An Analysis of the Potential of Digital Agriculture for the Australian Economy

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The impact that unconstrained digital agriculture may have on the Australian economy was estimated by modelling potential productivity gains arising from the application of digital technology. The size of the productivity gains modelled were determined using assumptions of the potential of digital agriculture to lead to more efficient and higher value production and sale of Australian agricultural produce. A 25% boost to the value of Australian agriculture ($20.3 billion increase from 2014–15 GVP) was estimated with all sectors benefiting. Areas providing the biggest cross-sectoral gains were labour savings from automation ($7.4 billion), genetic gains through objective data ($2.9 billion), closer tailoring of inputs to needs ($2.3 billion), and enhancements to market access and biosecurity ($1 billion).

Background

Digital technologies have the potential to transform Australian agriculture, leading to a revolution in profitability for farm businesses (Keogh & Henry 2016). An indication of the perceived potential of this revolution is the current upsurge in global investment in agricultural technology (agtech) (AgFunder 2017) which is generating associated hype and excitement. However, investment in agtech is occurring largely in the absence of any analysis of the overall benefit which might be derived from the application of this technology. While there have been assessments of the economic impact of individual technologies or groups of technology within sectors as digital agriculture has evolved, for example *The economics of precision agriculture* (GRDC 2017), there has not been an assessment of the potential impact of digital agriculture in its entirety on the Australian agriculture sector and the national economy.

In 2016, the Australian Government Department of Agriculture and Water Resources funded a Rural R&D for Profit research project called Accelerating Precision Agriculture to Decision Agriculture (P2D). The project, led by the Cotton Research and Development Corporation (CRDC) and involving all 15 Rural Research and Development Corporations (RDCs), was tasked with evaluating the current and desired state of digital agriculture in Australia and making recommendations to ensure Australian farmers overcome the challenges currently limiting digital agriculture and profit from the technologies (Leonard et al. 2017).

As part of the P2D initiative, a project was established which aimed to estimate the impact of unconstrained digital agriculture on the Australian economy. The term 'unconstrained' was used to refer to a situation whereby current limiting factors – such as lack of connectivity and uncertainty surrounding data rights – have been overcome and the full potential of digital technologies is able to be realised by all Australian farmers.

The project team is unaware of any similar efforts to estimate the impact of the application of digital technology across all agricultural sectors including forestry and fisheries. The following paper describes the approach that was taken in this research.

The aim of the P2D project was to suggest a pathway and provide solutions for the implementation of digital agriculture. This presupposes there is a benefit to be derived by stakeholders that justifies uptake, however even when there has been a demonstrated benefit recognised in the past, uptake has not happened as quickly or to the extent that many predicted given the benefits that supporting research suggested (Bramley 2009; McBratney et al. 2005; Williams 2014).

Reports of slow uptake have generally focused on sub-sets of digital agriculture technology or individual agriculture sectors. The P2D project has been unique in the sense that it adopted a whole-of-industry approach to resolving barriers to the implementation of digital agriculture. Thus, estimation of the benefits that might be derived needed to take the same whole-of-industry approach. Estimates of benefit were not designed to provide evidence for assessment of the value of individual pieces of technology but rather to estimate the value to the economy of creating an environment where digital agriculture was able to mature without barriers.

By estimating economy-wide benefits, the value for government, industry and research organisations in investing in infrastructure and other enabling technologies as well as forming appropriate governance and legislation frameworks could be determined; the ultimate aim being the development of an operating environment conducive to the development of digital agriculture for all stakeholders.

Defining Digital and Decision Agriculture

The full title of the P2D project – Accelerating Precision Agriculture to Decision Agriculture – introduces the fact that there are many different terms associated with digital agriculture. It is important therefore to define terms such as ‘decision agriculture’, ‘digital agriculture’ and ‘precision agriculture’, as they have been used in this report. Digital agriculture is a widely used term, however decision agriculture is likely to be a new concept to many. An understanding of why the term decision agriculture was coined for this project is useful as it informs approaches to this project’s methodology and scope, particularly in relation to development of the assumptions on which the economic modelling was based.

The P2D program has defined decision agriculture as a conclusion or action resulting from the application of knowledge and/or information that may be derived from digital agriculture (Leonard et al. 2017). Decision agriculture is enabled by tools and technologies including precision agriculture, the Internet of Things, digital monitoring systems, cloud computing and many other digital technologies and supporting systems.

Decision agriculture is directly enabled by a broad suite of digital technologies and indirectly supported by accumulated knowledge arising from research and development and scientific endeavour.

This definition of decision agriculture was determined in the context of this research as something distinct from digital agriculture as it recognises that the next step from the application of digital technology (and its associated data) is practice change informed by analysis of data acquired. The economic modelling reported here has not estimated the direct benefits of the application of technology but rather was based on assumptions of productivity improvement resulting from practice change induced by the application of digital technology.

The term digital agriculture can cover many forms of technology, from hardware to software to robotics to analytics. The boundaries are constantly shifting, and new technologies are emerging almost on a daily basis. The farm management challenges the technology is applied to, however, change at a much slower pace.

Growing a broadacre crop will always involve preparing the ground, selecting a variety of seed, planting the seed, monitoring and managing the growth of the crop, followed by harvesting, storage and marketing of the resulting grain.

Likewise, animal production will always involve a breeding process, birth of the progeny, then feeding, watering and maintaining the health of the animal, followed by sale and processing. For each of these stages the technology that applies will change, potentially significantly and disruptively, but the purpose that the technology is being used for stays the same (eg growing a successful crop or producing market-ready livestock).

Therefore, to provide a technology-agnostic and forward-looking estimate of the potential of digital agriculture, it is necessary to model assumptions of how much improvement is possible for the purpose that the technology is applied to, rather than adding multiple smaller incremental benefits of applied individual pieces of technology.

Methodology and Model

Benefits to the economy were estimated using the Centre for International Economics – Regions Food Processing model (CIE-Regions FP model), a general equilibrium model of the Australian economy with a focus on agriculture and food processing (Borrell et al. 2014).

The CIE-Regions FP model was developed to quantify the payoffs and distribution of payoffs from research and development (R&D) along the food value chain. It can be used to estimate the impact of productivity improvements which are applied as 'shocks' to the model.

Productivity improvements resulting from decision agriculture can be determined by estimating the cumulative impact of several factors, the first being the increase in productive potential delivered by digital technologies.

There are three critical factors which determine the productive potential of a plant or animal:

- the genetic potential of the plant or animal
- the environmental limitations placed on realising the genetic potential
- the decision making or management that exploits genetic potential within environmental limitations.

While farmers have limited short-term control over the first two, the third involves the application of production management skills and decision making, which is completely under the control of the farmer. The full implementation of decision agriculture would deliver farmers all the data, information and analysis that they need, in a timely fashion, such that all the constraints on productivity that are within the control of the farmer are eliminated. In this case, the productive potential would only be limited by the genetic potential and environmental limitations, over which the farmer has little control.

The availability of estimates of unconstrained productive potential differ between agricultural sectors. The grains sector, for example, is relatively advanced in this area with the

Commonwealth Scientific and Industrial Research Organisation (CSIRO)-led Yield Gap project (CSIRO & GRDC 2016). While other sectors may not be as advanced in being able to quantitatively define the gap between current performance and potential, the rationale supporting the concept is widely understood, and informed opinion is available on potential opportunities for sectoral improvement.

As well as potential increases in production, digital agriculture will enable other productivity improvements such as labour saving and changes in quality leading to higher prices (Keogh & Henry 2016).

The assumptions used in this research about potential productivity improvements that would result in increases in production, improvements in prices and any other factors, were formed based on information arising from a series of interviews with experts identified by each participating RDC. The interviews followed a structured process, first defining best practice and then applying known improvements that would result from the implementation of decision agriculture. The interviews also involved discussion of a series of 'what if?' scenarios relating to access to data, appropriate analytics, unconstrained connectivity, and level of adoption of digital technology.

The productivity shocks that were then applied to the CIE-Regions FP model were determined by grouping suites of similar technologies into production factors or key decision areas. For example, for the grains sector, better nutrient application was identified as a single shock since the contribution that better nutrient application has to the overall yield gap could be estimated and better nutrient application encompasses a suite of digital applications. Likewise, for the beef industry, animal health and monitoring were grouped as a shock since the contribution that increased animal health makes to productivity improvement can be reasonably estimated, and there is a distinct grouping of digital technologies that provide information for this factor.

These productivity shocks applied to the CIE-Regions FP model estimate the size of the opportunity under a best-case scenario. How much of that opportunity is potentially or eventually realised is highly dependent on an array of factors and may differ significantly between sectors. The resulting gross value of production (GVP) increases estimated for each sector are intended to provide an indication of the potential scale of the impact of digital agriculture, and the authors acknowledge that industry structural differences, economic and trade circumstances will determine the ultimate outcome for each industry.

Results

When the productivity assumptions for all sectors (Appendix 1, pages 22 and 23) were applied to the CIE-Regions FP model the estimated potential increase in the value of Australian agriculture was 25%, equating to a $20.3 billion increase in agricultural GVP relative to the 2014–15[1] outcome.

Table 1 summarises the potential benefit of unconstrained decision agriculture (as modelled by productivity improvement assumed to occur as a result of applied digital agriculture) to each sector (GVP) of agriculture and the Australian economy based on gross value of product (GDP).

All farm and post-farm sectors were estimated to benefit from decision agriculture with the cropping sector's potential proportional increase in GVP generally larger than the animal industries, however the benefit to the economy (increase in GDP) arising from the animal industries was estimated to be larger.

The baseline GVP figures used in this model are the 2014–15 official statistics for the sector. Increased commodity prices and production in most agricultural sub-sectors in 2016–17 resulted in a significant increase to the farmgate value of agriculture, up from $54.4 billion[2] to $63.8 billion (ABARES 2017). The total benefit derived from decision agriculture would therefore be anticipated to be larger if this output increase was to be maintained, however the proportional increase should be similar.

1 The baseline GVP figures in the CIE-Regions FP model use 2014–15 ABARES data.

2 The baseline sector value in Table 1 of $60.8 billion is higher than the ABARES figures for 2014–15 of $54.5 billion as it includes some post-farmgate processing activity.

Table 1: The impact of unconstrained decision agriculture to the Australian economy.

Sector	Baseline sector value (GVP)	Potential benefit to the sector		Potential benefit to the economy
	2014–15 ($ m)	GVP[1] Increase ($ m)	GVP Increase (%)	GDP[2] Increase ($ m)
Rice	260	78	30	46
Grains[3]	11,522	5,930	51	1,821
Cotton	1,413	394	28	692
Sugar	1,257	291	23	660
Horticulture[4]	1,018	403	40	951
Beef	10,461	1688	16	4,219
Sheepmeat	2,988	516	17	1,316
Wool	2,550	452	18	1,128
Pork	1,084	55	5	429
Dairy	3,343	497	15	1,298
Eggs	729	180	25	128
Chicken meat	2,084	503	24	371
Wine	5,865	706	12	630
Forest and wood products	14,864	5,511	37	7,484
Livestock exports	1,601	72	4	179
Red meat processing	14,533	2081	14	2,438
Fisheries and aquaculture	2,132	928	44	855
Total	**75,331**	**20,285**	**25**	**24,645**

1 Gross value of production (GVP) measures the actual production output of an establishment or sector.

2 Gross domestic product (GDP) is a summary indicator of economic activity, and measures the sum of the gross value added through the production of goods and services in individual sectors of the economy.

3 Including oilseeds and pulses.

4 Leafy greens, brassicas, and carrots only.

Sectoral breakdown

The relationship between farmers and processors, and the way that decision agriculture will depend on data flowing through digital value chains, is commented on in many other research reports. For the purposes of the economic modelling presented here, as far as possible the shocks applied and the impact estimated has been limited to activities for which decisions are made at a farm level. The data which contributes to those decisions may be sourced from beyond the farmgate, however the estimated benefit arises from an on-farm decision.

Some sectors, however, are structured such that it is much more difficult to separate pre- and post-farmgate benefits from decision agriculture. These sectors have been grouped in the vertically integrated sectors section.

Cropping sector

The cropping sectors were estimated to experience significant proportional increases in GVP, with sugar the lowest (23%) and grains the highest (51%). Cropping enterprises are generally more input intensive and have a high cost of production, so it is to be expected that the multiplier effects of equivalent boosts in on-farm productivity will result in larger impacts on GVP compared to other sectors.

Gains in export focused sectors such as grains, however, were estimated to have a much lower subsequent impact on national GDP. This is because most of the productivity increases in the grains industry would result in greater exports with no additional value-adding or processing. On the other hand, increases in horticulture GVP were estimated to have a much bigger impact on national GDP because most horticultural produce is either consumed domestically or is processed locally, with value added for export.

The grains sector was estimated to achieve a much larger proportional benefit than rice, cotton or sugar due to larger productivity improvement assumptions. For the purposes of this project the commodity groupings have been consistent with the RDC structure. The grains sector therefore consists of many different crops while rice, cotton and sugar have been modelled as single enterprises. One of the main estimated gains to productivity for the grains sector that may be achieved through decision agriculture is the ability of farmers to use data to make decisions about the most profitable cropping sequence to implement.

Improvements in productivity through crop sequencing and planting decisions account for the higher estimated increase in GVP for the grains sector compared to rice and cotton. Once the crop has been planted the GVP benefits for all the cropping sectors was similar.

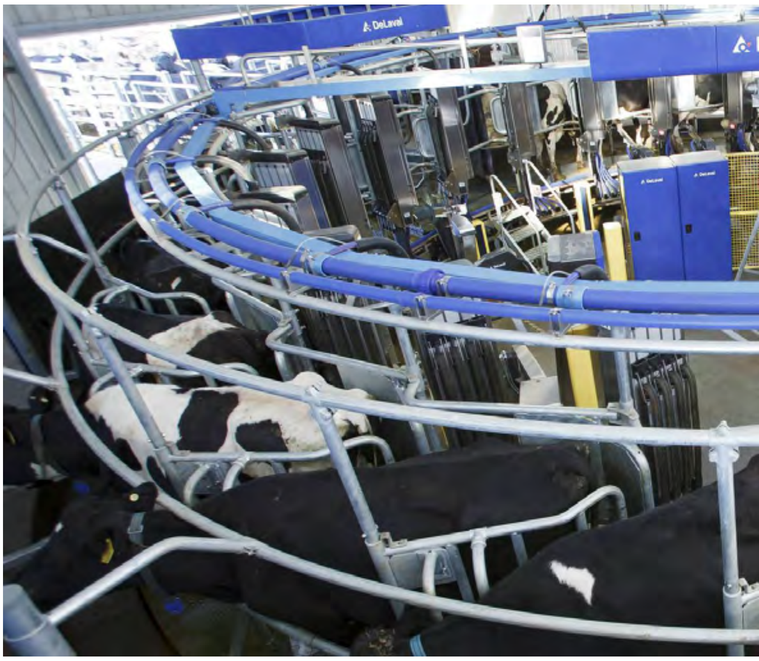
Sugar was estimated to have a slightly lower proportional benefit to GVP due to the lower amount of intervention opportunities available in the sugar cropping system compared to annual crops.

The high proportional increase in GVP estimated for horticulture was partially due to a projected post-harvest impact due to data being used to better inform farmers of product quality resulting in less loss during storage, handling and transport (a significant cost in the horticultural sector).

Animal sectors

A consistent proportional increase in GVP was estimated across all the animal sectors, except for pork. This difference is explained by industry structural considerations rather than a difference in the potential for the on-farm application of decision agriculture.

Increases in productivity for beef, sheepmeat, wool and dairy can all result in increases in product available for export. Pork on the other hand does not have strong export markets so increases in production need to be consumed domestically. This would likely result in lower prices and increased pork industry consolidation, consequently, pork GVP was not projected to increase proportionally in the same way as was the case for the other animal sectors. The potential for decision agriculture in the pork industry can



still be observed in GDP impact however, as the proportional increase (as a percentage of baseline GVP) is similar to the other animal sectors.

It is important to note that an estimated smaller proportional increase in GVP for the animal sectors compared to crops does not mean that there would be less opportunity for decision agriculture in the animal sectors generally. Most of the impact achieved through decision agriculture for the animal sectors was estimated to be achieved through better understanding of genetics and management to achieve productivity gain. In other words, there is a lot of improvement that can be achieved without fundamental changes to input rates or capital requirements.

The estimated overall productivity shock that was projected for the beef sector, for example, was 33% compared to 17% for grains (Appendix 1). Grains, however, was estimated to achieve a GVP increase of 51% compared to 16% for beef. Consequently, while the on-farm opportunity was estimated to be similar or even slightly higher for beef, some of the benefits of on-farm productivity improvement have to be passed to processers to induce more processing because beef needs to be further processed for consumption or exports. By contrast, cropping products can be directly

exported (eg wheat) or consumed (eg vegetables) without further processing, so the benefits of increased productivity for these sectors are mainly captured at farm level.

Because all the animal sectors have significant associated post-farm processing activity, the estimated impact on GDP of increased output was higher. For the dairy sector, the estimated GVP increase is only that which was related directly to on-farm activities and does not include flow through productivity improvements to the milk processing sector, which would be significant.

Vertically integrated sectors

The highly vertically integrated nature of businesses that dominate the egg, chicken meat, wine and forestry sectors makes it difficult to distinguish between impacts associated with pre-farmgate and post-farmgate activities. For example, chicken meat processors own the chickens throughout the production process with chicken growers being paid a grower fee; and in the wine industry, while there are many smaller independent growers, very large wine businesses that grow the grapes and make and market the wine also exist. Therefore, modelling for these industries included the downstream activity of egg and poultry meat processing, wine making, and paper and wood product manufacturing.

The estimated benefits arising from downstream changes were much more significant than pre-farmgate changes for all these sectors; the primary reasons for this varied for each sector.

The poultry sector structure involves chicken farmers as contracted growers achieving relatively fixed margins, meaning that the chicken owners (the processing companies) are estimated to realise most of the productivity improvements achievable as a result of decision agriculture.

In the wine industry, the biggest gains from decision agriculture were associated with improved forecasting of wine quantity and quality resulting in more efficient wine-making processes and better control of costs associated with required consumables.

The forestry industry has a unique set of circumstances related to the timelines associated with growing timber. There are very few intervention possibilities during the growing stage due to the length of time required for trees to mature, however there are estimated to be large efficiency gains available in the processing stage when wood is converted to timber.

Live export, red meat processing and fisheries

While there is certainly scope for the use of decision agriculture technology in the live export industry, the small amount of activities that make up the industry mean that there is limited ability to make fundamental and significant improvements resulting in a boost to the economy. The live export industry is fundamentally a logistics business with the added requirement of maintaining high animal welfare standards. Estimated improvements for the live export industry arising from decision agriculture were limited to improvements in transport efficiency and animal health and welfare.

Red meat processing

The red meat processing sector is estimated to benefit from decision agriculture in multiple ways. Direct efficiency gains through process automation are relatively straightforward, however additional gains will be made by using the same carcase data that is captured as part of the automation process for other activities such as improving marketing (eg connecting eating quality and provenance information).

Fisheries and aquaculture

The fisheries and aquaculture industry was estimated to potentially achieve one of the highest proportional increases in GVP modelled. Almost all of this increase was estimated to arise from the productivity boost that would be achieved from catching allowable quota in less time with reduced cost. While this seemed like a relatively simple shock to model, the practical barriers to achieving this are considerable.

Common Themes for Productivity and Profitability Improvement from Decision Agriculture

There were several common cross-industry themes that emerged while gathering information to build the assumptions for the model.

Optimising input use through variable rate technologies and practices

The application of variable rate technology (VRT) to increase productivity is an opportunity common to most agricultural sectors. Requiring a combination of both spatial and temporal data from a range of different data sources, VRTs are management tools aimed at reducing the variability of production through space and time. For example, in-field variability can be managed by providing a mechanism through which the application of inputs (eg fertiliser, seed, water) can be altered based on calculations using a combination of data sources.

VRT is well advanced in some of the broadacre cropping sectors, such as cotton and grains, however the modelling suggests the scope for significant further improvement is large. In the livestock sectors, there is strong interest in applying the principles of variable rate management to individual animal and pasture management.

While VRT can extend beyond nutrient application to pesticides, fungicides and other inputs, improving nutrient use (in grains and livestock sectors) is still the most common application of this technology. Table 2 displays the size of the opportunity that the modelling has estimated would be achieved across sectors through decision agriculture for better crop and pasture nutrition.

Increased process automation and labour savings

Labour is one of the most significant costs for most agricultural enterprises. There is a clear value proposition for farmers to adopt technologies which increase labour efficiency. The impact of digital technologies on labour efficiency is likely to be the greatest in sectors that have routine tasks with a high degree of predictability and which need to be performed with a high degree of accuracy.

Process automation, where sensors replace subjective human assessment of such things as animal health, will result in both labour efficiency increases and more accurate measurement leading to increased productivity.

An important part of the value proposition for adopting labour saving technologies will be improved workplace health and safety. For

Table 2: Cross-sectoral boost to GVP from better crop and pasture nutrition.

Sector	Practice	GVP $ million	Productivity improvement modelled (%)	Increase in GVP (%)
Rice	Crop nutrition	11.8	1.62	4.57
Grains	Crop nutrition	1000.1	2.85	8.68
Cotton	Crop nutrition	99.3	11.66	7.03
Sugar	Crop nutrition	97.6	17.72	7.76
Horticulture	Crop nutrition	103.1	14.73	10.13
Beef	Feed, landscape and water management	610.8	11.99	5.84
Sheepmeat	Feed, landscape and water management	163.3	12	5.47
Wool	Feed, landscape and water management	118.9	10	4.66
Wine	Irrigation and nutrient application	76.8	10	1.31
Total		**2282**		

Table 3: Cross-sectoral boost to GVP from process automation and labour saving.

Sector	Practice	GVP $ million	Productivity improvement modelled (%)	Increase in GVP (%)
Rice	Irrigation scheduling and application	38.9	5.32	15
Rice	Labour saving	17.8	2.44	6.86
Grains	Labour saving	878.0	2.5	7.62
Cotton	Irrigation scheduling and application	144.8	17	10.25
Cotton	Labour saving	33.1	3.88	2.34
Sugar	Labour saving	23.1	4.2	1.84
Horticulture	Labour saving	76.3	10.9	7.5
Beef	Labour saving	161.3	3.17	1.54
Sheepmeat	Labour saving	39.9	2.93	1.33
Pork	Feed systems	8.5	5.44	0.78
Pork	Labour saving	2.8	1.8	0.26
Wool	Labour saving	35.5	2.99	1.39
Dairy	Labour saving	102.8	6.64	3.08
Egg	Shed monitoring	20.7	1.63	0.24
Egg	Labour saving	24.9	1.96	0.29
Chicken meat	Shed monitoring	58.9	1.63	0.23
Chicken meat	Labour saving	69.5	1.95	0.28
Wine	Labour saving	20.3	2.65	0.35
Forestry	Labour saving	126.6	5.15	0.85
Forestry	Processing logs for timber	4102.8	30	27.6
Forestry	Labour saving	962.9	7.04	6.48
Red meat processing	Labour saving	400.4	2.86	2.76
Fisheries and aquaculture	Labour saving	101.5	4.3	4.76
Total		**7363**		

example, in the red meat processing sector the combination of objective carcase measurement and robotics could increase the accuracy of cutting while reducing product wastage and improving workplace health and safety.

One of the most common areas of labour saving will arise from the use of digital technologies for regulatory and compliance requirements. Meeting market and regulatory requirements is a major cost for many farmers. In some sectors, such as the livestock export industry, the regulatory burden has increased substantially in recent years. A common concern expressed by farmers in a range of sectors is that there is unnecessary duplication in compliance schemes and an over-reliance on traditional paper-based reporting. Digital systems provide more efficient ways of meeting information and compliance requirements, through automated data collection and reporting which can reduce costs and 'make life easier for farmers'.

Table 3 (previous page) provides estimates of the size of the gains that may be achieved through process automation and labour savings in different sectors.

Accelerating genetic gains using objective data

In recent decades, there have been major improvements achieved in plant and animal genetics using genetic benchmarking and genomics tools. Data analytics has the potential to accelerate these gains by integrating this information with performance data from other sources such as insights that link genetic, production and processing data. For example, there are potentially significant opportunities to increase the productivity of the livestock industries through integrating genetic and genomic data, with lifetime productivity information (eg weight gain, health status), and objective carcase feedback.

Even without further genetic gain, decision agriculture provides the capability through the assessment of objective data to select the most appropriate existing genetics or even make fundamental changes to cropping sequences or animal breeds for increased productivity and profitability.

Table 4 provides estimates of the gains that may be achieved through better breeding, genetic selection and rotation decisions as a result of the application of decision agriculture.

Improving market access through improved traceability and product assurance

Throughout the consultation phase of this project, decision agriculture was universally acknowledged as being important for the development of traceability and provenance platforms. Digital traceability and provenance systems are becoming increasingly important in maintaining and developing new high-value markets, and providing confidence for end users (and consumers) in relation to product safety and quality.

'Push' and 'pull' factors influence how traceability and product quality assurance systems are used in different agricultural value chains. Push factors include regulatory compliance issues such as industry-wide food safety programs which are regulated by government. Pull factors include certification programs which offer market premiums for products that meet certain specifications. In some cases, push and pull factors may occur simultaneously, and in all cases data plays a critical role in validating provenance claims.

While the economic impact of traceability and provenance platforms was not modelled, the consensus from every sector was that it would be one of the most valuable benefits realised from decision agriculture.

Strengthening biosecurity systems

Biosecurity is a significant challenge for Australia's agricultural sectors. Biosecurity monitoring platforms are critical for preventing the spread of pests and disease, and therefore the maintenance of markets and market access.

Digital biosecurity platforms (manual and automated) provide the potential to act as

Table 4: Cross-sectoral boost to GVP from better breeding, genetic and rotation decisions.

Sector	Practice	GVP $ million	Productivity improvement modelled (%)	Increase in GVP (%)
Grains	Crop rotation	1756.0	5	15.24
Sugar	Crop rotation	55.1	10	4.38
Beef	Breeding decisions	661.7	12.99	6.33
Sheepmeat	Breeding decisions	176.9	13	5.92
Wool	Breeding decisions	118.9	10	4.66
Dairy	Breeding decisions	154.8	10	4.63
Total		**2923**		

Table 5: Cross-sectoral boost to GVP from biosecurity management platforms.

Sector	Practice	GVP $ million	Productivity improvement modelled (%)	Increase in GVP (%)
Rice	Fallow weed control	7.5	1.03	2.9
Rice	In crop weed and pest control	2.0	0.28	0.79
Grains	Crop protection and weed control	91.0	0.26	0.79
Cotton	Crop protection and weed control	13.4	1.57	0.95
Sugar	Crop protection and weed control	9.5	1.74	0.76
Horticulture	In crop weed and pest control	4.2	0.6	0.41
Beef	Animal health and disease monitoring	254.7	5	2.43
Sheepmeat	Animal health and disease monitoring	136.1	10	4.55
Pork	Animal health monitoring	7.8	5	0.72
Wool	Animal health and disease monitoring	118.9	10	4.66
Dairy	Animal health monitoring	77.4	5	2.31
Egg	Animal health monitoring	38.1	3	0.45
Chicken meat	Animal health monitoring	106.8	3	0.44
Forestry	Disease and pest control	122.6	5	0.82
Livestock export	Animal health monitoring	28.1	2	1.75
Total		**1018**		

integrated management systems to mitigate the threat of biosecurity breaches. Due to the complexity associated with measuring the economic impact of biosecurity incursions, the potential economic benefit was not modelled for the research reported here. However, as with traceability and provenance systems, the consensus from every sector was that the platforms developed to enable decision agriculture would enable better biosecurity monitoring. While not resulting in an immediate economic benefit, the potential to stop an economic catastrophe in a sector or multiple sectors was perceived to be significant.

An immediate economic benefit was estimated to be realised from the improved management resulting from the data collected as part of broader biosecurity efforts. For example, the animal health data that is required to monitor for disease outbreaks is just as useful for measuring the performance and efficiency of animals for productivity and profitability gain. Likewise, in cropping sectors, monitoring for pest and disease is required for managing the crop's productive potential, but it is also the same information that can be used to track incursions of exotic pests and disease.

Table 5 (previous page) provides estimates of the benefits that may be achieved through management platforms that also form part of broader biosecurity efforts.

Discussion

The economic modelling that has been performed in this project has projected that significant benefits are available to the Australian economy and agricultural sectors due to productivity improvements made possible by decision agriculture. Implicit in the assumptions underpinning this modelling is that analysis of data acquired by digital agriculture will enable better decision making and changed practice, leading to more efficient and higher value agricultural production.

There are many barriers to overcome before digital agriculture can be implemented to the point where the productivity gains modelled here are able to be fully realised. Other papers arising from the P2D project describe some of these barriers and suggest measures that would alleviate them.

The size of the opportunity which would be provided by unconstrained digital agriculture, as indicated by the modelling reported here, suggests that implementation measures to ensure its rapid adoption should be pursued vigorously.

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About the Author

Richard Heath has been General Manager of Research for the Australian Farm Institute since February 2016, responsible for coordinating the Institute's research into a broad range of agricultural policy issues. He is a Director of the Grains Research and Development Corporation and has also been a Director of Nuffield Australia Farming Scholars.

Prior to AFI, he was Associate Professor of Agronomy and Farm Management for the University of Sydney, responsible for managing their North West Farms group. Richard served for six years on the Northern Panel of the GRDC, and owned a consulting business advising on the application of new technology in Australian agriculture.

Richard grew up on a family farm on the Liverpool Plains and was responsible for the cropping operations of the family business for 20 years following university.

In 2002, he travelled on a Nuffield Scholarship researching the precision application of fertiliser.

Appendix 1: Table of productivity shocks used to inform CIE-Regions FP model.

Sector	Practice	Productivity improvement modelled (%)
Rice	Fallow weed control	1.03
	Irrigation scheduling and application	5.32
	Crop nutrition	1.62
	In-crop weed and pest control	0.28
	Labour saving	2.44
		10.69
Grains	Fallow preparation	0.98
	Crop rotation	5.00
	Planting	3.28
	Crop nutrition	2.85
	Crop protection and Weed control	0.26
	Labour saving	2.50
	Yield forecasting	2.00
		16.86
Cotton	Crop nutrition	11.66
	Crop protection and weed control	1.57
	Operational efficiencies	0.85
	Irrigation scheduling and application	17.00
	Labour savings	3.88
	Optimising quality	10.29
	Marketing	0.24
	Reduction in supply chain cost	0.81
		46.30
Sugar	Fallow preparation	0.69
	Crop rotation	10.00
	Planting	13.45
	Crop nutrition	17.72
	Crop protection and weed control	1.74
	Labour saving	4.20
	Harvest and processing scheduling	5.00
		52.79

Sector	Practice	Productivity improvement modelled (%)
Horticulture	Paddock preparation	0.60
	Planting	10.00
	Labour saving	10.90
	Crop nutrition	14.73
	In-crop pest and weed control	0.60
	Storing vegetables	20.00
	Regulatory compliance	0.73
		57.55
Beef	Breeding decisions	12.99
	Feed, landscape and water management	11.99
	Animal health and disease monitoring	5.00
	Labour saving	3.17
		33.15
Sheepmeat	Breeding decisions	13.00
	Feed, landscape and water management	12.00
	Animal health and disease monitoring	10.00
	Labour saving	2.93
		37.93
Pork	Animal health monitoring	5.00
	Feed systems	5.44
	Automation	1.80
	Processing efficiencies	3.00
	Feed conversion improvement	20.00
		35.25
Wool	Breeding decisions	10.00
	Feed, landscape and water management	10.00
	Animal health and disease monitoring	10.00
	Labour saving	2.99
	Generic product marketing	5.00
		37.99

Sector	Practice	Productivity improvement modelled (%)
Dairy	Breeding decisions	10.00
	Pasture management	10.00
	Automation	6.64
	Animal health monitoring	5.00
	Regulatory compliance	0.44
		32.09
Egg	Animal health monitoring	3.00
	Nutrition management	3.15
	Shed monitoring	1.58
	Labour saving	1.90
	Product marketing	5.00
		14.62
Chicken meat	Animal health monitoring	3.00
	Nutrition management	3.14
	Shed monitoring	1.58
	Labour saving	1.90
	Product marketing	5.00
		14.61
Wine	Planting	10.00
	Pruning	10.00
	Irrigation and nutrient application	10.00
	Labour saving	2.65
	Grape harvest	10.00
	Consumables management	3.30
	Harvesting and winemaking logistics	0.86
		46.81

Sector	Practice	Productivity improvement modelled (%)
Forestry	Site selection	4.00
	Disease and pest control	5.00
	Pruning and thinning	4.00
	Labour saving	5.15
	Processing logs for timber	30.00
	Labour saving	7.04
		55.19
Livestock export	Transport and logistics	1.11
	Animal health monitoring	2.00
	Regulatory compliance	2.00
		5.11
Red meat processing	Livestock sourcing and assessment	2.00
	Labour saving	2.86
	Carcase utilisation	3.00
	Marketing	5.00
	Regulatory compliance	2.00
		14.86
Fisheries and aquaculture	Catching fish allowed under quota	30.00
	Operating boats at sea	5.00
	Labour saving	4.30
		39.30