The Data Farm

An investigation of the implications of collecting data on farm

A report for

by Jonathan Dyer

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Executive Summary

Data driven technologies have revolutionised every industry in which they've been widely adopted. Buying a book or some music, organising a holiday and even trading shares is a vastly different experience now to what it was 10-20 years ago. The information revolution is also making its way into agriculture. A new revolution requires new ways of thinking and new approaches to some old problems in order to prosper as a farmer on a data-driven farm. What new approaches, what new ways of thinking do those of us on agricultures front line need in order to adapt our mechanised industrial agriculture into the new reality of the information age?

The rise of a myriad of cheap sensors is combining with the GPS and the promise of near ubiquitous internet access to allow farmers to ask questions about their farms that haven't been feasible to ask in the past. Rather than treat their farms and soils as homogenous farmers can become flexible and adaptable to the natural variations that exist in their environments. Never before have farmers had tools to measure, quantify and respond to the natural variability that exists on their farms like they do in 2016.

Collecting data on farm has transformed from an expensive and laborious process that few farmers could be bothered with, to one that is relatively cheap and increasingly easy. Rather than being a one-off process, collecting, analysing and continually reviewing data can become a system for ongoing improvement on a farm.

Once accurate data is being collected at the farm level, such data can be aggregated and compared across different businesses, regions, and countries. Farmers can use this aggregated data to analyse farm business performance. The promise of this is the potential for real-time business benchmarking.

Third parties, including well known agribusiness multinationals are becoming interested in farm data at this aggregated stage, because it gives insights into how farmers are using various products. This leads to a strange phenomenon where a company's clients are also doing their product research.

There are many people who believe there is much value to be extracted from this data as evidenced by the venture capital flowing into new companies attempting to make use of it. This may be concerning to farmers who may not understand the motivations behind a company wanting to access farmer data.

There are other longer term implications of data technology in agriculture. Fears about commodity market manipulation may be overstated but concerns about control of data access are valid. Like all technologies there are potential benefits to farmers as well. More open supply chain data may allow for cheaper inputs and potentially even a new revenue stream for some farmers. It will certainly lead to better genetics and machines for farmers to use.

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Foreword

For as long as I can remember I've been interested in computers and digital technology. Despite growing up on a grain farm in the Victorian West Wimmera, my interest was strong enough to cause me to study information technology at university and work in the sector for a couple of years as a graduate. A few years later I left my corporate job to try life on the family farm. I could see digital technology coming into farming and that very few farmers have the technology background that I do.

We've been collecting various forms of data about our farm for more than a decade, but we've hardly been using it. 'Big Data' was starting to become a buzzword in the IT industry around the time that I had entered into agriculture and so I wondered, 'What's in this for farmers? Surely we could be using data better than we currently are?' This was a major motivation for applying for a Nuffield Farming Scholarship.

During our Global Focus Program (GFP) visit to Washington DC, a last minute change of plans saw us visit the US Naval Observatory. This was a fortuitous visit for me as the US Naval Observatory is the home of the Global Positioning System, more commonly known as GPS. Developed by the US Navy in the 1970s (Wikipedia, 2016), the GPS has enabled first military then civilian users to spatially track where they are on the planet.

The GPS has changed from sophisticated military hardware to technology that's integrated into virtually every smartphone that is sold today. The atomic clocks housed on that site have made the collection of geo-referenced data possible for all manner of industries including agriculture. When the GPS is combined with the rise of cheap sensor technologies, farmers are able to measure things on their own farm that have never been measured before.

It is this ability to capture data on farm that I sought to investigate during my Nuffield studies. I wanted to gain a better understanding of the potential for farm data collection for improving farmer practice and profitability. I wanted to cut through the hype surrounding the buzz of 'Big Data' and find out what this confluence of technologies has to offer farmers.

My Nuffield travels saw me travel to France for the Contemporary Scholars Conference before embarking on our Global Focus Program tour to England, the USA, Mexico, Brazil and New Zealand. During my personal studies I attended the 10th European Conference on Precision Agriculture in Israel, as well as returning to England, Brazil and the USA to investigative my topic in more detail. I also visited Canada for the first time, attended conferences in Canberra and Sydney and made some visits in Melbourne.

Acknowledgments

Literally the day after being presented with my scholarship in Launceston, Tasmania, my wife and I discovered that we were having our first baby. I owe my wife Tiarnee a huge debt of gratitude and time for her patience and support while I travelled, both before and after Tallulah was born.

Thanks also to my family business partners, Alwyn and Eric, for the extra efforts they put in on the farm while I was away.

The corporate investor of my scholarship is the Rural Finance Corporation. Their generous support of me, through the Nuffield program, is greatly valued. I hope this report shows a worthwhile repayment of the faith you have placed in me.

Abbreviations

AFBF – American Farm Bureau Federation

ATP – Agricultural Technology Provider

Case NH – Case New Holland Corporation

Climate Corp. - The Climate Corporation

CME Group - Chicago Mercantile Exchange Group

FBN – Farmers Business Network

GFP - Global Focus Program

GPS - Global Positioning System

OADA - Open Ag Data Alliance

OEM - Original Equipment Manufacturer

ROI - Return on investment

USA – United States of America

Objectives

The author has been generating and collecting data on farm for a long time. This data has been used to generate colourful maps, but not a lot more. It is now possible to collect vast amounts of data on farm but doing so must have a purpose. Wanting better ways to quantify, understand and record what is happening on farm, the following objectives were identified for further study during the author's Nuffield Scholarship:

- Investigate ways for farmers to use data they're collecting on farm.
- Understand why third parties are interested in gaining access to farmer's data.
- Provide some understanding of who benefits from collecting farm data.
- Investigate the broader implications for 'Big Data' technology in agriculture.

“Without data, you're just another person with an opinion.”
— W. Edwards Deming

“Remember that all models are wrong; the practical question is how wrong do they have to be to not be useful.”
– George Edward Pelham Box

“Over the last 50 years, computation and analysis have enhanced performance in the economy and in agriculture. Today, we wouldn’t think of heading to the field without our cell phone and wouldn’t hesitate to check the Internet to make sure that we were getting a good price. In the not too distance future, we’ll regard Big Data technology and information in the same fashion.” (Sonka, 2015)

Chapter 1: Introduction

Professor Sheizaf Rafaeli from the Centre for Internet Research in Israel says that through history there have been three major shifts or revolutions in the way people live and work. (Rafaeli, 2015)

They are*:*

1. *The agrarian revolution*, where people stopped being hunter-gathers and instead started growing crops and domesticating livestock. At this time the majority of the working population became involved in agriculture.
2. *The industrial revolution*, where the wealth brought from mass-production shifted people out of rural areas and into cities. This process is continuing globally. The majority of employment in the economy has shifted from agriculture to manufacturing.
3. *The information revolution* is the process that we are living through right now. Jobs are shifting from the manufacturing economy to the services and knowledge economy. The old saying is that knowledge is power.

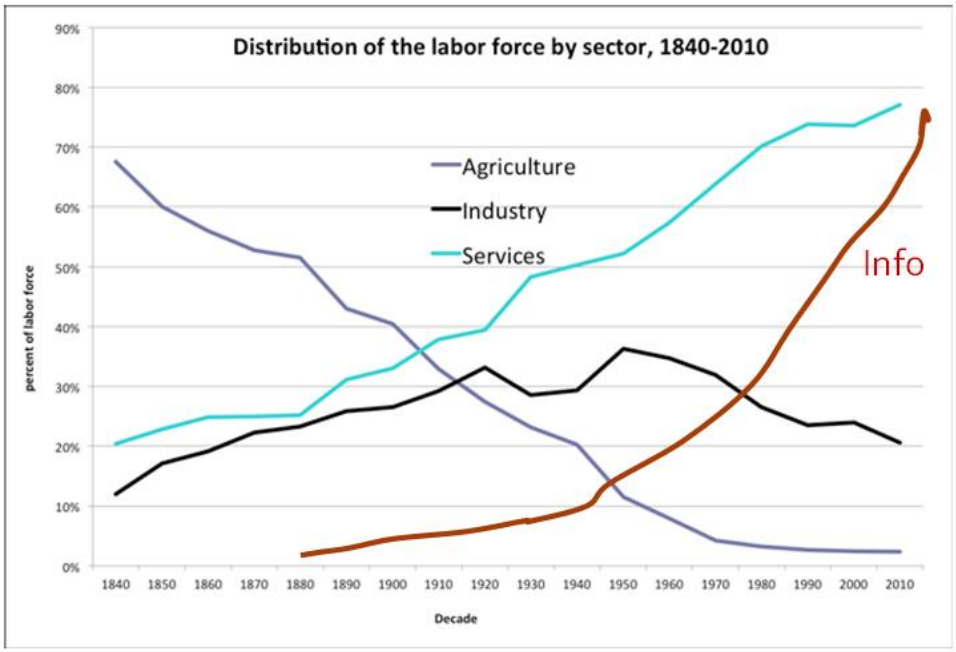

Figure 1 - Shezaf Rafaeli, 2014

Figure 1 gives an eye-opening perspective on what is happening and has happened to agricultural communities. Many rural communities across the world are lamenting a decline in rural populations and economies brought about by technological progress. But a 2013 Nuffield Scholar found that these changes have brought great benefits to society as a whole (Swift, 2015). The key point here is that the skills required to flourish following each of these revolutions are completely foreign to the ones before it.

*Farming seems crazy to a hunter gatherer***.** It is a different skillset that he has no knowledge of, or need for. If Rafaeli is right are we then hunter-gathers looking out across the river at a new information-driven world which will require new technologies, skills and attitudes to prosper in?

What will the information revolution mean for agriculture? What new approaches, what new ways of thinking do those of us on agricultures front line need in order to adapt our mechanised industrial agriculture into the new reality of the information age?

The focus of this report is on what these technologies mean for agriculture, and farmers specifically. A UK scholar has published an excellent report on data collection from an industry perspective (Allen, 2015). While many common themes have emerged in our reports, it is the author's intention that this report serves as an 'on-the-ground' perspective on data collection and the promise and implications it holds for farmers.

During the course of the author's travels it became clear that this study topic contained two distinct, yet related topic areas.

1. How can data be used on farm by farmers to improve farm practice?
2. How can farm data be used off farm to improve farm outcomes?

Chapters two and three predominantly relate to question one. The remainder of this report deals with the second question.

Chapter 2 – Using data on farm

There's a famous case study in the data analytics world about a well-known American department store chain that learnt to predict when its female shoppers were pregnant by their buying habits. The store discovered that pregnancy signalled a significant shift in female spending habits, so by targeting pregnant customers they could get their attention at an impressionable time in their lives.

This chain of stores got so good at doing this that they sent pregnancy related advertising material to a teenage girl who had been shopping at their stores. The father of the girl was incensed by the material and told the store so, only to have to apologise days later after learning the store had not in fact, made a mistake (Hill, 2012).

As farmers we deal with something that is every bit as complex, dynamic and intricate as human buying habits. We deal with nature and the natural world. Farmers have never before had tools to measure and respond to the natural variability that comes with interacting with the natural world. But the rise of data collection and technology allows us to do just that. Our farms and our soils are not homogenous, but for too long we've treated them as such.

Spending time with precision agronomists in Brazil highlighted this point. Fabiano Paganella of Plantec in Vacaria, Brazil described the challenge of data collection on farm in four steps.

1. Collecting
2. Processing
3. Interpreting
4. Application

These four steps encompass the challenge of precision agriculture (Paganella, 2015). These are the steps to be gone through when using precision technologies to solve problems on farm.

Collecting

It is possible to collect farm data on virtually any area of farm performance. If there’s an area of a farm that a farmer/ farm manager believes can be managed better, then data can be collected to aid in assessing and quantifying an issue. The spectrum of ways to collect data is as wide as the number of issues are on farm to collect data about. From very simple data logging via a smartphone or laptop, through to networks of remote monitoring sensor networks, collecting reliable data is no longer the challenge it once was.

Processing

Once collected, data must be processed into a format that is useful for farmers and advisors to use. Typically, this involves converting large datasets of data into a visual medium, better understood by humans. Examples of this may include graphing weather data, or laying a large series of plant health data points onto a map to give a visual representation of plant growth. Traditionally requiring some expert knowledge to operate, data processing tools are becoming increasingly automated and easier to use, leading to lower barriers to farmer adoption.

Interpreting

With data collection becoming increasingly commonplace on farm and automated processing of that data becoming increasingly automated, it is the interpretation of these pretty maps and well laid out graphs that is the challenge for farmers. Providing an appropriate context to what data points are being analysed and how that is impacting farm performance is crucial to making the most of data collected on farm. Often farmers engage trusted advisors or other outside professional help for this step of the process.

Application

This is the step that makes the previous steps worthwhile. With a newfound understanding of what is happening on farm and some quantification of the issue being investigated, a farmer now has the confidence to change management decisions based on the interpreted data. Making better and more informed decisions on farm is what justifies the expense and time required to capture better farm data.

But has the implemented management change had the desired effect? There is now a need to collect data relating to the different farming or management technique to verify that improvements are definitely being make. So the cycle of collecting, processing, interpreting and applying data based decisions is an ongoing one. Each time this cycle is attempted, a farmer learns something more about their operations and how to improve what they do.

Rather than being a one-off process, collecting and appropriately using farm data can become a system for implementing continual improvement on a farm.

Chapter 3 - Defining Big Data in agriculture

Introducing the main topic of a report in its third chapter may seem like a strange approach, but it is deliberate. The information revolution is only just beginning in agriculture. It is far more advanced in the health, finance and technology sectors. As a new term in the agricultural industry there is lots of hype and confusion around exactly what 'Big Data' is.

The best definition of 'Big Data' that the author encountered in the context of agriculture is the following:

> "Big Data generally is referred to as a singular entity. It is not! In reality, Big Data is much more a capability than it is a thing. It is the capability to extract information and insights where previously it was economically, if not technically, not possible to do so. Advances across several technologies are fuelling the growing Big Data capability. These include, but are not limited to computation, data storage, communications, and sensing." (Sonka, 2015)

This capability only comes once a farmer or manager is competently acquiring and managing individual data sources through the process outlined in the previous chapter. Combining data from multiple sources on farm can give rise to insights not previously available to a farmer, as indicated in the definition above. An example of this may be combining soil test, NDVI and yield data to discover that an area in a field is not performing to potential because it is being under fertilised. This is 'Big Data' in action at the farm level.

'Big Data' has broader implications as well. It is now possible to combine data sources from multiple farms over a given geographic area, in order to give insights not possible on one farm alone. An example of this may be comparing weed distribution and yield maps across farms to determine which agronomic practices result in the best weed control.

This approach can be applied ever more broadly, to the point where in a meeting at the CME Group in Chicago (Seamon, 2015) it was pointed out to the author that grain market watchers are starting to combine image processing software along with satellite imagery to better understand and forecast the health and progress of crop growth across regions, countries and continents. That is truly big data.

Chapter 4 – Third Party interest in farmer data

Background

Monsanto's acquisition of The Climate Corporation in 2013 for $US930 million (Monsanto, 2013) seems to have been a watershed moment for data use within agriculture. A meeting at the Climate Corporation in St. Louis revealed its annual operating budget is approximately $US800 million. (Anonymous, 2015) Putting those numbers together, it is reasonable to assume the company has spent well in excess of $US2 billion on its data venture to date.

Monsanto has made the headlines but John Deere has been shipping tractors, combines and other equipment with telematics capabilities since 2012. (Deere)

Google Ventures, the Venture Capital arm of the web-search giant has invested $15 million into Silicon Valley start-up the 'Farmers Business Network.' (AgFunder, 2015) Google Ventures also made early investments in other Agricultural Technology companies including The Climate Corporation and Granular.

There are people out there who believe that 'farm data' is going to be a big deal. This chapter outlines just a selection of the companies throwing themselves into agricultural data collection and their beliefs behind their approaches to farm data.

Agrichemical Companies

Bayer Crop Science - Digital Farming Team

Only commencing operations in 2014, Bayer's 'Digital Farming' team is a late entrant to the 'Ag Data' space when compared with its competitors. Late to the game they may be, but Bayer seems to be taking the possibilities of Big Data seriously. Hiring data scientists and starting this work at a time when the rest of the company is facing leaner times. Unlike some of its competitors, Bayer is not seeking to create a data based product to sell to farmers, nor is it trying to access farmers' data directly. It is trying to gather better insights using freely available datasets including soil surveys and weather data to educate its dealers and clients and inform its research and development into crop protection products.

During editing of this report Bayer AG, the parent company of Bayer Crop Science made a spectacular offer of $US 62 billion dollars to buy the Monsanto corporation. (Gullickson, 2016) This eye-catchingly large offer caused Fortune Magazine editor Alan Murray to speculate on the reasons for this offer in an editorial writing:

> *(Monsanto CEO) Grant believes agriculture is very much a part of the new industrial revolution, and the successful company of the future will need to use data about soil and weather to offer farmers precise and targeted advice about the seeds and chemicals they*

> *need to use. The company of the future won't just be selling seeds and chemicals, but seeds and chemicals and data as a service. That's why Monsanto acquired the Climate Company; that's why it attempted, unsuccessfully, to buy Swiss-based chemical company Syngenta ; and that's why Bayer is now after Monsanto.* (Murray, 2016)

While this is just one commentator's speculation, it's another piece of evidence suggesting a strong belief in the digital future of agriculture. The author noted above that Bayer was late to the digital agriculture game. It may have been trying to catch up in the fastest way possible.

Monsanto and the Climate Corporation

As outlined in the introduction to this chapter, Monsanto, through it's now subsidiary Climate Corporation, is spending enormous resources trying to become the market leader in farm data solutions and analysis. When asked why Monsanto wants farmer generated data, the answer from Pradeep Das, who is the Principal Researcher in Experimental Science at The Climate Corporation, was direct.

> *'We need to give growers the best information to show them how to get the most out of their seeds.'* (Das, 2015)

Later in the conversation he further added:

> *'We cannot assume that a farmer's investment in seed will be fully actualised on their own*.' (Das, 2015)

This was the motivation behind Monsanto's development of the FieldScripts product, a field based planting prescription model which pre-dated the Climate Corp acquisition by three years. But neither the uptake, nor the results of FieldScripts were what Monsanto had hoped. Dealing with the natural world and the infinite complexities of weather, soil, chemicals and the other variables of farming was far more difficult and data intensive than Monsanto imagined. Monsanto needed more data to know why its seeds were not yielding to their genetic potential. The extra weather insight capabilities and data processing knowledge gained from acquiring Climate Corp. were certainly helpful to the company in its quest, but it needed to get on farm. So in December 2014 Monsanto acquired 640 Labs, a technology start-up transmitting machine data from tractors and combines directly into the online cloud. As Monsanto's CEO put it at the time of the 640 Labs acquisition:

> *At The Climate Corporation, we strongly believe that leveraging on-farm data can help farmers maximize yields and optimize natural resource use,"* said David Friedberg, CEO of The Climate Corporation. (Farm Industry News, 2014)

Climate Corp. launched its series of farm data offerings at the 2015 Farm Progress Show in Decatur, Illinois, illustrated in Figure 2. It will be interesting to see whether using these products featuring farm-level data can be more useful and profitable for farmers.

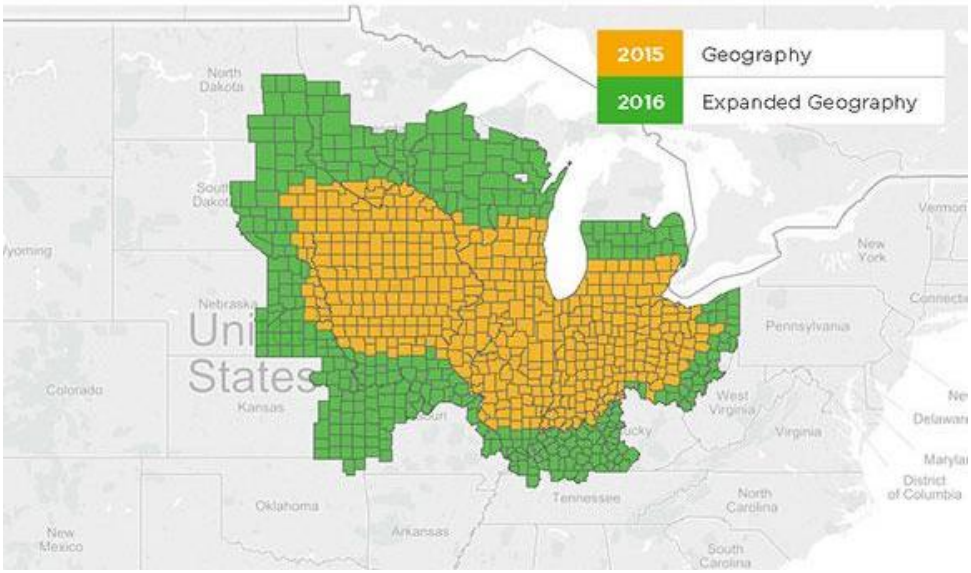

Figure 2 - Initial coverage area of Climate Corporations farm data analytics products.

DuPont/Pioneer - Encirca Services.

Pioneer have also recently launched their own data driven analysis and precision farming product called 'Encirca Services.' Pioneer are taking a much more 'hands on' approach to farm data and collection compared to their competitors. Realising like the Climate Corporation does that farm level data is needed to make the most of data analytics, Pioneer are sending their own 'Services Agents' out to individual farms to collect farm data, including yield and harvest data in order to give feedback about nitrogen and yield requirements.

This approach is the most labour intensive approach to farm data collection currently being marketed, but if successful could prove quite lucrative for Pioneer as it is quite ingenious. Putting that agent on farm means that Encirca services are being marketed as a premium service. This premium service of personally delivered prescription maps delivered by the agent also doubles as market research. Many companies are trying to figure out how to get farm data for free. Pioneer is combining it with a personalised service and turning it into a revenue stream.

Machinery Manufacturers

The three major farm machinery manufacturers are also getting involved in farm data collection. Selling the machines that do farm work, they have an inherent advantage over the agrichemical companies that would love to have access to on farm agronomic data as easily as they do. But like the chemical and seed producers, each of them has taken a different approach to collecting data.

John Deere

John Deere was the first large company to start collecting farm data *en masse*. It began shipping equipment equipped with telematics in 2011. Meeting with a Deere marketing representative in Moline, Illinois revealed that the original purpose of the Deere telematics solution, known as 'JD Link' is still its primary function today. This taken from one of the original JD Link Press Releases:

> *The new telematics system features the latest generation of JDLink equipment monitoring and the new Service ADVISOR™ Remote program. JDLink and Service ADVISOR Remote enable customers to remotely monitor conditions and status on their John Deere engine while allowing technicians to perform engine diagnostics and some repairs.* (John Deere, 2011)

The system provides Deere with several benefits including:

- It provides rapid feedback to Deere on the performance of their machines, allowing them to pick up issues and defects faster.
- It can allow for improvements in the manufacturing process.
- It gives insights into the way their machines are being used for their designers.
- It allows Deere dealers to provide remote diagnosis and support to their customers.

This meeting also revealed that the system has been a victim of its own success, growing exponentially as Deere both sold telematics equipped machines and fitted telematics to progressively more lines of equipment. Deere's servers have been flooded with ever increasing volumes of data, forcing engineers to focus on scaling the system instead of growing the services and insights that could be offered with all this data. The result is that the current solution does a lot to help Deere with its goals and business, but in the words of the representative, *'the service is a good two years behind where we wanted it to be*' in terms of customer interfacing services. (Schleusner, 2015)

AGCO

AgCo were not the first to market but they now have a telematics solution with their equipment that is comparable with the John Deere solution in the data it collects. AgCo does however have

a unique approach to the way it collects and transmits data. It collects data on machine performance and location in the same way and for similar reasons to Deere. The difference is that AgCo separates out machine data from crop production data and vows to merely transfer it to the software of the customers choosing and "*to not collect, store, view or use any of the (crop production) data*". (AGCO, 2015)

Case New Holland

Case New Holland Corporation (CaseNH) will be the last of the major agricultural machinery manufacturers to release their own integrated telematics solution across its range of equipment. A meeting with some researchers involved in the Open Ag Data Alliance (OADA) at Purdue University revealed this may not be a bad thing. Case NH was the first OEM to support the OADA (Auldt and Buckmiester, 2015) and is most likely going to be the first OEM to use completely open data standards to transfer information to and from its equipment (CaseIH, 2015).

Start-ups/ New Entrants

There is another category of businesses looking for access to farmers' data. Known as 'start-ups' these companies represent new money being invested in agriculture from non-traditional sources. It is fascinating to see new investment money from places such as Google Ventures and Accel partners - an investment firm that provided seed funding to Facebook, DropBox and others - flow into a very old industry.

Farmers Business Network

Meeting the two co-founders and head of product development at Silicon Valley start-up the 'Farmers Business Network' was an amazing insight into the innovative and disruptive attitudes coming across to agriculture from the technology world. As mentioned in the introduction to this chapter, FBN has investors with very little agricultural background and knowledge. When asked about why these investors are motivated to get into agriculture Co-founder Charles Baron said that '*Data has revolutionised or transformed every industry that is touched. They believe that agriculture will be the same.*' (Baron, 2015)

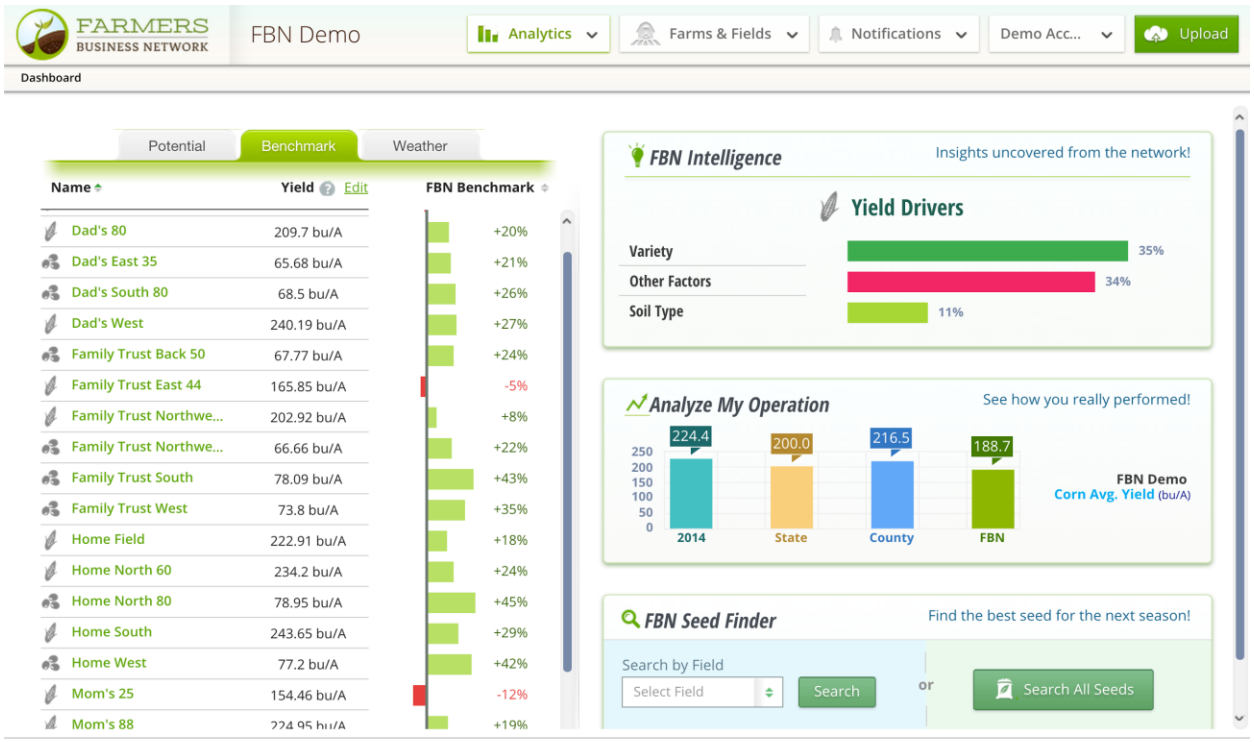

Figure 3 - Benchmarking farm performance using the FBN. (Magee, 2015)

FBN's approach to farm data was unique to every other business visited. FBN's product is a completely cloud based farm data management and benchmarking software for farmers. Once data is entered into the FBN it can be benchmarked; for example, corn hybrid yield data from a field can be benchmarked against other farms in the county and state. The software identifies the biggest correlations to yield variability, showing farmers what major factors may be costing them yield or efficiency. Subscription is $US500 per year, regardless of farm size. This is a compellingly cheap price point and farmers are currently FBN's only customers, meaning they do not sell or otherwise monetise farmer data. What they do however, is aggregate farmer data and allow farmers to benchmark their yields and performance against other farms with similar characteristics, such as soil, variety choice, location and other factors.

The business case laid out by Daniel Turkovich – Head of product at FBN was compelling:

> *'If you look at farming generally, million dollar businesses are dealing with billion dollar businesses and the billion dollar businesses have all the market information.'*

He then stated the goal of FBN was *'Giving information back to farmers and allowing them to make better decisions.*' (Turkovich, 2015)

Farmobile

Farmobile is another start-up company seeking to work with farm data. Another one of four organisations visited that have developed a device that sends machinery data to the cloud by plugging into the tractor/combines diagnostic system. The others being Climate Corp., Farmers Edge and OADA. Another unique business model, Farmobile charge farmers an annual subscription based on the number of devices they have and store their data in the cloud. The unique part of what Farmobile is doing lies within this quote from one of their brochures:

> "No safe-guards presently exist in agriculture for farm data. Farmobile set out to change this. We are the first company to provide farmers with true data ownership." (Farmobile, 2015)

Figure 4 – The Farmobile 'PUC' that gets mounted into farm machinery cabins. (Farmobile, 2016)

Rather than anonymising farm data and using it for other purposes, Farmobile are seeking to become a marketplace for farm data. They store farmers' data securely, then if organisations want access to farmer data they can make Farmobile offers (typically in $US/acre) for the portions of it they want. The selling point for Farmobile is that if (and only if) the farmer agrees to the sale the farmer will be paid, with Farmobile taking a commission.

FarmersEdge

In the words of CEO Wade Barnes, 'You are traditionally a hardware company, an agronomy company or a software company' and Canadian company FarmersEdge is seeking to be all three. With a much greater agronomic emphasis than the other independent companies visited, FarmersEdge offers several different packages for sale on a fee per acre basis. Charging for services this way is a model farmers are more familiar with, but can make using the service for large areas quite expensive. The cost of providing the software and necessary data hosting service for a 100 Ha field is not significantly different to providing it for a 50Ha field. FarmersEdge could potentially leave itself vulnerable in this way.

While being on the pricier side, FarmersEdge offer an array of agronomic offerings for various prices. FarmersEdge was the third company visited that has developed a solution to get machine information from a device plugged into customer's machinery. They also offer harvest map cleaning and analysis.

Chapter 5 – Raising Some Issues

Ownership or Access?

Essentially, once a copy of the data has been made available to another party then the original owner of the data has very little control of the data.' (Griffin, et al., 2015)

As the products and solutions mentioned in the previous chapter have become marketed more widely, there has been much discussion in rural media and amongst farmers around the issue of 'data ownership.' This is an issue that Australian farmers will encounter more and more as data collection technologies become increasingly commonplace. In trying to understand some of these issues we can learn a lot from the work the American Farm Bureau Federation (AFBF) has done around this issue.

The AFBF became involved in issues surrounding farmer generated data during 2013 and 2014. This was due to farmers getting concerned about clauses like the following in the contracts they were being asked to sign in their dealings with Agribusiness companies.

> *"If we use your data about your operation for purposes outside of consulting with your operation, we may aggregate and anonymize your data with similar data from other growers. (Thatcher, 2015)*

When researching the question 'who owns farmer data'? The experiences presented by the AFBFs Senior Director of Congressional Affairs, Mary Kay Thatcher the AFBF at the "Soil, Big Data and the Future of Agriculture" conference held in Canberra in July 2015 were identical to those encountered by the author during his travels. Every company queried on the ownership of farmer data gave variations on the same response 'Farmers own the data generated on their farm.' Everyone says the same thing. Farmers own their data. This might technically be true but it masks the real issue about the ownership of any kind of data.

As Dr. Terry Griffin from Kansas State University points out:

> '*Data is not like grain or other physical goods. For instance, a farmer can retain ownership of grain even when that grain is stored in an elevator comingled with other producers' grain. Data is electronic in nature as opposed to the physical characteristics of commodities or farmland. When copies of raw data are made, the copies are indistinguishable from the original and are considered identical****. Essentially, once a copy of the data has been made available to another party then the original owner of the data has very little control of the data****'* (Griffin, et al., 2015) – *Emphasis added.*

Owning the data created on farm is not the same thing as either controlling it or accessing it. The key issue for farmers is not who has ownership of the data generated on farm, but rather what

is being done with it. Take as an example this current policy statement from a large agribusiness company.

> *'We may anonymize Production Data to create anonymized data sets, unless you indicate that we may not do so via the MyJohnDeere.com account management options. Please note that we consider any anonymized datasets that result from our anonymization processes to be proprietary to John Deere. John Deere will be free to use, sell and disclose the anonymized datasets, and John Deere may offer or sell information and services that are derived from the anonymized datasets'.* (John Deere, 2014)

Robert Allen, a 2014 UK Nuffield Scholar provides an explanation as to what is going on here.

> *'Derived data are new datasets created by extracting information from raw data. In agriculture aggregated data are the most common form of derived data. Aggregation refers to the merging and degrading of raw data into a lower resolution output. Software providers offering services to many growers can, by default, generate archives of information on large acreages of land which have potential off-farm value when aggregated'. (Allen, 2015)*

The issue here is that farmers are being told data is owned by them. This may be mostly the case but farmers may be completely unaware their farm information is being aggregated and can be used to create products for an agribusiness company, or even on sold to a third party. There is nothing inherently wrong with agribusiness doing this, provided farmers are aware that data they have produced could be being turned into a potential asset by another company.

When asking farmers what they believed should happen to their data, the responses varied from carefree 'I don't care what happens to my data. If it can be used to make a product I might find useful then that's good.' To overly protective. 'That's my personal data and if I can't benefit from it then nobody can'. Whatever a farmer's position is between the extremes on this spectrum, most would agree they should be informed about what is happening to the data they have generated.

For further reading about the possibilities, nature of and problems associated with farm data ownership read the paper 'Big Data Considerations for Rural Property Professionals' by Dr. Terry W Griffin et al. from the Dept. of Agricultural Economics at Kansas State University.

Picking Winners – Which algorithm is best?

Another dilemma that will increasing be confronting farmers over the coming years is that of deciding which data analytics and solution provider is the most appropriate one for them. The author encountered several different companies offering products that assist farmers in generating variable rate seed and nitrogen applications in corn. Just a handful of these companies are:

- Climate Corporation – FieldView Pro
- Pioneer Corporation – Encirca Yield Nitrogen Management
- Winfield – R7 Tool.
- Simplot – SmartFarm.

These products have all been developed in the mid-west to help maximise corn farmer profitability. It seems inevitable that over time these products will be adopted for larger numbers of crops and larger numbers of areas.

The time will come when Australian farmers are presented with different choices about which, if any, of these solutions are effective. There is no obvious way for the effectiveness of these products to be independently assessed. The marketing and promotion of all these products focuses on their ability to either cut costs or increase yield though more targeted applications of seed and fertiliser. But their very nature means they cannot be compared side-by-side in a traditional replicated trial. These solutions are designed to be implemented at a whole field or farm scale. UK Nuffield Scholar Robert Allen describes the short-comings of traditional small replicated trials this way:

> *'These methods are not appropriate for analysing large observational datasets now being created. Observational datasets are by their very nature un-replicated, which means they fail the fundamentals of experimental design; i.e. randomisation, blocking and replication.'* (Allen, 2015)

Furthermore, different algorithms will perform differently in different conditions and seasons. One will be optimised for a slightly wetter climate, another for clay soil, another for loam. The best solution this year might cost a farmer money the next.

Allen points agriculture towards other fields such as the economics/econometrics to help in the quest to make the most of large amounts of un-replicated data (Allen, 2015). It seems that testing and interrogating these solutions will become a routine activity for farm based research organisations in the future.

Companies like those mentioned above have invested large amounts of research and development dollars in proprietary algorithms and may be reluctant to be completely open about these algorithms that make their solution successful. While it may go against their initial intuition, those that are transparent enough to show that their solutions are trustworthy will be the ones that see their products be a success and gain market share.

In defence of the poor multinational corporation

From the outset of this research a huge lingering question in the mind of the author was 'What's in it for them?' Many farmers interviewed also were questioning and even suspicious. 'What do

machinery manufacturers and chemical companies want with on farm data?' It turned out the answers to these questions were equal parts varied, counter-intuitive and fascinating.

The subject of 'Big Data in Agriculture' came up on two separate days during the 2015 Contemporary Scholars Conference in Reims, France. This author was taken aback during these sessions by the fear and mistrust of data collection technologies in the room. If these were agricultural leaders from the participating countries, then this did not bode well for the adaption of these technologies. This fear was even acknowledged during the authors visit to Climate Corp in St Louis, Missouri. (Bilby, 2015)

But when asked about their motivations for getting farmer data the interviewees at the Climate Corporation were candid.

> 'We need to give growers the best information to show them how to get the most out of their seeds.' (Das, 2015)

A comment like this may seem confronting to a farmer if taken at face value. Farmers themselves believe they know how to get the best out of the land that they farm. But there maybe something to it. The first ever 31.4 ton per hectare (500 bushel per acre) corn crop was grown in 2014 and that record was beaten again in 2015 with a 33.4 T/Ha (532 bu/ac) corn crop. This stands in a stark contrast to the US National Average of 10.6T/Ha (169 bu/ac) (Southeast Farm Press, 2015) The implication here suddenly becomes obvious. It is exorbitantly expensive to produce higher yielding corn varieties. Plant breeding technology is being hamstrung by overly risk-averse regulation. (Swift, 2015) There is little sense then in producing even higher yielding cultivars when the average US corn crop is yielding about 31% of its current genetic potential.

Perhaps there is a higher return for a research and development dollar by analysing farmer data and identifying ways that they could improve their management. These companies know how to get the most out of their seeds; what they do not know is why farmers are not getting the most out of their seeds. That is the motivation for trying to access farmer data.

If this is true for seed companies, then it is also true for agrichemical companies. This became apparent during a visit to the Digital Farming Team at Bayer Crop Science in Sao Paulo, Brazil. As in Australia, weed and insect resistance to chemical control is becoming a big issue for farmers in Brazil. If this is a concern for farmers it is also a concern for chemical manufacturers. New chemistries are likewise becoming increasingly rare and expensive to develop. Consider the new product released by Bayer 'Sakura'. Research has shown that under a deliberate misuse scenario weed populations can become resistant to it in as little as four generations. (Busi & Micallef, 2016) Bayer has a strong interest in this product being used correctly. It is much cheaper for an agrichemical company to still be selling farmers the same chemistry in 10 years than it is to develop another because of poor application practices.

An important issue to be recognised here is that farmers, often reluctantly, depend on large agribusiness, every bit as much as agribusiness depends on farmers continued income. Agribusiness has a direct interest ensuring we farmers use their products well and use them for the long term. Denying agribusiness the ability to innovate genetically through regulation and farmers denying it the ability to innovate though access to agronomic data risks driving up crop breeding and protection costs for everyone in the long term.

Chapter 6: Conclusion - Looking forward

> *Although of great potential importance, the Big Data phrase also is the latest buzzword to capture media attention. Interestingly, there seems to be a continual pattern in how we respond to such phenomenon; we tend to* ***over****estimate the potential initial impact and* ***under****estimate the long-run effect. Both perceptions can lead managers astray.* (Sonka, 2015)

This chapter discusses some of the longer-term potential impacts of big data arriving in agriculture. These are impacts beyond simply better seed or fertiliser management, which may be where farmers will often start when they are using data collection technology.

Farm Management

A common theme that emerged during the author's research was the impact that Big Data analysis and research could potentially have on farm management. In Chapter 3 'Big Data' was defined by Steve Sonka, Emeritus Chaired Professor of Agricultural Strategy at the University of Illinois as *'the capability to extract information and insights where previously it was economically, if not technically, not possible to do so.' (Sonka, 2015)*

Sonka notes further on in his paper that the economic part of his definition is what is changing dramatically.

> *Historically acquiring data on the farm's own operations was expensive. Therefore, we developed very sophisticated decision systems at the farm level, which enabled managers to make good decisions with relatively sparse data. However, Big Data offers the potential to dramatically lower the cost of data acquisition.* (Sonka, 2015)

If data on all aspects of a farm's performance can be collected at near zero cost, then what becomes of a farmer's ability to make good decisions based on limited information? In some cases, 'Big Data' will be as much a social challenge for the farmer as a technical one. The qualities that made a farmer succeed in the past may not be as useful on a data-rich farm. Farmers may need to re-evaluate their own strengths and weaknesses in order to achieve the best outcomes.

Sonka reinforced this point again in a face to face interview when he said:

> *'Big Data is diminishing the experience advantage in agriculture. It allows people to farm land and now know the history of the land.'* (Sonka, 2015)

What is often a farmer's greatest asset – decades of experience – may be less useful when the best and poorest performing areas of a farm can be identified through historical satellite imagery, soil mapping and nutrient testing. This sentiment was echoed by professors at Purdue University.

"Farms that can harvest that logistics and production data will be the ones to make the most money going forward. (Buckmaster, 2015)

The skills that farmers need to succeed may be changing. 'Big Data' may lower the barriers to farm management entry, by removing the advantage of experience and knowledge of local conditions. Farmers traditionally pride themselves on 'gut feel' and intuition. In a data driven agricultural world they will need to add the less 'feel good' skills of business data analysis and interpretation to their repertoire. Those businesses that manage to combine both analysis and intuition will become leaders in their field.

Data as a revenue source

Throughout the authors travels another issue that kept coming up was the idea that farmers should own and control their data and therefore earn royalties in exchange for its use. The American Farm Bureau Federation's agreement with agricultural technology providers (ATPs), 'Privacy and Security Principles for Farm Data', states that those with an economic interest in farm data should only use it when they have the farmers consent to do so. (American Farm Bureau Federation, 2015) The author also visited two start-up companies detailed in Chapter 4 that are investing millions of dollars in the idea that farm data is valuable and that value can be passed back to farmers.

Despite this the author's research was inconclusive on whether farmers could ever expect their data to become a supplementary income stream. Kansas State University researchers deal with some of the issues around monetarily valuing data in the paper '*Big Data Considerations for Rural Property Professionals* (Griffin, et al., 2015)'. It is difficult, they reason, to value data, not only because of the ownership issues discussed in Chapter 5, but also because data can be copied at almost zero cost. If multiple entities hold a copy of a farm dataset, who then holds the value; the original creator, or the holder of the identical copy?

Another mid-western professor also expressed major reservations about this idea, stating in an interview that farmers are never going to be paid for data in a meaningful way. (Sonka, 2015)

So it remains to be seen which understanding of farm data will prevail. These academics and others interviewed, all believed that having readily available access to business performance information was where the real money was going to be made with farm data. The real value is not in the raw data itself, but rather in how a farmers understanding of what happens within their own business is enhanced by evidence-based data.

Commodity Markets

The ability of farm machinery manufacturers (OEMs) to collect data as farmers enter their fields and begin to harvest crops has been viewed as a potential threat by some farmers. Chapter 5 in this report describes how companies can anonymise farm data and it has been feared that this anonymised data could be used to trade futures and options in various commodity markets around the world. The theory goes that if OEMs know what is being harvested over large areas, they may have access to better market information than farmers and other traders in the marketplace and maybe able to use this market information to their profit, potentially at the expense of the very people that supplied them their farm data. Either by trading themselves or selling the information to a third party who could profitably trade commodities.

The American Farm Bureau Federation was so concerned about this possibility that it was explicitly mentioned in the AFBFs 'Privacy and Security Principles for Farm Data' agreement with these agricultural technology providers (ATPs), as indicated in the following extract from this agreement:

> ***Unlawful or Anti-Competitive Activities****: ATPs should not use the data for unlawful or anticompetitive activities, such as a prohibition on the use of farm data by the ATP to speculate in commodity markets.* (American Farm Bureau Federation, 2015)

While this sort of behaviour may be a technical and legal possibility, there are two powerful reasons that this is unlikely to ever be a significant issue either in Australia or the USA. The first is that if evidence of this behaviour ever were to become public, farmers would cut off their supply of data to these OEMs very quickly. This is a powerful disincentive to them as they depend on this data for many other reasons highlighted in previous chapters.

Secondly, it seems likely that commodity market participants can already obtain all the crop health related information they require legally and in a much simpler way than by collating potentially inaccurate and disparate farm data information from across large regions. It was implied during a meeting with Fred Seamon, Senior Director of Grains and Oilseeds at the CME Group, that the serious commodity trade participants are already using satellite imagery to better understand crop growing conditions across counties/shires, countries and continents. This is a much more simplified approach compared with using farm data for this purpose.

Farm level data just simply is not relevant to commodity traders. It is too detailed and 'noisy' to be useful to them. They need to know how events and seasons are unfolding across entire regions and they can now get this data as they need it via ever improving satellite services. Farm-level data is relevant to farmers. If global agribusiness can use satellite data for planning and informing their business, then surely farmers can do the same.

Supply Chain Disruption

The author encountered another surprising implication of using big data technologies during this research. The possibility of supply chain disruption for both farm inputs and produce. This is worth noting, as this is one of the longer term impacts of data use within agriculture that many have not seen coming and it will have significant impacts on many rural businesses.

This idea was first raised during the author's studies in a conversation at Kansas State University with Assistant Professor of Agricultural Economics Dr. Terry Griffin. Dr. Griffin introduced the author to the concept of 'economic rent'. Wikipedia describes economic rent as "any payment made (including imputed value) or benefit received for non-produced inputs such as location (land) and for assets formed by creating official privilege over natural opportunities." (Wikipedia, 2016) The problem, Dr Griffin suggests, is that ATPs are trying to use their farm data related products to create an artificial scarcity using an input, namely farmer generated data, which is easily copied. (Griffin D. T., 2015)

Farmers the world over are all too familiar with players further up the agricultural supply chain taking out a disproportionate piece of farm income. An example of this is the way the costs of agrichemicals drop markedly after their original manufacturers patent runs out. So this issue is not a particularly new one for agriculture, but Dr. Griffin pointed out that data in other industries has destroyed the economic rents of previously very profitable supply chains. The way that Apple Inc. disrupted the music industry with its iTunes store is one example of this. Dr Griffin also cited another example that interested the author.

Amazon Inc. has disrupted, amongst other things, the book publishing and retail markets by publishing books and selling them direct to customers online. With a significantly lower cost base compared to traditional 'bricks and mortar' stores savings could be passed onto consumers, gaining Amazon a huge market share and influence in this industry. Dr Griffin was implying that similar disruption could happen to agricultural supply chains. (Griffin, 2015)

It was stunning then to visit the Farmers Business Network (FBN) in Silicon Valley in California as the author's last overseas visit for these studies. The meeting with Daniel Turkovich, Head of Product at FBN had none of Dr. Griffin's economic terminology but all the implications he was suggesting. The FBN approach is best summarised by the following quote from the meeting. *'If you look at farming, million dollar businesses are dealing with billion dollar businesses and the billion dollar businesses have all the market information* (Turkovich, 2015)*.'* This theme was echoed in a January 2016 FBN blog post announcing a new product 'FBN Procurement Services.'

> *"Most multi-million dollar businesses have specialists employed to manage procurement, but farmers lack these resources." "Through FBN Procurement Services, we put that purchasing power back into farmers' hands. (Zook, 2016)"*

With benchmarking data from a myriad of different farm businesses across the United States, FBN now possesses real-time information on farm input prices across the USA. It can show its farmer members this information through its benchmarking service, handing back market information to farmers. Taking this a step further, FBN can now use this data to go straight to input manufacturers and organise direct marketing from input factories or importers, bypassing the regular distribution networks. FBN claims price reductions of farm inputs between 15-40% using this model (Zook, 2016). Even if typical savings are on the lower end of this estimate, this is enough to make a huge difference to farm profitability, but at the same time to disrupt many input supplier relationships.

It may be some years before similar business models get established in Australia, but when it happens farmers will welcome increased competition for their business.

Recommendations

1. Farmers should reflect on their own skillsets; what they know about their business and what they would like to know more about. Once they identify these weaknesses they can start to use data collection technology to understand a problem more fully.

2. Using algorithms generated from farmer data for applying farm inputs such as fertiliser and seed hold much promise for improved farm management. Understanding these new products in an Australian context will be a challenge initially. Farm research organisations will need to gain experience and research these new tools as they are released in order to prove their suitability in our Australian context.

3. Reliable and openly accessible soil and climate data underpin agricultural decision support systems. The Australian Farm Institute recently found that '*Australian governments should increase available funding for soil mapping and weather recording stations*.' (Australian Farm Institute, 2016) This author completely agrees. Better data will underpin better research outcomes and on farm decisions.

4. Language in current contracts and legal agreements regarding farmer data and its uses is full of jargon and difficult to find much less understand. Plain language descriptions of uses for farm data should be used in all contracts with farmers. Where these are not provided farmers should seek clarification on meaning prior to signing.

5. All agricultural technology providers should wherever possible use the open data standards being developed and promoted by the Open Agriculture Data Alliance in the USA.

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Plain English Compendium Summary

Project Title:	The Data Farm - An investigation of the implications of collecting data on farm.
Nuffield Australia Project No.:	
Scholar:	Jonathan Dyer
Organisation:	Nuffield Australia / Rural Finance Corporation
Phone:	0353922691
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Objectives	The objectives of this research were to: • Investigate ways for farmers to use data they are collecting on farm. • Understand why third parties are interested in gaining access to farmer's data. • Provide some understanding of who benefits from collecting farm data. • Investigate the broader implications for 'Big Data' technology in agriculture.
Background	Farmers are increasingly able to collect data about all aspects of a farms performance. This report investigates the opportunities for farmers to use farm data profitably and the issues they will encounter while doing so.
Research	This research was conducted during 20 weeks of international travel during 2015. Research was conducted to better understand how farmers could better collect and use data on farm. Countries visited were France, England, USA, Mexico, Brazil, New Zealand Israel, Canada and several domestic visits in Australia.
Outcomes	A report on how farmers can use the data they generate on farm, an understanding into why agribusiness wants insights and access to farmer data and some of the longer term implications of digital technologies within agriculture.

Implications	This report should clear up some confusion around data use on farm, who can access it and why they want it. It should give farmers confidence to ask questions about data and a reason to start using it themselves. In the future access to data will change agriculture, just as it has changed many other industries.
Publications	SPAA Expo – Horsham - 2015 LEADA Field Day – 2016 Nuffield Australia National Conference - 2016