Digital Agriculture

Farming in the Digital Age

A report for

By Andrew Slade

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Executive Summary

In what is currently considered the digital age, agriculture remains the least digitised major industry and is yet to realise the opportunities increasing digitisation has to offer. The precedent is being set by the information communication technology, media and finance sectors that are fundamentally more suited to digitisation and seeing increased productivity growth beyond those industries yet to undergo the transition. Agriculture is justifiably a difficult industry to digitise however with a growing global population there is a fundamental need to increase food production whilst being mindful of the associated environmental impacts. As investment in agriculture increases and technology advances, the potential is for agriculture to enjoy a renewed resurgence in productivity growth enabled by the adoption of digital technologies.

Globally, investment in Agri-food tech is increasing, with California accounting for nearly half of global investment in this emerging sector. Despite this, much of the productivity gains resulting from the application of new Agtech in broadacre systems are largely restricted to cost reductions through better allocation of inputs. Furthermore, much of what is currently available is focused on single use case solutions and fails to meet the growing requirement of producers to integrate into existing farming production systems or generate genuine business insight.

It was made clear during several meetings that there isn't the return on investment needed to generate the widespread adoption of new technologies and in many cases the solutions that are offered haven't been developed with the farmers needs as a primary focus. Globally, farms are lacking the necessary connectivity infrastructure and digital literacy needed to implement digital solutions effectively and the situation in Australian agriculture is no different.

The potential for digital agriculture lies both in on farm productivity gains and increased returns beyond the farm gate. Decision agriculture is the step beyond precision agriculture and recognises the application of digital agriculture, resulting in an action or practice change informed by the analysis of data and information collected via digital means (Heath, 2018). The potential is to be more reactive to situations that arise, maximising the impact correct decision making has on overall business performance by removing the constraints on

productivity that are within the control of the farmer (Heath, 2018). However, perhaps the greatest potential of digital agriculture is in the marketing opportunities that may exist in linking production data and farming practices direct to the consumer and leveraging a premium as a result. This approach requires the rebuilding of trust, between consumers and producers of food, and the industry as whole will need to become increasingly transparent and responsive to consumer trends if it is to take advantage this.

Despite much of the hype surrounding Agtech there is still a way to go before agriculture can capture the real potential of digital agriculture. Producers need to consider each solution based on its merit and suitability to their farming operations and how it fits within the growing suite of digital technologies employed on farm. Farmers need to better evaluate how data is collected and organised to ensure it can be used effectively to inform business decisions and take advantage of potential marketing opportunities. Grower-owned data cooperatives should be given further consideration as a means of achieving this whilst ensuring data is used and distributed in a way that is beneficial to farmers.

Moving forward, farmers will need to develop a better understanding of digital technology in order to implement and use it effectively. There is a growing need for consultants specialising in identifying digital technology that provide measurable on farm benefits and who can assist in the implementation and integration of Agtech into increasingly complex farming systems.

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Foreword

I've always been passionate about farming and growing up it was a normal to be working on the farm with my parents when not at school. Our farming operation has grown considerably since that time, primarily off the back of prime lamb and beef production, during a period where these were considered the poor cousins to broadacre cropping. Much of this was due to our focus on productivity, with an emphasis on efficient system design and engineering solutions that reduced our labour inputs. However, over the past decade our farm and many others in our region have transitioned to broadacre cropping as rainfall has declined and cropping systems have advanced, leading to improved profit margins over and above what has been achievable from our livestock enterprises. In part this is due to a higher rate of technology advancement and adoption within the cropping sector and this ultimately led me to question where the profitability gains will come from for broadacre livestock systems and whether we will see 'autosteer' for sheep and cattle.

This was initially the objective when I started my Nuffield journey, looking for specific Agtech solutions that would enable the automation of livestock systems. As I began my initial travels through Eastern Australia and became more immersed in the Agtech sector, I quickly came to the realisation that there were larger issues relating to all sectors of agriculture that would need to be solved before "livestock automation" could become a reality. There is an underlying feeling among many producers that much of the Agtech that is currently available fails to offer a clear ROI or meet the requirements of producers. There has also been a distinct lack of thought around how digital solutions and Agtech fit into existing agricultural systems and become part of the broader management ecosystem.

Ultimately this became the focus for my travels and research, specifically understanding why the adoption of digital agriculture is critical to the future of our industry, what the underlying issues are with what is currently offered and how these can be overcome. My hope is that this report offers some insight to producers and industry alike around how to best move agriculture forward into an increasingly digitised future and maximise the potential benefits this may bring.

Acknowledgments

The Nuffield journey has been one of the most rewarding and challenging experiences of my professional career. Since submitting my application back in 2017, to the completion of this report, there is little doubting the positive impact the Nuffield Scholarship has had for both my personal and professional development, for which I am extremely grateful.

I would like to thank my investors, CSBP and Integro Private Wealth, for their support of my scholarship and belief in the positive impact the Nuffield organisation has on Australian agriculture. I would also like to thank Nuffield Australia for giving me the opportunity and for their support and understanding throughout journey.

To my Africa Global Focus Program group, thank you for the unforgettable memories. The close friendships formed on our trip remain the most valuable outcome of my scholarship and I look forward to these friendships continuing into the future.

None of this would have been possible without the support of my parents David and Lyn and everyone else involved within the farming business. To my brother in-law Scott and the rest of the team, I am extremely appreciative of your hard work and commitment on the farm, ensuring the business ran smoothly during my travels.

Abbreviations

ABARES: Australian Bureau of Agricultural and Resource Economics

AFI: Australian Farm Institute

AI: Artificial Intelligence

API: Application programming interface

DSE: Dry Sheep Equivalent

EU: European Union

FAO: Food and Agriculture Organisation

GDP: Gross Domestic Product

GFP: Global Focus Program

GiSC: Growers information Services Cooperative

GMO: Genetically Modified Organism

GPS: Global Positioning System

GVP: Gross Value Productivity

ICT: Information and Communication Technology

IoF2020: Internet of Farming and Food 2020

IoT: Internet of Things

IP: Intellectual Property

LoRaWAN: Long Range Wide Area Network

LPWAN: Low Power Wide Area Network

LTE: Long Term Evolution

MGI: McKinsey Global Institute

NFF: National Farmers Federation

ROI: Return on Investment

UK: United Kingdom

USA: United States of America

VC: Venture Capital

Objectives

The purpose of this report is to look at the current state of digital developments within agriculture and come to an understanding of the role it will play in the future of Australian agriculture.

The key considerations are as follows:

- Understanding the current role digital solutions play in agriculture.
- Recognising the current limitations of digital Agtech.
- Identifying potential opportunities and consequences for the industry.
- Recommendations for industry moving forward.

Chapter 1: Introduction

Agriculture has seen two major advancements in productivity over the last century with the mechanisation of agriculture and the green revolution through the 50s and 60s (Pingali, 2012). The green revolution is credited with preventing the starvation of up to a billion people worldwide and laying the foundations for global food security in the period since. However, with the Food and Agriculture Organisation (FAO) predicting the global population to reach 9.6 billion by 2050, food production must similarly increase whilst at the same time reducing inputs and emissions to comply with society expectations around food production. The case for improving global food production is clear and there is growing consensus that digital technologies will play a major role in increasing food production to accommodate further population growth.

Since 1977, Australian agriculture has enjoyed steady incremental productivity gains, averaging 3.3% through to 2000/01, however this has slowed in the period to 2015/16 averaging 1% across all broadacre sectors (Boult, et al, 2018). Perhaps more concerning is that farm productivity growth has remained stagnant in the period from 2010-2016 with the most recent data showing total factor productivity is in decline (Figure 1.). Much if this can be attributed to poor seasonal conditions but it does highlight concerns around the ability of current agricultural systems to manage climate variability.

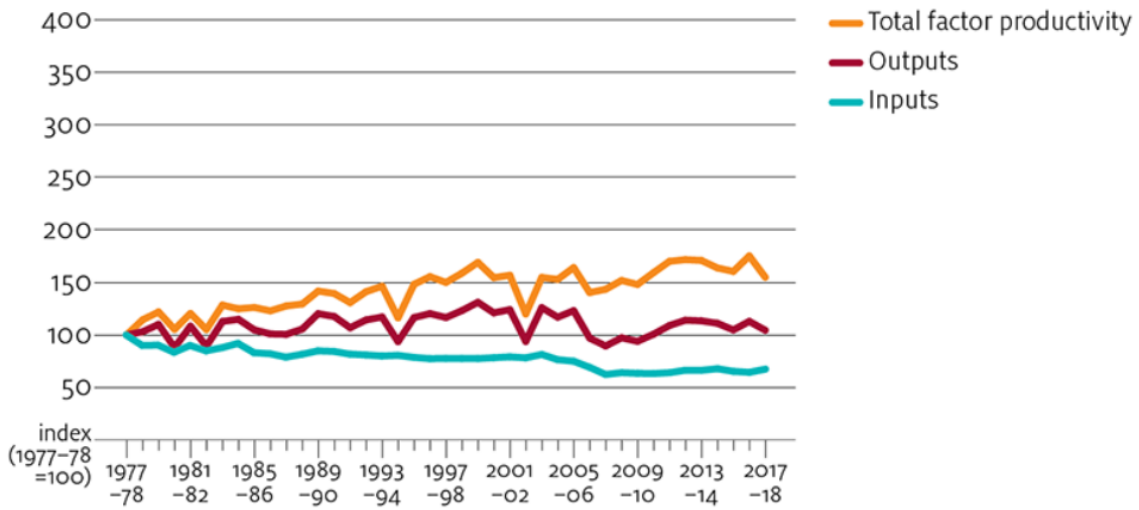

Figure 1. *Total factor productivity, output and input, all broadacre industries Australia, 1977-78 to 2017-18 (Source: ABARES)*

Despite these recent productivity trends, total agricultural productivity is expected to grow at 1.5% in the short term to 2024 with the National Farmers Federation (NFF) setting its sights on the sector being worth $100 billion by the year 2030, an increase of 67% from 2016/17 levels (NFF, 2018). The primary driver of this growth is expected to come from the digitisation of agriculture with a recent report by the Australian Farm Institute (AFI) indicating unconstrained digital agriculture could inject up to $20b into the agricultural sector (Heath, 2018).

The potential of digital technology to transform agriculture was made clear during a meeting with Michael Horsch, founder of Horsch Machinery, where he commented "Agriculture is in a state of major change" (Horsch, 2018). At the 2018 AFI conference it was proposed that digital agriculture is the new post-industrial revolution that agriculture needs (McBratney, 2018). The current business model for broadacre farmers to maintain profit margins is to be the lowest cost producer of increasingly globalised commodities (McBratney, 2018). The concern for Australian producers with this approach going forward was emphasised during a meeting in Ukraine where it was evident that Australia's major competitors are rapidly improving productivity by implementing modern and cutting-edge technology on a large scale whilst operating in a business environment that has lower cost of wages and regulatory restrictions (Huizinga, 2018). These regions still face challenges, including political instability and corruption, however it highlights the need to move away from producing a commodity and towards a differentiated value-added product. The focus on producing commodities at the lowest cost is also a risk to sustainable practices globally unless there is a new mechanism that allows consumer-dictated market forces to reward producers for sustainable farming practices.

Rationalisation of farmland is a global trend with Australian broadacre farms steadily increasing since the 1980's to average over 10,000 dry sheep equivalents (dse) per business during which the number of farming entities in Australia has fallen below 50,000 (Figure 2). This has generated the scale needed to maximise the efficient implementation of new technologies and led to productivity gains across broadacre sectors. However, the fundamental problem with this approach was highlighted during a meeting with Bryan Hocken (2018), a well-respected livestock farmer from New Zealand. Bryans experience allows him to operate his farm and the natural resources available to him as efficiently as possible whereas the next generation coming into the business may not possess the same set of skills and

intricate knowledge to achieve the same level of productivity without the aid of technology. This is particularly true as farm size gets bigger and area under management increases and was emphasised by United Kingdom (UK) Nuffield Scholar Robert Allen (2018), who commented that the intrinsic knowledge of the land and the ability to maximise the production potential from every acre of farmland is reduced as farms get bigger.

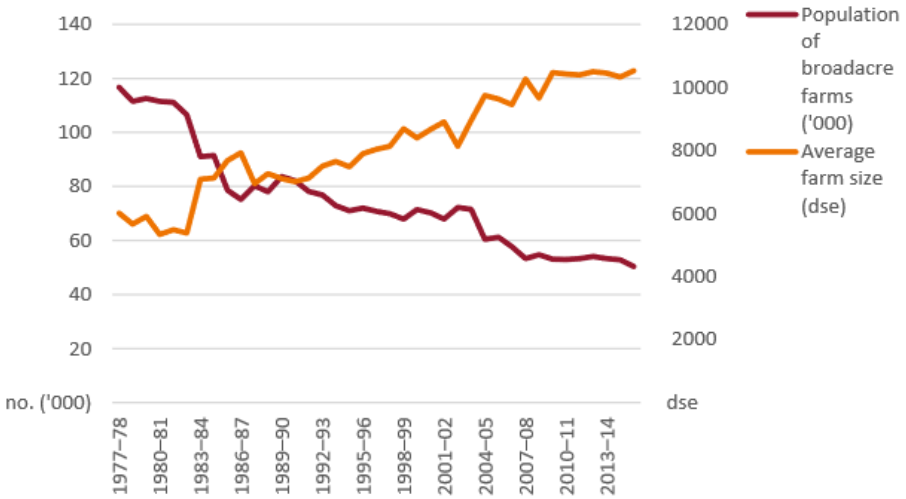

Figure 2: *Farm population and average farm size, all broadacre industries, Australia, 1977-78 to 2015-16 (Source: ABARES).*

It is increasingly clear that digital technologies are playing a larger role in everyday life and will open new possibilities to those who are willing to embrace it. Expectations around how food is produced are shifting with European-based supermarket chains driving change in production systems by setting their own standards around chemical residue limits and what is deemed acceptable in production practices (Horsch, 2018). This is particularly evident in the developed world where society is demanding food produced with reduced environmental impact and improved animal welfare outcomes (Berckmans, 2017). This demand is reflected in the level of investment agriculture is beginning to attract. In 2018, venture capital (VC) invested in Agrifood tech reached US$16.9b globally with much of this investment aimed at disrupting existing agricultural production systems and supply chains (Agfunder, 2018). Technology hubs such as Silicon Valley in California have a fundamental drive to disrupt existing systems and agriculture needs to be ready to embrace these when they occur (Lavender et al, 2018). Agriculture is not immune to disruption and there is a real threat to current agricultural systems being surpassed by newer systems enabled by disruptive technologies. However, despite this level of investment it is still unclear to the average farmer

how digital ag fits into existing production systems, how to take advantage of potential marketing opportunities or what these benefits even are. What is clear however is that Agtech and the digitisation of agriculture is not a fad and the way food is produced in 2050 will be vastly different to current production systems (Nolet, 2018).

Chapter 2. Current State of Digital Agriculture

This chapter deals with the 'now' of digital agriculture and seeks to understand the current Agtech landscape and how it is applied to agriculture in general.

2.1 Industry Digitisation

Digital agriculture can be loosely defined as the use of new and advanced technologies, hardware, software and robotics, integrated into the existing farming value chain to improve food production (Heath, 2018). Due to the rate of development in the Agtech sector, the boundaries that encompass digital agriculture are constantly shifting and it is an ever-evolving definition. The head of digital innovations at John Deere stated that the development of the industry is at a similar point to the early computer operating systems in the 80s where the market is saturated with new entrants vying for a piece of the Agtech pie (Arthur, 2019). Currently, agriculture is the world's least digitised industry with terms such as 'digital agriculture', 'smart farming', 'big data' and 'decision agriculture' being relatively new concepts to the industry (Nolet, 2018).

The Information and Communication Technology (ICT), media and financial services industries are leading the way when it comes to industry digitisation and are seeing higher productivity growth rates, relative to less digitised industries, as a result (Manyika et al, 2015). This is indicative of the growing positive relationship that is emerging between overall digitisation and productivity growth. Agriculture was classified by the McKinsey Global Institute (MGI) digitisation index as the least digitised of the major industries and when compared with advanced manufacturing and oil and gas, that have relatively high levels of industry digitisation, agriculture had significantly lower productivity growth between 2005 and 2014 (Manyika et al, 2015).

Initially the digital innovation in the leading industries focused on expanding business through advances in enterprise software for managing operations (Manyika et al, 2015), which is comparable to where the agriculture sector is currently poised. Today these industries are using big data analytics to generate insight to inform better business decision making (Manyika et al, 2015). The divide between those 'using' digital technology and those 'using it more' is increasing at a rapid rate with most sectors only using a fraction of the capabilities

associated with technology. The sectors that are not utilising the full potential of digital technologies are drifting further behind the digital leaders that are transforming their core processes using digital tools (Manyika et al, 2015). Agriculture is only scratching the surface of what is possible and is lagging other industries with regards to digitisation and is subsequently not enjoying the productivity gains expected.

2.2 Concepts to consider

Before moving on to how digital agriculture is currently applied there are a few concepts that should be introduced. These are the hype cycle, the law of accelerating returns and the diffusion of innovations. These are important concepts to consider as they help explain why Agtech is struggling to gain traction despite expectations and why it is important to adopt technology when it becomes commercially viable.

2.2.1 The hype cycle

The hype cycle is an important consideration for industry and businesses as it differentiates between the hype surrounding new technology and the reality of the commercial promise.

The five key phases are as follows:

1 **Innovation Trigger**: Technology breakthrough. Usually no usable products and unproven commercially viability.

2 **Peak of inflated expectations**: Publicity highlights several success stories building momentum for the technology.

3 **Trough of disillusionment**: Experimentation and implementation fail meet expectations and interest in the technology declines.

4 **Slope of Enlightenment**: Benefits of the technology begin to be better understood and the commercialisation of the technology begins to accelerate.

5 **Plateau of Productivity**: Mainstream adoption increases as the commercial viability becomes more defined.

Figure 3 is an illustration of this theory and demonstrates where emerging technologies fit into the cycle and the likely timeframe over which the plateau of productivity will be reached. Importantly much if what is relevant to agricultural, particularly blockchain, Internet of Things (IoT) platforms, autonomous small robots and general artificial intelligence require more development before reaching the plateau of productivity. Despite the level of hype generated

within the industry around some of these emerging technologies, it is important to recognise that most are still a way off in providing real productivity gains.

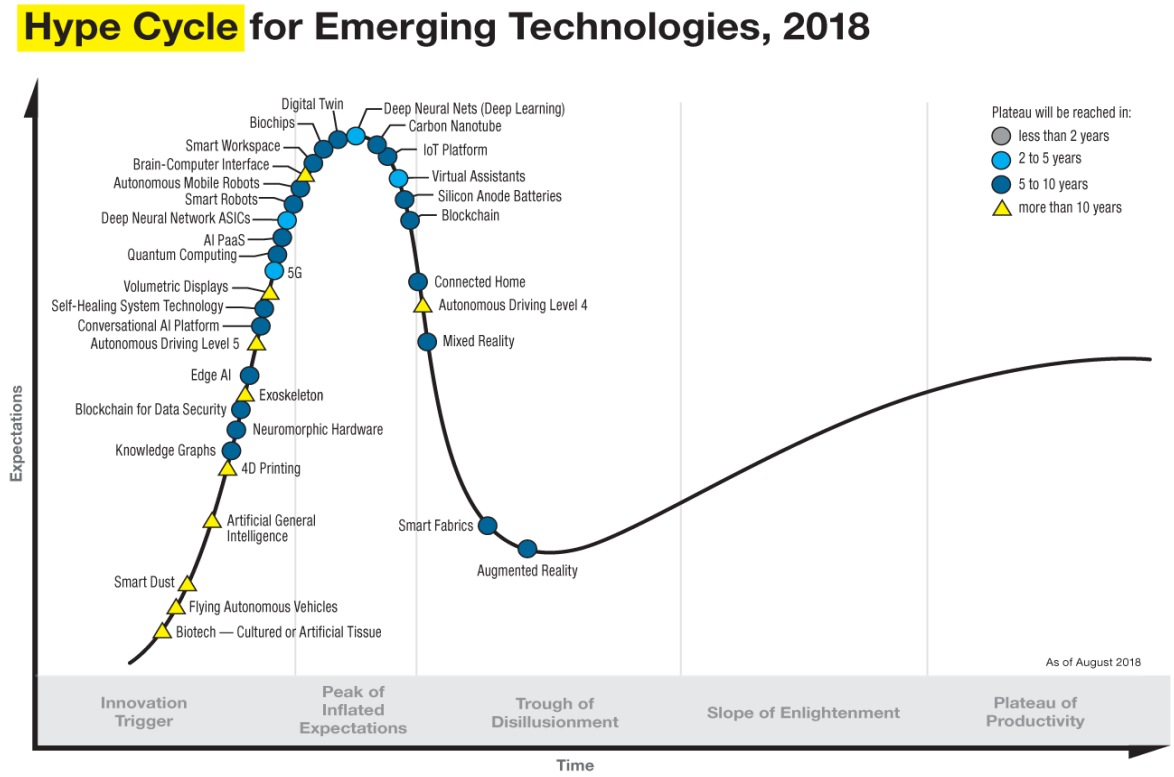

Figure 3: *Hype Cycle for emerging technologies, 2018. (Source: Gartner)*

2.2.2 Law of accelerating returns

This theory as applied to technology indicates the rate of technology development is exponential. Current computing technology is capable of a similar number of calculations per second to that of the human brain and is likely to exceed that of the earths combined population by the year 2050 (Figure 4). The rate of technology progress doubles every decade and as such the progress made in the 21st century is likely to be the same as that which had been made in the previous 200 centuries. In the context of this report this theory is significant as it highlights the importance of embracing new technology into agriculture. Farmers need to be willing to adopt and grow with technology when it becomes viable. As adoption is delayed it becomes increasingly difficult to comprehend new technology and the competitive advantage of those who are early adopters will increasingly grow as the rate and capabilities of technology increases.

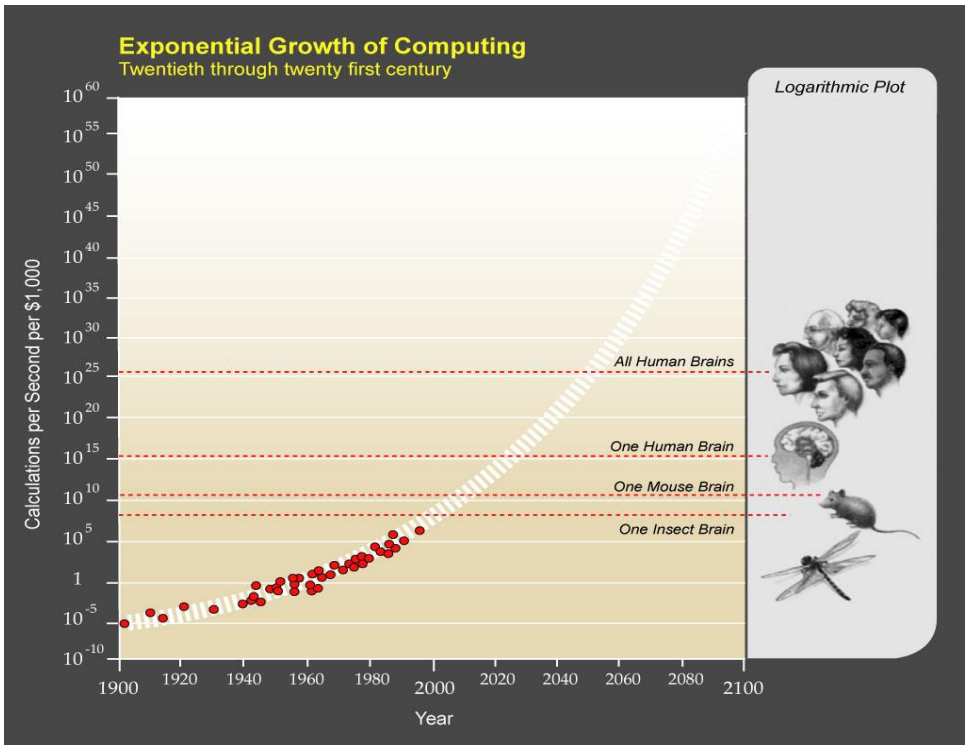

Figure 4: *Exponential growth of computing from the twentieth to the twenty first century (Source: Kurzweil, 2001)*

2.2.3 Diffusion of innovations

This concept shows how innovations are diffused through a population over time and is broken into five main categories (Figure 5).

1. **Innovators** – Risk takers, introduce new innovations into the system
2. **Early Adopters** – Comfortable adopting new innovations and are considered the stamp of approval for an innovation triggering critical mass uptake
3. **Early Majority** – Rely on evidence before adopting, rely on feedback from early adopters
4. **Late Majority** – Sceptical about new technology and will usually adopt as a result of peer pressure or economic necessity
5. **Laggards** – Typically conservative, resistant to change and bound by tradition

There are five main characteristics of innovations that determine how positively an innovation will be responded to by a potential farmer/end-user:

1. **Relative Advantage** – The degree to which an innovation is seen as better than the idea, program, or product it replaces.

2. **Compatibility** – How consistent the innovation is with the values, experiences, and needs of the potential adopters.
3. **Complexity** – How difficult the innovation is to understand and/or use.
4. **Trial ability** – The extent to which the innovation can be tested or experimented with before a commitment to adopt is made.
5. **Observability** – The extent to which the innovation provides tangible results.

The reason for introducing this concept is to address why Agtech is failing to gain the traction expected. To be successful the proposed innovation must comply with each of these characteristics and fundamentally much of what is available does not nor does it offer a return on investment (ROI) over and above current production practices. Additionally, to reach the early majority, and thereby enable the commercial success of new innovations, there needs to be more collaboration with early adopters. This segment provides the stamp of approval for innovations and ultimately determines its success or failure. It is important to also identify those in the industry who have the capability to effectively trial and implement innovations and give them the greatest chance of success.

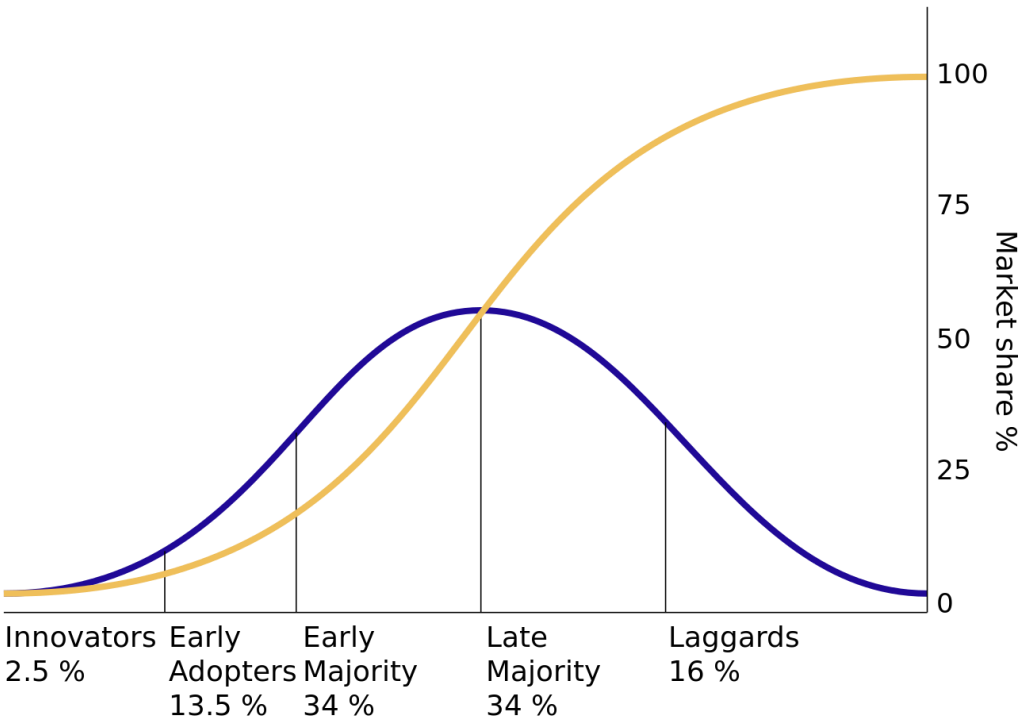

Figure 5: *Diffusion of innovations (Source: Wikipedia, 2019)*

2.3 Current Application in Agriculture

As explored earlier, widely adopted digital innovations in other industries have progressed, past the point of enterprise management software, and towards providing genuine business insight. The same cannot be said for agriculture where the current state of digital agriculture can best be described as a range of bespoke solutions working independently of other solutions (Fitch, 2018). Much of the Agtech that is currently available offers solutions to better target and reduce overall inputs but very few offer solutions that increase overall production (Allen, 2018). This is backed by data from Australian Bureau of Agricultural and Resource Economics (ABARES) that shows across all broadacre industries inputs reduced significantly from 2000 through to 2009 and are currently still below 2003 levels. In this period total factor productivity has grown on average by 1% largely as a result of the reduction in overall inputs (Figure 1). Cropping sectors have made the largest contribution to overall gains in productivity, likely the result of the development in cropping technologies and reallocation of inputs towards more efficient cropping production. However, the most recent trends indicate that the rate of productivity growth between broadacre livestock sectors and broadacre cropping is narrowing (Boult et al, 2018).

The productivity trends are at odds with the hype that surrounds Agtech and the much-promised benefits it will bring. The rise of digital management programs is one such example of this and were described during one interview as glorified record keeping programs that currently offer no real business insight or financial benefit (Allen, 2018). The lack of financial benefit associated with Agtech was further explained during a meeting with Michael Horsch (2018), founder of Horsch Machinery. Michael has significant farming operations in Germany and Czech Republic and is a member of an elite invite only cropping benchmarking group. Fundamental to this group is a full disclosure policy where members have full access to how other members operate. His insight from being involved with this group was that even though best practices are shared between members there is still a large variation in business performance principally as a result of a stronger focus on business and operational fundamentals by the better performing businesses. Critically this variation in business performance is unrelated to the adoption of new technology with the better performing farms typically not adopting and using the latest digital technologies. For those farms that do, there is an over reliance that technology will improve business performance (Horsch, 2018).

The lack of ROI associated with the on-farm application of Agtech was observed on other highly productive farms during this study, with a visit to David Christensen's farm in Oxford, UK, reinforcing the views of Michael Horsch. David's dairy farm is self-described as being low tech bordering on no tech and yet is widely recognised as among the most productive and profitable dairy businesses in the UK. It is clear the current offering of digital technology does not yet provide the ROI needed to stimulate widespread adoption and only serves in addressing specific production related issues, replacing existing forms of technology or grower intuition, without providing tangible gains in business performance.

2.4 Growing Investment in the Agtech Industry

Agtech is a relatively new sector in the broader agricultural landscape and has seen significant growth in venture financing, from relative obscurity in 2010 to US$1.8b in 2017 (Figure 6). Much of this investment is focused on technology and innovations that will help provide greater scale, sustainability and predictability in a sector that is inherently unpredictable (Lavender et al, 2018). The current wave of investment includes but is not limited to IoT devices, blockchain, automation, swarm farm robotics and data analytics (Lavender et al, 2018).

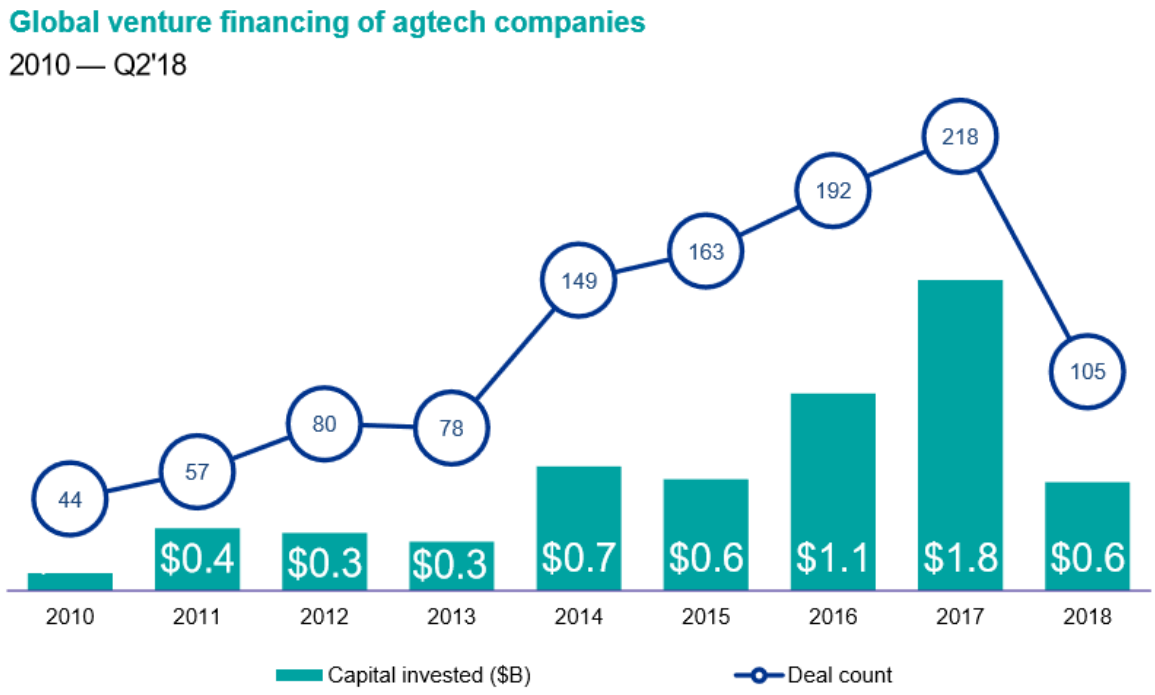

Figure 6: *Global venture financing of Agtech companies. (Source: Venture Pulse, KPMG).*

In comparison Agrifood technology, which is inclusive of Agtech but also includes technologies relating to consumer facing components of the agricultural supply chain, has seen significantly greater levels of investment totalling US$16.9b in 2018 (Agfunder, 2018). Importantly the current investment trends indicate a maturing of this sector with interest and investment coming from the likes of Google, Amazon and Microsoft who have been at the forefront in applying and taking advantage of the benefits digitisation has brought to their respective industries. Examples include investment by Microsoft into the Farmbeats program and the creation of partnerships with Agtech providers using their Microsoft Azure platform.

The USA, China, Brazil and India currently have the most mature and highest levels of investment in Agri-food, largely by necessity due to growing domestic populations. Israel, Australia, New Zealand and The Netherlands are also seeing significant growth in their respective Agtech sectors however investment is focused more around single use case solutions (Nolet, 2018). USA VC invested in Agtech accounted for 47% of global capital deployed (Pitchbook, 2017) with the majority coming from Silicon Valley. The average investment deal in the USA is also significantly greater than other regions with a greater focus on disruptive technologies that will have a bigger impact on food supply chains (Lavender et al, 2018).

Existing agrichemical and machinery manufacturers are also playing a major role in the evolution of the Agtech sector. The degree of collaboration and consolidation has been covered in previous Nuffield reports (Dyer, 2016) but given the level of interest and investment there have been some major developments since. Dyer, 2016 highlighted the acquisition of Climate Corp, a provider of digital solutions, whose services covered some 92m acres as of 2016, by Monsanto in 2013 for US$930m. In 2016, Bayer acquired Monsanto in a US$66b deal and in turn has achieved what is a one-stop-shop for seeds, chemicals and production software for farmers. This follows a trend of consolidation with agrichemical manufacturer Dow Dupont, the parent company of Pioneer Seeds, purchasing Granular, a farm management program developed in the USA, further aligning chemicals, seeds and digital software solutions and expanding the pool from which data can be collected.

2.5 Drivers of investment within the Agrifood tech sector

The motivation for investing in digital agriculture varies dependent on whether the investment source is an existing agricultural company looking at consolidation, VC towards a start-up/new

entrant or from non ag related tech companies based in Silicon Valley. As mentioned above, large agrichemical companies like Bayer, Dow Dupont and John Deere are investing significantly in aligning digital services into their respective core business. As has been demonstrated by the ICT, media and finance sectors, data collection and analysis has provided significant insight and growth within their respective industries. The major agrichemical companies are no different, with millions of acres under management in their respective digital platforms, they can analyse on farm production data to enhance the pace of product development. Understanding how various farm inputs are used and being able to predict usage also provides significant logistical advantages resulting in shorter supply chains and more targeted distribution strategies.

Among growers there is a feeling that the larger agrichemical companies will use this data to manipulate supply in a way that is disadvantageous to farmers. Whilst being a possibility, this type of manipulation against farmers would lead to a breakdown of trust between suppliers and producers and could result in reduced market share for the offending company. Providing there is competition between the agrichemical companies, and they remain unaligned with the food supply chain and supermarkets, this flow of production data is beneficial to growers. Ultimately, it is in the interest of these companies to increase food production hand in hand with the grower and not at their expense.

Start-ups and new entrants have a very different approach and reason for existing. UK Nuffield Scholar Robert Allen (2018) explained that “simply put, a start-ups primary goal is to be bought out by a larger company”. These entrants typically offer single-use targeted technology and nine out of every ten of these start-ups will ultimately fail (Fitch, 2018). In order to find the right solutions and push the boundaries of what is possible there needs to be failure and there appears to be no shortage of capital available seeking to achieve this. The VC sources that provide the funding for these start-ups aren’t so much motivated by small scale consolidation of Agtech companies but rather broader disruption of existing production practices. Disruption creates opportunities to influence what and where food is grown and the goal is to not only improve the efficiency of food production but to tap into the growing trends of transparency, traceability and sustainability (Lavender et al, 2018). The influence and objectives of Silicon Valley sourced VC should not be underestimated with US$5b of VC in Agrifood tech originating in Silicon Valley from a global investment pool of US$16.8b. As explained in a meeting with Michael Horsch (2018), Silicon Valley has a culture that is

inherently disruptive and will increasingly influence the way food is produced and the future direction of global agriculture.

2.6 Investment by Region

Government investment in digital agriculture is also increasing around the globe as a way of ensuring sufficient food supply for growing domestic populations and facilitating continued growth of agricultural sectors more generally. The Australian Government, through accelerator programs, government grants and research initiatives, accounted for 44% of investment in Australian Agtech and 88% of Agtech investment instances in 2017 which represents a greater proportion of total investment compared to other regions (Nolet, 2018). However, despite this level of government investment in Australia, it does little to make up the shortfall in private sector investment. Overall investment in Agtech is significantly lower in Australia, trailing other regions despite agriculture playing a greater role as a portion of total gross domestic product GDP (Table 1).

Table 1: *Agtech investment by region for 2017 (Source: USSC, 2018)*

	Total Agtech Investment	**Agtech Investment per Capita**	**Agricultural Contribution to GDP**
Australia	$27M	$1.08	2.43%
United States	$1.87B	$5.8	1.01%
Canada	$153M	$4.22	1.43%
Israel	$52M	$6.05	1.17%

The immediate impacts of government investment are less obvious when looking for a lift in productivity as it is typically directed at pre-seed and seed opportunities where technology is in the early development phase and not commercially applicable. In contrast VC investment is typically larger and directed at later stage investment rounds where Agtech is being commercialised and scaled, thus having a greater impact on productivity. In 2017 there was no investment in later stage Agtech in the Australian Agtech sector compared to the trend globally where approximately 25% of investment is targeted at later stage opportunities (Nolet, 2018). The disparity in investment in Agtech per GDP and the source of investment is

a cause for concern for the Australian agricultural sector and more needs to be done to facilitate private sector investment.

Government investment in the European Union (EU) and UK has a particular focus on innovation hubs aimed at developing the Agrifood sector. IoF2020 is a collaborative project led by Wageningen University involving over 100 private and public sector entities from 20 EU countries. This initiative was funded by the EU's horizon 2020 innovation and research program and has an overall operating budget of €34million. The focus of this project is to accelerate the adoption and development of Agrifood tech and strengthen the competitiveness and security of farming and food chains in Europe. Likewise, the UK has also invested significantly in Agrifood tech with an investment of £90m in four Agri-tech innovation centres aimed at providing the private sector with a mechanism that fosters and accelerates the commercialisation of Agrifood tech innovations. These are the Agri-epi centre, Centre for Innovation Excellence in Livestock, Crop Health and Protection and Agrimetrics. This targeting of government investment is a model that should be looked at more closely in Australia to give new innovations the greatest chance of reaching commercialisation.

Chapter 3. Limitations and Issues with Agtech

With so much technology available why is it that agriculture remains one of the least digitised industries? Growers are often accused of not adopting technology, however, if a clear ROI can be demonstrated, farmers are usually quick to adopt. This chapter will investigate the current limitations and issues with Agtech, from both the farmer perspective and that of technology providers and explore why the uptake of digital technologies has been limited.

3.1 On-farm application

Existing farming systems can operate very profitably without needing to invest heavily in new Agtech however this is likely to change moving forwards as the level of interest in Agrifood tech increases and the sector matures to point where a clear ROI can be demonstrated. A sentiment shared during many of the interviews completed for this project was that the current offering of Agtech is not necessarily making farming more profitable but in the right cases it is making it easier (Klinefleter, 2019). One of the more successful technologies in recent times is Global Positioning System (GPS) and autosteering applications that has a clear ROI off the back of reduced inputs, improved accuracy and targeting of inputs. As a generalisation though, the complex nature and inherent unpredictability of agriculture makes it a difficult industry to digitise when compared to industries such as manufacturing, where processes are repetitive within a controlled environment.

The Agtech solutions that are currently offered to farmers can broadly be described as single case solutions designed to address a specific problem. Farmers have been slow to adopt these solutions mainly because many of the products aren't fit for purpose (Cooke, 2018). The failure to deliver on the hype and publicity of new Agtech has resulted on technology fatigue and farmer disengagement and moving forward may inhibit the widespread adoption of digital technology in agriculture (Fitch, 2019). Agtech is currently driven and ultimately constrained by the engineering and development largely at the expense of on farm usability (Cooke, 2018) with not enough providers asking whether their product is useful and fits a genuine need (Fitch, 2018). This disconnect between developers and on farm application not only reduces usability of Agtech but also fails to recognise the need to build into existing farming systems and integrate existing knowledge and skills.

Lack of data standardisation and integration is a significant issue facing Agtech. There is potential to generate a lot of data through the implementation of Agtech, but farmers are still lacking actionable information and business insight. Without integration between providers and data standardisation this insight isn't possible as the data is not in a format where meaningful analytics are able to be applied. Lack of integration extends to business and financial data by in-large remaining separate from production data. This link is needed to prove a solution can generate a ROI worthy of the investment and create the insight needed to make better business decisions. There is also a certain level of farmer fatigue associated with implementing multiple digital systems on farm whereby each system is independent of the other requiring the farmer to operate and maintain multiple systems. Moving forward the lack of common standards applicable to agricultural data needs to change. The agricultural industry would benefit from the development of reference architecture for software development and a standardised data vocabulary to not only improve the outcomes from what is currently available but to aid in the development of better Agtech solutions in the future.

3.2 Technology Providers

There is a large culture gap between Agtech start-ups and farmers, with many start-ups in the current Agtech scene offering a technology solution looking for a problem. As a result of this large disconnect agricultural software providers have done a poor job in understanding and showing what is important and demonstrating value to farmers (Arthur, 2019). Figure 7 shows a snapshot of the Agtech industry as of 2018 and highlights not only the growth in the sector but also the fundamental flaws. With so many offerings, the marketplace is over saturated and as a grower it is difficult to discern which provider can provide a solution beneficial to the business. This also creates the problem for farmers in picking a provider that will not end up being one of the nine in ten start-ups that fail. Doug Fitch, founder of Agworld, highlighted the fact that tech companies tend to fail as they struggle to build enough momentum to get through the early adoption phase (Fitch, 2019). The lack of investment in later stage tech development highlighted earlier in this report is indicative of this and prevents many Agtech start-ups from becoming commercially viable.

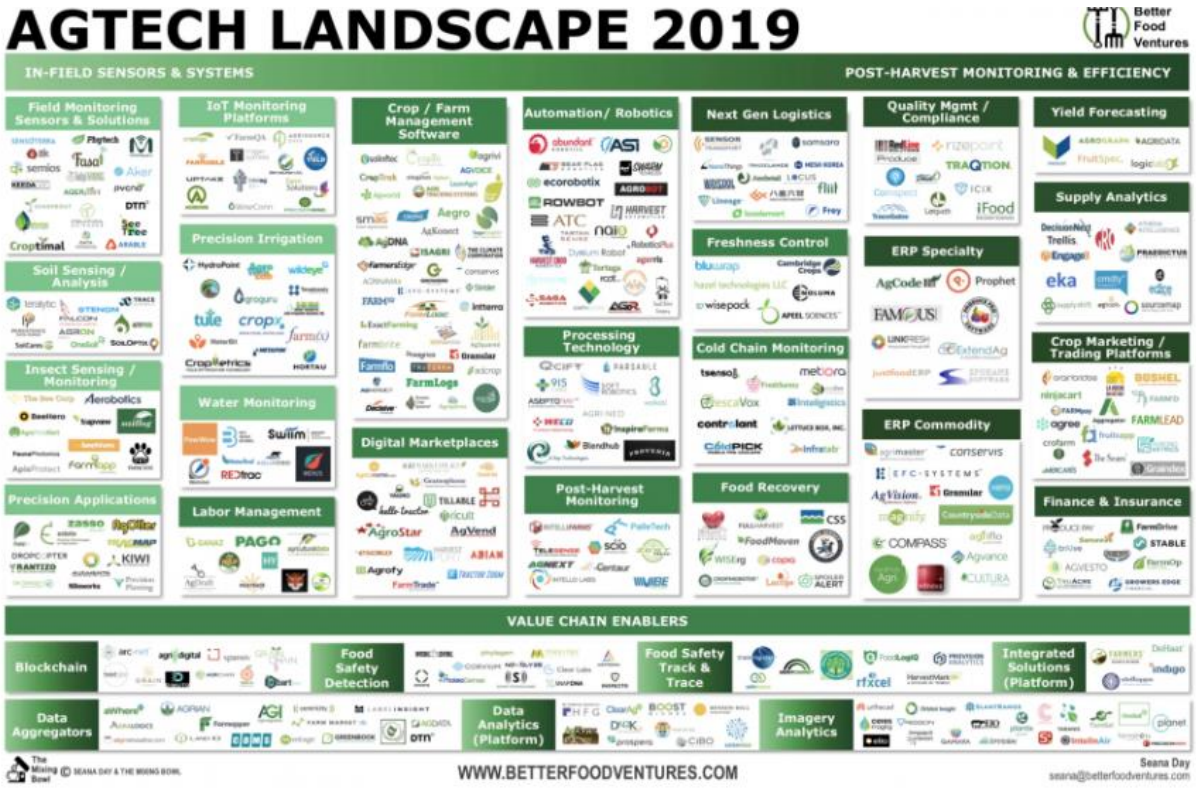

Figure 7: *Agtech landscape 2019, (Source: Mixing Bowl Hub 2019)*

Customer support and backup is also an issue many providers struggle with as invariably technology fails and farmers have neither the time nor expertise needed to troubleshoot. Access to farmers for product development has also been an issue for Agtech providers however there are now avenues through grower groups that may help facilitate this vital process. Currently solutions are targeted with limited ability to be customised to different needs. The unique nature of agriculture requires flexible solutions able to cater to varying geographies and applications whilst being robust enough to withstand the rough nature of agriculture. As one Agtech provider commented, “upon initial development we aimed to develop the product to military specification however on farm trialling demonstrated this to be severely inadequate” (Anon, 2018).

Domestically, Australian agriculture is lacking the ability to trial technology alongside other providers and integrate into an inclusive digital ecosystem. Developers that do not provide opportunity for multiple integrations with other software or hardware and present data in a standardised manner will ultimately fail (Cooke, 2018) and is an issue that needs to be better addressed by industry. Another issue with Agtech and industry funded research is the overprotection of Intellectual Property (IP) (Prior, 2018). Industry needs collaboration to create solutions to fully take advantage of digital agriculture and the protection of IP prevents

this collaboration from occurring and the further development of technology to the benefit of the agricultural industry.

3.3 Data and trust

One of the major constraints facing agriculture is trust around data ownership and an unwillingness to share data (Allen Stevens, 2018). Much of this mistrust is understandable as growers grapple with the prospect that companies with the ability to aggregate and analyse data could potentially use this data to manipulate markets at the expense of the producer. In the wake of revelations about poor data stewardship practices by Facebook this concern is not completely unfounded however if the agricultural industry cannot move past these concerns the potential for digital agriculture is severely limited. The common misconception by farmers is that the data they collect is valuable and shouldn't be shared unless someone is willing to pay for it. To a certain extent this thought has merit particularly with regards to sharing data beyond the farm gate with supermarkets and food distributors for marketing purposes. On the production side of the equation, data aggregation and the development of decision tools and genuine business insight has huge potential and without access to data these tools cannot be developed.

The lack of access to data is also an impediment to new digital businesses and innovations entering the market (Heath, 2018). Production data is predominantly held by farmers and a selection of larger management platforms with millions of hectares under management. If the industry is serious about realising the potential of digital agriculture these data sets need to be combined and made accessible for the right purposes. Structures that facilitate this are beginning to gain traction in other regions. Examples include Grower's Information Services coop (GiSC), The Ag Data Coalition and Farmers Business Network in the US and some larger agricultural cooperatives and holders of agricultural data in Europe agreeing to a code of conduct around the sharing and access to data whilst promoting the benefits of sharing data (Moller and Sonnen, 2018). The 2016 Nuffield Australia report by Jonathan Dyer delves in this topic more deeply and is a fantastic resource for those interested. What is clear however is that the Australian agricultural industry is lagging with respects to how and what agricultural data can be used for and is an area that should be addressed as a matter of priority.

Much is also made of historical data and the potential to incorporate large historical public and farm-based data sets. This is the approach currently being undertaken by Agrimetrics in

the UK. However, the existing problem is that a lack of standardisation, high levels of data cleaning and organising into common datasets makes this an extremely difficult process. Particularly, the use of farm data is problematic as the accuracy of historical data is questionable and potentially of little value. As one UK farmer explained "there is a lot being made of crunching historical big data however the majority of data collected to date is worthless" (Price, 2018). The question that should be asked is how much the industry can rely on the insight this data is going to generate when the collection methods have been questionable.

Moving forward the industry needs to ensure the collection of data is done in a way that ensures the accuracy and validity of the insights that are going to be generated. Furthermore, protocols should be developed and adhered to so that future data is standardised and can be compiled in a structured way.

The common standard now widely accepted to help facilitate this is the **FAIR** principle:

- **F**indable: Assigning the data an identifier and having rich metadata to describe the data and ensuring it findable through search portals.
- **A**ccessible: Data should be openly accessible using standardised protocols. If this is not desirable or preferred due to privacy or confidentially, these reasons should be made transparent
- **I**nteroperable: Data should use commonly agreed formats and languages and vocabularies.
- **R**eusable: Data should maintain its original richness and not be diminished for the purposes of explaining findings. Provenance information about how the data was formed should remain with the data and appropriate licensing to ensure data can be reused.

This standard should be a central consideration for data collection moving forward in order to promote the sharing and re-use of data for the purpose of maximising knowledge development and innovation.

3.4 Education and Support Networks

Another factor limiting the potential of digital agriculture is the level of digital illiteracy and absence of an advisory network focusing on the implementation and integration of Agtech within a farm business. Farmers by necessity have a diverse range of skillsets ranging from

business management, machinery operation, engineering, mechanics, animal husbandry, agronomy and an endless list of other skills needed to operate modern farming enterprises. Much of these skills are learnt on the job, passed down from older generations, or developed through institutional training.

As the world is becoming increasingly digitised, farmers must also develop new digital skills in order to integrate new technology into existing farming systems effectively. The rate of technology development makes this increasingly difficult with education and training in this area already distinctly inadequate. University courses and training programs must adapt to these requirements and equip farmers with greater digital literacy and provide courses specifically designed for a new type of digital farm advisor. These courses must also cater to the growing need for agricultural data scientists specialling in agriculture, rather than the current model whereby innovative farmers with some digital literacy try their hand at generating insight or perhaps even less suitable, data scientists from other industries attracted into agriculture without any agricultural expertise. Farmers have the necessary implicit knowledge to ensure the insights generated are correct but rarely the skills to effectively extract the full value of the data. Inversely data scientists have the necessary skills to effectively analyse and extract insight but not the fundamental knowledge of agriculture to ensure the usefulness and validity of these insights.

Just as farmers are increasingly using external advisors for agronomy, grain marketing and business management a new type of advisor is needed specific to digital agriculture and its implementation. The sheer volume of new Agtech that is available makes it difficult to discern which solution is beneficial and fits a genuine need and general digital illiteracy makes it difficult to wade through the hype generated through publicity. An Agtech advisor would ideally understand the capabilities and limitations of new technology and whether the implementation will genuinely improve business performance. This type of advisor would also fill the void that exists around implementing and integrating new technology into the growing ecosystem of on farm Agtech and provide ongoing maintenance and support. For this to occur farmers need to understand the potential value of digital solutions and demonstrate a willingness to adopt and implement digital Agtech so that sufficient demand is generated for these types of services.

3.5 Infrastructure

Perhaps the biggest limitation preventing the widespread adoption of digital agriculture is a lack of on farm connectivity. This has been well covered in previous Nuffield reports (Graham, 2016) however it is worth highlighting the reasons why connectivity is crucial to industry digitisation. There are a range of options now available using low power wide area networks (LPWAN), such as LoRaWAN and Sigfox, whereby IoT devices can be implemented and low volume binary data packets transmitted at relatively low cost. This type of network is useful up to a point in enabling the rollout of devices with low power requirements over large distances. However, it is limited in its ability to transmit real time data and enable the automation of processes based on the analysis of data. In order to facilitate this type of functionality, real time data transmission and analysis through Artificial Intelligence (AI) is needed which requires faster data speeds only capable using Long Term Evolution (LTE) networks. For the current range of Agtech and applications LPWAN is adequate and will continue to play a role, however the technology of the future is going to have increased data requirements in both size and form and if farmers are to fully take advantage of this LTE networks will be a necessity.

Chapter 4. Opportunities

If the agriculture industry is going to fully capitalise on the potential of digital agriculture, it is important to understand where the opportunities lie and what the unintended consequences may be. This chapter will explore the potential of digital agriculture at the farm level, beyond the farm gate and the industry collectively.

4.1 On Farm Production

The current suite of digital agriculture solutions focuses primarily on monitoring, observations and the recording of information within farm management programs. This approach is providing small incremental gains in productivity but little in the way of a significant ROI. These small gains can in themselves can lead to more significant gains as explained by Danny Klinefelter during an interview at Texas A&M. The 5% rule implies that a 5% increase in production, 5% reduction in costs and 5% increase in price received can result in a more than 100% increase in net return as the effect is cumulative, multiplicative and compounding (Klinefelter, 2018). Simplistically this is demonstrated in Table 2 whereby the increase in net profit is 119%. As initial margins become tighter this effect is more pronounced and can lead to significant gains in farm profitability. For this reason, the financial impact of different Agtech solutions should not be overlooked, providing in themselves they offer a return worthy of the investment. Given they offer a minimum viable product, technology providers and the farmers who employ technology should focus on small incremental gains rather than waiting for the finished product (Prior, 2018).

Table 2. *The 5% rule as explained by Danny Klinefelter Texas A&M.*

	Initial	**Increase**	**Outcome**
Yield t/ha	3.8	5%	3.99
Price $	270	5%	283.5
Revenue	1026	10.25%	1131.165
Costs	$900	-5%	$855.00
Profit/Loss	$126	**119%**	$276.17

Management programs used for crop planning and recording currently amount to little more than glorified notebooks (Allen, 2018) and an effective way for large agrichemical companies to harvest production data and further the development of agricultural inputs (Gingerich, 2019). While this can be seen as beneficial to agriculture more generally, they provide little apparent ROI to growers and agriculture must move beyond the collection of data and look towards generating genuine insight. As one interviewee put it "the trend globally is data with platforms being the current fad" (Heath, 2018). Decision Agriculture is the term that best describes this next step as it recognises the application of digital agriculture resulting in an action or practice change informed by the analysis of data and information collected via digital means (Heath, 2018). The potential of this application is to be more reactive to situations that arise, maximising the impact correct decision making has on overall business performance by removing the constraints on productivity that are within the control of the farmer (Heath, 2018). In this scenario, production would only be constrained by the environmental limitations and the genetic potential of what is being grown (Heath, 2018).

The full impact of decision agriculture was modelled in an AFI report with the potential for overall productivity to increase by 25% relative to 2014/15 output (Heath, 2018). For broadacre agriculture it is likely that the grains industry has the most to gain with Gross Value Productivity (GVP) modelled to increase by 50% compared 17% for both beef and sheep meat. However, the overall stimulating productivity effect is much greater for red meat, 33%, than grains, 17%, as there is a higher level of domestic value adding and associated flow on affects throughout the supply chain. Improved management through advances in genetics, nutrition and rotations were modelled to have the greatest productivity impact. Despite the common perception that automation will be the saviour of agriculture, the relative productivity gains were modest in comparison ranging between 2.5-3.2% for grains, beef and sheep meat to 30% in forestry. Importantly these gains don't consider the economic impact that traceability and provenance may provide, and this has the potential to be the most valuable outcome from the digitisation of agriculture.

4.2 Marketing

The greatest potential that digitisation of agriculture offers, lies in the ability to combine digital assets and capabilities to create new products and business models (Mckinsey, 2015). The view of many of the interviewees was that there is an increasing appetite among consumers for food provenance and more specifically linking production data with the food that is

consumed and that the real value in digital agriculture is linking direct to the consumer (Horsch, 2018). Consumers are becoming more informed about the food they are eating and will demand transparency in the food chain. Commodity markets are based on the premise that the primary crops are indistinguishable from each other and the potential to distinguish between production practices may be facilitated through the application of blockchain type technology. The market is already seeing this distinction with food marketed as non-GMO and a range of other marketing ploys unfounded in science, with consumers willing to pay more for the perceived benefits perpetuated by marketing.

With climate change an ever-increasing concern amongst consumers, the potential is for blockchain technology to provide a mechanism for consumers to pay a premium to growers who produce food in an environmentally sustainable way. Much of the responsibility for reducing the carbon footprint of farmers globally is enforced through regulation and other push factors such as the restriction of fertiliser applications, herd sizes and other regulatory actions being undertaken in parts of the EU. Ultimately the consumer may also play a part in reducing global emissions from agriculture. This is possible if demand exists for food that is produced in an environmentally sustainable way that effectively creates the pull necessary to incentivise a change in production practices.

The multitude of quality assurance programs associated with food production imposed either by industry or further through the supply chain is currently playing a role in this space however in reality these usually amount to little more than box checking exercises for farmers with little to no accountability. As we are currently seeing with the rise of animal activism and opposition to gene technology in crops, there is growing distrust around food production. Agriculture has become a victim of its own success as the productivity gains of past 50 years have seen the worlds food production left to an increasingly smaller portion of the world's population and consumers becoming more disconnected from the realities of food production. This trend must be reversed, and digitisation of agriculture provides the best means to tell the story of agriculture to consumers (Lamb, 2018). It is vital that the potential to add value is owned and controlled by farmers and the value isn't solely captured by the distributors of food. This is already occurring in some regions with supermarkets stipulating that farm production data and practices are shared as a condition of supply. This may ultimately lead to a situation where supermarkets are attracting a premium for food without necessarily rewarding the farmer in turn.

Supply chain disruption is also a possible outcome of digital technology with the potential to find efficiencies in logistics and food distribution. These gains are more likely to be passed on to consumers in the form of cheaper food as opposed to higher farmgate prices unless there is significant disruption in the supply chain. A typical food supply chain involves farmers, processers, distributers, wholesalers, retailers and consumers. A view taken by one interviewee was that producers, processers and retailers are fundamentally irreplaceable whereas wholesalers and distributers may be considered a dispensable part of the supply chain (Horsch, 2018). The potential to bypass wholesalers and distributers may unlock more value to be spread among the other players in the supply chain.

Another opinion expressed in a separate interview was that no part of the supply chain is immune from disruption and retailers could also be squarely in the firing line (Allison, 2018). This phenomenon has already been seen in retail with Amazon using the power of digital technology to revolutionise commerce and disrupt the retail business model. In the words of Jeff Bezos, founder of Amazon, “your margin is my opportunity” and the potential is to use the power of digital technology to develop new avenues to the consumer that bypass retailers.

4.3 Further Considerations

Whilst there are significant opportunities, it is also important to consider the unintended consequences that may arise through the digitisation of the agricultural industry. One of these is the effect digital agriculture would have on farm size and the consolidation of agricultural land. This trend is likely to continue or accelerate as a result of increasing digitisation (Klinefelter, 2019). As highlighted in the introduction, the divide in productivity growth between industries and companies that are using digital technology and those who are using it more, is increasing as those at the forefront are moving further ahead due to the law of accelerating returns and the increasing rate of technology advancement. In an industry that is typically low margin there is often little capital available to smaller producers to invest in new technology. Larger family and corporate style businesses are much better positioned to tap into the potential of digital agriculture as they have better access to the capital needed to invest in new technology. In terms of marketing and the selling of a provenance story, the reality is bigger corporate farms are still small when viewed from the perspective of the global marketplace and will be more likely to have the scale necessary to guarantee continuity of supply and have a recognisable presence.

In order to take advantage of these potential marketing opportunities it is important that farming practices are palatable to the consumer. There are countless practices in agriculture now that, whilst necessary to some degree, are unpalatable to the wider population. Marketing through transparency and traceability is only effective if all the cards are one the table. As raised during one meeting there is no point tracing a story that is bad and the exclusion of certain production aspects from the overall story only serves to erode trust and will ultimately fail (Horsch, 2018).

Conclusion

In a world that is becoming increasingly digitised, agriculture remains the last major industry yet to realise its true potential. There is little doubt that global food production and utilisation needs to improve in order to feed the growing world population. This problem is not new to society and previous generations have increased global food production through innovation and the adoption of new technologies.

As demonstrated in other industries, increasing digitisation has much to offer in increasing productivity and there is little evidence to suggest the same is not true for agriculture. Whilst, the complex nature of food production systems makes this a difficult goal to achieve, as the level of investment in Agtech increases, the tools needed to improve and optimise food production systems will become available. However, the expectations that surround the potential of Agtech have not yet resulted in tangible measurable benefits for producers aside from specific single use applications provided by a limited number of solutions. To realise the full potential that the digitisation of agriculture offers, the Agtech industry needs to mature and rationalise and offer increased integrations between technologies.

Fundamentally, there is a disconnect between the solutions that are currently available and the reality of what current production systems need from Agtech that offer a clear ROI. Integration of Agtech solutions into existing production systems and the broader developing digital ecosystem is essential moving forward and until this is achieved the uptake of digital technology will remain stagnant.

The opportunities that will arise from the digitisation of agriculture exist both for on farm production and post farm gate value. On farm, the potential is to optimise management decisions based upon the analysis and interpretation of data to the extent that each decision made maximises production constrained only by genetic and environmental limitations. The greatest potential for digital agriculture lies in linking food production directly to consumers and increasing the value received on farm based upon provenance, sustainability or some other metric consumers are willing to pay a premium for. Given our production systems in comparison with other regions, Australian producers are well positioned to capitalise on this and may well provide an important point of difference as our major global export competitors close the productivity divide that currently exists.

The collection and aggregation of agricultural data is essential to making this a reality and the Australian agriculture industry needs to identify strategies to facilitate this whilst retaining a level of control over how data is used. Farmer-owned data cooperatives are one way in which this can be achieved, whilst allowing the level of control needed to ensure the value that is extracted from data is passed to the producer. Whilst not a focus of this report, farmer-owned data cooperatives were observed in Europe and the USA and should be given serious consideration in Australia.

Given the nature of technology advancement, the opportunities of digital agriculture will be closer to being realised by the time this report is published. These opportunities should not be underestimated and those in the industry willing to embrace digital technology and think strategically about its implementation will position their business more favourably moving forward.

Recommendations

The purpose of this report is to illustrate the potential of digital agriculture and provide recommendations to farmers and industry around how this potential can be realised. The recommendations listed below have been divided between those that apply specifically to producers and those applying more generally to the broader agricultural industry.

Recommendations for Producers

1. **Identify the need:** Not all solutions will have a fit in the business, and it is important to identify what the needs are and invest in solutions that offer a clear ROI. The level of hype surrounding technology can lead to heightened grower expectations, however it is important to think strategically about how new Agtech can be implemented on farm. Investment decisions should be made based on shorter payback periods as the rate of technology advancement makes old technology obsolete at an increasingly faster rate.
2. **Look for integrations, customer support and business potential:** Integrations with other providers and looking for software with application programming interface (API)'s is essential to avoid tech fatigue and position a business to get the most out of the data collected. Software and Agtech suppliers should be treated much like a machinery dealership whereby customer support and backup play a major role in investment decisions. It is important to consider the longevity of start-ups and the potential for the loss of data.
3. **Organise and protect data:** Look at how the data is collected and organised to ensure it can be used effectively to inform business decisions and take advantage of potential marketing opportunities.
4. **Transparent farming practices:** In order to take advantage of marketing opportunities and take advantage of consumer trends, it is important that farming practices are transparent and palatable to consumers. The absence of transparency will result in a loss of trust between the consumer and producer and undermine efforts to tap into this opportunity.

Recommendations for Industry

1. **Develop solutions with leading producers and industry:** Solution providers need to work closely with leading producers to develop products and demonstrate commercial viability. There is also scope for industry bodies to facilitate demonstration sites to further develop and integrate new technology into the growing digital ecosystem.
2. **Integrate and rationalise:** Currently the Agtech market is over-saturated with solutions looking for a fit in current production systems. Moving forward Agtech providers will naturally begin to consolidate and offer integrations with other providers. Those that don't risk becoming obsolete as producers become increasingly hesitant to invest in single use technology that does not integrate or allow for data to be used for other purposes.
3. **Connectivity:** Without connectivity the potential of digital agriculture cannot be realised. There are increasing examples of grower groups and individual farmers looking to solve this issue independent of the major telecommunication companies. In the absence of any viable alternative solutions, and without significant government investment, this is an approach worth considering.
4. **Education and consultation:** Increasingly farmers will need to develop an understanding of digital technology in order to implement and use it effectively. Similar to the way farmers use agronomists and farm business consultants, there is a need for new type of consultant specialising in digital technology and its implementation. Ideally this consultant would identify technology that will provide measurable on farm benefits and assist with the implementation and integration into existing farming systems.

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Plain English Compendium Summary

Project Title:	Digital Agriculture: Farming in the Digital Age
Nuffield Australia Project No.:	1804
Scholar: Organisation: Phone: Email:	Andrew Slade Glenridge Park 542 Mallawillup Rd Kendenup Western Australia 6323 +61 433 779 426 Andrew.slade@glenridgepark.com.au
Objectives	The purpose of this report is to look at the current state of digital developments within agriculture and come to an understanding of the role it will play in the future of Australian agriculture. The key considerations are as follows: • Understanding the current role digital solutions play in agriculture • Recognising the current limitations of digital Agtech • Identifying potential opportunities and consequences for the industry • Recommendations for industry moving forward
Background	Global food production must increase to feed the growing global population. On farm productivity growth has slowed in recent decades and the digitisation of agriculture could provide the means to increase global food production.
Research	Digital technologies currently don't offer on-farm productivity gains worth investment in new Agtech. Solutions that are currently offered need to integrate better into existing production systems and the data collected used to generate decision support tools.
Outcomes	Growers should invest wisely in digital technology, looking for integrations and clear return on investment opportunities. Industry should look at how data is collected and used by the broader industry to ensure the potential benefits of digital agriculture are realised.
Implications	Digitisation of agriculture can have benefits for both on farm decision making and marketing opportunities. For production the potential is to improve decision making to the extent that production is maximised constrained only by environmental and genetic limitations. Beyond the farm gate there is the potential to link production practices through to the consumer and attract a premium for food that is produced using more sustainable production methods.
Publications	Nuffield Australia National Conference, Brisbane, September 2019.