Australian Government

Department of Agriculture and Water Resources

House of Representatives Standing Committee on Agriculture and Industry

Inquiry into Agricultural Innovation

Submission from the Department of Agriculture and Water Resources

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Table of Contents

Introduction

On Thursday 13 August 2015, the Standing Committee on Agriculture and Industry (the Committee) adopted an inquiry referred by the Minister for Agriculture, the Hon. Barnaby Joyce MP, asking the Committee to inquire into and report on the role of technology in increasing agricultural productivity in Australia.

Innovation is recognised as a driver for productivity growth. Innovation is fundamentally about experimentation and involves the acceptance or tolerance of the risk of failure. Innovation activities include more than just R&D and rely heavily on implementation and take up. These aspects of innovation mean that it can be difficult to measure reliably to assess economic, social or environmental costs and benefits.

Technology and innovation has had a significant role in increasing the productivity of Australian agriculture. Efficiencies and yield increases have been generated by a number of factors, including new crop varieties, selective animal breeding and precision agriculture techniques. Currently, new ‘smart’ information technology which harnesses ‘big data’ is becoming integral to farm equipment and decision-making, helping farmers use data to further improve their productivity. A 2011 study by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) has shown that farmers generate a $12 return within 10 years for each dollar that the government invests in agricultural research and development (R&D). There have been several recent studies, reports and policy papers that discuss the link between innovation and agricultural productivity gains. These are summarised at Appendix A.

Past innovation has increased productivity in agriculture and there is wide scope for future gains. Future productivity gains may come from the integration of developments in other sectors such as engineering, mining, information and communication technology (ICT) and data analytics. Technologies that may increase productivity include robotics, imaging, nanotechnology, gene technologies and integrating ICT with farm equipment.

However, there are barriers to the uptake of research and development (R&D) outcomes. These barriers can, and must, be addressed if agricultural productivity is to continue to increase. In addition, the agricultural production environment and the context in which agricultural commodities are traded and consumed is shifting and becoming increasingly dynamic, providing challenges for Australian agricultural innovation policy.

This submission outlines current Australian government initiatives relating to agricultural innovation, information on barriers to farmer adoption of innovation, and some examples of innovative technologies that are, or could be, applied to agricultural production. A list of publications, with summaries, is provided for further reference.

Current policy initiatives

Rural Research and Development Corporations

Australia's rural research and development corporations (RDCs) are widely recognised as world leading practice in agricultural research and development. A critical part of this success is the role of industry, which shares the responsibility for funding with government. This co-funding model provides a sound basis for close collaboration between researchers and industry.

The Australian Government provides funding of approximately $700 million per year to rural R&D. This funding is distributed to a number of R&D organisations, including the RDCs, Cooperative Research Centres (CRCs), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), universities, and other recipients via specific government programs. The RDCs are among the largest recipients of government funds, in total receiving approximately $250 million per year in government funding to match producer levies.

There are 15 RDCs, each relating to an industry or group of industries. They commission and manage targeted research and foster uptake and adoption based on the identified needs and priorities of both industry and the Australian Government. Some RDCs also provide marketing services to industry.

The RDCs are governed by independent boards and are accountable to the minister through legislation and funding agreements. The government shares strategic direction and priority setting for R&D activities with the RDCs.

Further information on the RDCs is available from the Council of Rural RDCs website: www.ruralrdc.com.au/

Australian Government's Agricultural Competitiveness White Paper

The *Agricultural Competitiveness White Paper*, released by the Australian Government in July 2015, includes a chapter on 'farming smarter' which outlines initiatives to generate more and better research and development, targeted to areas of highest priority and accessible to farmers to help improve their business.

The *White Paper* demonstrates the government's strong commitment to the current rural RD&E system, and also outlines measures to strengthen it. The measures include setting rural research, development and extension (RD&E) priorities that reflect the needs of farmers (further described below), additional funding for collaborative research and adoption (via the Rural R&D for Profit Programme, outlined below), and improving the efficiency of the RDCs by reducing administrative costs and improving governance arrangements.

The *White Paper* is available from the Australian Government website:
http://agwhitepaper.agriculture.gov.au/

Rural RD&E Priorities

The White Paper announced new farmer-oriented Commonwealth RD&E priorities to target rural RD&E funding. These priorities were developed following significant consultation, and will help to align government investment in RD&E with the areas of research that have the greatest potential benefit to agricultural productivity and farmer profitability.

The new Australian Government Rural RD&E Priorities are:

- **advanced technology**, to enhance innovation of products, processes and practices across the food and fibre supply chains through technologies such as robotics, digitisation, big data, genetics and precision agriculture;
- **biosecurity**, to improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers;
- **soil, water and managing natural resources**, to manage soil health, improve water use efficiency and certainty of supply, sustainably develop new production areas and improve resilience to climate events and impacts; and
- **adoption of R&D**, focusing on flexible delivery of extension services that meet primary producers' needs and recognising the growing role of private service delivery.

These RD&E priorities for agriculture are consistent with the national Science and Research Priorities announced on 26 May 2015 (see below).

Rural R&D for Profit Programme

Rural R&D for Profit is a $200 million competitive grants programme providing grants to the RDCs and partners for collaborative research which enhances farm-gate profitability and supports the continued innovation of Australia's primary industries. The programme began in 2014-2015 as a four-year programme due to finish in 2017-18 with funding of $100 million.

As part of the Agricultural Competitiveness White Paper the government committed to extend the programme to a total of eight years and increase funding with a further $100 million. The additional funding recognises the role of the programme in funding research to address cross-sectoral issues, increasing the level of collaboration in agricultural research, funding research into cutting-edge technologies and delivering applied research outcomes to farmers.

Round one of the programme has been completed, and 12 projects have been funded to the value of $26.7 million. Several of these projects are applying new technologies to agriculture or are helping farmers to integrate and understand data. For example, one project will integrate the latest imaging and robotics technologies to provide tree crop farmers with decision-support tools to help improve production and profit. Another project aims to improve seasonal forecasting and develop tools to help farmers make the best of seasonal climate forecasts to maximise their productivity.

More information on the Rural Research and Development for Profit grants programme is available from the Department of Agriculture and Water Resources website: http://www.agriculture.gov.au/ag-farm-food/innovation/rural-research-development-for-profit

Australian Government Science and Research Priorities and Practical Research Challenges

In 2015 the Australian Government released a set of Science and Research Priorities and Practical Research Challenges to focus investment in areas of immediate and critical importance to Australia and its place in the world. The priorities of most relevance to the agriculture sector are:

- Food. This priority emphasises the importance of research that will lead to enhanced food production through:
  - novel technologies, such as sensors, robotics, real-time data systems and traceability, all integrated into the full production chain
  - better management and use of waste and water, increased food quality, safety, stability and shelf life
  - genetic composition of food sources appropriate for present and emerging Australian conditions.
- Soil and water. This priority includes research that will lead to better understanding of sustainable limits for productive use of soil, freshwater, river flows and water rights, terrestrial and marine ecosystems.
- Environmental change. This priority includes research that will lead to:
  - Improved accuracy and precision in predicting and measuring the impact of environmental changes caused by climate and local factors
  - Resilient urban, rural and regional infrastructure
  - Options for responding and adapting to the impacts of environmental change on biological systems, urban and rural communities, and industry.

The Australian Government Science and Research Priorities and Practical Research Challenges can be found at the science.gov.au website, hosted by the Department of Industry, Innovation and Science: http://www.science.gov.au/scienceGov/ScienceAndResearchPriorities/Pages/ThePriorities.aspx

Examples of innovations applied to agriculture

Emerging technologies from a wide range of sectors have the potential to not only be relevant to agriculture, but to revolutionise it. Three examples are used here, however there are many more. These example technologies are related and are likely to influence the development of the others.

Nanotechnology

Nanoscience and nanotechnology are the study and application of extremely small things and can be used in many fields, such as chemistry, biology, physics, materials science, and engineering. In agriculture, nanotechnology has potential in detecting and treating disease, delivering agrochemicals and bio-stimulants and as sensors.
Examples of nanotechnology research for application to agricultural production can be found at 'Nanowerk' – a website that provides news and information on nanotechnology: http://www.nanowerk.com/spotlight/spotid=37064.php

Robotics

Robotics represents a well-developed technology that is readily available in various forms to many agricultural businesses. It has potential to save labour costs and to incorporate a range of data sources and technologies. Data collection, monitoring, seeding, harvesting, and pest and disease control are just some of the potential applications. Collaboration across sectors on the development of new platforms can create economies of scale, and algorithms to analyse and present data for decision making, is an area for further research. Some examples are:

- The Australian Centre for Field Robotics at the University of Sydney has developed the solar-powered Ladybird vegetable robot to conduct surveillance, mapping, classification and detection for a variety of different vegetable crops. More information is available at the University of Sydney Centre for Field Robotics website: http://www.acfr.usyd.edu.au/

- Unmanned aerial vehicles ('UAVs'), drones and other surveillance technologies offer producers the ability to monitor and track stock location, pasture conditions and crop growth. More information is available at the Grains Research and Development Corporation media webpage: http://www.grdc.com.au/Media-Centre/Ground-Cover/Ground-Cover-Issue-118-Sep-Oct-2015/Farmings-new-eyes-in-the-sky

Precision/decision agriculture

At present, precision agriculture uses integrated data from various sources to develop precise calculations of necessary inputs to achieve desired outputs, and to minimise the incidence of pests and diseases. Precision agriculture provides an example of the scope to develop existing, embedded, innovation into new productivity gains. The future of precision agriculture could lie in a different but related approach: decision agriculture, which integrates spatial and seasonal data at a site-specific level for producer decision making. For example, precision agriculture has been applied in potato production, in a Horticulture Australia Limited project. More information is available in the April/May 'Potatoes Australia' newsletter at the Ausveg website: http://www.ausveg.com.au/publications/PA/PA-AprMay2015.pdf

Barriers to the adoption of emerging technologies

It is well understood that there are barriers to achieving the productivity gains that could flow from the adoption of technological and research outcomes. In 2007 the World Bank identified six contextual challenges which heighten the need to examine how innovation occurs in the agricultural sector:

1. Markets, not production, increasingly drive agricultural development.
2. The production, trade, and consumption environment for agriculture and agricultural products is growing more dynamic and evolving in unpredictable ways.
3. Knowledge, information, and technology increasingly are generated, diffused and applied through the private sector.
4. Exponential growth in information and communications technology has transformed the ability to take advantage of knowledge developed in other places or for other purposes.
5. The knowledge structure of the agricultural sector in many countries is changing markedly.
6. Agricultural development increasingly takes place in a globalised setting.

(See *Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems* at http://documents.worldbank.org/curated/en/2006/01/7178260/enhancing-agricultural-innovation-beyond-strengthening-research-systems)

More recently, at the 'Soil, Big Data and the Future of Agriculture' conference in June 2015, Dr Brian Keating, Executive Director of Agriculture, Food and Health at CSIRO, stated that social and institutional challenges are likely to be more significant to digital agriculture than the technical challenges. He categorised these as:

- data confidentiality;
- data ownership and control;
- system complexity and incompatibility; and
- human dimensions of farming.

Dr Keating's presentation is available on the conference website: http://soilbigdata.org/

Both sets of challenges highlight the importance of Australian farmers having access to, and most crucially being able to use, information. This information relates to domestic and international market demand, customer preferences, R&D outcomes, resources, inputs and their own production environments.

There can be a lead-time of up to 20 years from undertaking R&D to adoption of the outcomes by farmers. It is difficult to reach conclusions about barriers to adoption in a general sense, as research on barriers to adoption is often tied to specific programmes. Existing research and feedback from farmers has suggested that the barriers to farmers' adoption of new technology can include:

- the absence of reliable cost-effective remote and rural access to broadband capacity
- older farmers' lower likelihood of adoption (due to lack of skills, education or resistance to change)
- lack of skills needed to adopt new technology
- different learning styles (some farmers prefer face-to-face communication and will not engage with mass communication electronic tools which disperse R&D outcomes)
- seasonal conditions and financial capacity to adopt R&D outcomes.

Barriers to adoption of R&D by farmers can be reduced when research is focused on practices most likely to be adopted by involving farmers in research design. Effective extension programmes can also reduce barriers to adoption.

Dis-adoption can also occur when farmers revert to older practices after R&D is complete and extension ceases, for example on completion of pilot studies under three- or four-year project lifecycles. Not adopting R&D can be just as valid as adopting, if the farmer determines adoption would not increase their enterprise's productivity and/or profitability. The farmer may perceive a market advantage to dis-adoption or non-adoption where dealing with organic or genetically-modified-free markets. Examples of barriers to adoption are provided at Appendix B.

Appendix A – Publications on innovation and agricultural productivity

Australian agricultural productivity growth: Past reforms and future opportunities (Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES, 2014)

This publication is available from the ABARES publications pages on the Department of Agriculture and Water Resources webpage:
http://www.agriculture.gov.au/abares/publications/display?url=http://143.188.17.20/anrdl/DAFFService/display.php?fid=pb_apgpfd9abp_20140220_11a.xml

This report draws together several studies on agricultural productivity. It examines how Australia's past agricultural and economy-wide reforms have contributed to agricultural productivity growth, and considers some opportunities for future reforms to promote productivity growth. The report concludes with a chapter on opportunities for government to assist in improving productivity growth. The areas highlighted are:

- facilitating structural adjustment and efficient resource use across farms
- reducing unnecessary regulatory burdens and setting appropriate regulatory standards
- investing in RD&E and an efficient agricultural innovation system
- building human capital through improving labour availability and skills.

Public investment in agricultural R&D and extension: an analysis of the static and dynamic effects on Australian broadacre productivity (ABARES, 2011)

This publication is available from the ABARES publications pages on the Department of Agriculture and Water Resources webpage:
http://data.daff.gov.au/brs/data/warehouse/pe_abares20110914.01/RR11.07_PubInvAgRandD.pdf)

This research provides evidence of the important contribution of public RD&E to broadacre total factor productivity in Australia. It finds that, over the past 50 years, knowledge and technology accumulated from past public investments in RD&E in Australia and overseas have accounted for almost two-thirds of average annual broadacre productivity growth.

The analysis conducted for this report led to a subsequent calculation by ABARESthat a $1 public investment in RD&E leads to $12 in benefits generated by farmers in the long term. The key findings of the study include:

- Public R&D and extension account for two-thirds of agricultural productivity growth
  - importantly, around half of these productivity gains can be attributed to spillovers from international research
- Increasing expenditure on R&D is one possible avenue to increase productivity growth
  - But there can be lags of many decades between investment and payoffs and so past investment decisions are likely to drive productivity outcomes for some time.

- While R&D contributes to long term knowledge accumulation, extension can generate higher returns in the short run. The challenge for policy makers is to strike a balance between funding short term or lasting productivity improvements.
- Given limited public funds and competing demands, it is important to find the right balance between:
  - R&D with a farm production focus, R&D aimed at addressing natural resource pressures, and R&D directed further along the supply chain
  - Improving incentives for increased private investment in R&D. In particular, regulatory systems that balance the risks and benefits of new technologies
- A key issue is the path to market for new technologies
  - For example, while there is a lot of potential to apply DNA techniques to plant and animal improvement, regulatory hurdles—and the cost and length of time taken to clear them—can be a significant disincentive to invest
- Social concerns can affect agricultural production by increasing uncertainty, regulatory burden and input requirements.

Harvesting productivity: ABARES-GRDC workshops on grains productivity growth

This publication is available from the ABARES publications pages on the Department of Agriculture and Water Resources webpage:
http://data.daff.gov.au/brs/data/warehouse/pe_abarebrs99014452/harvesting_prod.pdf

This report presents the findings from a series of workshops on productivity in the grains industry conducted by ABARES and the Grains Research and Development Corporation (GRDC) under the Harvesting Productivity Initiative. The workshops were held in July 2009 with groups of grain growers and agricultural consultants. The key outcomes include:

- Workshop participants believed that the main drivers of past productivity growth related to:
  - better knowledge about cropping systems
  - increased use of new technologies
  - expansion of grain farming areas
  - increased farm size
  - improved plant varieties.
- In the view of workshop participants, the main causes of productivity slowdown were:
  - drought
  - slower spread of new technology
  - smaller advances in farming systems and technology
  - knowledge constraints
    - it was suggested that, to an extent, productivity gains in the past had been made relatively easily by addressing well-understood limitations such as nutrient deficiencies, and that current constraints were much more difficult to solve.

    - in particular, there is currently insufficient knowledge to solve some of the problems which can be identified with sophisticated data collection methods such as yield mapping
  - shift in research priorities away from productivity.
- Looking forward, workshop participants suggested that possible drivers of future productivity growth were likely to arise from:
  - region-specific extension via a private consultancy model
  - improved business management and decision-making skills
  - varietal improvement—yield, abiotic stresses (frost, moisture, nutrients), biotic stresses (fungus)

Productivity in the Australian dairy industry: pursuing new sources of growth (ABARES, 2014)

This publication is available from the ABARES publications pages on the Department of Agriculture and Water Resources webpage:
http://www.daff.gov.au/abares/pages/publications/display.aspx?url=http://143.188.17.20/anrdl/DAFFService/display.php?fid=pb_piadid9aasf20140904_11a.xml

ABARES conducted a comprehensive assessment of dairy farm performance by analysing farm survey data and gathering information and views from dairy farmers and others at a series of regional workshops. The results of this study highlight key performance trends in the Australian dairy industry; productivity growth at industry and farm level by region, drivers of productivity growth, and constraints to future growth. Key findings are outlined below.

- Growth in productivity for the Australian dairy industry has occurred over the past three decades at an annual average rate of 1.6 per cent a year, although rates of growth differ across the regions, reflecting relative changes in regional industry structure. These differences also reflect the extent of uptake of new technologies within a region, and the characteristics of each region that affect the types of farming systems used.
- Two key drivers of the observed growth in dairy farm productivity have been the exit of relatively less efficient farms from the industry, and the widespread adoption of new technologies and management practices that allowed dairy farmers to reduce the quantity of inputs required to produce a given quantity of output.
- Workshop participants identified a variety of technologies and management practices that have contributed to productivity growth either directly or indirectly, including:
  - improvements to milking shed design and layout
  - milking equipment
  - herd genetics
  - pasture varieties and feeding systems.
- Other changes such as improved education and training were also important, but the direct productivity benefits were often less tangible.
- Workshop participants also highlighted some constraints likely to face dairy farmers in the future from issues such as animal welfare and the environment. While addressing

such issues might generate benefits for society as a whole, the cost associated with implementing the required changes to dairy farm operations could constrain productivity growth.

From R&D to Productivity Growth: Investigating the role of innovation adoption in Australian agriculture (Rural Industries Research and Development Corporation (RIRDC), 2011)

This report is available from the RIRDC publications webpage: https://rirdc.infoservices.com.au/items/10-160

This report found that innovation is a key driver of productivity and economic growth and of the competitiveness of agriculture and other industries. However, because the innovation process is complex and innovation data is limited, the links between innovation and R&D investment, and its effects on productivity, are difficult to quantify. The report evaluates the role of innovation adoption within the agricultural innovation process. Specifically, a conceptual framework is developed to assess the innovation process and the interacting drivers influencing innovation adoption and productivity, including R&D investment. The report includes background material on the proportion of farms innovating in 2006-07 and 2007-08 and the types of innovations adopted.

Australia’s Agricultural Future (Australian Council of Learned Academies)

This report is available from the Australian Council of Learned Academies website: http://www.acola.org.au/index.php/projects/securing-australia-s-future/7-australia-s-agricultural-future

This report explores the choices and challenges the agriculture sector faces on the path to sustainable growth in a changing market. It maps opportunities to increase productivity and build new comparative advantages. The report found that:

- Australia’s agricultural sector has a comparative advantage in the export of bulk commodities and increasing opportunities to respond to the growth in demand for high-value products domestically and in Asia.
- Australia’s reputation for ‘safe, clean and green’ food is a major comparative advantage that needs to be sustained and underpinned by internationally recognised standards and certification.
- In order to meet increased demand, the sector will need to efficiently manage its soil and water resources, including the risks associated with climate change and climate variability.
- The sector will need to attract capital and skilled labour in competition with other sectors of the Australian economy.

- Accelerating the uptake of advanced technologies, communications and knowledge systems, and integrated workflows for decision making and planning, are critical for success along the whole value chain.
- Ongoing investment in research and development, both private and public, is vital to underpin this uptake.
- A range of community concerns with regulatory, social and political implications important to the future development of agriculture need to be acknowledged and managed sensitively. These include issues such as food safety, labelling, gene technology in plant and animal breeding, foreign investment and foreign workers, alternative land-use on pastoral leases and farm ownership.

Appendix B – Example of barriers to adoption – ownership and use of 'big data'

Big data, such as that used by decision agriculture, has vast potential for agricultural production but also offers many challenges. The following discussion elaborates on the social and institutional challenges identified by Dr Brian Keating, Executive Director of Agriculture, Food and Health, CSIRO at the 'Soil, Big Data and the Future of Agriculture' conference in June 2015.

- Data confidentiality

Large Australian land holdings can be difficult to de-identify in publicly available mapping products. Businesses may be reluctant to invest in new mapping, data analysis or cloud-based technologies that offer inadequate protection or de-identification of sensitive data.

Global Positioning System (GPS) enabled farm equipment may upload cloud-based data about the location or movement of equipment on farm. Default settings on equipment can be set to alert the manufacturer of the requirement for new parts or servicing based on machine hours. This may add to the cost of production for farmers if parts are automatically despatched.

Where data is collected from GPS-enabled farm equipment, there needs to be a definition and agreement as to ownership of, and rights to, the data and whether it lies with the manufacturer, or the farmer. Consideration could be given to restricting manufacturers to prevent on-selling of producer data without their agreement (for example to fertiliser or herbicide suppliers).

These issues are being resolved as ICT security technologies progress and become integrated into governance, risk management and planning for businesses and government. For example, the American Farm Bureau Federation has worked with growers and technology providers to develop principles about data transparency which now have 37 corporate signatories including Monsanto, John Deere and DuPont Pioneer.

- Data ownership and control

Australia has five-year data exclusivity provisions which provide protection of pre-patent data, for example for the development of new pesticides. This protection can be both an incentive to invest in new innovations, and at the same time can discourage other companies from investing in development of the same types of products, by applying exclusivity to the originator product.

The time periods associated with these provisions have been debated as part of complex trade negotiations, however Australia's five-year exclusivity represents a balance between businesses getting a return on investment in innovation and enabling competition to bring prices down for the rest of the community.

- System complexity and incompatibility

Producer decision-making must account for climatic and environmental unpredictability, as well as complex data and ICT systems. Systems need to combine data from disparate sources that may be in different format, resolution or scale.

For example, Meat and Livestock Australia has established an information integration project to combine diverse datasets such as biosecurity (identification and traceability), genetics (genotypes, breeding), production data (saleyards), processing (Meat Standards Australia grading) and retail (branding, consumer insights).

International resources may not be relevant for Australian conditions and national resources may not be relevant for regional areas. Similarly some systems may not easily transfer across sectors.

Technical problems may include incompatible systems and/or hardware including farm machinery and interfaces, and poor or non-existent linkages from precision agriculture tools and components used in the field through to the supply chain. Due to inadequate ICT connectivity (including on-farm wireless, 3/4G telecommunications, limited mobile phone, National Broadband Network or high speed internet coverage) some producers experience problems using data and apps.

- Human dimensions of farming

Farmers need to synthesise information to make decisions, and the vast amount of data generated by information systems may hamper rather than enhance decision-making.

Decision-making systems can be powerful tools and are being constantly developed and refined. However, analysis is required to transform data into information, and information into decisions. Producers therefore need to apply judgement when making decisions supported by these tools.

Deriving user-friendly insights that support decision-making can be difficult. Analytical tools can only be as good as their supporting data and processes and there will always be unknown, unforeseen factors (such as factors specific to the site, or the season) that can lead to unexpected outcomes.

In developing agricultural data integration systems, companies such as John Deere have identified that to maximise grower adoption, ‘easy to use, integrated documentation systems that deliver clean data’ and ‘comparative, cross-customer benchmarking services to increase actionable insights’ are required.