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The Australian digital farmer: challenges and opportunities

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Abstract. Any agricultural farm enterprise is a complex undertaking. Physical, economic, social and technological factors demand equal attention if a farm enterprise is to succeed. To be successful a farmer needs to ensure the optimal use of farm inputs to achieve high productivity. Technological developments have dragged farmers into the digital age and have significantly altered the management of such inputs. This paper considers the disruption brought about by digital farming. Major technical, legal, policy and social challenges and opportunities are outlined in the context of digital farming in Australia.

1. Introduction

Any agricultural farm enterprise is a complex interaction of inputs and outputs. Some of these are within the control of the farmer such as farm inputs whereas environmental factors such as the weather, climate, soils and water availability are sometimes beyond the control of the farmer. The digital disruption promises unclear impacts but potential gains. The adoption of digital technology in the farm is best described as uneven [1]. The potential for the Australian economy through modeling methods show positive gains. The estimated Australian farm investments in digital technology is less than \$5 million compared to global investments of more than \$4 billion in 2015 [2]. Digital agricultural technology is in infancy in Australia compared to the US, Denmark and Israel [3].

As with the Industrial Revolution Industry 4.0, the agricultural sector too has evolved from the Agricultural Revolution 1.0 characterized by labor intensity, Agriculture 2.0 of high productivity gains from the Green Revolution and then to Agriculture 3.0 of precision farming deploying guidance and sensing systems, telematics and data management. Agriculture 4.0 features digital smart farming with physical products enhanced by additional non-physical services and the emergence of an agricultural eco-system with a subset of this revolution extending to autonomous unmanned decision systems of robotics and artificial intelligence.

In 2015-16 there were 85,681 agricultural businesses in Australia [4]. Both the area and the number of businesses using precision agriculture techniques increased during 2015-16. Controlled traffic farming continues to be the most prevalent of these practices and is undertaken by 6,600 businesses (a 14% increase on 2014-15) over an area of 6.7 million ha – a 28% increase from 2014-15 estimates. The total agricultural land is estimated at 391.86 million ha [4].

This paper describes the challenges and opportunities facing the Australian digital farmer. The gains from digital farming are given together with an assessment of adoption and maturity levels and considerations of ‘big data’ issues. Then technical barriers facing the digital farmer are outlined to suggest some of the reasons for the uneven and slow adoption of technology in the farm. The legal and institutional factors such as ownership of farm data, privacy, and transformational barriers describe unique challenges. The next section addresses policy matters in the new digital economy. The



discussion is followed by addressing the ‘next gen’ digital agriculture in Australia and suggests some recommendations to enable digital agriculture to grasp the opportunities. Access to the marketplace through higher productivity, leadership and value propositions are a part of the mix in cross-industry collaboration within a strategic framework.

Any digital farm leverages latent value from data gathered from smart tools and equipment on farms. Uses of the data include phenomics, farm use software engineering, data analytics, precision agriculture and farm management systems. Phenomic tools offer non-destructive and high throughput methods measuring and analysing phenomes and genomic traits to quantify crop performance in response to the environment. Software engineering help map and analyze land use and crop performance on farms. Applied data analytics contribute to quality assurance and longitudinal datasets. However, unresolved challenges include the use of ‘big data’ on how to store the information and managing the raw data as intelligence.

The use of digital tools to manage Australian agriculture has continued to increase with ongoing reduction in chemical use, careful use of fertilizers and flexible approaches to grazing management to reduce erosion and increase productivity [5]. Economic modeling has shown that the implementation of digital agriculture in all Australian production sectors could lift gross value of agriculture by \$20.3 billion, an increase of 25% from 2014-15 levels [3].

Definitions

Digital farming is means the connected knowledge-based farm production system that employs intelligent network and data management tools that enables the automation of sustainable processes in agriculture [6]. It is synonymous with smart agriculture and digital agriculture.

Precision farming uses global positioning systems (GPS) to enable the guidance of farm vehicles that are used for seeding, fertilizing and harvesting operations. This may involve the expansive use of telematics and data management not only in broadacre farming but also managing exact requirements for individual heads of animal stock, individual trees or plants to thrive optimally.

Decision agriculture is the end-point or action resulting from the use of knowledge and/or information that may be derived from digital farming.

Skinner’s evaluation of Australian digital agriculture maturity levels from precision to decision agriculture models has shown that there is a low maturity level across all categories of digital agriculture [7-8]. Skinner suggests an actionable cross-industry digitization plan. Indeed value-adding to farm data may be achieved by the pooling of individual farm data as ‘small data’ [7].

The immaturity of digital agriculture in Australia is the result of interrelated factors including leadership, trust and legal barriers, information technology infrastructure and the availability of appropriate data. To this list may be added the lack of digital literacy in data analytics and a lack of an understanding of how to garner decision-support systems and tools [3].

In 2016 the Australian government’s Rural R&D project on Accelerating Precision Agriculture to Decision Agriculture (P2D) Heath evaluated the current and desired state of digital agriculture in Australia and to make policy recommendations [9]. The evaluation specifically sought to estimate the impact of unconstrained digital agriculture on the Australian economy. ‘Unconstrained’ here is taken to mean a situation where any current limiting factors have been overcome and the full potential of digital technology realized by all Australian farmers.

The P2D study estimated that unconstrained digital agriculture would add a 25% boost to Australian agriculture with a \$20.3 billion increase from 2014-15 gross value products for all sectors. Labor savings from automation was estimated at \$7.4 billion, genetic gains from the use of objective data \$2.9 billion, and savings from the careful monitoring of inputs to needs \$2.3 billion and profits from the enhancement to market access and biosecurity \$1.0 billion.

The assessment is that digital technology has the potential to transform Australian agriculture and profitability for farm businesses. Productivity gains of 10-15% in cropping systems have been separately estimated with half gained through input efficiencies and the other half through increases in output [1]. Economically there appears that there is much to be gained from digital agriculture.

2. The digital farmer: challenges and opportunities

To be a fully-fledged digital farmer there needs to be a conscious decision to embrace technology in every aspect of the farm enterprise. It would require a personal re-education program to know and understand aspects of the technical and institutional environment as well as an investment strategy to get the best possible equipment available for the farm. Such technical and institutional requirements take place within a social milieu where the sharing of information and knowledge is bounded by one's network and social circles. These are challenges and barriers that any digital farmer must overcome to grasp the opportunities.

It is not uncommon to find that the older generations of farmers often rely on net-generation millennials, for help to solve simple IT problems. But on some farms the net-savvy children may be at boarding school or university. In the absence of such help farmers may have to turn to their 'significant other' or to their neighbors. On the farm, external connectivity to the internet may not be available all the time. Even if the internet connectivity were available, the requisite speeds may be insufficient at critical times of the day or the speeds might be unreliable over different times of the week. These technologies come at a price, given that the nature of the market for digital agriculture products is one where there may be more price and service-takers than there are price or service makers [10]. The suggestion is that there are multifaceted problems that digital farmers must grapple with over and above the primary activity of farming.

2.1. Digital agriculture and information technology

Over two-thirds of Australian farmers rely on the mobile network to access the internet. The 3G or 4G (third or fourth generation wireless mobile telecommunications technology) towers located throughout the farming areas in Australia either suffer from unstable connectivity or the inability to get or stay connected [11]. Even when connected the user might experience fluctuating speeds for effective through-put when uploading and downloading data. External data connectivity is a significant challenge for farmers seeking to adopt and to deploy many technology-based innovations on the farm. Previously, telecommunication service providers had a universal service obligation (USO) that obliges providers to ensure that telephony services and prescribed carriage services are reasonably accessible to all people in Australia on an equitable basis (<http://www.acma.gov.au>).

On the issue of connectivity, a study of the implications of digital agriculture concluded that Australian farm businesses are operating with broadband connections that are slower, more expensive to acquire and less reliable than those available in other countries that compete for similar agricultural export markets.[1]

Suggested 'work-arounds' to resolve the external connectivity requirements include *Farm Mobile* that stores collected data in memory and then deploy a passive uplink connection (PUC) when an internet connection becomes available [12]. But even with this solution, the lack of mobile phone reception or access to the internet to transfer data remains. The challenge is to find better ways to link to the internet to integrate farm information

Another suggestion is to develop an on-farm connection using forms of 'radio networks' to supplement current standard WIFI networks. But there is still the need to connect to the internet to view the live feed and access to cloud-based analytics [10].

2.2. Digital agriculture and legal issues

Digital agriculture is poised to positively change the industry by enabling informed farm management decisions. While there is the availability of a large cache of data and information together with software to facilitate the analysis of the data, there is however the need to pay attention to emergent legal issues. The control, ownership and maintenance of the privacy of the data provide challenges as well as opportunities. Seemingly innocuous, questions of ownership of farm data, the lack of confidence and certainty in the quality of the data raise several interrelated legal questions.

Generally, the legal framework governing Australian agricultural data are intellectual property, privacy and statutory obligations. Under intellectual property law, confidentiality, trade secrets and

data ownership are most relevant to agricultural data. Privacy, with reference to the Australian *Privacy Act* 1988 (Cth), refers to the handling of personal information about individuals is as relevant as the obligatory submission of farm data to the Australian Bureau of Statistics for statistical purposes [1].

It may be argued that data generated on the farm belongs to the farmer. However, this begs the question of who is the farmer – the owner of the property on which the farm enterprise takes place, the contract harvester or the manufacturer of the machinery that has on-board real-time sensors collecting production data?

Unmanned aerial vehicles (UAV) or drones have been used to remotely sense farms to capture data on cropping patterns, heat and water stress, fertilizing regimes and other useful information. Farmers may commission contractors to perform such functions which may also include an analysis of the data or they may perform the analysis themselves. In such situations the farmers who commission such work ‘owns’ the collected data.

While an argument that the data collected by drones over any farm may be considered personal information given the close connection of the farm as private property, a counter-argument may be run to suggest that the provisions of the *Privacy Act* 1988 (Cth) may not apply to individuals who operate drones in their private capacity. The Act applies to the handling of personal information about individuals by governments and to those organizations to which the Act applies.

There is uncertainty in the law in the imagery captured by satellites and drones. A view has been put that UAVs fall within the definition of an optical surveillance device of the *Commonwealth Surveillance Devices Act* 2014 and if so existing Australian surveillance laws could apply [13].

Ownership rights of farm data involving parties other than the owner of the property may be managed and controlled by agreement either by contracts of service or contracts for service. The agreements should spell out the ownership of the data explicitly by specifying rights over the data generated, and the permitted uses of that data by the contractor.

Another legal facet to the ownership of farm digital data is that of responsibility and legal liability. A key element in the food production chain is that digital data may demonstrate compliance with legislative obligations. Given society’s heightened expectations for food safety and production methods, additional elements of transparency and traceability will become readily available to consumers, manufacturers and regulators alike.

In Australia most farm operations are owned and controlled either by individuals, families or corporations who also manage most aspects of the supply and production chain [14]. Digital technologies adopted in these operations also rely heavily on basic contractual and licensing agreements that describe how data can be collected on the farm, how it is controlled, shared and accessed by third parties.

In the US and in New Zealand the regulatory environment to protect farmer’s ownership rights over digital and other data have been in the form of industry Codes of Practice [1]. Such codes spell out the limits for the use of the farm data and third-party usage. For example, the American Farm Bureau’s *Privacy and Data Principles 2014* [15] and the New Zealand Dairy Industry’s *Farm Data Code of Practice 2016* [16] are designed to encourage best practices in the ownership, control and access of agricultural data.

There is a need to re-think the collection of farm data, data management practices and improving transparency. Datasets that need manipulation into useful forms create barriers that make the datasets accessible only to a small set of experts. Such datasets need to be FAIR – findable, accessible, interoperable and reusable [12]. To prevent technology galloping away from practice and regulation human interactions with the technology should be better understood rather than to regulate the technology itself [17].

2.3. Digital agriculture and policy matters

For policy makers the challenge is to identify the assistance to digital farmers to achieve their potential and in so doing also provide some security for the national economy. [1 Executive Summary] New skills training and development will be necessary when introducing current technologies to

enterprises. It implies accepting the high throughput costs and the greater reliance on smarter farm machinery.

The digital farm in the 21st C will be one where there is a heavy reliance on GPS to provide live information on where herds of cattle are dispersed and the direction of their movements on the farm. Electronic collars not only provide data of the stock's location but also other identification information of each head of cattle. Robotic meat processing may replace the need for human intervention and manual methods. Selected examples of farm technology in practice are summarized in [2, 18].

What are the policy requirements that may cement the place of digital agriculture within the national economy? Cross-industry collaboration has been suggested – agriculture, information technology, farm machinery – in concert with government and strategic developments and its implementation, that is situated within a dedicated, consistent and unified regulatory framework [19]. There is also a need for a data management code of practice so that both digital farmers and those supplying the digital equipment are at one in terms of data use, data ownership and data security. To achieve the higher standards of practice there will inevitably be the need for certification and accreditation [20]. The adoption of such practices will bring about monetary benefits as well as confidence and other social benefits to digital farmers. Two other policy recommendations arising from the Precision Agriculture to Decision Agriculture (P2D) project include investments in telecommunication infrastructure and the adoption of new investment models, again involving private and public entities [3].

2.4. Digital agriculture and social aspects

Digital agricultural technology is a skills-based industrial model accompanied by digital business and production methods. The model significantly challenges traditional farmers who may require upskilling and the adoption of a mindset of constant change and digital literacy. Education and capacity building in digital literacy is sorely needed to fill the identified capability gaps.

In Australian farms in 2016, the average age of farm providers (farmers) was 56 years and the average time the provider was involved in farming was 35 years. Such demographics suggest an 'ageing' of farmers in Australia which may mask the reinvigoration of Australian agriculture [4].

A survey has shown that there are more than 4,000 jobs per year in agriculture according to advertising statistics [21]. However, the number of graduates supplied by Australian universities has declined significantly by more than 20% to the number needed to satisfy the job market. Digital farming could become far more interesting, rewarding and challenging to the new generation of farmers. Digital farmers as the future custodians of the Australian landscape will assume responsibility for the management of native vegetation, landscape sustainability and biodiversity and contributing to addressing global issues of carbon emissions and the carbon economy. Automated farm vehicles using GPS could be fully autonomous, as remote sensed and UAV data guide farm management decisions in precision agriculture. At the same time, farmers would need increased personal skills and capacities together with expert advice in IT and other aspects of the farm economy from others.

Australian farming in general may yet become an attractive investment and career choice for many young new graduates from universities. Every Australian farmer now relies on an average of six local paid professionals and consultants to advise them on diverse aspects of their business from crop and agronomic advice to IT, grain trading and financial planning rather than a farmer trying to do everything themselves as in the past [22].

The data suggests that a dearth of graduates taking up agriculture as a career [21]. The challenge will intensify if there are no concerted efforts by all, including governments. One observer has said that farming should be a career choice and not a sentence [22].

3. Future of digital agriculture in Australia

The next generation of digital agriculture in Australia may see a growing maturity with leadership demonstrated both by the private and public sectors. The value proposition is the confidence in further investments and a greater adoption of digital, innovative practices in all aspects of farming. A high

degree of trust and confidence will follow the lifting of legal and other institutional constraints presently restraining digital agriculture. These developments are premised on a level of sophistication in digital literacy, data analysis and decision support systems [3].

The P2D project made thirteen recommendations regarding digital agricultural policy, strategies, leadership, digital literacy and industry enablers [3]. The recommendations enable digital agriculture to be more competitive in the international marketplace. The projected future in Australia is an agricultural landscape that will be characterized by one which is digitally integrated at all stages of production from the use of genomics and genetic modification of crops and livestock to transport logistics at the farm, at the farm gate and through to the abattoir and market place.

Modern farming problems may require smart technologies and solutions that rely more on science and technology rather than on farming know-how that has been passed on from one generation to another. The know-how may in the future be digital and data driven that rely on sensors, information systems and computer decision support systems.

4. Summary and conclusion

The farmer in Australia is at a crossroads today with a choice of either taking the well-trodden path or the path provided by the digital revolution. The agricultural revolution 4.0 brought about by digital technology promises potential gains but with unclear impacts. The agricultural disruption in the farm has introduced new tools that produce value laden data for objective decisions and management systems. The data also are fed into biological studies of productivity, software engineering applications, data analytics and precision agriculture. Economic modeling has shown the lifting of the gross value of agriculture with an increase of 25% from the 2014-15 levels.

A critique of digital agriculture is that the use of technology on the farm may sometimes be isolated from knowledge of agriculture and an understanding of on-farm realities and business problems. Technology might compound the problems and challenges instead of contributing to solutions and doing the actual work of the farm.

There is a need for a deeper understanding of big data and its impacts on digital agriculture and more importantly the manner it has changed farming societies. These societal impacts loom large as the application of big data analytics has fundamentally changed farming practices and farmer interactions.[1] A critical question is: What happens when the predictive analysis starts to match local knowledge? Do we have ‘singularity’ to borrow a phrase from artificial intelligence? The answer, it seems, is that there is a greater need to re-double efforts to undertake both the objective science-based research and social research in the farm to understand what is happening and to explore trends and drivers.

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