is looking for commercialisation of outcomes and patents.
- Very positive.
- Depends, some are excellent others are poor. 'Culture Fit' important as well as an appreciation of deadlines. Corporate requirements, budgeting and communication between our company and researchers can all pose problems. Culture tends to be driven by strategic direction of research agency department heads.
- Positive, have brought products to market for organisations. They have expertise and facilities. Collaboration done on a project by project basis. Some projects partners reach out to begin project. Others, we will approach organisations. About 50/50.
- Have not spent long collaborating. Have noted IP issues. Large overheads associated with bureaucracy. Government research providers are protective of IP; which inhibits commercialisation. Commercial (market demands) have limited impact on research and collaboration decisions thereby effecting the usefulness of collaboration. Feel that government institutions are often unaware of the fact that their innovations are only a small part of larger commercial product. Tend to overstate importance and undervalue the necessity of input and work needed to be done around their innovation in terms of both other products and marketing components.
- Some staff in some RDCs better than others in recognising and responding to commercial imperatives.
- USQ and CRDC both quite good.

Australian with international partnership

- Very effective in cotton industry. Less so in grains.
- Our work is underpinned by these collaborations. Collaboration with government communities provides access to expertise that you otherwise would not have within the company.

Australian

- They are very good to deal with in the manner that we are exposed.
- Good.
- Don't work with/haven't worked with government agencies.
- Generally, the organisation is great, but you may work with a not so great individual. Also, you can often work with great partners who do great things, but they are bound by their administration. The major problems come from legal situations, eg IP fights. We are a small business so have to accept contracts put in front of us. We don't have legal capacity to challenge IP etc. In fights, we need to work in the best interest of our organisation. RDCs will work in their own best interest and have extensive funds for legal conflicts.
- It's not really relevant to our own needs, however, I would imagine it can be effective for larger organisations given the correct framework to operate in. I think state and federal government departments need to collaborate more with the GRDC, universities and CSIRO.
- Effective, however, commercial imperative not understood, timeframe for delivery not always compatible.
- Rely on relationships with specific organisation. More specifically staff relationships within those organisations. Impact of management within those organisation on culture and staff retention is problematic.
- Can be effective, however, it is expensive and inefficient bureaucracy. We pay around 2.2 x salary of worker. QDAF are the only ones with expertise.
- Yes, provided that there is a path to market. Works best when role of state DPI is in extension and post basic and strategic research is limited.

Is your company likely to collaborate with government research providers in Australia in the future?

Multinational

- Yes, Likely.
- Yes.
- Yes.
- Yes. Will continue to collaborate. Will build on relationships that have worked reasonably well in the past.

Australian with global partnership

- Yes.

Australian

- Collaborate and expand where possible. Gives secure income and IP etc. Collaborating can be frustrating when small projects. Can lead to cashflow issues. Big guys with money throw their weight around while little guys have to string a multitude of projects together to be viable.
- Will work with anyone. If approached with ideas will expand our work if it gets us ahead in the market without being bogged down with process.
- Yes, with the DPI.
- Yes, but often have to take risk based on seasonal research and start without contracts signed.
- Likely.
- Yes. Although even with monopoly they may price themselves out of some of the more marginal research. There is a concern that laboratory expertise is retiring and there are no new graduates to fill the void. Graduates tend to go private. Overseas graduates leaving to return to countries of origin.
- Yes. However, there is an issue with succession planning for core researchers.

What are the main benefits and/or disadvantages associated with collaboration with government research agencies in Australia?

Multinational

- Raise profile in scientific and farming community (reputational benefit).
- Those with good science can provide skills and knowledge.
- Benefit; access to expertise or tech that may not be available in-house. Australian Animal Health Labs at CSIRO has been a valuable collaborator in the past. Disadvantages; scale, products and concepts applicable to Australia are not researched as payoff limited. Need applicability to US and EU markets (unsure about the degree in which government research recognise the impact of market scale and the impact this does or doesn't have in selecting avenues of research).
- Advantage: CSIRO adds credibility and independence. Disadvantage: Not agile, stuck in old ways.

Australian with international partnership

- Access to wide range of science disciplines and high-level science skills/networks.
- Advantages are accessing expertise and boosting research capacity. Disadvantages are that government agencies tend to move at a different pace. While this is not always ideal, our company and its collaborators work through this. It is definitely not a deterrent to conducting research.

Australian

- Long-term security with this type of research.
- IP arrangements are a barrier. Specific to our industry and the way government is going, ie have lost a lot of good people. The ability to do research is diminished at the moment. With government, collaborations you run the risk of project being cancelled. Funding from RDC can disappear when staff or researchers move on.
- As a small business, it is difficult to attract funding, which is why we have had to partner with bigger industry names such as MLA. In addition, contract agreements may not always be agreed upon.
- Administration and process are the biggest constraint, especially where multiple partners are involved. The benefit is that you know they are good for the money.
- Benefits are better utilisation of skills in the industry. More efficient use of resources, less duplication. No disadvantages as long as the collaborative partners enter into agreements in the right spirit. With declining R&D funding I do not see there is any alternative to more collaboration in our industry.
- Advantages are scientific discipline. Peer reviewed, evidence based research. Quality and credibility. The benefits for government are access to distribution infrastructure and manufacturing. Provide pathway to commercialisation.
- Advantages: experience, excellent facilities. Disadvantages: inefficiency, bureaucracy.
- Corporate overheads are significant, although the quality of researchers is high, we are very open to collaboration.

Have you worked with Australian RDCs in carrying out research programs or in commercialising research outcomes in Australia?

Multinational

- In their current form, they are only a conduit for matching funds.
- Research collaboratively with GRDC.
- Yes, both formal and informal arrangements. Informal often based around transfer of knowledge of industry needs and market trends.
- No.

Australian with global partnership

- Research programs and commercialising research outcomes is facilitated through GRDC's funding mechanisms which are provided in a way that is easy for industry partners to access and apply for proposals.

Australian

- Yes.
- On and off. Have also been involved with CSIRO on a few small dealings.
- Yes, in many ways. They have sustained on-farm R&D and are intrinsically linked with R,D&E for our industry. They supply research facilities to public R&D.
- Have worked with MLA regarding developments in the beef industry.
- RDCs do research for farmers, so as a grower group, it makes sense to be a part of that.
- Yes, we do a lot of work for the GRDC.
- Yes, HIA.
- Yes. Additionally, we have made some attempts to encourage collaboration between RDCs. There is tendency to keep ideas in-house and avoid sharing.

From your perspective, what are the main advantages and disadvantages associated with working with RDCs in Australia?

Multinational

- Steadily improving over the last 10 years.
- Access to the industry and marketplace knowledge. We periodically liaise with RDCs to keep abreast of direction. However, have limited input on direction of RDC focus.
- Benefits: donor company funding arrangements. Involved with CRCs which are unique structures within global agriculture. Disadvantages: not always successful.

Australian with global partnership

- Partnered funding creates some shared commitment. RDCs are well focused on their industry, not trying to jump in and out of many sectors. It's a good way of bringing many small farmer businesses together to fund research in a coordinated way.
- Primary advantages that come from working with RDCs is the ability to bring collaborators together. High quality and high level of two-way communication. RDCs value path to markets. There are no significant disadvantages. Any challenges are typically small and easily overcome.

Australian

- Worried about what will happen with RDCs, ie dollar for dollar matching. Comes down to people. Issues can be resolved quickly.
- The ability to leverage off projects for funding is important as a small business. Doubles ability to do research and attracts university collaboration. Disadvantages however, could be IP rights.
- When interests align there is a big benefit. Gives access to increased capabilities and funding. Disadvantage: when RDCs undergo big structural changes (happens reasonably often) it is a hassle; no-one knows what is going on.
- I find them generally really good to work with although I can imagine this varies from project to project.
- Management opaque. Stakeholder impact uneven. Unknown unknowns make value of research difficult to ascertain. Need to convince levy payers.
- Advantage, access to government funds. Disadvantage, long timeframes (inefficient not agile in using research at intermediate stage or adapting to market conditions).
- Advantages are particularly with multi-partner collaborations, including RDCs, when purpose is to capitalise on overseas research and adapt to Australian market.
- We need to be first to market; collaboration with industry and trading of IP/resources often achieves this. Collaborations with RDCs tend to take longer in delivering market ready products and are at a disadvantage because of this.

In your experience, how do arrangements associated with agricultural R&D collaboration in Australia compare with arrangements in overseas locations?

Multinational

- The RDC system is a positive for Australia. Unique in the world and is positive for conducting activity in Australia.
- Some here are excellent, best in class.
- The CRC program is useful and unique. The view from the US was that it would be hard to replicate as there is less inclination/ incentive to pool resources. In US, there is good decentralised collaboration between industry and universities/government researchers. Need for orchestrated industry-wide structures not as strong in US.
- Too early to say for Australia. Extensive collaboration overseas.
- US universities are very good and we employ their graduates. Some US universities have the view that they should be striving to educate students for the workplace. Large focus on outcome. Particularly agricultural universities. Some US universities are lenient with IP retention in research projects funded by our company. They are prepared to let us have access to IP to freely develop it within products. In this way, the universities recognise that our company is much more likely to fund more research at the university. Our company favours ongoing funding agreements as opposed to traditional project based collaboration. Allows relationships to build and for entities to align priorities and focus on nominated issues.

Australian with global partnership

- There are more avenues in the US, but Australia has a good system. Australian agriculture is a much smaller community which can be a good thing. Apart from that, Australia isn't too different in comparison, and collaborations are just as strong despite perceptions of weak relationships.

Australian

- General push for private entities to do own research. We say not enough investment in R&D. Australia has a good system with CRC and RDC model and changes to enable big business to do things. Australia does well in comparison – grass not always greener over there.
- Haven't had much experience with overseas collaboration and system frameworks. However, we do work with a Beef and Lamb NZ project as they couldn't secure any funds, so they approached us to assist with their capabilities and capacity to undertake the research.
- A little less government intervention in Australia than occurs overseas. Particularly regarding use of chemical compounds.

SECTION IV: Effects of Australia's Regulatory Environment on R&D

To what extent do Australian intellectual property (IP) laws either encourage or discourage private-sector investment in agricultural R&D in Australia?

Multinational

- Good IP laws, no major issues.
- Not an issue.
- Australian IP laws encourage investment.
- Positive, especially data protection. Strong IP and data protection.
- Australian IP laws are relatively consistent which encourages investment. Lags US in some areas. Can patent genetic material in US, in Australia it is not possible. More expensive to research or import products which use patented genetic material from outside companies. Harmonisation of IP laws important. Consistency and stability important for investing.
- Less about laws themselves, more about application. Discouragement usually comes from IP lawyers trying to get greater proportion of IP value.

Australian with global partnership

- Unsure.
- Australia is good in general. There is very little concern for the private sector in having to protect their IP. Australia has solid IP laws and even more so in comparison with some other countries.

Australian

- IP maintenance for clients that commission the work, but is also important for us.
- IP is odd. Issues from the start with how we propose IP means we have troubles working with some people. Dying breed that are holding onto information. Very few ideas will come along and not get done in this industry. Rather than spend money on protecting IP we focus on getting the research done and into the community. IP is a problem with CSIRO work as they are too focused on trying to generate IP income. Have walked away from a project as CSIRO wouldn't budge. Some individuals are good but haven't done a whole lot of work with them since.
- Recent investment in a project resulted in IP going to 3rd party provider who then charged our company for utilisation of research outcomes. As a consequence, our company will not work with that company again. Lesser position taken on DPI proposal to get the work done. Sometimes you are confronted with contracts which don't necessarily coincide with your perceptions, however if there is demand for the work to be done and you have no other option you get on with it, even if it is at cost to your business in terms of return on investment.
- Doesn't really impact our company except where multiple partners are involved. And disagreements impact contract negotiations and funding.
- This is not my area of expertise, however, I do believe that we need to take a balanced view. It's nice for farmers to be able to get access to cheap generic imports, however, this needs to be balanced with the need to incentivise large multinationals to invest in R&D in Australia. I fear that at present we are on a train of decreasing global importance that is being reflected in declining spend on R&D.
- IP laws are encouraging but expensive/laborious to get IP (four to five years).
- Our company has plant breeding rights (PBR) for some varieties. PBR provisions are very good in Australia. Lack of enforcement overseas is difficult particularly in places like China. PBR needs to be enforced within the country where they are breached. Our company licenses varieties in countries overseas including South Africa, Ghana etc however we do that through companies we trust. IP protection comes by way of trusting the company not to disseminate genetic material rather than IP law.
- IP laws can be difficult to negotiate which can deter new entrants. Our company manages serviceably well due to long experience and in-house knowledge.

To what extent do Australian agricultural chemical or other regulations encourage or discourage investment in agricultural R&D by your company in Australia?

Multinational

- Australian regulations are some of the best, rational and science based in the world. Australia however, is not a major target for multinationals. Australia is 0.3% of world population and we only feed 0.7% of the world population. Big companies are interested in opportunities in Brazil, Europe and the US.
- Cost of importing chemicals and seed variety frequently prohibitive. National testing and biosecurity regulation costly and likely to be duplicating similar measures implemented overseas.
- Predictable regulatory environment. Good, fast and science based. Market size still the major (limiting) factor.
- Australian biosecurity laws are strict. Costs to register formulation and vaccines in Australia are a significant hurdle. Perception of high costs or time needed to navigate Australian regulation can instil unease around the Australian market.
- Export Slaughter Intervals (ESI) in Australia are frequently much larger than in overseas countries. Where there is no ESI specified by the importing country, default ESIs are set which are often unreasonably long.

Australian with global partnership

- There are some issues concerned with regulation. Particularly GMOs. State variability is a big issue (ie moratorium in SA and talk of changes in WA). This is hard to work around and limits the potential to utilise new technologies.

Australian

- No impact.
- Our company needs to ensure it doesn't break any laws; in terms of pesticide regulations. This makes it difficult at times to research what farmers want to know.
- Few barriers to entry. Few regulations for fertiliser impact. Untested fertiliser coming in because of this. Testing not strenuous.
- Costs to register new chemicals are expensive and prevent new chemicals being adopted particularly where there is a small market, such as for small horticultural crops.
- Regulations on ammonium nitrate content of product are a serious restriction on range of products that can be developed. Restricts composition of product. Legal requirements change if composition greater than 35%. Similar laws are not in place overseas. Overseas laws regarding production emissions are more stringent which effects investment in process development.

To what extent do Australian research and development tax concessions encourage or discourage investment by your company in agricultural R&D in Australia?

Multinational

- Secondary consideration. Our company isn't going to stop doing research simply due to changes in the R&D tax concession. Having said that, it is important to match main competitor nations with R&D incentives so we can promote Australia as a competitive place to do R&D.
- Not sure.
- Not a lot. Below the bottom line. Biology is the major determinant in location of investment, eg fungicide development occurs in regions with fungi not regions with best tax incentive. Good research IP protection and data management also important.
- Not a great impact.
- Encourages. But does not influence decision to invest in R&D to a large degree.
- Not sure. Probably not influencing decisions significantly.

Australian with global partnership

- Slight benefit but cannot count on it and during times of drought/market stress when profits are low/non-existent the tax benefit does not help.
- Tax incentives are quite helpful but not a key driver to our research motives, ie tax incentives are great but not having a tax incentive won't cause our company not to conduct a research project.

Australian

- Important but at the end of the day look at them for what they are, part of the ROI equation. Our company does research regardless.
- Our company invests heavily in R&D; however we have not investigated our eligibility to receive tax concessions. In addition, farmers provide a lot of data used in R&D that could potentially make them eligible for tax concessions, however they would be unaware if they are eligible.
- R&D tax concession is quite important. Whilst our direct spend is relatively small the tax concessions definitely help justify spending on areas of R&D that would otherwise not be undertaken.
- They have a small impact.
- See as more of a bonus rather than an influencing factor of R&D investment. A large increase in the tax benefit would be required before a change in investment behaviour occurred. Doubling tax concessions may lead to more riskier investments.

To what extent does the size of the Australian agricultural market either encourage or discourage investment by your company in agricultural R&D in Australia?

Multinational

- It impacts a lot. Small size prohibits activities. Our company is highly reliant on building upon basic research conducted overseas. Costs would likely be too high to conduct research from basic up.
- Small size is a disadvantage. The prevalence and ease in which genericised chemicals enter the market is a concern. The unreliability of the cropping market is also an issue. The amount of a particular commodity planted can vary between years as well as the input requirements.
- The small market size strongly discourages investment. R&D generally can't stand on its own in Australia and is dependent on research from overseas to compliment.
- There are areas in Australia that have idiosyncrasies which call for adaptation of products, eg the Great Barrier Reef etc. Our company seems able to adapt their products successfully.
- Yes, it is a hindrance. It is hoped that solutions that develop in Australia will evolve into solutions developed elsewhere. Australia is also seen as technologically advanced. Investing in R&D in Australia helps our company get ahead of competition as technology uptake and improvement happens relatively quickly.

Australian with global partnership

- No impact.
- Markets are a big factor. What our company does is look at what value opportunities exist in markets and evaluate the cost of running an R&D program to take advantage of those opportunities. Obviously, the research priority and costs do not always add up and not all investment opportunities are viable both financially or to benefit the market.

Australian

- Research performed on the basis of clinical assessment of cost benefit analysis including market size.
- Research investment as percentage of overall spending is dependent on size of the market. When times are really tough we have to reassess our R&D spending.
- Market size is an important consideration; the more successful the better as it allows our company to be more aggressive, particularly with the disruptions caused by big data. Currently working with other companies to expand market opportunity.
- I wish the Australian market was bigger, so I suppose it directly influences our R&D investment decisions in a negative way.
- Small market may deter competitors. Not worth the infrastructure outlay.
- Australia is just big enough to justify R&D. Our company has a small amount of direct exports. The royalty received from licensing in these markets is relatively small to the point where the effort to establish relationships overseas might not justify the costs in hindsight.
- Doesn't impact our decision-making.

Are there any other factors (other than those listed in the last four questions) that either encourage or discourage your organisation from investing in agricultural R&D in Australia?

Multinational

- Political language at the highest level remains important. Need a clear message that international companies and global collaborations are welcome. Multinational taxation has to be well measured and targeted and not become a witch hunt.
- Generic markets and seasonal variability are both major discouraging factors.

Australian with global partnership

- Most decisions are based on market influences; primarily the scientific market where gaps are identified and the expertise (people in the R&D community) are available to help. The availability of the scientific community as a resource the key factor.

Australian

- Growth in our company from production only to production, processing and marketing has been the biggest factor in our increase in R&D funding.
- There is a massive struggle with international collaboration around R&D, ie Canada, US, Brazil all have significant databases (and New Zealand, although small is a good database). Can't seem to get traction with international collaboration, particularly with genetics and genomics. Possibly a problem due to geography and trade relationships, as well as return on investment as Australia is considered a small market. These internationals could be concerned with decline in market share too. For example, our company wants international collaboration, as having access to international information on a global data platform would increase our accuracy in breeding values. At the same time, internationals won't take Australian information on genetic conditions for fear of it decreasing their accuracy. It's a one-way street. This is an issue as it inhibits Australian export of genetics – it is almost a non-tariff barrier to trade. Miscommunication between our company and government departments due to differences in skill sets and backgrounds has been an issue in the past. Contract length is an issue. Stakeholders are concerned with return on investment and want it ASAP. Our company can't get traction on projects greater than two years in length. At the moment, we have for example a six year project and at year four investors are asking for the results, and are unsatisfied with the fact that the outcomes won't be deliverable for another two years – it is lengthy investment. This means it is difficult to secure long-term investment on larger projects which limits R&D capabilities.
- Need to have security in payments (knowing that research funders are good for the cash).
- Pace of adoption a deterrent. Chemicals sprayed two times a year making time horizon difficult. Later stage adopters need several years to notice benefits from early adopters of new products.

SECTION V: Market Factors

In your experience, how important are R&D outcomes that are achieved overseas as likely sources of future innovation in Australian agriculture?

Multinational

- Very important. Big issues and large-scale projects, eg new bioscience technology and global earth imaging are all developed overseas. Also, robotics development is a global activity but doesn't mean Australia shouldn't play a part.
- Yes, very.
- Overseas innovation is a major source on innovation for Australian farmers.
- Very Important.
- Critical.

Australian with global partnership

- Quite important, especially in the area of chemistry, biotechnology and mechanics/mechatronics. We don't have companies of the scale needed in Australia to invest in some of these areas.
- For laboratory based science our company will look at what is occurring overseas and leverage from that. However, when it comes to agronomy, this is not so easy nor usually leveraged. This is because the Australian environment is unique and agronomic forces are too variable across the country and production areas.

Australian

- Very important in getting an outcome.
- Important to know what's going on because we don't want to reinvent the wheel. Will bring specific skill sets in on sabbaticals.
- Important but limited access to information on genetic conditions and breeding values, for example is an issue.
- Just as important as everywhere. Developing innovations is relatively easy, but working with farmers to get the systems working right for them and their system is hard. They need to see value. We are able to supply new technologies but the real question is whether we can demonstrate a value proposition for farmers.
- Extremely important. We are a relatively small market and it is inevitable that overseas R&D outcomes have the potential to directly influence Australia.
- As a development company, we need basic research to develop products. Overseas basic research and new compounds hugely important.
- New tech is important. Adoption of machinery, digital ag equipment etc. However, our company is a customer rather than participants in development. In the case of chemicals, our company observes the performance of overseas chemicals in similar environments to help determine whether we should spend money to register products in Australia.
- Highly important. There are soil similarities and nutrients. Much of the technology, seed treatments and varieties have similar effects worldwide. Where genesis is overseas, freedom to operate can be big constraint.

In the future, do you anticipate that the majority of new agricultural innovations will be a result of R&D activities by the major agribusiness companies, by government research agencies, or by small start-up companies?

Multinational

- Securing Australia's innovation position by adapting global R&D is critical. Also need smart local research that creates new IP to blend with global R&D to solve Australian issues.
- Recent large mergers such as Bayer and Monsanto are changing the operating environment. Will result in large companies doing the bulk of the work. However, that work will be in late stage research and product development. Start-ups will work in early stage but costs will be too high for them to take through to commercialisation.
- Major agribusiness in collaboration with some governments, universities and start-ups.
- Likely all will continue to play a part. Biggest hurdle for start-ups is funding although there are more funds starting to flow now.
- Small start-ups increasing, particularly in IT solutions/products.
- Combo of all three. Likely to be more by major agribusiness with prospecting in government agencies and start-ups. Start-ups likely to find niche opportunities in tech.

Australian with global partnership

- The majority will come from private sector, both large and small companies
- The biggest innovators at the moment are start-ups which are operating as a spin-off of government agencies or private agronomy services (particularly big in the US). This will continue; however, the major agribusinesses and multinationals will be the biggest provider/conductors of R&D.

Australian

- Will come from all of these, but all do not need to be involved in every instance. For example, in the case of privately developed plant varieties, engagement with the public sector actually creates a risk of loss of ownership.
- Use everyone – crazy thing is lapsed patents. It's amazing what people will do despite not having a commercialisation pathway. Look at the opportunities over there and find potential technologies which have not been taken forward.
- Major RDCs and government research agencies. Start-ups don't really have much of a place, if any, here.
- Innovation isn't a problem, adoption is. Zero resources allocated to extension and communication, zero budget to work with growers is a big issue. For example, MLA spend no money on the wheat belt. They assume that all producers are experts. No money to increase sheep flock despite huge potential. No effort to understand grower needs/demands.
- Agricultural companies will increasingly be the main source of new products and innovations.
- Collaboration with government will be important.
- Less from government owing to the fact less is being funded. Government do have a user pay model so it may be the case that more of the government research will be done using funds from private agribusiness.
- Agribusiness will do more. Increasingly companies like ours will take on more research activities that were formally associated with government departments as funding gets cut back and capabilities of private industry increase. Collaboration between companies and government will be really important. Need critical mass of big corporations.

What do you think would be the likely outcome of a future reduction in public-sector investment in agricultural R&D in Australia? Would that stimulate or discourage investment by your organisation and the private sector more generally?

Multinational

- Need to maintain public sector who have skills in pure/basic science to keep interest and partnerships with global partners. For example public-sector agency does the basic science while global corporate solves the technical issues such as digital applications, seed technologies and packaging.
- Capital, IP and technology is mobile and will go to wherever the best partnership opportunities are available. If not a conducive partnership environment in Australia will simply go offshore.
- Cut back would not be helpful. Important for industry collaboration and supporting and identifying farmer issues.
- Corporates will move into some areas. Will determine direction of research and make it more commercial. The lack of opportunity for collaboration may curtail some investment.
- For our company, a drop in Australian public-sector expenditure won't have a material impact as R&D program will tend to be in proportion with global R&D budget. The process is mainly concerned with appropriating overseas research into the Australian market. Some research will only be done by public institutions such as basic research with industry-wide applicability and research which is too expensive or has high costs associated with research infrastructure to justify potential rewards in the Australian market from the perspective of one company.
- Impact of lack of resources for education has been the biggest problem, as the flow of graduates has dried up. Private companies need skilled and educated talent available to operate successfully. A reduction in public-sector R&D resources wouldn't greatly alter our companies approach to R&D investment. Our area of R&D has never had significant public funding. Depends somewhat on type of technology. Sensor development relies heavily on government and university research and collaboration. Might encourage it slightly overall. Not certain.

Australian with global partnership

- Would put strain on the productivity increase of the sector and therefore reduce the likely investment in future R&D – downward spiral.
- There is a lot of public-sector research that impacts across the whole sector and at other times the outcomes have quite narrow applications. Reduction in public-sector R&D would definitely impact the community that our company aims to serve, as well as our own research, and therefore our company would need to fill the gaps that result from investment decline by working more efficiently than current arrangements.

Australian

- If R&D concession drops, it will be bad for the industry and decrease investment potentials. If the public sector drops off, private sector will have to pick up the slack in order for innovation to occur.
- Reduction in CRC funding is a real worry for our company as they account for 50–60% of R&D in our sector.
- It will decrease leveraging ability which will in turn reduce the amount of private investment.
- Biggest innovation in agriculture in the last 10 years has been the mobile phone. People need to realise that agriculture is more than just growing plants and animals. Products and services in Australia have always ranked in top 10 markets for investment for multinationals, and while we are only a smallish market we have a stable government, and are a first world country where farmers have access to capital. In our experience, Australia has never been a market that internationals don't want to be involved with.
- It will absolutely discourage it. We need to do whatever we can to maintain public-sector funding. We also have an obligation to ensure this it is used effectively and matched by the private sector. There is no way that the private sector will naturally fill any void – there will simply be a net reduction in R&D.
- Will discourage investment. Particularly if there are fewer opportunities to collaborate. Our company has an established set of well-funded collaborators so we would not anticipate much change if there was a squeeze.
- Some R&D will be picked up by private business however will be less investment overall. Some research (more basic) is only done by government, higher education research facilities etc. So far spending by public sector in our sector has remained reasonably steady.
- Investment = Innovation. If public funds reduce then our company funding will need to increase to stay ahead of the market. There is a need to continually innovate to stay ahead of the generics.

There are currently some major mergers and takeovers proposed in the international agrichemical sector. What factors so you think are contributing to this, and what will be the likely outcome in relation to future R&D investment by these companies?

Multinational

- There are two factors driving continuing aggregation, the increased cost of innovation requiring a greater scale of R&D to justify costs and need to have an integrated solution that protects innovation for a long time (easier for a company that has lots of skills).
- Economies of scale; reduction of duplication of office roles is a particular target. Less certainty that there will be consolidation of on-ground research due to the diversity in species and geographic locations of company operations.
- Merger allows for more R&D and better ROI as reduces the extent of duplication. Incentive for more collaboration as in-house management becomes more onerous.
- Companies looking for synergies, and to reduce duplication.
- Reduction in duplication. Resources shared would mean less overall expenditure however, it would be more efficient.

Australian with global partnership

- Costs, especially regulatory costs are a major factor behind the mergers. I think it will reduce the pace of new chemistry and biotech development – a negative outcome.
- One of the major factors contributing to the current mergers is the conclusion of a phase of over-investment and over-build of capacity that has occurred while commodity price markets have been high. The cycle back to lower commodity prices is leading to less revenue and the need to create efficiencies through mergers. Private R&D funding is cyclical like the markets and will rebound again.

Australian

- US patents on genetic sequences have restricted our company's ability to run part of our genetic evaluation program. The impact is that our company will no longer conduct R&D in that area due to limited ability to work with some material.
- Consolidation happens everywhere. Provides opportunities for small businesses to become big businesses and creates room for new small businesses.
- Mergers are obviously a function of companies looking to gain efficiencies and toe the line on acceptable levels of market power – it is unfortunately an inevitable fact we face. On balance, this is not a good thing for R&D investment as I think the incentive to invest in R&D, all other things being equal, is less when there are fewer market players. However, at the extreme, there is no sense in having too many players, and none of them making enough money to make a profit or to spend on R&D.
- Chemical companies will tend to spend less on registration of products. Will develop chemicals, and let the end user pay for registration of those chemicals.
- Less incentive to differentiate products. This is also exacerbated by generic companies. Big companies will likely focus on holistic tech packages which incorporate their products.

SECTION VI: General

Do you think that the private sector is likely to increase or decrease investment in agricultural R&D internationally or in Australia in the future? (Why?)

Multinational

- Can increase significantly in Australia if we play our cards right; dining boom in Asia will drive interest from investors and result in the recognition of Australia as a significant player in this market.
- Private investment will increase due to larger market opportunity.
- Increase. Increased demand for agricultural products from limited resources will drive innovation.
- Consolidation will lift the amount of activity due to efficiency gains.
- Increase but with consolidation and joint ventures with other companies will be more efficient.

Australian with global partnership

- Continue to increase slowly, as governments are likely to continue to cut back funding to support other budget areas such as health.
- Private-sector investment will continue to grow at the current rate. We are in an age of technology in agriculture and all of the signals are there in terms of bringing innovation to agriculture.

Australian

- Increase. For serious businesses, you need to build resilience and take opportunities. Blue sky research is a potential pot of gold. However, there is not as much R&D in these areas anymore, eg molecule discovery and genetics are safe because we know the outcomes.
- Our company group is in charge of companies that provide services to grower groups. Expansion of their businesses in the next five years will require additional investment.
- We will need to increase as levies won't be increasing. Private sector will become more important.
- Private investment will grow due to technology opportunities, eg data analytics and software will generate new market opportunities.
- It's hard to say. I'd love to think it will increase, however, I can see why global players would focus their attention on larger developing countries where the return on investment in potentially greater.
- Companies will realise need to keep ahead of curve and invest more in R&D. Already seeing in some markets overseas that big multinational companies are dominating and conducting a lot of research in-house and keeping it private.
- Increase.

What government policies do you feel need to be amended, discarded, or introduced in order to encourage greater private-sector investment in agricultural R&D in Australia?

Multinational

- Red tape an issue. Compliance costs for regulation and biosecurity high and processes are time-consuming. Cost and ease of doing business are both important.
- Regulation for transgenic crops needs to change. Also need to look at potential restriction of generic companies. Other start-ups will have an impact. May have to change business model to accommodate disruption from on-demand purchasing platforms, eg Ali Baba.
- Export slaughter intervals need to be addressed. Better legislation where importing specifications not present. Make sure regulations for chemical registration and biosecurity is commensurate with risk. Where possible, harmonise with overseas regulation.
- Ethical imperative to improve policy for emissions standards.
- More tax deductions might help. Tax relief should target R&D projects and activities rather than designated R&D entities.

Australian with global partnership

- One small one is to allow some off-label experimentation with agricultural chemicals (on small scale) on farms. I think a lot of this happens anyway but would be good to have it encouraged, that would get the manufacturers behind it some more.
- At the moment policy prevents a large amount of work with GMOs. The issues are not just about the dinner table conversation either. It is the processes of licencing and dealing with clients and compliance to develop and trial GM technologies. Particularly, for example, the new breeding technologies that deal with things such as genome editing. Chemical regulation is also a big one with the current and ever-increasing regulations surrounding the use of chemicals in Australian agriculture. Australia has the opportunity and should be in the place to be more influential and lead global conversation so that we can have our market served. For example, the US sees the Australian market as small and therefore not worth them registering here. This barrier needs to be lowered and regulations need to change. Australia is unique and offers some unique opportunities

Australian

- There needs to be more obvious support for the policy of government matching R&D levies dollar-for-dollar. Our company supports the formation of CRCs as they are fantastic vehicles for collaboration, however at the moment there is nothing related to our sector. Of the 20 to 30 companies working in our sector only two have internal research and all rely on global capacity. Extension is a major issue! It isn't classified as R&D so is a struggle to resource. Our company has relied on private sector to extend genetic information. The lack of ability to fund extension has led to what research we do being poorly adopted. The research community is not equipped to deal with small private-sector research. Private-sector R&D often doesn't result in many scientific journal articles, this makes it a struggle to attract investment and collaboration from universities and their researchers. Our company is attempting to overcome this by using a graduate program where graduates and other students can work on projects at zero cost to producers. R&D generally limited to applied research and development because of low risk appetite from corporate boards.
- Don't believe policy will solve any issues with regards to private investment. The best option is to ensure that governments continue to invest in RDCs; this results in a better return for taxpayers.
- More R&D tax offsets and incentives for companies to bring overseas technology to Australia. Better IP protection to reward those companies who do develop truly novel new solutions that increase productivity
- Currently few regulations around nutrient specifications and new molecules entering into use. Look at tax concessions. Need to address ways to improve collaboration between public and private enterprise; three-year funding of departments is too short. Need to increase length of projects to build continuity and allow basic research to emerge.
- Tax offset easiest and cleanest. Replenishing lost skills by employing graduates is a challenge, given low numbers of graduates. Unsure of whether policy can address this issue. Anything that mitigates risk
- Policies vs attitude. Strong emphasis on the need to get attitude and working relationship between collaborators right. Particularly in the case of government. Need to make clear expectations and identify a pathway to market and the roles each party will play from basic research through to commercialisation. Management of research critical. Actual useful policy changes/measures not particularly obvious. Culture being the important component in successful collaboration and R&D investment execution.

Observations Arising from Interview Responses

The survey was specifically designed to gather qualitative rather than quantitative information, and hence responses have not been aggregated in order to generate statistical information. The responses do provide sufficient information, however, for some generalised observations to be made. These are as follows:

- Respondents generally anticipate that their organisations will continue to invest in agricultural R&D in Australia, and most anticipate that the level of investment in the future will increase.
- Most of the private-sector investment in agricultural R&D in Australia conducted by the companies included in the survey involves either Experimental Development or Applied Research, and there is only very limited private-sector investment in Basic Research.
- Large multinational companies appear more likely to engage in collaborative research with public-sector research agencies, whereas smaller Australian companies conduct most of their own research, and are much less likely to collaborate with public-sector research organisations.
- Private-sector companies that engage in collaborative research with public-sector agencies are generally positive about the results of collaboration and intend to continue to engage in these arrangements, however they also identify a number of issues that may limit the success of collaborations, including:
    - cultural and motivational differences, with some public-sector researchers more focused on publishable outcomes rather than commercial results
    - some public-sector researchers and research agencies do not adequately focus on project timelines and budgets
    - the bureaucratic nature of some public-sector agencies, and the differing motivations of researchers and research managers
    - difficulties in resolving IP ownership
    - a lack of understanding of the commercial realities (and costs) associated with getting a new product to market.
- Private-sector companies collaborating with Australian public-sector agricultural R&D organisations perceive multiple benefits, including access to technology and expertise, credibility benefits associated with engagement with the public sector, and advantages associated with enhanced scientific discipline.
- Private-sector companies collaborating with Australian RDCs in research activities are generally very positive about the experience, and many note improvements in the quality of collaboration over recent years. That noted, there was some criticism of their lack of agility and relatively slow progress in achieving project outcomes.
- Private-sector companies generally perceive Australian intellectual property laws to be beneficial and to encourage investment in R&D, but reference challenges in negotiating IP ownership issues with public-sector R&D collaborators.
- Private-sector companies strongly support Australian agricultural chemical regulations and biosecurity regulations, although note some challenges associated with harmonisation of Australian and international regulations.
- The Australian R&D tax concession is perceived as a positive incentive to invest in agricultural R&D, although is not considered to be a major factor in investment decisions.
- The relatively small size of the Australian market is considered by many to be a limiting factor in agricultural R&D investment decisions.
- Overseas agricultural R&D outcomes are considered to be of major importance as a

source of innovations for Australian agriculture, noting that considerable development is often required in Australia to adapt these to Australian conditions and production systems.

- Private-sector companies investing in agricultural R&D in Australia strongly support the maintenance of public-sector research agencies as a major contributor to the agricultural R&D system in Australia, perceiving the public sector to be complementary to the private sector.
- Uncertainty over regulations of GM crops is generally perceived to be a factor that discourages investment in agricultural R&D in Australia, and also creates some uncertainty about the value of investments in some of the newer genetic technologies.

In summary, private-sector companies included in this survey have quite positive views about the benefits associated with investment in agricultural R&D in Australia, and believe such investment will increase and become more important in the future.

4. Survey of Australian Private-Sector Agricultural R,D&E Investment

To supplement the information obtained in the interviews reported in the previous section, a mail survey (Appendix 4) was conducted between March and April 2017. The survey was distributed to approximately 200 Australian agribusiness companies (not represented in the interview process) that may potentially have invested in agricultural R&D, either on a stand-alone basis or in collaboration with public sector or other private-sector organisations undertaking agricultural R&D.

Following the initial mail out, the sample population was contacted twice to encourage participation in the survey which remained open and active for four weeks. At its closure, a total of 18 completed responses to the survey had been received. While the response rate was quite low, it was considered that the information arising from the survey would add additional information and provide a useful complement to the information arising from the interviews. Given the limited sample size, the statistics arising from the analysis of the survey results should be considered to provide a broad indication of industry views, rather than represent a robust statistical sample that could be inferred to represent the entire population.

Size and Nature of Business

The survey respondent population included businesses across a range of agriculture industries including broadacre cropping, livestock, horticultural production, dairy, technical services, precision agriculture, agribusiness consultancy and advisory, trade, and business and resource management.

Figure 12 shows the gross annual expenditure on R,D&E indicated by responding companies. Some 56% of respondents indicated a gross annual expenditure equal to or less than $500,000, 28% spent between $500,000 and $1 million, and 18% spent more than $1 million.

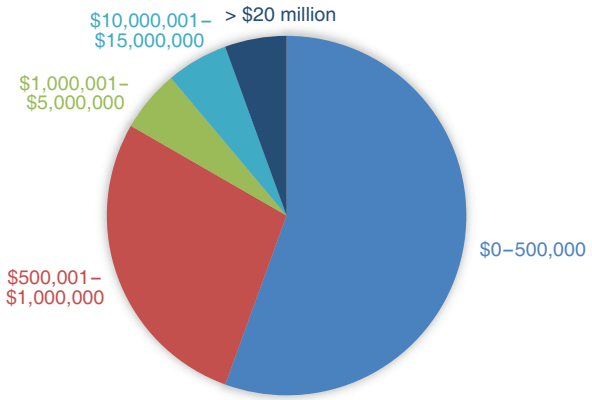

Figure 12: Gross annual expenditure on R,D&E of survey respondents.

Research and Development Activities

Survey respondents were asked to classify research activities based on the type of research conducted. The classification system provided for this question used the definitions contained in the ANZSRC (Appendix 2) for pure basic research, strategic basic research, applied research, and experimental development.

The data indicated that 50% of respondents conduct some form of pure basic research, 56% conduct strategic basic research, 78% conduct applied research, and 89% are involved in experimental development. On average, the total proportion of research activities associated with each classification was 7%, 12%, 34% and 44%, respectively.

Respondents were also asked to indicate the proportion of R,D&E conducted by own staff, commercial contractors, and public researchers. The results were that:

- 89% of respondents used their own staff for, on average, 77.5% of all R,D&E activities conducted
- 67% of respondents indicated the use of commercial contractors to conduct, on average, 32.5% of all activities
- 45% of respondents indicated the use of public-sector researchers to conduct on average 21.5% of all R,D&E activities.

Respondents were then asked to indicate the proportion of R,D&E funding used by source. The data showed that all respondents funded R,D&E using at least some proportion of *own funds*, overall accounting for an average of 70.28% of total investments. Sixty-two per cent of respondents funded R,D&E *in partnership with another commercial organisation*, accounting for 15.84% of total investment funds, and 62% *in partnership with a public research organisation* that accounted for, on average, 27.9% of total funding.

Collaboration

Participants were asked what public-sector research organisations they have collaborated with or commissioned to conduct R,D&E, and were then asked to rate those organisations based on aspects of their performance. Of those that had collaborated with public-sector institutions 45% had collaborated with CSIRO, 67% with Australian universities and state departments, 50% with RDCs, and 28% with another organisation not specifically listed. Table 5 shows the mean rating assigned to the listed organisations by the proportion of respondents that responded to the question (78%).

The CSIRO and 'Other' providers (commercial research companies) were ranked highest, while the state agriculture departments were ranked lowest by companies procuring R&D services, although it is evident that different providers have different strengths.

Companies with annual research expenditures of less than $500,000 were most critical of research providers, which is probably a reflection that these companies would be less likely to have a full range of legal and contract negotiation skills available in-house, and would therefore face a proportionally greater cost to negotiate project arrangements.

Table 5: Average rating of agricultural R&D organisations by aspect of performance.

Criteria	CSIRO	Australian universities	State department	Rural R&D Corporation	Other
Contract negotiations and finalisation	3.5	3	3	2.8	3.3
IP and legal arrangements	3.4	3.2	2.8	3.1	3.3
Staff professionalism and skills	4.5	3.4	3.7	3.5	3.7
Cost efficiency	3.0	2.9	3	3.3	3.7
Standards of facilities and equipment	3.9	3.9	3.2	3.3	3.3
Communication with collaborators	3.8	3.3	3.3	2.8	3.7
On-time completion	3.5	3.1	3.2	3.3	3.7
Reporting and documentation	3.8	3.6	3.4	3.9	3.5

(1 – very poor, 3 – average, 5 – very good)
Other = commercial technology provider.

Factors that Influence R&D Investment Decisions

Respondents that had not collaborated with a public-sector agency, were asked to comment on the reason(s) why. Some of the reasons given included difficulty in collaboration processes, the lack of appropriate skills and expertise, poor company focus, control of information, and poor commercialisation procedures and culture. Some businesses also identified that the gap was not about innovation, but more so about having the capital and expertise necessary to increase standards.

All respondents were also asked to comment on:

- The likelihood of increasing or decreasing R,D&E expenditure in Australia in the future.

  The majority of respondents indicated that their company is likely to increase R,D&E, however, 33% of respondents indicated that their future investment intensity was either unknown or dependent on factors attributed to business/operational priorities, partnership opportunities, innovation and commercialisation model structures, and the underlying need for R,D&E in a specific area (Figure 13). The small proportion of respondents that indicated a likely decrease in R,D&E expenditure, attributed their actions to priorities focusing business activities overseas.

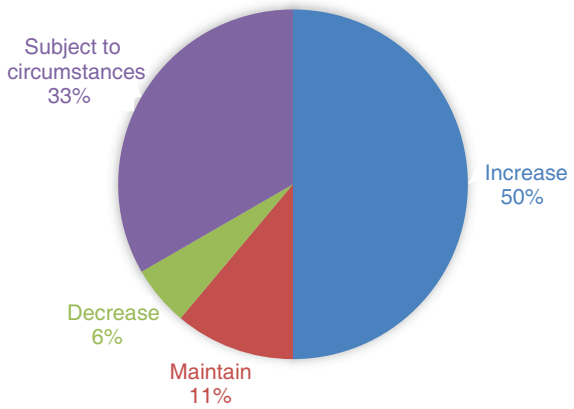

Figure 13: Future trends in R,D&E expenditure.

- The main factors that encourage and discourage current, and potential future increases, in R,D&E investment by their company in Australia.

  There was an array of factors given by the survey respondents affecting decisions relating to increasing or decreasing R,D&E investment in Australia. There was no overriding consideration that was common to the companies surveyed with investment decisions relating specifically to individual firm or industry characteristics (particularly internal capabilities), competition in product markets, R&D tax incentives, location and resource related factors such as spill overs from national public and private research outcomes, cooperation with external research providers, and human capital.

  Key themes influencing decision to increase or decrease investment in R,D&E identified among survey responses included:

  – access to external R&D outcomes.
  – availability of capital
  – return on investment
  – availability of skills
  – position in relevant markets
  – protection of IP
  – sustainability of government funding for partnering state departments and RDCs
  – complexity associated with project and contract arrangements
  – complexity associated with application requirements and procedures
  – credibility of entities, people, and project proposals.

  Respondents described the initial knowledge, visibility and accessibility of external R&D as a predetermining factor in the coordination

of research efforts made by the private sector. Most investment in R,D&E carries some risk. Partnering with, or using the outcomes of publicly-funded R,D&E reduces risk for private investors, so detailed and transparent knowledge of public-sector efforts can have a significant impact on the formation of R&D investment and strategy.

Reasons given for not increasing investment in R,D&E included access to capital and the rate of return on investment. In addition, access to the knowledge, skills and expertise required for specialist R&D developments or related projects in Australia was identified as particularly challenging for private businesses.

All responses noted the importance of research conducted as part of collaborative partnerships in conjunction with public research bodies in the delivery of R,D&E outcomes in an Australian context. It was also mentioned however, that there are disincentives for collaboration particularly for SMEs. For example, the transactional costs associated with the contracting stages of projects were often seen to be too onerous, uncertain, cumbersome, and costly. The unintended outcome of the cost of compliance for collaborative processes is that government support becomes disproportionately directed towards large companies who have the resources and capability to meet reporting requirements.

- If the knowledge of investment intensity in R,D&E made by other companies would affect their company's investment in R,D&E.

  Twenty-eight per cent of respondents indicated that knowledge of R,D&E investment by other companies would be beneficial and could foster links with experts and other individual and like-minded groups operating in similar or related fields. Respondents also identified the potential for this type of knowledge to stimulate competition (ie in sourcing of funds and collaborators), provide a benchmark to inform strategy, enhance R,D&E due to accessibility and sharing of resources, increase efficiency and earlier delivery of outcomes, and minimise unnecessary duplicate research.

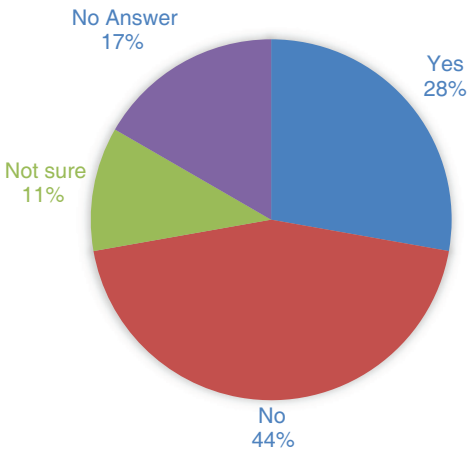

Figure 14: Would the knowledge of investment intensity by other companies would affect their company's investment in R,D&E.

  Forty-four per cent of respondents indicated that they would not be affected by the knowledge of other companies' R,D&E intensity, either due to their current operating or market environment, or because they were unable to envisage any benefit derived from this type of information. The remaining proportion of respondents indicated N/A or provided no answer.

Finally, participants were asked to rate the importance of the R,D&E Tax Incentive, Australian IP ownership laws and arrangements, and the skills and capacity of Australian researchers/research institutions as factors in decision-making about R,D&E expenditure (Table 6, over page).

It is evident that opinions differ somewhat on the importance of the R&D tax concession and Australian IP laws, but there is stronger agreement about the importance of the skills of the researcher and the institution as a key factor in making decisions about investment in agricultural R&D.

Table 6: Scale-rating of the importance of factors affecting decision-making about R,D&E expenditure.

	No importance	Minor importance		Average importance		Major importance	Total
R&D tax concession*	11.1%	11.1%	0%	16.7%	22.2%	38.9%	100%
Australian IP laws*	0%	27.8%	11.1%	16.7%	16.7%	27.8%	100%
Skills and capacity of researchers/institution*	5.6%	5.6%	5.6%	16.7%	27.8%	38.9%	100%

* n=18

As noted earlier, the limited sample size of companies which participated in the survey means that these results should be considered to provide a broad indication of the perceptions of those involved, rather than a definitive and statistically robust measure of attitudes throughout the industry.

5. Discussion and Recommendations

Defining the level of investment in agricultural R,D&E and related activities in Australia, and much of the world, is difficult due to the ambiguous definitions of R,D&E used by statistical agencies when collecting information. Beyond these reporting issues this study also found further complicating factors associated with an objective assessment of the value of private R,D&E in Australia. They include such things as valuing innovation culture as well as the spill over effects of international and cross-sectoral investment.

A thorough and detailed understanding of the level of investment in R,D&E in Australian agriculture will require a more tailored approach to the collection of data and information about public and privately-funded research projects and collaborative arrangements. If this data was made more available it would serve the dual purpose of informing policy and funding strategy about gaps and trends in research funding as well as identifying research capacity and resources available to investors in R,D&E.

Recommendation 1:

A more descriptive methodology should be developed by the agriculture sector in conjunction with the ABS for categorising agricultural R,D&E expenditure to better inform industry strategy and investment decisions.

While assessing the total investment in agricultural R,D&E in an objective and comparable format is not easy, factors which influence decisions by private entities to invest in R,D&E were able to be determined. They include such things as:

- market structure, size, and maturity
- the ability to extract a return on investment (ROI) and the speed with which that can be done
- access to R,D&E resources such as funding, infrastructure, and a skilled workforce
- confidence in forming effective collaborative partnerships with matching commercialisation cultures.

The extent to which these key factors influence investment decisions depends on a company's internal resources and capabilities, their strategic approach to achieving competitive advantage through innovation and their willingness to link investment strategies with external support mechanisms, such as collaborative partners.

Collaboration

Effective R,D&E can be thought of as the successful translation of research outputs to commercial outcomes; a process that is regrettably poor in Australia. This process often involves public-private interaction to facilitate adoption pathways for research initiatives. Multi-stakeholder platforms (MSP) have been a popular mechanism for increasing collaboration with the aim of increasing knowledge transfer between farmers, researchers and other stakeholders to enhance innovation capacity (Hermans et al. 2017).

The increasing diversity and multidimensional character of participatory research for sustainable agriculture and related areas such as food security and natural resource management, has led to studies suggesting the need for alternative collaborative research methods (Hermans et al. 2017; Neef & Neubert 2011). Novel approaches to collaboration are required to adequately cater for the diversity and dynamics of agricultural research projects and commercialisation procedures.

Responses from industry interviews indicated that many companies were discouraged from

investing in collaborative R,D&E due to previous negative experience in public-private interactions. Conflicting research objectives, uncertainty around scope for public investment, expensive fixed cost structures, intellectual property constraints and a lack of understanding of commercial outputs were all given as causes for negative experiences.

Key characteristics of complex problems in agricultural systems are their multiple dimensions (biophysical, technological, sociocultural, economic, institutional and political), and their embeddedness across different scales, hierarchical levels and interdependent actors (Hermans et al. 2017).

Generally, the public sector is oriented towards fundamental or basic research while the private sector works more with applied and experimental research. This can be the cause of tension in some collaborative arrangements since the required focus of government initiatives (concerning public good, public access and public accountability), and universities (whose success metrics are based on academic publications), are commonly thought to displace the potential for widespread innovation and commercialisation of research outcomes in a manner that satisfies private-sector objectives. Given this, it is important to consider a process to identify common goals with mutual benefits, a key factor in developing successful partnerships between the public and private sectors (Braidotti 2015).

This is particularly the case for some major Australian universities, that have developed a business model that is broadly depicted in Figure 15. The overriding focus of much research is publication metrics, which in turn improve the international ranking of the university and make it more attractive to high fee-paying international students. Some of the resulting revenue is used to cross-subsidise research projects which result in publishable outcomes and so the cycle continues. Unfortunately, collaborative research with industry partners does not fit well within this business model, as the focus of that research is commercial outcomes and it may be disadvantageous to the commercial partner to have the results published.

It should be noted that this model does not apply equally to all Australian universities, and recent changes to research quality assessment implemented by the Australian Research Council to incorporate a measure of industry impact may also assist to improve the collaboration culture within universities. Nevertheless, the attractiveness of university researchers as collaborators with industry will remain limited unless this culture changes.

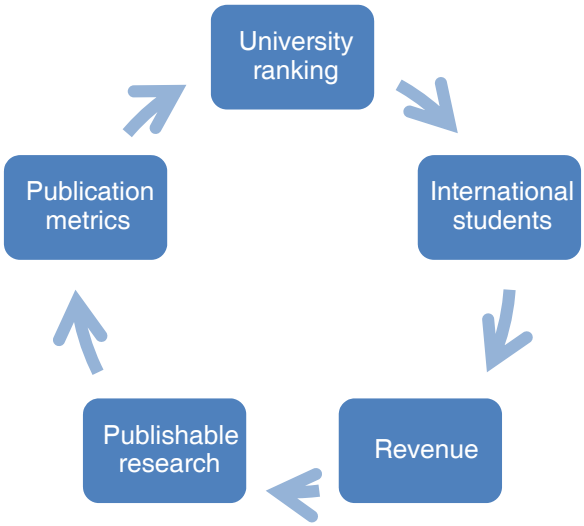

Figure 15: The vicious funding cycle of some Australian universities.

Many of the organisations interviewed were taking proactive steps to address the perceived differences in commercialisation culture to enhance the prospects of public-private collaborative partnerships. They were doing this through engaging in programs to train graduate and postgraduate students about market-driven and outcome-orientated R,D&E strategies. There was a strong consensus view that by focusing on administrative culture and commercial awareness a more effective R,D&E partnership environment would result.

The calibre and quality of science performed by public institutions was rarely questioned by the interviewees or survey respondents. A lack of confidence in scientific output is not limiting private investment in R,D&E in Australia. Direct funding incentives for private investment in R,D&E public-private partnerships in the absence of programs to

match commercialisation cultures would therefore appear to be questionable.

Recommendation 2:

Participation in programs which attempt to match innovation and commercialisation culture between public and privately-funded organisations should be incentivised. This would include such things as industry-based research or work placement programs as well as student internships.

Hermans et al. (2017) found that ongoing engagement of stakeholders in R,D&E activities maximises the potential for contributions of complementary insights, a broadened knowledge base, and social learning towards process feasibility and viability. These interactions and participation enable stakeholder groups to understand the ways in which their interests, needs and objectives differ, as well as recognise fundamental interdependencies and the need for concerted action at different levels to overcome constraints and reach common R,D&E objectives. In short, stakeholders are more likely to accept or support innovation adoption when they have been part of the development process.

Public Funding

Public subsidies and tax incentives are common tools used by government to stimulate R,D&E. These tools create mechanisms that directly influence decisions of companies to improve their innovation processes through R,D&E investment strategies (Afcha & Lopez 2013). Interview responses indicated that the use of public funding for private R,D&E was particularly important in alleviating some of the risk associated with research that was in the longer-term interest of the general public, but would not deliver short-term outcomes for the investor. This perception coincides with studies (Afcha & López 2013) that have documented the positive impact of public funding on internal R,D&E, especially the decision to conduct R&D internally and externally simultaneously.

The usefulness of the Australian Government R&D tax incentive for the organisations interviewed was generally dependant on the size of each organisation. Larger companies regarded the tax concession as a secondary factor in decision-making and generally had decision-making processes around R,D&E investment that were independent of external funding influences.

Smaller businesses however, identified tax incentives as a major factor affecting investment decisions. Tax incentives helped to lower the financial risk of investing in R,D&E and in some cases led to research being funded that would otherwise have not been conducted. It is important to recognise that the types of research conducted by different sized organisations are likely to be quite different. Smaller companies are more likely to be participating in novel, cutting edge research than larger companies who need to invest in closer to market solutions. Tax incentives may only be significant in decision-making for a small amount of investment in R,D&E however, it is R,D&E that is the critical first step in the innovation pathway.

Recommendation 3:

The current Australian Government R&D tax incentive should be maintained with the eligibility criteria made more transparent and the application process streamlined.

Decreases in public-sector funding of R&D have the potential to limit productivity increases in the agricultural sector and discourage private-sector investment in R,D&E. The primary concern expressed in interview responses was that the effect of decreased funding would diminish the impact of RDCs and CRCs which provide a unique and coordinated R&D platform focused on industry objectives.

Reduced support for R,D&E also has the potential to discourage businesses and the skilled workforce (eg researchers and industry professionals) from looking for opportunities in Australia, forcing them to seek other options offshore. In an already highly competitive international research environment, this situation would pose a threat to Australia's employment and research sectors, now and into the future, and affect the nation's reputation as a quality R&D provider. Particularly concerning for interviewees was the potential for a significant

reduction in the quality and volume of R,D&E conducted in Australia.

Recommendation 4:

Australian governments should commit to sustain and ideally increase the availability of public funding for agricultural R&D and associated infrastructure in Australia, acknowledging the importance of a robust public-sector agricultural R&D system as a major factor to incentivise increased agricultural R&D investment by the private sector.

R,D&E markets

Research outcomes achieved overseas have important impacts on R,D&E activity in Australia. This is particularly true for the fields of chemistry, biotechnology, mechanics, and mechatronics, as Australian businesses typically lack the scale and investment capital necessary in these areas. There is limited international spill over of research in many of the applied environmental sciences and particularly in agronomy due to the unique Australian climate.

Interview and survey responses indicated the considerable number of small Australian businesses spending less than $500,000 on R,D&E annually. R,D&E expenditure of this magnitude limits the capacity to conduct blue sky, or basic research specific to the Australian market or environmental setting. Despite this, some exceptions such as small biotechnology firms looking to penetrate the market with new IP, do exist. Some examples include the sheep lice treatment, Avenge, for which imidacloprid was adapted for use on sheep, and the development of the herbicide Sakura for annual ryegrass control.

The availability of the scientific community as a resource was identified as an influence on R,D&E investment decisions. Many of the interviewees reflected on the difficulty in not only connecting with the scientific community regarding current and potential research interests and initiatives, but also in the ability to identify and access relevant expertise willing to form collaborative relationships. Smaller organisations, in particular, described the difficulty in identifying potential research partners, as well as the challenges associated with making themselves and the organisation's research interests known to the wider community.

The experience of the researchers involved in preparing this report mirrored the experiences described by those respondents to interviews or surveys that were part of this project. Few, if any Australian university agricultural faculties provide a detailed catalogue of research projects in progress or completed. Similarly, few Australian rural RDCs provide a systematic and accessible catalogue of research activities which incorporates details of researchers, the duration of the project, the size of the project, the anticipated outcomes and progress to date.

In contrast, the Current Research Information System (CRIS) maintained by the United States Department of Agriculture provides a readily accessible database that enables organisations to identify current research (and hence to avoid unnecessary duplication) and also to identify researcher expertise, facilitating collaboration between the private sector and public-sector researchers. There is a very strong argument that the implementation of a similar database in Australia would enhance the potential for private- and public-sector collaboration, especially by smaller private-sector organisations.

Recommendation 5:

The Australian Government, in conjunction with the CSIRO and the Council of Rural RDCs should develop a framework for a standardised database to be used to record details of agricultural research projects currently underway or completed in Australia, and once established it should be a condition of public funding that recipient research organisations record and maintain information about all research projects on that database.

The cost and uncertainty of regulatory compliance was raised by many of the interviewees as a significant barrier to investment in R,D&E. Australia is perceived to have a high cost regulatory environment with a lot of duplication of product

safety trials that may have already been carried out internationally. The potential for regulatory differences between states (eg the ban on GMO crops in South Australia) in an already small market is a further disincentive.

Australian regulations for the registering of pesticides and veterinary medicines were a particular focus of many of the companies interviewed. The unique agricultural environment that exists in much of Australia requires bespoke products, however, often the only companies that have the capacity and capability to deal with the regulatory costs are multinational organisations which are less likely to invest in what would be a very small market for their scale of production. There have been concerns raised that consolidation in the agrichemical industry is leading to less focus on investment in R,D&E and subsequent product development applicable to small markets. The pesticide and veterinary medicine regulatory environment in Australia would appear to be an additional factor affecting the viability of investments in R,D&E for the Australian market.

Recommendation 6:

Australian regulatory approval procedures should recognise and use the results from approved international approval processes to reduce the cost of compliance for developing products for the Australian market.

Mergers and acquisitions

Mergers and acquisitions (M&As) are driven by the opportunity to expand, diversify and increase production and profitability by increasing market share, which therefore increases the scale required to drive innovation and support corporate sustainability. Currently, six companies dominate the biotech seed and agrichemical industries: Bayer, Monsanto, Dow, DuPont, Syngenta, and BASF. The recent proposal of some major takeovers in the agrichemical and seed sectors, including that of ChemChina and Syngenta, DuPont and Dow, and most recently, Bayer and Monsanto, has prompted concerns regarding the potential implications for R,D&E investment within the agricultural industry.

The three largest agribusinesses that would result from these mergers would represent 62% of the world markets' patented seeds and 62% of all pesticides.

It is inevitable that the total number of R&D programs will be reduced following these mergers however the investment in R,D&E by the combined entities will still be significant. Whether fewer, better resourced R&D programs can achieve the same outcomes for the benefit of industry as a greater number of less well-resourced programs is yet to be seen. Interviewees were split on whether the mergers would lead to more or less research intensity.

The risk for Australia arising from these changes is that the resulting major multinational corporations will not have a strong interest in the Australian market, given its relatively small size and unique production systems. Australian rural RDCs, the Australian Government and the CSIRO have expertise and capital of sufficient scale to enable active engagement with large multinationals and in doing so to encourage a greater focus on research areas of relevance to Australian agriculture. Such arrangements should be encouraged, and the rationale for them regularly communicated to the farm sector and the wider community.

Recommendation 7:

Australian Government agricultural R&D agencies should develop and actively encourage collaborative partnerships with large agribusiness companies in order to leverage the expertise and resources of these organisations in seeking opportunities to enhance Australian agricultural innovation and productivity.

Agricultural extension

Australian governments have largely withdrawn from the provision of productivity-related agricultural extension services, with those public extension services that are still maintained tending to focus on public-good issues such as environmental issues and natural resource management on-farm.

A private-sector farm advisory service has developed, which many argue provides more specialised, relevant and timely advisory services for farmers, and which farmers are willing to pay for. Such services are more prevalent in the cropping, horticulture and intensive livestock sectors than in the broadacre livestock sector, although there are signs an advisory sector is also emerging for broadacre livestock producers.

While these developments are not new and have been occurring over the past two decades, it is apparent that private-sector companies which undertake investment in agricultural R&D find that the lack of public-sector extension services limits the 'pathway to market' for new products, and may be slowing the rate of adoption of new innovations in the sector. It is highly improbable that governments will decide to reinstate public-sector agricultural extension services, and in any event this would be a retrograde step that would stymie the growth of private-sector advisory services. What is required, however, is more formal processes to create opportunities for close collaboration between public- and private-sector research organisations and private-sector farm advisors. Several rural RDCs and regionally-based universities have implemented programs that involve collaboration with private-sector farm advisors, but there is a need to enhance these programs, and make them a routine element of RDC activities and to embed them in major research projects.

Recommendation 8:

Australian Government agricultural R&D agencies and universities should develop and implement regular and effective engagement and collaboration with relevant private-sector farm advisors, recognising these now constitute the major communications pathway by which Australian farmers become aware of, and consider the adoption of new innovations.

The private sector will continue to play an increasingly important role in fostering the adoption of innovations that enhance productivity in the Australian agricultural sector. However, it is apparent that innovation adoption is more likely to be optimised through a combination of both public- and private-sector activities, with the ideal outcome being a situation where a robust and well-resourced public-sector agricultural R&D system is engaged in strong collaboration with private-sector organisations, and the activities of both play a complementary role as part of the entire national agricultural R,D&E system.

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Appendix 1: Survey – Factors Affecting Private-Sector Agricultural Research, Development and Extension Investment in Australia

SECTION I: Company information

1. Company name
2. Location of company headquarters
3. Company annual revenue (International and Australia – agricultural products)
4. Company annual revenue (Australia – agricultural products)
5. Major agricultural product lines (Australia)

   ……

   ……

6. Major agricultural target markets (agricultural commodities)

   ……

   ……

7. Total staff (international) ……. Total staff (Australia) …….

SECTION II: Current agricultural R,D&E activities

8. Approximately how many staff does the company employ in R,D&E?

   International (excluding Australia) ……. Australia …….

9. Approximate company R,D&E expenditure annually:

   International (excluding Australia) ……. Australia ……..

10. Anticipated future trends in R,D&E expenditure (next five years):

    Increase Stable Decrease

11. Does your company operate its own research facilities (laboratories, research stations), or outsource its R,D&E activities (or a combination of both)?

    ……

12. Location of major R,D&E activities (either own facilities or commissioned R,D&E)?

International	Australia
----------	----------
----------	----------

13. Can you provide an approximate percentage breakdown of the type of R,D&E conducted by your organisation (both in Australia and internationally) using the following R,D&E categories provided by the Australian Bureau of Statistics (ABS)?

> **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 practical 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, which is directed to producing new materials, products, devices, policies, behaviours or outlooks; to installing new processes, systems and services; or to improving substantially those already produced or installed.

Pure basic research (%)	…….
Strategic basic research (%)	…….
Applied research (%)	…….
Experimental development (%)	…….

14. Approximately how much of the R,D&E conducted by your organisation globally is:

– conducted entirely by the organisation for its own purposes …… %

– in collaboration with another company (non-government) …… %

– in collaboration with government R,D&E agencies …… %

SECTION III: R,D&E collaboration

15. Have you collaborated with government research agencies in Australia (state DPIs, CSIRO, universities)?

16. What is your company's opinion of the effectiveness of R,D&E collaboration with government research agencies in Australia?

17. Is your company likely to collaborate with government research providers in Australia in the future?

18. What are the main benefits and/or disadvantages associated with collaboration with government research agencies in Australia?

19. Have you worked with Australian RDCs in carrying out research programs or in commercialising research outcomes in Australia?

20. From your perspective, what are the main advantages and disadvantages associated with working with RDCs in Australia?

21. In your experience, how do arrangements associated with agricultural R,D&E collaboration in Australia compare with arrangements in overseas locations?

SECTION IV: Effects of Australia's regulatory environment on R,D&E

22. To what extent do Australian intellectual property (IP) laws either encourage or discourage private-sector investment in agricultural R,D&E in Australia?

23. To what extent does Australian agricultural chemical or other regulations encourage or discourage investment in agricultural R,D&E by your company in Australia?

24. To what extent does Australian R&D tax concessions encourage or discourage investment by your company in agricultural R,D&E in Australia?

25. To what extent does the size of the Australian agricultural market either encourage or discourage investment by your company in agricultural R,D&E in Australia?

26. Are there any other factors (other than those listed in the last four questions) that either encourage or discourage your organisation from investing in agricultural R,D&E in Australia?

SECTION V: Market factors

27. In your experience, how important are R,D&E outcomes that are achieved overseas as likely sources of future innovation in Australian agriculture?

28. In the future, do you anticipate that the majority of new agricultural innovations will be a result of R,D&E activities by the major agribusiness companies, by government research agencies, or by small start-up companies?

29. What do you think would be the likely outcome of a future reduction in public-sector investment in agricultural R,D&E in Australia? Would that stimulate or discourage investment by your organisation and the private sector more generally?

30. There are currently some major mergers and takeovers proposed in the international agrichemical sector. What factors so you think are contributing to this, and what will be the likely outcome in relation to future R,D&E investment by these companies?

SECTION VI: General

31. Do you think that the private sector is likely to increase or decrease investment in agricultural R,D&E internationally or in Australia in the future? (Why?)

32. What government policies do you feel need to be amended, discarded or introduced in order to encourage greater private-sector investment in agricultural R,D&E in Australia?

Appendix 2: Australian and New Zealand Standard Research Classification

Pure basic research is experimental and theoretical work undertaken to acquire new knowledge without looking for long-term benefits other than 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 practical 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 and/or practical experience, which is directed to producing new materials, products, devices, policies, behaviours or outlooks; to installing new processes, systems and services, or to improving substantially those already produced or installed.

Source: 1297.0 – Australian and New Zealand Standard Research Classification (ANSRC), 2008.

Table A3.1: Comparison of agricultural extension services in six EU countries (data for 2002 for the Netherlands and 2001 for the other countries).

	France	Germany	Greece	Netherlands	Spain[a]	UK[b]
Government support for coordination at national level	Various coordinated bodies	A federal commission	In the process of being overhauled	On certain aspects (innovation phase)	None	On certain aspect (environment)
Political competence of local and regional authorities as regards technical support	National competence	Competence of the *Länder,* specific organisation of each *Land*	National competence. In the process of being overhauled. Rural development centres being created	Provincial competence and national competence (but the latter only for innovative activities)	Competence of the region (*Autonomía*). Specific organisation for each region	Distribution of competence between Northern Ireland, England, Scotland and Wales
Main issues on which reflection on the target groups of technical support is focused	*Articulation of sectoral and territorial development.* Reflection in the inclusion of farms formerly excluded from development actions (diverse groups, depending on the organisation)	*Co-existence of Länder with very difference histories and agrarian structures.* Reflection differs according to the *Land*. In *Länder* of former East Germany, how to deal with the void created by institutions dismantled at the time of reunification. In the others, an accent on 'professional' producers (eg Schleswig-Holstein) or all types of farms (eg Bavaria, Baden-Wartenberg)	*Modernise, acknowledging there is duality between 'multifunctional' agriculture and specialised agriculture.* Reflection on the simultaneous implementation of two ways of development: rural enterprises with farming activity and specialised farming	*Control environmental aspects of modernised agriculture.* Reflection on the relative role (zoning) of agriculture, 'natural' space and the other economic and domestic activities in a space often described as overpopulated	*Continue the modernisation of agriculture in a situation of extreme structural heterogeneity.* In particular, reflection on the relative importance to grant to different groups (conflicts between family farmers and absent landowners); inclusion of poor part-time family farms	*Reconciling farm production and environmental protection.* Reflection on zoning that gives priority to a particular objective and, in protected areas (eg countryside stewardship), technical support for the entire population concerned
Main sources of funding	Professional taxes; income from land tax; public funds; paying services	Differs depending on the *Länder* but subsidies from the *Land* even when there is a private consultancy	European funds mainly; private consultancy at a charge	Public support mainly for the innovation phase and paying services for the rest	European funds mainly; private consultancy at a charge	Public funds for environment and rural space; para-fiscal taxes for advice on products; consultancy at a charge

[a] Study more particularly on the Extramadura region; [b] Study more particularly on England.

Source: Cerf et al. (2002) and Labarthe (2002).

Source: Laurent, Cerf and Labarthe (2006).

Table A3.2: Rationale for extension activities.

	Construction of a strategic view of the sector in the medium term	Technical coordination of training and advisory activities	Typical means of action	Areas of action	Categorisation of the target public	Integration of constraints resulting from the wish to combine different objectives	Countries where this logic prevails in the technical support devices studied
Logic of occasional intervention	No	No coordination concerning desirable content of advice and its evolution, but specialised agencies to link training supply and demand but specialised agencies to link training supply and demand	Construction of a training and information supply	All the agricultural and rural activities in which there is a demand for training	Any demand from the agricultural and rural world (in reality large farms and so-called 'professional' farmers)	Shifted onto the individual producer	Spain, Netherlands, UK
Logic of specialisation	On certain aspects related to the domain of specialisation of the institution; certain environmental problems or certain products (oil seeds, milk, etc)	No global coordination. Collective reflection on certain aspects related to the domain concerned and coordination of interventions in that domain	Mixed. Information, training and accompaniment of the putting into practice	Interventions only on certain aspects related to the institution's domain of specialisation	In relation to typical situations of production or environmental problems	Shifted de facto onto the individual producer	France, Germany, Greece, Spain, Netherlands
Sectoral logic of global advice	Reflection on scenarios of trends in agriculture and its relations with the rural world and society in general	Coordinated programming of advisory activities. Independent and specific extension organisations but coordination by national bodies	Accompanying the putting into practice	All the agricultural rural activities	Reflection on evolution of the target public	Reflection on the tools of global advice	France, Germany
Project accompaniment logic	Reflection in terms of local development		Assistance for information searches, training, and project organisation	All the agricultural rural activities	Rural inhabitants	Reflection on the viability of an integrated project	Greece

Source: Cerf et al. (2002), Labarthe (2002) and Laurent (2002).

Source: Laurent, Cerf and Labarthe (2006).

Appendix 4: Survey – Private-sector agriculture R,D&E investment in Australia

Australian Farm Institute

Private-sector agriculture R,D&E investment in Australia

1. Company name:

2. What are your company's primary activities/product lines?

3. What is your company's approximate annual expenditure on R,D&E?

- ○ $0 – 500,000
- ○ $500,001 – $1,000,000
- ○ $1,000,001 – $5,000,000
- ○ $5,000,001 – $10,000,000
- ○ $10,000,001 – $15,000,000
- ○ $15,000,001 – $20,000,000
- ○ > $20 million

4. Can you provide a breakdown of the nature of your company's R,D&E using the following R&D categories provided by the Australian Bureau of Statistics (ABS)?

a) Pure basic research – experimental and theoretical work undertaken to acquire new knowledge without looking for long term benefits other than advancement of knowledge.

b) Strategic basic research – experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of practical discoveries. It provides the broad base of knowledge necessary for the solution of recognised practical problems.

c) 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.

d) Experimental development – systematic work, using existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products, devices, policies, behaviours or outlooks; to installing new processes, systems and services, or to improving substantially those already produced or installed.

Pure basic research (%)	
Strategic basic research (%)	
Applied research (%)	
Experimental development (%)	

5. What percentage of your company's R,D&E is conducted by:

Own staff?	
Commercial contractors?	
Public sector researchers?	

6. What proportion of your company's R,D&E funding is:

Conducted solely in-house using own funds?	
Funded in partnership with another commercial organisation?	
Funded in partnership with a public research organisation?	

7. Which public-sector research organisations have you collaborated with or commissioned to conduct R,D&E? (Please specify where possible)

CSIRO	
Australian universities	
State department	
Rural R&D Corporation	
Other(s)	

8. Of the public-sector organisations you have collaborated with or commissioned to conduct R,D&E, please rate each of te following aspects of their performance: (Rating: 0 – N/A, 1 – very poor, 2 – poor, 3 – average, 4 – good, 5 – very good)

	Contract negotiations and finalisation	IP and legal arrangements	Staff professionalism and skills	Cost efficiency	Standards of facilities and equipment	Communication with collaborators	On-time completion	Reporting and documentation
CSIRO								
Australian universities								
State department								
Rural R&D Corporation								
Other								

Other (please specify)

9. If your company has not collaborated with a public-sector agency in Australia, what are the main reasons for this?

10. Looking to the future, do you think your company is likely to increase or decrease its R,D&E expenditure in Australia, and why?

11. What are the main factors that encourage and discourage current, and potential future increases, in R,D&E investment by your company in Australia?

12. Would knowledge of investment intensity in R,D&E made by other companies affect your company's investment in R,D&E? If so, how?

13. How important are the following factors in decision-making about R&D expenditure?

	No importance	Minor importance		Average importance		Major impotance
R&D Tax Concession	○	○	○	○	○	○
Australian IP ownership laws and arrangements	○	○	○	○	○	○
Skills and capacity of Australian researchers/research institutions	○	○	○	○	○	○

Australian Farm Institute Publications

Research Reports and Discussion Papers

The Australian Farm Institute publishes research reports and discussion papers arising from the annual research program. These publications aim to identify strategic farm sector issues and promote potential solutions to policy-makers and agribusiness leaders. Research topics are initially formulated at the Institute's annual Australian Agriculture Roundtable Conference, which involves Australian farm and agribusiness leaders, researchers and policy-makers, members of the Institute and guest speakers, as well as members of the Institute's Board, Research Advisory Committee and staff.

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Review of Australian Agriculture's Trade Performance 2016
The Implications of Digital Agriculture and Big Data for Australian Agriculture
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Part 2: The Public and Private Sector Grain Advisory Systems in Australia
Part 3: International Grains Extension Models and Future Directions for the Australian Grains Industry Extension System
Opportunities to Improve the Effectiveness of Australian Farmers' Advocacy Groups – A Comparative Approach
Is Counting Farmers Harder than Counting Sheep? *A Comparison of the Agricultural Statistical Systems of Australia, the United States and France*
Assessing the Opportunities for Achieving Future Productivity Growth in Australian Agriculture
Does Australia Need a National Policy to Preserve Agricultural Land?
Transport Costs for Australian Agriculture
Private Sector Investment in Agricultural R&D in Australia

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