Tracing farmers' exploitation, alienation and agency through technology

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This thesis is submitted in total fulfilment of the requirement for the degree of

Doctor of Philosophy

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March 2020

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Abstract

Grain growers are caught in a system of production which is characterised by the privatisation of the farm services sector, global trade, machinery automation, and technologies. The commodity chain is structured so that costs are passed on to farmers through what they buy and sell. As a consequence of this structure, farmers are exploited and subject to the condition of alienation.

Previous research has revealed the challenges of farm-scale efficiencies and the demise of rural areas due to farmer-exodus. Since Kautsky's original publication of *The Agrarian Question* in 1899, there is still limited material offering a new sociological understanding of farming and the humanistic effects of farm trade. Therefore, this doctoral study is about farmer-exploitation, alienation, and agency, together with the role of political economy, and the function of the commodity chain. It draws upon historical works from labour theorists to seek a better understanding of the humanism of work and participation in commerce in reference to the relations and networks that exist through farming.

To trace farmers and their operations, this research uses actor network theory by deploying some of the methods that sit within this approach. Reflexive photography creates a hybrid method with digital images supporting the findings. The photographs in this thesis help to transport the reader to the research setting that is family operated grain growing farms.

The key findings are that agency is a property of farmers, land and their machinery. It was found that technology and science facilitated farmer-agency to re-arrange humans and non-humans to hold science stable on farm through strong networks. Technology is responsible for facilitating farmer-agency, which is used as a tool and then it becomes a force, to exert control over farm production. This thesis makes a significant contribution in understanding modern farmer exploitation and how farmers can work to overcome their vulnerability in socio-political economy.

This research is place-specific in the dryland agricultural zone of the Wimmera Southern Mallee region of Victoria, but it contributes to a global understanding of what makes farmers act.

Statement of authorship and originality

Except where explicit reference is made in the text of the thesis, this thesis contains no material published elsewhere or extracted in whole or in part from a thesis by which I have qualified for or been awarded another degree or diploma. No other person's work has been relied upon or used without due acknowledgment in the main text and bibliography of the thesis. No editorial assistance has been received in the production of the thesis without due acknowledgement. Except where duly referred to, the thesis does not include material with copyright provisions or requiring copyright approvals.

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Signed by Amity Ballantyne Carolyn Latham

27th March 2020.

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Date

Acknowledgements

The personal journey of writing a thesis has been transformational. With sincere gratitude I acknowledge the people and organisations who have made this research possible.

Foremost, this research was generously funded by Regional Development Australia (RDA) Grampians Region to grapple with the contemporary social issues of rural population decline and dispersal. I was supported by an Australian Government Research Training Program (RTP) Stipend and RTP Fee-Offset Scholarship through Federation University Australia. For facilitating the RISER scholarship program, I sincerely thank RDA Grampians Region Chair, Stuart Benjamin, and the board members. I also extend my gratitude to the Wimmera Development Association board and executive, as well as Federation University Australia. Thank you to all for having the foresight to invest in place-based regional and rural research through RISER.

A heartfelt thank-you is extended to my Principal Supervisor Professor Keir Reeves. Any kind words I offer about Keir's inquiry, experience, aptitude, camaraderie and agency will fall short of reality. It has been a joy and an honour to be one of his students. RISER was pioneered by my former Principal Supervisor, Dr. Timothy Harrison. His dedication to rural research and his efforts to create and obtain funding for this entity made my scholarship and this thesis possible, for which I will always be grateful. I also offer sincere thanks to my Associate Supervisor, Professor John McDonald. John was an excellent source of intellect and wisdom for the conclusion of this journey. It was a privilege to co-author and publish a paper with both John and Keir, and to present this research at the 2019 EPIC conference at Providence, Rhode Island. I wish John all the best for his future as Executive Dean at Charles Sturt University in Wagga Wagga.

On my Horsham campus it was a pleasure to teach and research alongside my fellow RISER colleagues and friends Cathy Tischler and Amy Isham. Bachelor of Social Science liaison officer, Leonie Barnett, offered endless encouragement and sensible advice over the three and a half years. Head librarian Ann Jardine, and Janelle Patterson, lent me not only books but their ears. I wish to thank Peggy Hsu, Cheryl Claridge, Kay Steel and Robert Watson for traveling to Horsham to support RISER's academic development. Wendy Wright and Lauren James, from Research Services were immensely valuable for their advice and assistance. And finally, a sincere thank you to our Head of Campus, Professor Geoffrey Lord for his unwavering research support through his community connections, his positive perspective, and a place for RISER to feel at home on campus.

A commitment to study doesn't just involve the person enrolled, rather it is a team effort. My children Clive and Camilla have been exceptionally thoughtful, patient and caring. The sticky notes left on my desk offering kind words of encouragement always made me smile. My husband Tom is the most inquiring and hard-working farmer I have ever known, so I hope that this thesis reflects the narrative of what it takes to be a modern farmer. An extended thanks also goes to my

family members: Penny and James, Sue and Tom Snr, April, Woody, Helen, and Mandy, for each demonstrating their unwavering support throughout this academic journey and for taking an interest in what I was writing. And most importantly to my mother, Rosemary Latham, a fellow graduate of Federation University Australia (formerly Ballarat Centre of Advanced Education). As a child I remember watching her study a Bachelor of Business (Accounting) late each night and on the weekends. It was her belief in education that has somewhat led to me down this path. I am indebted to her as role model and her ability to listen without judgement nor prejudice throughout my academic journey.

Even though studying mostly from my farm office has indeed felt isolating at times, I've had genuine friends keen to listen and ask about my progress: Kym and Julie Lyons, Trish Flynn, Lisa Cameron, Robyn Gulline, Dani Smith, Emily Smith, Michelle Hair, Nicole McDonald, Geoff Park, Steve Wickson, Alana Johnson, Angus Hume, Patricia Geraghty, Joan Lily, Peta Maddy, Kelsey McDonald and my Bachelor of Social Science students. Two great supporters passed during this PhD journey sadly missing out on my findings: Mallee farmer Peter Robins and VCMC project manager Dr. Phil Wallis. The Collaborative Research Centre in Australian History (CRCAH) offered a broader research network with like-minded scholars, as well as a connection with the *Before/Now* editorial team in the last few months leading up to completion.

I would also like to thank all of my research participants, for trusting me and the process of actor network theory as it was exceptionally hard to explain in lay terms. Their faith in my observations, photos and casual conversations during the months of fieldwork made this thesis possible. A heartfelt thank you is extended to Robyn, Barry and Warren Blake; Lachie Lang; Damien Ricketts and the staff at Emmetts Machinery; Ashley Lynch and Pioneer Seeds; Craig Cleary from Rural Bank; John Simpson, Laura Maher, Steve Todd and Trevor Gillespie from Cargill, as well as the other participants who were either knowingly or unknowingly traced along the way as part of the research method.

The Wimmera and Southern Mallee offers unique opportunities for prosperity with scope to embrace innovation. I hope that my PhD demonstrates just how much social capacity sits within the region and the power that lies within us.

Thank you to all.

List of abbreviations

ACUP	Australian Chemical Users Permit
Ag Vic	The Victorian Department of Jobs, Precincts and Regions (as of 1 January 2019) formerly Department of Economic Development, Jobs, Transport and Resources, commonly known as Agriculture Victoria
ANT	Actor Network Theory or Actor-Network Theory
APVMA	Australian Pesticides and Veterinary Medicines Authority
BAS	Business Activity Statement
BCG	Birchip Cropping Group
CFA	Country Fire Authority
CTF	Controlled Traffic Farming
DSLR	Digital Single Lens Reflex
EPR	End Point Royalties
EU	European Union
FTA	Free Trade Agreements
GI	Geographical Indicators
GM	Genetically Modified
GPS	Global Positioning System
GRDC	Grains Research and Development Corporation
GRN	Growers' Registration Number
ha	Hectare
JD	John Deere
MRL	Maximum Residue Limit
NDVI	Normalised Difference Vegetation Index
NGR	National Growers Registration
PBR	Plant Breeders' Rights
PC	Personal Computer
RDA	Regional Development Australia
SP	Self-propelled
VIC (Vic)	Victoria
WDA	Wimmera Development Association
WSM	Wimmera Southern Mallee

Glossary

Agency	A human sense and a concept that it's possible to reshape the way things are by purposefully redirecting one's actions.
Air cart	Also referred to as a commodity bin, an air-cart is a fan-forced trailing wagon that holds seed and fertilizer for sowing.
Air seeder	Traditionally gravity fed, an air seeder is the planting equipment for sowing seed. They may have discs, shears or knife points to cut the soil for seed placement. Connected with tubes, the seed is pressurized from the cart which relay the seed into the sowing boots.
Boom-sprayer	A boom-sprayer, or boom-spray, is a trailing implement used to apply liquid fertilizers, pesticides, herbicides, fungicides and trace elements to crops and weeds during their vegetative cycle. The boom height and nozzles are adjustable to ensure that crops receive the correct amount of the liquid. A tractor is generally selected as the prime mover for large applications.
Cash on day sales contract	Farmers can elect to sell their physical commodities at the point delivery to the grain buyer. This form of marketing refers not only to elevator companies and processors buying products but also to the organized cash sales at commodity exchanges and over-the-counter cash trading.
Commodity chain	The commodity chain links farm production to world markets through the processes and systems used by agricultural organisations to gather resources, transform them into goods or commodities, and finally, distribute them to consumers while making a profit through each stage.
Crop-topping	Crop-top, crop-topping, and top dressing are verbs used to describe the application of herbicide to a mature crop to avoid weed seed set the following sowing season.
Deferred merchandise account	Rather than using cash or an overdraft to pay for inputs, some agricultural resellers offer clients a payment deferral account. The account is cumulative, allowing farmers to postpone paying for inputs until after harvest and manage cash flow. Deferred merchandise accounts generally offer a lower interest rate than an overdraft with a bank or rural lending institute.
Header	Also referred to as a combine harvester or combine, the term header is used in Australia to describe the self-propelled harvesting machine that de-heads the crops, separating the seed from the dried plant material. The grain tank

	stores the seed and the chopper and chaff spreader release the straw from the rear of the machine.
Grain receiving site	Grain receival, receiving centres, or sites are equivalent to grain elevators in the USA. Trucks deliver grain to these sites from farms. They are often located on railway lines for haulage to port. These sites are where the physical trading of grain takes place between growers and grain buyers. They feature silos, bunkers, weigh bridges and test stations. Various private grain buyers operate these sites, depending on the State and grain buyers' competition.
Maximum residue limit	The maximum residue limit, or maximum residue level, is the maximum amount of chemical residue that is expected to remain on delivered commodities that will not be a concern to human health.
Paddock	Paddock is the Australian word used for a field. It is a fenced space used by farmers for cropping or grazing, or a combination of both enterprises.
Pre-emergent	A pre-emergent is one herbicide application to the crop prior to its emergence from the soil, or even prior to it being sown, to kill the weeds that are growing from the summer into the autumn sowing period. A pre-emergent minimises the competition for the new crop during its first stages of growth.
Post-emergent	A post-emergent is a targeted herbicide which does not affect the growing crop, but targets weeds that are a different classification. For example, a post emergent may be applied to broad weeds in a grass crop.
Reseller	A reseller is an agricultural agency which buys farm inputs, such as chemical and fertiliser from a wholesaler, and re-sells the products to farmers. Resellers may offer agronomic advice as a fee for service, or build their agronomic capacity into the price that farmers pay for the product. The term reseller is interchangeable with retailer.
Seeder	Refer to air seeder.
Sowing	Sowing is the act of mechanically planting seeds in the soil during the cropping window. In the Wimmera Southern Mallee winter crops are generally sown from April to June.

Self-propelled sprayer	An SP sprayer is one stand-alone item of machinery used for boom-spray applications. In the cabin, the machinery software can be compatible with the header and the tractors for farm data management.
Ute	A ute is the Australian abbreviation for a utility vehicle that features a tray back for tools and slide on and off equipment, such as a fire-fighting tank. The American equivalent is a pick-up truck.
Sowing window	The sowing window is the optimal period of time for sowing the crop.
Supply chain	The sequence of processes involved in the production and distribution of a commodity.

Preface

This thesis was written at a time of heightened anti-farmer sentiment in Australia during the second decade of the 21st Century. There was a shift in consumer perspectives. Rather than seeking farming efficiencies, there was a new movement that emphasised farm substitution. Plant-based meat became the solution to mitigate climate change. Animal-ethics activists trespassed on farms; they released farm animals and hid cameras in livestock sheds. Campaigns called for global veganism. A website marked every grazing farm and abattoir with a GPS drop-pin.

Farmers felt targeted through these modes of dissent, which spurred industry groups to promote and justify Australian farmers through more than 50 campaigns. As a result, tens of millions of dollars are currently being spent by industry and government promoting agriculture's credentials to the public as a counter-attack on the issues such as climate change, chemical use, land clearing, irrigation and animal welfare.

How this investment in community trust will work in favour for farmers is yet to be measured. It's a long-term spend to seek to change the opinions of younger generations of socially informed metropolitan Australians. The greatest challenge is that only a minority of the public comprehend that most of time farmers comply with all of the governing regulations imposed on their production. The divide between the country and the city seems to be widening.

This thesis has been prepared to place farmers' exploitation at the centre of socio-cultural political arguments. In doing so it challenges the prevailing and possibly increasing invisibility of the Australian grain grower.

INTRODUCTION

Tracing farmers' exploitation, alienation, and agency through technology

Concept

According to Karl Kautsky's *The Agrarian Question*, economists have long been preoccupied with the issues of farm ownership and management. The debates over economically feasible farm sizes are enduring and market failure is said to explain farmer-exodus and subsequent rural population decline. Agriculture has indisputably developed enormously, but not according to the pattern traced by industry, rather it follows its own laws (Kautsky 1988). Kautsky seeks to explain how agriculture develops under these laws of development by studying small-scale commodity producers and observing the structures that enabled them to operate. This research follows on from the ideas of Kautsky's original publication in 1899, noting that there is limited material offering a new sociological understanding of farming. Australian agricultural research into plant, animal and soil science is superior. However this sentiment cannot be shared in regard to the social science of crop production.

This PhD study commits to a sociological analysis of modern farming in the Wimmera Southern Mallee region of Victoria. It is guided by political and economic principles that Australian farmers operate in a free market. The premise for this study is that farmers, and more specifically grain growers, are exploited through the structures of the commodity chain subjecting them to the condition of alienation. I argue that technology enables agency among grain farmers and in the process it overcomes this exploitative nature of the modern agricultural economy. This thesis asks the research questions about how farmers use technology to exert control over their production in order to overcome their exploitation.

Farmer-exodus may be related to the humanistic conditions of commodity production more so than the economic challenges it offers. This doctoral study investigates farmers and their operations, and the kind of relations that exist to make farms function. This PhD research explores the stability of farmers' network relations by tracing humans, non-humans and/or objects, and their obligations, origination and alliances. The purpose of this research is to work towards an in-depth understanding of the relationships that farmers generate to overcome the exploitative and capitalist nature of political economy. How farmers operate their farms within the commodity chain offers insight into what they can and cannot control.

Alienation is used as the theoretical and humanistic tool to explain farming experiences. Alienation marshals meaning in humans' relations with their product, their work processes, themselves and their social connections. The theory surmises that humans have no control and they wholly submit to their position as a worker under capitalism. This research relies on a range of guiding principles and epistemological judgements by using an actor network approach to go

beyond readily accepted assumptions. This approach to study farming offers new perspectives on the everyday practices of grain production. It makes farming specialised when bulk commodity production is very much generalised. It seeks meaning in farmers' relations to draw conclusions pertaining to the humanistic effects of broad-acre farm production. Actor networks create a coherent account of the complex assemblage without separating the natural from the social, and the economic from the material. The discussion is non-linear and unpredictable as the observations from the field unravel sequences. The data offers complete descriptions of the actors that are employed in crop production, harvest, and the sale of commodities. The agentic elements are identified and explored in depth to determine farmers' ideological and economic alliances to help explain how things are held in place and come to exist on farms. Numerous data points offer relevance and significance to understand what makes farmers act. Semiotics are relied upon to help explain farming relations in the Wimmera Southern Mallee.

The photographs in this doctoral study supplement the observations and interviews with farmers. These digital images serve as a record of material elements of the research setting. They explicitly document farm practices using machinery and technology in order to provide the reader with a visual sense of the complexity of farming in the Wimmera. This means that actor network theory together with the photographs are a hybrid methodology. Together they present data and findings that offer the reader an open and meticulous insight into farming without distinctions and hierarchies. The reader is presented with a detailed account of farm operations with the aim to transport them into the research setting.

This thesis presents two different language styles – the infra-language of actor network theory as well as Australian agricultural and farming terminology. This thesis must communicate effectively with the lay person, with no previous farming experience. To bridge these languages, clarification is required to define and re-define meanings throughout the document. Actor network theory was deliberately selected for this study because it accounts for the importance of non-humans in explaining the social context of farming in the Wimmera Southern Mallee. It also alleviates some interview bias from the reflexive researcher because actor network theory as a methodology isn't shaped nor tailored in the same way as formulating research questions.

Whilst this ethnographic research offers a place-based perspective of the Wimmera Southern Mallee region of Victoria, specifically the median rainfall zone of the southern Wimmera, it's equally relevant and applicable to other regions of Australia and internationally as it contributes to global ethnographic understanding of what matters to farmers and their relations through technology.

Researcher's position

This study relied on insider-research. My background in this subject contributes to a longitudinal understanding of networks on farms and agricultural science. I am a farmer,

landholder and a grain grower. I live on a family farm in the southern Wimmera and my livelihood depends on grain and hay production. I've worked as a private agricultural practice change consultant in no-tillage cropping, controlled traffic farming systems, and in dairy. I formerly owned and operated my own farm machinery hire business specialising in technical precision planters. I worked for The Lion Group of Malaysia for two years, advising on machinery units for peanut, soy and corn plantations on economic land concessions in Cambodia. I have worked on and off for the Victorian Department of Agriculture in community capacity building, farm economics software and plague locust response. I coordinated the farm apprentice program at Longerenong, the local vocational agricultural college. My career commenced with farm forestry trials in saline soil for economic development in the Central West of New South Wales.

Throughout this twenty year career span, I have always lived and worked in rural areas. Through my work and communities I have been connected with farmers and farming families in positions where they have shared their feelings of economic vulnerability and workplace stress. These formative experiences with a broad range of farmers and their enterprises, have provided the motivational forces driving this doctoral study. My position as an insider-researcher are woven throughout this thesis to add value to the findings and the theoretical discussion.

Themes

This thesis marshals six themes in order to question how farmers exert control over their production and to argue that technology enables agency. The nature and scope of this doctoral study is broad and requires a scaffolding to run throughout the thesis. This framework applies a re-interpretation of the Marxist theory of alienation in relation to the practices of modern farming. The approaches to actor network theory contributes to the research context to connect the idea of farmers' material relations with non-humans such as machinery, technology and land. The purpose of a conceptual framework is to provide reference for the research by aligning the epistemology, ontology and methodology. The conceptual framework for this thesis draws upon Smyth (2002, 2004) to fulfil certain conditions necessary to ensure the credibility of the framework as a research tool to support the investigation. "It is recognition through metacognition that tentative theorising can lead to the creation of new knowledge" (Berman and Smyth 2015 p. 127). The following themes are introduced to elucidate this conceptual framework and bridge the document for argumentative coherence.

Political economy

Political economy is constituted by human capacity using biological, mechanical and chemical engineering to overcome the natural obstacles of production. This is indeed true for Australia because the agricultural industry is characterised by farmers' capacity to produce. Yet

this farm production outcome is considered a joint-effort. It is said to exist from the capability, research, innovation and the presence of the services sector, not just farmers' capabilities alone. The services sector consists of agencies that support farmers to supply the market and this economic activity in the agro-food complex is ruled by the capitalist mode of production. Moreover, the antithesis between farmers as land owners and the farm services as wage-proletariat offers an antagonism in this present day.

Australian grain growers may be localised on individual farm units however they operate within the broader structures of the global political economy. Farmers control their businesses. They advance their agricultural production through science, technology and financial management to be competitive over time. The interaction of farmers with members from the farm services sector, as well as their machinery and technology, sheds light on the structure and dynamics of farms. This doctoral study examines these relations providing for farmers' continuity under the capitalist mode of agriculture that exploits them without forcing them to sell their assets and exit the industry.

In this thesis political economy is used to explain the relationship between politics and the economy while also delineating the broad structures that have led to the globalisation of agriculture. As a construct it rests upon production, which in turn relates to human nature and humans' capacity to take natural resources and transform them into goods for sale. Higgins states that the structural transformation of on farm production "leads to a loss of agency by small-scale commodity producers as global agribusiness conglomerates exercise increasing control over the agri-food system" (Buttel et al., 1990; Le Heron, 1993; Bonanno et al., 1994; McMichael, 2000 in Higgins 2006 p. 51). Yet while political economy is necessary, it often fails to grapple with the interaction of farm level particularities in the context of these larger structures (Busch and Juska 1997).

Political economy reveals the arguments about the way in which farmers are positioned (Harvey 2016). The term political economy is often used synonymously with economics to indicate matters that study resource allocation and the determination of aggregate economic activity (Jayaraj 2012). It is overtly simple to argue that the requisite scale of efficiency to meet the pressures of globalisation is what is responsible for farmer exodus. In order to understand capital the contradicting unity of production and self-realisation needs to be defined (Harvey 2016). This contradiction can be seen in the simultaneous rises of bulk commodity prices and rise in land values and input prices.

A critical political economy assumes the existence of atomistic individuals, but it does not explain why humans and corporate actors enrol in projects that lead to dependence, such as re-purchasing hybrid seed. The works of Marx, specifically his earlier writing and *Capital Vol 1*, is relevant as a framework for contemporary social inquiry. This is because "key features of nineteenth century capitalism are clearly recognizable, and even more strongly developed, in the

early twenty first century" (Jayaraj 2012 p. 9). Marx wanted to show how the functioning of the market expropriates value from the working class. Marx did not attribute this capture of surplus value to bad behaviour on the part of individuals, but to the impersonal functioning of a class system (Shonfield 1965). Marx focussed on macro-economics, employing groups such as state and class to explain social phenomena. The basic tenet of all phenomena concerned with social change is on the economic system of the society and its ramifications (Jayaraj 2012).

Globalisation has led to farmers being forced to engage in the production process, distribution and consumption of transportable bulk commodities. Under these conditions, with cartels, free trade agreements, and the floating of the Australian dollar since the 1980's, farmers are colloquially said to compete on a global playing field. Farmers' vulnerability to worldwide supply and demand has been held accountable as the force driving farm-size expansion that is directly correlated with farmer-exodus. Critical agricultural capitalism consists of fewer producers, greater production and a stronger economy. This capitalist mode of agriculture has happened outside farming. Agricultural reproduction is not infinite; the sector consists of unrestricted actors participating in the pursuit of capital gain. Thus rather than a closed-loop of production with nature it is more spiral-like and out of control. Harvey (speech 2016) refers to this as bad infinity.

Commodity chain

Primary production is significant for Australian domestic and export trade. In 2015 over one quarter of the agriculture production sector consisted of grain, pulses and oilseeds (Kalisch Gordon 2016). According to the National Farmers Federation (2017) there are approximately 85,600 farm businesses with 304,200 people directly employed in Australian agriculture. In the 2016-17 financial year the gross value of farm production was valued at $60 billion dollars and contributed 3% to Gross Domestic Product (ABARES Dec 2017).

The organisational structure of agriculture is referred to as a commodity chain. Also known as a supply chain, the commodity chain enables farmers to produce near-identical bulk commodities and to safeguard national commodity production. Farming practices are moderated by others in this chain even when connections seem implausible. For cropping these chains consist of farmers and the services sector. The sector is positioned between growers and food processors. The purpose of farm services is to increase farm productivity and profitability. The farm services market is structured by agronomists, training, freight, farm finance, machinery and equipment manufacturing, sale and repairs, research and development, grower extension groups, farming contractors, print and social media, real estate and farm technology to name a few. These organisations are positioned in the economy by farmers paying for their service. Payments take a range of forms including levies, end point royalties, plant breeder's rights, subscriptions, fee for services, retail, value-adding, and research funding.

In recent decades the Victorian State government retreated from the provision of farm extension services. New spaces in this market soon emerged for the expansion and creation of private companies to offer agronomic and similar services. These companies profit from farmers' modes of production by offering service and advice to improve farming productivity. They offer skills and services in agronomy, quality assurance systems, precision agriculture, weather forecasting, crop-grazing techniques, farm succession planning, farm business consulting, informal training, and alike. There seems no end to these organisations seeking farming clients. These organisations operate in a free market that is designed to profit from agricultural production. These behaviours emphasise the competitive nature that contribute to this market-driven economy. A key theme for this study is that private companies have positioned farms as units of their production to reduce the farmer to what Marx would define as the most miserable sort of commodity.

As a nation, global competitiveness comes by supplying high quality grain compliant with the stringent market conditions. Farmers are legally required to meet these extensive quality standards set by regulators and as a consequence many actors are aligned to safeguard production. Levies are deducted at grain sales and this is matched with government funding to finance the peak industry body, the Grains Research and Development Corporation (GRDC).

Farmers are not subsidized and their inputs and grain prices are influenced by the value of the Australian dollar and global supply and demand. To buffer the terms of trade grain growers increasingly look to technology to enhance their productivity. Automation, data management and large-scale efficiencies are key management strategies advocated to Australian grain growers by governing politics. Therefore this thesis argues that farmers feel coerced and powerless to challenge the political conditions under which they operate because their core business is externally driven by the free market.

Multiplicity of farmers' skill sets

A farm is often the primary place of residence for farmers and their families. It is a way of making a living that acquires a meaning far deeper than almost any other occupational identity and activity. In that sense farming is beyond a vocation and it can be very challenging to explain through language alone. Farmers' actions are rooted in economics as much as they are ideology. According to Vanclay farming is "a socio-cultural practice, it is governed, informed and regulated by social processes" (2004 p. 213) therefore, thesis builds on Vanclay's concepts of social processes through sociomaterial research, which is discussed in the methodology in Chapter 3.

Farmers are wholesalers of goods with somewhat limited market options. They lease from landholders, share farm with other farmers, and are debtors to the bank. Through these relations they take on varying elements of financial and personal relationship risk. Farming

requires diverse skills, many of which many are self-taught such auto electrical, plumbing, mechanical, firefighting, farm safety, and animal nutrition. In these roles and tasks, farmers' decision-making may not always align with strategic financial management.

Farmers are capitalists and labourers within a farm business structure. They have power as business managers in that they are able to select who they trade with, but at the same time their choices can be governed by loyalty or access. As Vanclay (2004) highlights, because of this multiplicity it's important to acknowledge that farming is a traditional, social and cultural practice rather than just a technical activity or occupation. The multiplicity of the farmer will be described in detail in the fieldwork.

Alienation

The condition of alienation is said to exist for those in commodity production under capitalist relations. Alienated labour is a concept in which Marx considered to be at the core of capitalist system. The synopsis is that the powerful are in one position to exploit the less powerful and as a consequence of this power-relations disparity, the less powerful are alienated. This thesis is developed under the basic notion that the consciousness of farmers is dominated by the ideological superstructures with which they interact. The conceptual framework includes the presumptive idea that farm production processes create a cognitive wedge between the farmer and their true sense of self. It is this wedge that is alienated labour or false-consciousness, which inhibits and prevents human self-fulfilment. This PhD thesis is founded on this concept to argue that alienation is an inevitable condition of farming.

Alienation, as a concept, may have potential to explain or at least re-evaluate the exodus of farmers from the industry. It may also be relevant as a precursor for rural mental health and farmer-illness such as anxiety or depression. For what the theory of alienation lacks in length and delights in obscurity in *The Economic and Philosophical Manuscripts 1844*, it makes up with sub-contextual humanistic, psychological and economic logic to explain the social relations of labour. This research aims to fill this gap in the social studies of agriculture and rural science.

It is implicit that costs are passed onto farmers when there is no place for them to pass on their costs. They are not able to build any cost of production into their bulk commodity price to recover from price rises. Instead they can only increase production to absorb those costs. As wholesale price-takers, farmers are the workers in agricultural political economy. They are the source of surplus labour for the services sector. This is why the concept of alienation offers a new point of departure for analysing farming and farm labour. Alienation positions the farm services sector as capitalists and exploitative in nature. Alienation, as a research theme for this thesis, is discussed in further detail in the literature review.

Agency

Agency is found and theorized through the research methodology, which is an actor network approach. This doctoral study examines the semiotics of farming under the Australian commodity chain context. It focusses on the roles and rituals of social interaction and the practices by which farmers maintain their legitimacy in isolation of the landscape. It examines technology that give agency to farmers and machines. This enables the researcher to see the effects that farmers generate from their farming practice. The reason for this ethnographic examination is to look beyond what industry expects from farming, and instead offers fresh understanding of how agricultural science determines farming activity in the Wimmera Southern Mallee.

An actant is an entity that performs in network relations with other actants (Noe and Alroe 2003). The term actant replaces the term actor since the latter implies only human agency (Higgins 2006). Higgins (2006) defines agency as a property of humans and non-humans through the arrangement of relations, not just those which are social relations. Agency is performative in that it is constituted in and by these relations (Higgins 2006). The notion of translation is characterised as the transformation of objects as they are enrolled into the network and mobilise actants of the network (Noe and Alroe 2003).

Like power, agency as a composite produces an effect. Farming practices are composites of humans, machines, farm inputs, soil, rainfall and data. Agency is what has to be explained when others actively enrol in this composite. The effect of this assemblage supports the hypothesis that farm practices, as collective assemblage of actants, have agency.

Tracing alienation, exploitation and agency

Free market economics, a Marxist theory, and an actor network theory approach, whilst used to explain the complex situation of modern farming and farming practices in the Wimmera Southern Mallee, they are not ideologically, economically nor indeed scientifically compatible. This leads to an internal tension in this thesis that seeks to use these approaches and theories to explain socio-political positioning of the modern farm. It is unknown whether the humanistic condition of alienation exists or not but it we need to accept the premise of alienation is a suitable framework for re-interpreting modern farmers even though this is dependent on ones' political persuasion.

To trace, means to follow. The method is explicit in that the sequences of human action is observed and directly noted to look for patterns and reasons. If the qualitative description that traces the network identifies that actors can generate agentic effects as a collective, it is said that a black box exists. A black box is the actor network semiotic to describe this assemblage outcome. *Intéressement* is another actor network semiotic. This is defined as the participation of humans, non-humans and objects, whereby the concerns of one world are translated through

another, and then disciplined or maintained in order to stabilize a powerful network. Under this condition of manoeuvre, where farmers are manipulated and exploited through their working relations, it would suggest that farmer- alienation exists.

The globalisation of agriculture can be thought in the terms of the extension of actor-networks. These networks includes non-humans and objects as equal actors in the network. Marxism includes nature and products into the theory of alienation justifying that non-human actors are not only symbolic rather they are necessary for the functionality of farmers and farms. Actor networks are used to explain the relations between institutions, farmers and nature. This approach points us to a new way of social science. It identifies points of research and at the same time, points of action. At these points of action, such as machinery break-downs and when global positioning systems fail, are when controversy is offered. These places of controversy allow me, as the researcher, to identify how networks are structured by looking at what is held together. I am able to examine how farmers can re-position themselves in relation to the institutions that facilitate their participation in the commodity chain.

Actor network theory argues for the abolition of macro and microeconomics. Individuals act on behalf of organisations which needs de-coding to understand the mechanisms of the commodity chain. For example, Wimmera Southern Mallee grain growers do not attend pre-harvest information events by Graincorp. Instead they gather at a local rural venue like a Country Fire Authority shed to meet the employed representatives. These representatives speak on behalf of the organisation's site logistics plans, storage capacity, the forecast market price against the site-price differentiation and the estimated grain inflows for the upcoming harvest. Actor networks allow an analysis of extended networks, through mediations by humans and things, like numbers, instructions and contracts, all by tracing what is linked together.

Digital imagery

Digital imagery is a qualitative methodological approach. This method is adopted to complement and promote the specific collection of results. Digital imagery is a practical method to enhance the richness of the written narrative. Whether many or few images are included, the use of images has a dualist effect; firstly they allow the researcher to reflect on their fieldwork experience of observations of others and place, and secondly they allow the reader a sensory ethnographic experience of the field of study.

The digital images selected for this thesis are used to help frame actor networks. The images render movements still while capturing actors' interactions. Photography is a supportive ethnographic practice to draw out more sophisticated ideas about farming. At the same time these images acknowledge the researcher's reflexivity in the process of observation. All of the images respect the human experience of working with machinery, technology and nature. They each show an un-prescriptive response to the environment.

As a part of the conceptual framework, the use of digital images in agricultural and cognate fields assists the non-farming reader. The images provide a sense of the machines, equipment and vastness of paddocks in modern farming. The aerial photographs are used as a sensory approach to spatial heterogeneity. Often words fall short from describing reality so these images are purposely presented to assist the reader's journey through this presentation of theorizing.

Central argument and research questions

This PhD study speaks on the behalf of Australian farmers. It gives a voice to farmers that may feel as though they are part of silent and futile race for capital accumulation. Every farmer and every farm is different, but they all operate in a free economy. This market works for some farmers, whereas others fall out which explains why farmers have such different experiences through what they do.

This thesis is founded on the overarching and fundamental argument that farmers feel coerced and powerless to challenge political conditions under which they operate. Their core business is externally driven by their need to improve farm production techniques. For this PhD thesis the central argument is that technology enables agency among grain farmers. In the process of understanding its purpose, the investment, and use, farmers have technology as tool and a force to overcome the exploitative nature of the modern agricultural economy. Therefore, this research sets out to understand the relations that technology facilitates to explain farming phenomena in the Wimmera Southern Mallee.

There are two key questions for this thesis. Firstly, how do farmers participate in the commodity chain through their farm operations? This question is to identify and interrogate the role of actors in farming networks. It is designed to capture everything that is traceable. The roles of machinery, technology, women, the internet, families, nature, neighbours and the farm services sector will be found through associations. This question supports the examination of what is at stake for farmers in their relation to farm production. The stability and nature of relations that exist through farmers as consequence of farm labour are integral for the findings. Human and machinery performance, as well as the roles and the formalities of these interactions, together with the practices by which farmers maintain their validity are all summoned. By identifying the actors, or agents, in the networks this research will be able to show the complex nature of farming and authenticate that farming is not an isolated practice.

This question aligns with the research method. It encompasses humans and non-humans and gives them agency. The relationships between farmers and the inanimate objects such as tools, which they need to operate their business, is captured through observations. They are found by tracing actors' connections and associations. This question is planned to describe what is typically overlooked in agricultural research, specifically farmers' relations with technology

and data. Political economy is based on money and the commodity chain is based on supply and demand for commodities. This question is about following farmers and tracing their associations to understand how they participate as primary producers on farms which are linked, somehow, to the agro-food complex. This question is a precursor to the second question which is, how do grain growing farmers use technology to exercise control to overcome exploitation?

The purpose of this next question is to study the activities which farmers undertake to overcome the exploitative nature of the commodity chain. This question asks how technology is used, such as what are the actions, associations, movements, modifications, tricks or partnerships where farmers make an effort to change their conditions using technology found on farms.

This question can be achieved by observing the sequences of farm processes to investigate farmers' capacities to control their farming complex. An examination of farm labouring activities will highlight the relations that farmers can and cannot control. By using actor networks, defining these agents as either mediators or intermediaries will help to elucidate what these relations mean to farmers and how they come to be stabilised in their farm system.

Science and technology does not just appear on farms, therefore a theoretical and practical understanding of how they cross the farm boundary is required. Science and technology is a tool to exercise farmer-agency. This question asks how farmers exercise technology to ameliorate the alienation that they may feel.

A spatial re-consideration reminds the reader that farmers' work alone in repetitive tasks located in regional and rural locations. This question serves to illustrate Kautsky's laws of agricultural development together with Bruno Latour's groups and group formation. This question is asking about how agents come to be aligned to enact agricultural science and generate collective effects through agency.

How farmers exercise control to overcome their exploitation in the commodity chain signifies a level of consciousness of the worker. The tension is that perhaps not all farmers are conscious of the structures of the commodity chain, and the wider implications from political economy, to be aware of exploitative tendencies of capitalism. This study is not about making farmers aware of the conditions under which they work, rather it seeks meaning through the unconscious actions of farm practices and farm labour to understand what matters to farmers, through their technology, connections to people and their land to offer a new sociological understanding of farming and the humanistic effects of farm trade.

Thesis structure

The structure of this thesis comprises of an introduction, four chapters and a conclusion. Chapter one explores a range of literature examining the Marxian and capitalist notions of labour in relation to farms. It is divided into three parts, with part one of the literature review introducing the reader with details of the theory of alienation that encompasses the four elements of the

concept and their different meanings. As well as the original writings and implied senses, modern examples of alienation in farming are provided to increase the scope of the review and to demonstrate how alienation may be perceived today. Part two of the literature review explores labour theorists, Hannah Arendt, Georges Friedmann and Karl Polanyi, to analyse their views of how labour is shaped through capitalism and political economy. Polanyi and Arendt are used to situate decision-makers within a locally defined rationality and locate decision-making with the individual. Part three leads the reader into the methodology by demonstrating that agency as a notion cannot stand alone as it belongs to a property of humans and non-humans, and in being so it requires a social research methodology such as actor network theory to perform its analysis.

Chapter two explores the theories of the methodological approaches deployed to examine how and where farmers exert control over political economy. This chapter introduces actor network theory, which is a family of theories within the field of sociology of translation and technosciences proposed by Bruno Latour, Michel Callon, and John Law. This doctoral study utilises some of the frameworks from within actor network theory to examine agents' associations and explains how agency is distributed as a collective and performed by farmers, machines and other entities. Two specific approaches, the model of diffusion and translations and the sociology of translations, are discussed in detail. This chapter also explains the rationale for adopting digital visual material as a sensory ethnographic practice to produce a hybridized-method research approach. This chapter concludes with details of the methods explaining the fieldwork, the author's position as a feminist insider-researcher, the data collection and the sample for the study.

Chapter three presents the data structured as two case studies. These results are designed to linguistically transport the reader to a commercial grain growing farm in the Wimmera Southern Mallee. The purpose of the results is to show how farmers use humans and non-humans to overcome exploitation, and to provide the foundation for the theoretical discussion.

In this chapter the first case study follows the social life of a growing crop of hybrid genetically modified canola, logging the farming operations and people who visited the paddock. The second case study concentrates on three different models of combine harvesters and the associated technologies, and how they enrol the farmers and the service sectors that support them. Both of these case studies are designed for a reader from a non-farming background, offering digital images to support the ethnographic study and to render relations momentarily still.

Chapter four presents the theoretical discussion and findings from the data. This chapter marshals the actor network theories and concepts to explain farming phenomena. It is structured as five discrete themes to address the research questions. Theme one is about the concrete and the abstract value of yield maps. The purpose of this theme is to clarify that reference is not something which is added to by words. Latour's concept of circulating phenomena is introduced to explain the gap between the world and how we explain it. Farmers' connection to product is

demonstrated as the transition of the physical crop reduced to abstract data. This occurs by undertaking the sequence of stages at harvest with technology where phenomena crosses the boundaries from the plants to the yield map, giving the paddock transportability, universality, mobility and standardisation.

Theme two explains groups and group formation. It offers a conceptual explanation of how networks come to be active, stable and unstable on farms through the ideas of disruption and goal-sharing. Latour's four concepts of mediation are presented, together a definition what the term technical means in farming networks. This theme follows the conceptual rules of actor networks to explain how farms and farm practices are constructed.

Theme three shifts the focus into the farming practices, alliances, neighbourly relations and the role of nature to specifically examine how agency makes farmers enact science using an actor network approach. This theme compares two farmers to explore the contradictions and controversies that intervene with actors' points of view. It offers reasons why bulk commodity producing farms and farmers are varied and different despite landscape and climatic similarities. This theme explores the role of farmer-agency and it shows that social agricultural research on farm is not about which farmer grows the higher yielding crop, it's about the actors farmers' stabilise to hold science and technology in place, to overcome exploitation. This theme builds on the work of Latour (1987) *Science in Action*. The precision cropping system called controlled traffic farming is used as the main example for this theme.

Theme four faces the conundrum of agriculture exploiting nature and the Marxian theories of the reproduction of nature. Actor network theory is called upon to overcome the nature – society's dualism to explain whether alienation exists when nature is considered as limiting in farming systems.

Theme five acknowledges the absence of women found during the fieldwork but at the same time explores poignant moments of engendered controversy.

The conclusion revisits the central argument of this thesis that farmers are subject to exploitation under the structures of which they work. The conclusion appraises the central research question of how farmers exert control through their relations. In doing this it provides a critical evaluation of the methodology applied throughout the thesis and concludes by offering that farmers overcome the exploitative nature of the agricultural economy by how they use technology.

To understand the concepts and central argument of this thesis, it is necessary to turn to the literature review to further understand these ideas that I have outlined.

CHAPTER ONE

Literature review and theoretical underpinnings

While reading Ernest Mandel's *The Marxist theory of alienation: three essays* (1973) I was struck by Marx's critical social theory and its far-reaching implications. It was from this moment I perceived that such an interpretation could provide a new line of inquiry for a powerful analysis of the largely capitalist Australian farming sector, one that accounts for how farmers and farm labour is structured in the modern economy. The concept of alienation, and labour-related literature, as a conceptual framework are used to support my field-based findings that underpin the central question of how farmers exert control over their production for this doctoral dissertation.

This literature review provides the reader with a fundamental understanding of alienation and labour as intellectual concepts. By drawing upon a range of sources, I offer a specific reinterpretation relating to contemporary Australian farming. The period I examine spans from the mid-nineteenth century to the present day. Underpinning this approach is the conviction that Australian agricultural social research offers new scope to understand the social relations of farm labour in a modern political economy. It considers technology as a facilitator of change and power.

This literature review is designed to help the reader to look beyond what we take for granted as farming and farm labour by using the thoughts and ideas from a wide range of researchers in sociology, agricultural science, economics and health sciences. This is an examination of the social relations of labour in the context of farm production. This literature takes into account the historical relations of labour and explains the concepts of alienable labour and what this means in a contemporary situation of commercial farming. This review also engages with the questions of how to construct modern economic relations as an object of political theorizing by bringing Karl Polanyi, Hannah Arendt and Georges Friedmann's writings of labour into conversation in Part two.

It is both a virtue and difficult in Marx that everything relates to everything else that he has written (Harvey 1982). Therefore, it is approaching the impossible to study the concept of alienation without simultaneously working on all of the other aspects of this theory however this chapter aims to keep the theory of alienation relatively exclusive to the four elements. Block quotations have been used sparingly to help demonstrate the complexity of Marxist concepts. Some of these blocks integrate seamlessly into the text for explanation, where others may seem less integrated because they generally consist of writings and language used over 150 years ago. Ultimately the study of labour, regardless of when the work of others was written, requires careful attention to understand the theoretical co-relationships in agricultural under a capitalist

economy. This literature review is about re-constructing the approach to alienation and labour in agriculture in Australia. This section is framed to interrogate how Wimmera Southern Mallee farmers, in many respects as ideal capitalists, exert control over their production to overcome their exploitation in the commodity chain in the present day.

The term ‘labour’ is used, even when the spelling is ‘labor’ is referenced material, to reflect the Australian-English interpretation of this text.

PART ONE

PART 1. The theory of alienation

The aim of Part one is to define the meaning of alienated labour in context with modern farming. This section is not to inundate the reader with the definitions, the linguistic complexities of translation, spirituality nor the history of ownership of the theory. This part discusses the philosophical originality and then suggests re-interpretations based on the research of others from agriculture and cognate fields. This work examines the capitalist relations pertaining to the condition of alienation that exploits farmers without dissolving them absolutely. This research argues that farmers are exploited by their socio-political position through relations with their product, work processes, and their social connections, and unless they actively engage in particular farming relations and exert agency to exercise control, they wholly submit to their position in the commodity chain.

> [It] is no longer clear what alienated men are alienated from. The intellectual problem of dehumanization is how to make an evaluation of a discontent pass for an objective description, or at least for another's evaluation. (Horton 1964 p. 284)

Horton’s (1964) thoughts upon the ambiguity that alienation offers and the silence that it brings is insightful for this research. Farmers can be easily identified by where they farm and they can be further narrowed into commodity producing groups, growing season, farm size and equity ratio. However, the juxtaposition is that multi-national corporations, research and development corporations, statutory agencies and government trade officials are un-identifiable for their decision-making and it is these particular powers that bring alienating effects. Farmers cannot identify the humans who make the decisions that facilitate their trade.

Labour is closely connected with the concept of alienation. Under capitalism the outputs of production belong to the employer. The employer then expropriates this surplus that has been created by others and as a consequence generates alienated labour. In the condition of alienation, work does not always lead to self-fulfilment. Human beings are thus dominated by their own

social relations. Marx's *Capital: a critique of political economy Volume 1,* and *The Economic and Philosophic Manuscripts (1844)*, together with other writings, are based on the idea that humans are in a state of alienation; a state where their own creations appear to them as alien, hostile forces, and instead of controlling these creations, they are controlled by them. In the chapter "Alienated Labour" in *The Manuscripts*, alienation is encapsulated as:

> The alienation of the worker in his object finds expression as follows according to the principles of political economy: The more the worker produces, the less there is for him to consume; the more values he creates, the more he loses value and dignity; the more his product is shaped, the more misshapen the worker; the more civilised his object, the more barbarous the worker; the more powerful the work is, the more powerless becomes the worker; the more spirit there is in the work, the more devoid of spirit and slave of nature the worker. (Kaufmann 1972 p. xlix)

Apart from Marx, the theory occupies a position of importance and influence in the writings of Engel, Hegel, Erich Fromm, and Jean-Paul Sartre. As a consequence, reinterpretations of alienated labour are by no means limited. According to Schacht "the term is usually employed in connection with the separation of something from something. It is not always used to refer to the separation of someone from something; the subject of alienation is not always a person" (1972 p. 244). Alienation is therefore connected to range of societal issues. As Schacht (1972) identified, alienation is usually identified when people are directly affected by matters that impede their self-realisation.

For this research the theory may have potential to explain or at least re-evaluate the position of family owned farms in political economy. Alienation may potentially explain the exodus of farmers from the industry and the expansion of large farms in rural communities. Because the theory considers separation as a condition it may help to elucidate matters relating to population decline and dispersal that cannot be explained entirely by the laws of political economy.

Historiography of alienation

History is just one of a series of discourses about the world. These discourses do not create the world, but they do appropriate it and give it all the meanings it has (Jenkins 2003). Events have taken place and it can only be resurrected through historians' use of media, such as books and documentaries. The theories of alienation are documented, and while they remain concrete evidence, they are open to different interpretations. Marx provides extensive primary material reflecting his interpretation of the consequences of the industrial revolution and capitalism upon the working classes. Most importantly however, the reader recognises that

Marx's views are formed by his ideologies. Horton (1964) summarizes Marx's alienation as more fluid and conditional:

> Alienated thinking is especially apparent when the sociologist thinks about alienation... today dehumanisation has set in, the concepts have been transmogrified into things instead of evaluations about things, and it is no longer clear what alienated men are alienated from. (Horton 1964 p. 284)

Ethnographers working with farmers in their workplace would concur with Horton's ideas. Unless alienation can be realised by the worker and the researcher, it remains as an unknown and an unconscious condition. Written in the summer of 1844, *The Manuscripts*, are the most important of Marx's early writings (McLellan 2000). This is said to be Marx's first draft of economics and the starting gate for the remainder of life's work. The ideological positions taken by Marx in *The Manuscripts* are evident in his later writings. *The Manuscripts* refers to the worker and makes observations that are necessary to explain political economy. Alienation contrasts economic scenarios as it explains the non-physical and intangible conditions of the worker. According to a range of sources, Marx was never a capitalist as he lived a personal life of loss and poverty. If this had changed throughout his career, I wonder if Marx's writing would have changed relative to his socio-political position?

Based on his co-dependent theories, Marx wrote of alienated labour with the expectation that the reader understands, and is of general agreement with, his range of concepts such as ground rent, division of labour, competition and exchange value (McLennan 2000 p.85). He writes that political economy starts with private property, but he insists that this does not give meaningful explanation for the separation of labour and capital, and of capital and land. Marx analysed the concept of private property based on the concept of alienated labour and political economy proceeds from labour as the very soul of production and yet gives labour nothing and private property everything. A tension exists because farmers are property owning capitalists. Farmers' net worth can equate to tens of millions of dollars. Nonetheless alienation offers opportunity for the re-interpretation and a new way of thinking about the position of the farmer in relation to the structures of the commodity chain especially under modern technological advancements.

In *The Manuscripts* Marx re-articulates and translates alienated labour as the workers' creation of the relation of another man who does not work and is outside the work process to this labour McLennan (2000 p. 89). The relation of the worker to work also produces the relation of the capitalist to work. These definitions of alienation are abstract and unfamiliar but what we can surmise is that workers' realise that there is more to life than just work to profit themselves and others. Private property is the product of the necessary result of alienated labour, of the external relation of the worker to nature and to them self. Farmers' capital increases over time, but simultaneously they work for other capitalists in services sector. Private property is not only the

basis and cause of alienated labour but also a consequence of it; they are mutually influential. In *The Manuscripts*, Marx wrote:

> So what we have to understand now is the essential connection of private property, selfishness, the separation of labour, capital, and landed property, of exchange and competition, of the value and the degradation of man, of monopoly and competition etc. – the connection of all this alienation with the money system. (McLellan 2000 p. 86)

To Marx, the ultimate goal of human beings is to pursue real freedom and that increased wages would do little to emancipate human beings. He believes that human beings are creators of history, and they have the ability to untie themselves from being alienated. Human beings should be freely associated people as a whole. This segue, the liberation from alienation, offers insights into the notion of farmer-agency and to look whether farmers' decision-making is free, or just simply aligned to actors who are available and loyal in their farming network.

Analysing alienation

This research is about examining farmers' control over their production by identifying the actors and their relations with those in their farming networks. Alienation is a human state of being – the state of being alienated or estranged from something or somebody (Kaufmann 1972). Alienation is relationship based. Alienation is an elliptical term that requires completion in two directions (Kaufmann 1972). Kaufmann (1972) defines it as a relationship between A and B where A is a specified person or a group of persons: an individual, a social class, a whole generation, a people or perhaps a smaller group. As a subject, A are farmers. "B also needs to be specified, and confusion frequently and typically results from the failure to specify from whom or what A is supposed to be alienated" (Kaufmann 1972 p. xxii). Defining what or who B is, being the actors or agents, is the key part of the research process. Kaufmann (1972) provides a list of suggestions including individuals, a group of people, society in general, oneself, nature, or even the universe. A farmer can also be alienated from what they do, as work or labour, or from the things such as their production.

Four key themes of investigation aligned with the elements of alienation are used in this PhD literature review to discuss the theory. Headings are used to define the four Marxist elements of alienation, with the re-interpreted heading for this thesis in the heading below. Literature about Australian farming practices and conditions offers contemporary meanings to argue the exploitative tendencies of the free market and agricultural trade.

I. Commodities: workers relate to their product as if it were alien, opposing them as an independent hostile power.
II. Farming: workers become alienated from themselves in the process of production, as work was not viewed as their home.

III. Self: workers' 'species-being' or communal essence is not realised in the work they produced.

IV. People: individuals found themselves alienated from other individuals. Commodities

Commodities

Commodities are capitalist's tradeable objects. Capital is a sum of commodities, specifically their exchange values, which is a social relation of production. Classical economists see capital as natural, rather than socially conditioned, because they see it as material products (Singer 1980).

The origin of profit lies in labour. The product of labour is merely a summary of the activity of production. Marx writes that the product of labour is externalization and production itself is the activity of this externalization (McLennan 2000). The alienation of workers from their product means that their labour becomes an object, an external entity, which is outside themself and alien to them. The effort they make for the object turns against them as a hostile force which makes the worker becomes a slave of the object they produce. If the products of labour do not belong to the worker, but confront them as an alien and hostile power, it is because it belongs to the employer. The more the worker produces, the less he can possess and therefore falls under the domination of their product which is capital. In other words, workers work to make someone else more profitable than themselves. There is a level of awkwardness in explaining this for farmers, but even as they increase in property size, their costs increase proportionately and those they pay are unaccountable for their production. Farmers may feel either hostile or futile as result.

According to Marx in *The Economic and Philosophical Manuscripts of 1844* "labour does not only produce commodities; it produces itself and the labourer as a commodity". Through globalisation farmers produce themselves; they are a commodity through their labour. Marx continues his framework with "the object that labour produces, it's product, confronts it as an alien being, as a power independent of the producer" (McLellan 2000 p. 86). Farmers' labour produces a product that is representational of the labour that it required, referred to as the objectification of labour. A modern standpoint is the greater the agricultural productivity by farmers, the less the commodity is worth. This is also proportionate to individual farmers financing larger scale machinery and higher inputs to produce the bulk commodity. As a consequence, farmers' labour is objectified.

The misery of the worker is inherent in Marx's early writings, specifically in his chapter pertaining to alienated labour in *The Manuscripts*:

> The realisation of labour is its objectification. In the political economy this realisation of labour appears as a loss to the worker, objectification as a loss of the object or slavery to it, and appropriation as alienation, as externalization. (McLellan 2000 p. 86)

Marx argues that the worker puts their life into the object. Those working with farmers would agree that many farmers too put their life into their farm and their production. In a Marxian view this means that farmers' lives no longer belong to them, but to what they grow. Revealed in *The Manuscripts* alienation is a situation in which the worker's activities and products take on an independent existence and become hostile powers working against them. The process and the product become the power, and it is the structures of political economy is what opposes farmers as the material forces that offer such humanistic turmoil.

The products of human labour enter an alien objective world as independent entities (Law 2011). This was also referred to later by Marx in 1867, in *Capital Vol One,* as commodity fetishism. By alienating the product and placing it above labour, the worker is doubly deprived. This means that in practice the worker suffers from threefold loss: a loss of reality, a loss of the object and a loss of selfhood.

Commodities as materiality

Commodities are political. They provide material culture and as valuables they are the heart of economic exchange theory (Appadurai 1986). The fundamental attribute of commodities is exchange because they have economic value. Generally, commodities are considered as goods. Farmers would define commodities as the distinguishable primary products that they grow, such as grains or wool, because they have value and they are reflected in their balance sheet as total assets. This value can be stored, or when sold it provides income to the farmer to repeat their cyclical production.

> Economic exchange creates value. Value is embodied in commodities that are exchanged. Focusing on things that are exchanged, rather than simply on the forms or functions of exchange, makes it possible to argue that what creates the link between exchange and value is *politics*, construed broadly. (Appadurai 1986 p. 3 original emphasis)

Appadurai (1986) suggests that commodities are distinguishable from products, objects, goods, artefacts, and other sorts of things – but only in certain respects and from certain points of view in a variety of societies. For the economist however, commodities are simply things. They are the rights to things produced and they circulate through the system as they are exchanged for other things (Kopytoff 1986). Kopytoff (1986 p. 64) also recognises that "the production of commodities is also a cultural and cognitive process: commodities must be not only produced materially as things, but also culturally marked as being a certain kind of thing."

A culturally informed biography of a commodity would contain meanings specific to its origin. Kopytoff (1986) demonstrates that societies differ in the ways commoditization, as an expression of exchange, is structured and related to the social system by the factors that stabilize and expand as well as the cultural and ideological premises that suffuse its workings. Exchange is a universal feature of social life, and according to Kapferer (1976) it is the very core of it.

Kapferer (1976 p. 12) asks us to pay particular attention to the "cultural understandings which underlie maximisation or any other tactic or strategy," which implies that for this doctoral research to understand agriculture in the Wimmera Southern Mallee we first need to understand the cultural exchange behaviours.

Money has a significant role to play in this process of exchange. Harvey (1982) explains that money is like any other commodity as it too has a value, exchange value and use value. The exchange values of all other commodities are measured against these specific conditions of production of the money commodity. It is from this standpoint money functions as a measure of value and its exchange value ought to reflect that fact (Harvey 1982 p. 11). Money's use value facilitates the circulation of commodities and it functions as a medium of circulation.

To be saleable and exchangeable for money, commodities need to share commonality. Kopytoff (1986 p. 69) states that the "perfect commodity would be one that is exchangeable with anything and everything else, as the perfectly commoditized world would be one in which everything is exchangeable or for sale. By the same token, the perfectly de-commoditized world would be one in which everything is singular, unique, and un-exchangeable."

The Australian government invests in agricultural agencies to ensure commodities produced by farmers in the Wimmera Southern Mallee and nation-wide fit an exchangeable criteria through particular quality assurance safeguards, sample tests, setting residue limits, withholding periods and quality segregation systems for markets. Yet in no system is everything equal and homogenous for reciprocal exchange. As Kopytoff (1986) recognises, only in a pure-Marxist system under capitalism, is everything a commodity and exchangeable for everything else within a unitary sphere of exchange. Referring to Bohannan (1959) and his studies of the Tiv in Nigeria, their "multi-centric economy is an economy in which a society's exchangeable goods fall into two or more mutually exclusive spheres, each marked by different institutionalization and different moral values." (Bohannan 1959 p. 492). The first sphere was a moral market for the exchange of commodities of subsistence, such as yams, cereals and tools. The second sphere includes prestigious commodities, such as slaves and cattle which took place though rituals or the exchange of brass rods as the general currency. The third sphere was the rights-in-people other than slaves, particularly rights-in-women, and wards (Bohannan 1959).

A philosophical problem of value and value equivalence exists. The Tiv selected items which share relative values, such as yams and tools, as the labour to collect the yams versus the labour to make a simple tool are comparable. Kopytoff (1986 p. 72) describes the Tiv's multi-centric economy as "the feat of simplification of what is naturally an unmanageable mass of singular items." Given the brass rod is the only general currency it seems that the three-sphere exchange has reached it technological limit. The excessive commoditization associated with capitalism is thus not a feature of capitalism per se, but as a result of making things more

exchangeable for other things, and to the system as a whole, by making more and more different things widely exchangeable (Kopytoff 1986).

Does this offer a re-vigourisation and pledge to return to bartering and peasant-based subsistence living in the Wimmera Southern Mallee? I don't think so. We have reached a stage where farmers have too much to lose and the global agri-food complex is designed to invest in primary production through corporate farms and research and investment. But valuing commodities beyond a monetary number, and reminding ourselves as farmers of the principles of paddock to plate, is perhaps one way to re-connect with the purpose of production. Marx didn't evaluate workers' thoughts of what they made, but self-realisation in the product continues to offer a way to consider alienation through primary products.

Culture

Communities can have cultural ownership of commodities. Claret, Champagne, Valencia and *Sud de France* all demonstrate types of commoditization using product differentiation through regional locality. Geographical Indications (GIs) are an example of how commodities with exchangeable values can be meaningful within and beyond the community producing the goods. GIs are intellectual property rights embedded in place-names and the place that evoke the typical qualities of agricultural commodities and foodstuff that originate in particular districts (Cleary and van Caenegum 2017). GIs unique purpose is to preserve social and environmental sustainability (Taylor and Taylor 2017). They require international registration and protection necessary for trade agreements and negotiations.

Geographical indications are also referred to as Geographical-Origin-Brands, Geographical Indicators, Appellations of Origin, and Indications of Origin depending on the country of origin. These serve to organise local producers and production to promote identity and tourism. The protection of GIs is of growing importance all over the world (Arfini et al 2011). Australia's Free Trade Agreement (FTA) with the European Union (EU) is hinging on this agreement. The EU has asked Australia to protect 236 spirit names and 172 agricultural and other foodstuff names as GIs in Australia (Department of Foreign Affairs and Trade 2019). The names relate to a range of sectors including, dairy, meat, smallgoods, horticulture, confectionery, oils, beer and spirits. The decisions on EU GIs that will be protected by Australia will be considered by the Government during FTA negotiations. Any commitments on GIs in the FTA will depend on the overall outcomes the EU is prepared to offer Australia, including market access (Department of Foreign Affairs and Trade 2019).

Appellation laws are traditionally justified by the idea of *terroir*: a French word designed to encapsulate a blend of land, tradition, and human know-how (Hughes 2006). There is no direct English translation of *terroir,* but the idea is that the product's qualities come from within the territory (Hughes 2006). It is not an exaggeration to say that some countries link

terrior to national identity (Guy 2003). This notion implies that the local producers are entitled to exclusive use of a product name because no one outside the locale can truly make the same product. Of course, when the geographic name has great prestige such as Bordeaux, Napa, Champagne or Swiss chocolate, exclusive control results in economic benefits for local producers regardless of whether there is really anything unique about the local products or the quality of the producers' work. Kopytoff (1986) suggests that the singling of objects by groups within a society poses a special problem because when it bears the stamp of collective approval it takes on the weight of cultural sacredness. Nevertheless, appellation laws offer local producers a tool to differentiate their products on the market and escape price competition (Belletti et al 2017). In Australia, GIs are not seen as cultural commodities to reflect the farming regions, rather Cleary and van Caenegem (2017) identified that the domestic interest on GIs has been framed almost exclusively in terms of gains and losses in international trade.

There is traditional opposition to GIs due to trade negotiations (van Caenegum, Cleary and Treguier 2016). While Australia was one of the first countries to sign a bilateral agreement with the EU in the context for wine trade it was in perspective of protecting Australia's exports of wine, rather than an explicit consideration of GIs as a potential contributor to rural development and sustainability (Cleary and van Caenegum 2017). The Australian government sees extended GI schemes as a barrier and burden to export free trade, and that it opposes the policy to expand trade for national benefits. Cleary and van Caenegum (2017) argue that this preoccupation could be at the expense of the wellbeing and sustainability of rural, regional and remote Australian communities. It can be argued that these national policies that enable trade disconnects Australian farmers from their produce. There is no national facilitation for cultural identification of Australian grown bulk commodities through localities, breeding heritage, soil properties, nor ethnicity of the growers, all of which would connect Wimmera Southern Mallee farmers and their communities to their products.

Knowledge

The Australian grains and oilseeds industry produces between 35-45 million tonnes of grain per annum from an area of more than 20 million hectares (Grain Trade Australia 2016). "Some 660,000 deliveries of grain are made by farmers to grain accumulation entities around Australia each year" (Lawson 2013 p. 46). This means that the coordination of bulk commodities from farms to port presents a long-distance and relatively complex flow to achieve exchange.

> [T]here is always the potential for discrepancies in knowledge about commodities. But as distances increase, so the negotiation of the tension between knowledge and ignorance become itself a critical determinant of the flow of commodities. (Appadurai 1986 p. 41)

Appadurai (1986) states that commodities represent complex social forms and distributions of knowledge. Knowledge can be segregated as two poles (i) the production knowledge, such as

technical know-how and (ii) consumption knowledge to use the product (Appadurai 1986). “It may not be accurate to regard knowledge at the production locus of a commodity as exclusively technical or empirical and knowledge at the consumption end as exclusively evaluative or ideological. Knowledge at both poles has technical, mythological, and evaluative components, and the two poles are susceptible to mutual and dialectical interaction” (Appadurai 1986 p. 41). Of course, unlimited transitions and transactions may take place between these extreme poles however this model helps to depict the nature of circulation and exchange itself.

Wimmera Southern Mallee grain growers may not be the knowledge-production pole for their commodities. A controversy exists in the Australian grains sector in the determination of production knowledge. Plant-breeders, or patent-holders, claim ownership of plant cultivars and crop varieties. It is thus debatable as to which ‘owner’ of the commodity holds the technical production knowledge: the plant-breeder or the farmer who takes all of the production risk.

End point royalties (EPR) are structured under the *Plant Breeder’s Rights Act* 1994 (Cth). The Act replaced the *Plant Varieties Act* 1987 (Cth) after Australia joined the International Convention for the Protection of New Varieties of Plants as “an incentive for the private sector in Australia to become more active in plant breeding” (Lawson 2003 p. 38). The EPR is applied on the outcomes from exercising the patent called the Plant breeder’s right (PBR) on the sale of the harvested material (Lawson 2013). This is an automatic deduction imposed on grain growers when they deliver their harvested commodity to the buyer. The EPR is calculated according to the amount of harvested materials rather than the materials purchased at the time of first sale (Lawson 2013). There is no cap to the EPR sum that grain growers are required to pay. The more grain that is produced by farmers in the Wimmera Southern Mallee, the greater the revenue for the private sector through the EPR they pay for the production.

In the US, the hybrid varieties of corn lose their vigour and yield less, therefore seed-saved or ‘bin-run’ corn is not ideal. In Europe, ripening conditions are not favourable for seed-saving either, so farmers are encouraged to buy seeds from commercial breeders. However, in Australia, and especially the low to medium rainfall Wimmera Southern Mallee region where dry and hot late springs and summers favour grain drying, farmers can retain their non-hybrid seed at harvest and re-plant the following season to save costs.

In 1995 the Industry Commission reported that “[t]he result for Australian agriculture is that ability of farmers to bulk up their own seeds for the self-pollinated field crops and annual pasture plants meant that only governmental breeding programs were sustainable” (in Lawson 2003 p. 40). The development of research and development corporations (RDCs) formalised commodity-specific institutions to coordinate research strategies and investment under a board-structure with statutory obligations. RDCs relied on production levies and co-investment from taxpayers.

In the early 2000s the Grains Research and Development Corporation (GRDC) which is responsible for cereal, pulse and oilseeds research, moved towards market-based plant breeding programs and established Australian Grain Technologies Pty Ltd, HZR Wheats Pty Ltd, and InterGrain Pty Ltd (Lawson 2003). Joint-ventured were entered into with Arista Cereal Technologies Pty Ltd and Canola Breeders Western Australia Pty Ltd (Lawson 2013). This resulted in GRDC retaining shareholdings between 18 – 39% across each of these companies (Lawson 2013). GRDC has also retained some breeding activity for minor crops where EPRs are not considered feasible. In the 2013-14 financial year, GRDC collected $117.5M from grower levies plus $68M from the Commonwealth Government (Kalisch Gordon 2016). Over the last twenty years GRDC has been strategic in how they have generated income through relations with private companies.

> Plants pose a problem for commerce – in some circumstances, the plant in itself is both the product (the harvested material) and the means of producing the product (the propagating materials). This means that buying the plant also buys the potential to make the plant and continue making the plant, potentially dulling the incentive to make and sell better plants because the innovator cannot capture and appropriate the values of the improvements. (Lawson 2003 p. 45)

Lawson identifies that commerce is the driver in the agricultural sector of Australia, especially in the grains industry. How this silent crevasse between farmers, and the private sector and government transpired is explained by Pritchard (2005) in the shift in paradigm for protectionism of manufacturers. In the 1980s the Australian Government's trade policies shifted fundamentally. This was typified from a shift away from protectionist buffer fund for wool and grain schemes towards the advocacy of multilateral liberalisation and integration into global markets. By the 1990s, largely through the enactment of competition policy laws, domestic agricultural marketing arrangements were deregulated in favour of market principles (Pritchard 2005). Neoliberal agriculture was a policy choice driven by ideological insistence within influential policy communities including multi-national companies, overseas trading partners and politically connected farmers with off-farm financial security.

> Whereas each of these policy spheres involved separate administrative processes and trajectories, nonetheless they intersected in the sense of offering a similar policy vision, and therefore routinely involved the same institutions and personalities advocating ideologically consistent positions ranging across these various domains. (Pritchard 2005 p. 5)

According to Corden (1996 p. 149) the boom in economics training in Australia during the 1970s and 1980s led to the situation where "senior bureaucrats in key departments… have (almost all) been qualified economists." Economics played a key role in decision-making in Australian politics. Morgan (2003) states the community's interests are best served by creating space for capital. This has previously involved a rollback by the state and forcing privatisations and

private contracting. It also involved policies that extended the visible hand of the state through measures to protect capital interests, for example, the strengthening of intellectual property laws (Lawson 2003).

The reforms and deregulation in Australia's agricultural sector to achieve policy goals have not been developed nor driven from the heartlands of farming and farmers (Pritchard 2005). It highlights that rural production systems are not understood in the Australian context (van Caenegem et al 2015). Pritchard (2005 p. 10) states "that the conversion of Australian agricultural policy to the neoliberal ideal has involved far more than merely an allegedly correct set of policy prescriptions being embraced." Australian agriculture policy but has been converted to a single ideological position through a like-minded community of policy makers to dominate the terms of debate over agricultural policy (Cordon 1996; Pritchard 2005).

Commodity prices

The pursuit for productivity fuelled the growth of complex societies (Barr 2009). The Australian grains sector has been increasing production for over a century (Barr 2009). The gross value of Australian farm production, buoyed by higher than average commodity prices, is expected to be $59M despite the prolonged drought and widespread bushfires (ABARES 2020). But while output has been increasing through time, the market demand for agricultural products has generally risen more slowly (Barr 2009). Grain prices are influenced by global supply of which farmers have no control. The world wheat indicator price is forecast to average slightly higher at US$225 per tonne in 2020–21, up from US$220 per tonne (ABARES 2020b). Lower production in the Black Sea region, the European Union and the United States is forecast to result in higher prices. In the medium term to 2024–25, world import demand for wheat is expected to continue to increase. A rise in demand for agricultural products can be associated with a growing world population, rising living standards and changing diet composition (Keating and Carberry 2010). However, prices are projected to fall gradually in real terms over the projection period due to world supply growing faster than demand (ABARES 2020b).

> To understand the changes occurring in rural Australia, one must start with farm commodity prices. Without an understanding of the behaviour of farm commodity prices, little else will make sense. (Barr, 2009 p. 5)

A problem exists when farmers do not understand these externalities that have an invisible impact upon their farm and business. Keating and Carberry (2010) suggest that the issues of input costs, commodity prices, terms of trade, and productivity growth are not new as they have been fundamental to the business of farming and the focus for agricultural research for 50 years or more. This research argues farmers feel coerced and powerless to challenge political conditions such as these, under which they operate.

The result of gradually increasing farm productivity and inelastic market demand is the long-term real decline in the market value for agricultural products (Barr 2009). There is now concerning evidence of an emerging plateau in international agricultural productivity where the impressive annual productivity gains are starting to slow (Keating and Carberry 2010). Alston et al. (2009) suggest that the growth in global yields per hectare of maize, rice, wheat and soybeans crops was slower during 1990–2007 compared with 1961–90. In Australia, there is also evidence that the rate of productivity gain is declining for the broadacre cropping sector. The growth rate in total factor productivity fell 50% during 1989–2005 compared with the period 1977–94 (Kokic, Davidson and Rodriguez 2006). In Australia, soil moisture availability strongly influences productivity gains which is tangible for farmers to comprehend and easier to manage than no control over the externalities and mechanisms of the global markets.

According to ABARES (March 2017) the index prices paid by farmers for commodities used as inputs, such as fuel and lubricants, chemicals, fertilizer, seed and labour, as well as fixed farm-operating costs, have all increased since 2002. The producers of agricultural inputs are not in the same position as farmers as these prices do not reflect the market price of agricultural commodities. “For Australia, the long-term trend is clear: the terms of trade for agriculture decline in the long run, although this is partly disguised by cycles of high and low prices caused by drought, short-term under supply or oversupply and international exchange rate fluctuations” (Barr 2009 p. 9).

Alienation offers a practical and tangible explanation to understand farmers’ distress due to these conditions that farmers have no power over the price of commodities. To remain competitive they are forced to increase their productivity to keep up with the declining terms of trade (Barr 2009). Productivity improvement can be achieved in many ways. Some examples for grain growers are new varieties of seed, increasing fertilizer rates and foliar applications, improving timeliness of operations and managing risk most effectively by identifying the limitations of the season. Productivity is achieved through expenditure, trialling and learning. Farmers must produce more from a given number of farm inputs (Barr 2009). It is not just the farm’s inputs that increase in cost over time, but the cost of living for the family in the business (Barr 2009).

> Those who choose not to, or who are unable to pursue increased productivity, will find that their farm effectively becomes smaller as the years progress. The farm will remain physically unchanged, but the value of what it produces will have declined. It will become economically smaller. (Barr 2009 p. 9)

In times of falling farm returns the natural reaction for farmers is to seek to minimise costs while aiming to maintain output. The consequences of this management strategy is that while productivity may seem to be stable, farm assets are being depleted. “[R]isk of financial loss almost always forms part of a farmer's decision to invest in increased inputs” (Barr 2009 p. 9).

Grain growers measure the rainfall to calculate the likelihood of achieving their optimal yield. As the likelihood of average rainfall decreases over the growing season, so does the application of granular or liquid fertilizers to achieve the yield. This is a reactionary cost saving method to manage production risk. But the long-term effects of reinvigorating the depleted level of soil nutrients and replacing worn-out machinery requires greater expenditure in the future (Barr 2009).

Handling

Grain handling technology and equipment have changed over time but the costs associated with handling the commodities are still passed back to the grain grower. Grain transport, handling and storage facilities, and their costs, are of practical and financial importance for farmers (Kingwell 2017). The costs, along with other costs further along the supply chain, lessen a farmer's grain production profit margin (Stretch et al. 2014). The supply chain costs in Australia for wheat, travelling 200 km from farm to port, starts between A$60–75/t (Stretch et al 2014). This can account for 30 percent of production costs; the single largest cost item for a grain producer in a typical year (Stretch et al 2014). Farmers face significant fixed and operational costs, but some of these costs are not as transparent as others as there is no invoice trail for them to follow, enforcing disconnection between farmers and their product.

> Within grain supply chains there is variation in deductions for shrink and dust between regions and crop species. The technical and financial basis for the variation in these deductions is not well documented. Some costs in the supply chain, such as research and development levies, or end point royalties attract far more scrutiny and media attention than dust and shrinkage. (Stretch et al 2014)

According to Stretch et al (2014 p. 8) "the pricing of grain is principally determined on international markets with supply chain costs being sequentially deducted to generate a farm gate price." But not all grain is sold for export because domestic consumption for stock feed and food processing shares global price parity. Farmers may have more control, and an improved connection to bulk commodities, if they were given the full value of grain and they were responsible for their supply chain transactional costs. "When things participate simultaneously in cognitively distinct yet effectively intermeshed exchange spheres, one is constantly confronted with seeming paradoxes of value" (Kopytoff 1986). The value of this pricing policy doesn't seem to consider the producer, rather it supports those operating within the commodity chain.

To demonstrate the complexity of the grain supply chain and associated pricing of grain, Stretch et al (2014) created a schematic diagram for AEGIC (see Figure 1 below).

Figure 1. A schematic overview of a supply chain and associated pricing of grain.
(Source: AEGIC 2014 in Stretch et al 2014)

Grain marketing has shifted from statutory control into private hands (Kingwell 2017). "The ownership structure of grain handling and storage has in most states shifted out of grower ownership into private company control" (Kingwell 2017 p. 443). This statement is true but Kingwell does not explain the process how grower-owned grain elevators were sold to private grain buyers with limited consultation with localised farmers, which then changed the grain catchment zones and increased the costs associated with grain delivery and off-farm storage.

Farming

This section of the literature review examines the second element of alienation as the process of labour, or rather the activities that are undertaken which we define as farming. For Marx, production is the direct activity of the individual and through this production of objects the individual reproduces himself and sees his own reflection in a world which he has constructed (Schacht 1972). This is a key characteristic of the theory of alienation. Since the product does not belong to the worker, she cannot find achievement in her work. This results in the product as just a summary of the activity of production. It makes labour exterior to the worker and not a natural part of herself.

In 1844 in *The Economic and Philosophical Manuscripts* Marx described the process of alienation as:

> Therefore he does not confirm himself in his work, he denies himself, feels miserable instead of happy, deploys no free physical and intellectual activity, but mortifies his body and ruins his mind. (McLellan 2000 p. 88)

The relationship of the workers to their activities is alien. Since the alien object dominates the workers, they become powerless and hostile to the external world, in the meantime they lose imagination and creativity in the objects upon which they work. Mandel (1973) interprets this explanation of alienation as men who work and produce something, reproduce their idea which was initially a thought process. According to Sayers (2011) alienation takes form in many areas of life but particularly labour. The separation of labour from its product demonstrates alienation in the labour process.

> … the activity of the worker is not his own spontaneous activity. It belongs to another and is the loss of himself. (McLellan 2000 p. 89)

Marx's idea that work activities belong to another is tangible. In the context of farming in the Wimmera Southern Mallee there are tasks which farmers may not completely own. Machinery break downs, no satellite signal, drought, flood, and high interest rates on finance are some activities that may be caused by others. This element offers scope to consider where farmers place themselves in relations to others through what they do.

Finance

Debt is an important source of funds for farm investment and ongoing working capital for many grain farms (ABARES 2019). However the long-term viability of a farm is affected by its

capacity to service debt, meaning that the farm as a business unit needs to generate enough profit to meet interest costs and make payments for ongoing inputs. “From 2000–01 to 2017–18, borrowing to fund land purchases and ongoing working capital were the main components of average grain farm debt. Increased borrowing for ongoing working capital over the period was a result of increases in average farm size, more intensive cropping, changes in grain payment methods and greater use of purchased inputs” (ABARES 2019).

At the national level, between 2000–01 and 2017–18 the average debt of grain farms trended upwards in real terms, mainly resulting from an increase in average farm size rather than changes in debt composition. However, since 2010–11 the annual rate of increase in average debt per farm has slowed. In 2016–17 average debt of grain farms increased by 7 per cent to around $913,000 in real terms (ABARES 2019).

In regards to equity, increases in average total debt of grain farms have been largely matched by equivalent changes in total farm equity as a result of increases in land values and average farm area operated. According to ABARES (2019) about half of grain farms had an equity ratio greater than 90 per cent but on average these farms are relatively small with only 53 per cent of their total receipts from selling crops in 2016-17 (see Table 1 below). Only 12 per cent of grain farms had an equity ratio less than 70 per cent. On average, these were relatively large grain-producing farms that obtained around 71 per cent of total cash receipts from crops. The larger farms with higher levels of debt and lower equity are generating more profit than the smaller farms with less debt and high equity. It needs to be noted that in this survey ABARES have not made a distinction between family and corporate farm ownership.

Table 1. Farm performance by equity ratio for Australian grain farms 2017–18

Equity ratio	Unit	More than 90%	70 to 90%	Less than 70%
Proportion of farms	%	55	32	12
Total area operated	ha	1,650	3,241	4,409
Total area sown to crops	ha	578	1,160	2,094
Crop receipts	$	304,500	677,900	1,075,800
Total cash receipts	$	570,600	1,085,000	1,525,500
Total cash costs	$	327,200	748,700	1,159,700
Farm cash income	$	243,300	336,300	365,900
Crop receipts as a proportion of total receipts	%	53	62	71

(Sourced from ABARES 2019 Australian Agricultural and Grazing Industries Survey)

According to Barr (2009) the decision to leave farming is generally made by farmers operating medium sized farms. The definition of a medium sized farm must be challenged by space and time, underpinned by real terms such as land values, equity, and crop receipts. Evidence from ABARES data suggests that it is not the larger-scale, highly-geared farmers with lower equity that exit the industry because these farms are businesses that invest in science and technology to effectively service financial commitments. On the other hand, quantifying the effects of exceptional circumstances, such as prolonged drought, still remains as a challenge for the financial resilience of all farmers and their farm businesses.

Harvey (1982) identifies the relative tensions in the theory of ground-rent and the appropriation of excess profits from landed property. Harvey notes that family farms do not necessarily comply with the traditional theories of accumulation and exploitation. Family farms can be capitalists and landowners, and expropriate surplus labour from offspring.

> Owner-occupiers are liable for the purchase price of the land, and even when the land has been handed down freehold over many generations the income forgone by virtue of the fictitious capital locked up in the 'value' of the land cannot be cavalierly thrust aside. (Harvey 1982 p. 365)

When farmers are not the owners of their product the condition of alienation and exploitation from the commodity chain could be said to exist. Forward selling commodities, and similar contracts such as hedging and traded derivatives called futures, allows the farmer to lock-in a commodity price for contracted tonnage. This risk management strategy can increase the pressure on the farmer to supply the buyer with the agreed quantity and quality of grain by a specific date. Failure to do so generally results in the producer paying the difference that could not be delivered or buying the commodity from another producer to fill the contract.

Marx examined the position of the farmer in the economy, aware that the private property owner was also the worker. According to Postone (1996) the critique of labour in capitalism is possible, as to is the critique of capitalism from the standpoint of labour. Postone (1996) suggests that the character of labour constitutes the basis for a historically specific analysis of social domination. Therefore, a present-day analysis of the farm labourer may determine just how the economy works through the farmer and where social domination exists to stabilise the structure of the commodity chain.

The psychological effects of financial stress have been studied (Bergeman and Wallace 1999; Reich and Zautra, 1983) yet interestingly in the context of alienation, community social relations and social inclusion have been examined and found to be interrelated with financial risk taking (Montpetit, Kapp and Bergeman 2015; Duclos, Wan and Jiang 2013). There is a gap in the literature pertaining to evidence of the on-farm actions, or any workplace action for that sake, from which decision-making in practice under financial stress are carried out. The fieldwork and methodology in this PhD research therefore is prepared to examine if and when farmers modify

machinery, misuse equipment, delay replacing parts, take short-cuts in practices, and create substitutes to keep operations on track to meet financial demands and avoid paying for the labour of others.

Technology

Technology is adopted by farmers as a method to increase their productivity by decreasing their requirement for farm labour and improve decision-making through data. The advance in technology tools and precision technologies are identified as the one of the top ten megatrends in agriculture, which have not only "effected the structure of agriculture, but also have affected the socioeconomic status, health, and safety of the agricultural workforce." (Donham and Thelin 2016 p. 24). Farm workers are replaced by increasingly larger and technologically advanced machinery and equipment,

> Genetically modified crops, new plant protection products, global positioning technology creating near robotic planting and harvesting machines, robotic dairies, drone airplanes for surveillance of crops and livestock, and biofuel production are all current realities. Mechanization of agriculture has been ongoing since the mid-1800s, but this new phase of machines replacing human labour is occurring at a much higher rate in industrialized countries. (Donham and Thelin 2016 pp. 28-29)

The continuous flow of new technology into agriculture means the continuous remaking of the farmers that use it. According to Barr (2009) advanced farm mechanisation and technologies offers farmers new prospects for staying in the productivity race. Mechanisation and technology brings with it a different set of relations. This remaking is generally considered in relation to nature, but the humanism of farming is the remaking of the farmer. From their study of women's relations with technologies during breast cancer treatment, Boer and Slatman (2018) create an integrated social theory of how technologies mediate human perceptions and how they approach their world and are present in it. Using the work of Latour (1994), Akrich (1992) and Verbeek (2006) they argue that people's actions are not only the result of individual intentions and the social structures in which human beings find themselves, but also of their material environment (Verbeek 2006 p. 366). In other words, how the world appears to humans and how humans act in the world is always to a smaller or larger degree constituted and transformed by artefacts and technologies (Boer and Slatman 2018).

The technological advancements in agricultural machinery is no longer a post-Fordism division of labour through specialist maintenance and repairs. An example of this change is at the John Deere Technology Innovation Centre (JDTIC) which is part of the Research Park at the University of Illinois in Champaign. The Park comprises of over 100 companies and employs research professors and staff and also provides students with the opportunity to focus on advancing technologies (John Deere 2017).

> And in agronomy, in-house agronomists help investigate issues in the crop sciences, and once identified, help John Deere design more productive machine solutions. (John Deere 2017)

Opportunities such as the JDTIC are plausible to advance Australian agricultural productivity. Daley (2012) assessed that Australia's regional universities appear to have made little identifiable contribution to local development. Conversely Ball et al (2017) shows there is a rising level of investment to commercialize agricultural robotics as demonstrated by an increasing number of new start-ups. Australia's rural regions including the Wimmera Southern Mallee are almost certainly at more risk of missing out on many of its benefits than metropolitan cores, universities included.

The interaction of technologies through the de-structuring of government departments and research and development corporations for cross-industry investment may help deliver a vision for survival strategies for regional areas. Thus, in the context of alienation, bridging the gap between the farmer using technology and the developer of farm technology, may result in changed relations between labour and the act of production.

Occupational health

Agriculture is one of the three most dangerous occupations worldwide (Brumby 2020). Globally, the sector employs an estimated 1.3 billion workers and according to the International Labour Organisation (ILO) it is estimated that at least 170,000 agricultural workers are killed in their workplace each year (Brumby 2020). Nationally, agricultural mortality rates have remained consistently high in the last decade with widespread under-reporting of injuries. In 2018, 26% of worker fatalities were in the agriculture, forestry and fishing sector and they account for less than 3% of the Australian workforce (Brumby 2020).

Farms are a dangerous place to live and work. Tractors remain the most dangerous risk on farms. In 2014-2018 a study by Safework Australia showed that 69% of deaths were a result from vehicles, with tractors being the cause of 23% of these fatalities (Brumby 2020). Of all 188 farm accident deaths over a five year period, 30% occurred to people over the age of 65 years, 18% occurred to those under the age of 15 years, 92% occurred to males and 9 fatal mis-shootings were recorded (Safework Australia, cited in Brumby 2020). The distance of many farms from emergency dispatch sites can make rescue and first aid difficult. At the start of 2020 six farm deaths occurred in just eight days marking a tragic start to the year.

The National Centre for Farmers Health was established in 2008 to improve the health, wellbeing and safety of farm men and women, farm workers, their families and communities across Australia (Farmer Health 2018). This is a partnership arrangement between Deakin University and Western District Health Services in Hamilton to facilitate knowledge transfer across multi-disciplinary agencies working in rural areas. Their farmer-related key health

indicators include weight gain, stress, respiratory disease, trauma, sun protection, depression and alcohol consumption (Farmer Health 2018). Accredited Agri-safe nursing practitioners attend field days and locally funded clinics to test farmers' health and interpret occupational surveys. They offer recommendations, such diet, hearing protection, and respirators, to increase farmers' lifespan through healthier and safer choices. Agri-safe has been present at the Wimmera Machinery Field Days for the last three years. Even though the centre has been operating for twelve years with global connections and research acumen "little is known of the lifestyle behaviours and prevalence of chronic disease in the Australian agricultural workforce" (Pinidiyapathirage et al 2018). A cross-sectional health survey in rural Queensland was undertaken from 2013 to 2015. The results showed that short-term high-risk alcohol consumption was more prevalent among the agricultural workers (Pinidiyapathirage et al 2018). High-risk alcohol consumption was categorized as men having more than six standard drinks or women having more than four standard drinks on a single occasion of drinking at least once a month.

The operational safety of working with technologically advanced, large-scale farm machinery offers new scope to investigate the structural effects of this farming modernisation. However, according to Donham and Thelin (2016 p. 29) "there is currently no research to identify the benefits, or unknown unintended consequences, relative to the health of farm operators or workers of these new technologies." According to Aitken (2020) whole body vibration, of which is experienced when operating a tractor, temporarily reduces the strength of muscle and ligaments. As a consequence, farmers' risks to their health and safety increases when they jump down from machinery and move into uncoupling heavy equipment from the tractor.

From a biological perspective and considering the consequences of using machinery, labour theorist Hannah Arendt (1958) offers that physical movement is integral to the interpretation of the social relations between humans and mechanisation. Her research into the physicality and roles of labour contextualises farmers as labourers and offers the reader insights into the human consequences of technological advancements and machination. Arendt writes that implements become one with human rhythmical movement, such as the swing of an axe, however opposed to the naturalness of using a tool as an extension of a limb, machines such as tractors and headers, are merely artificial and are best suited to the performance of the *animal laborans* (Arendt 1958).

> The decisive difference between tools and machines is perhaps best illustrated by the apparently endless discussion of whether man should be "adjusted" to the machine or the machine should be adjusted to the "nature" of man…… Unlike the tools of workmanship, which at every given moment in the work process remain the servants of the hand, the machines demand that the labourer serve them, that he adjust the natural rhythm of his body to their mechanical movement. (Arendt 1958 p. 147)

Arendt does not suggest that labourers become servants to the machinery but implies that labourers work with the mechanical process rather than the natural ability of the human body. Over time as technology has advanced and farming has become automated, farmers are perhaps servants to their farm machinery now two-fold: they work with the machine against their natural human rhythms enduring the vibrations and noise from the machinery, and they are a servant to the financier for its purchase. Arendt's observations of the interaction between humans and machinery provides the opportunity for an epidemiological analysis, beyond the statistics of farming accidents. Arendt's theories are discussed in greater detail in Part two of this chapter.

Self

This section is about the element of species-being, and how farmers relate to nature through actively arranging it to meet societal and personal needs. The humanism in farming is possibly overshadowed by technology, economics, environmental risk, drought, and trade. Perhaps too quickly farmers' personal needs are dualistically categorized into either mental or physical health, overlooking farmers' sense of self, identity, agency and capacity. Harvey (2016) brings an analysis to the theory of social space to understand a range of disciplines, elucidating that the politics of production is more about the politics of self-realisation than not. This element of alienation summarises and suggests how humans arrange and organise themselves. This third element of the theory of alienation is where we ask whom organises who when it comes to the constructs of an agricultural industry?

Agriculture is the intersection of nature as resource, and human nature as an instinct, combined in both creativity and purpose for production. Kaufmann (1972) writes that alienation involves a painful sense of isolation, self-doubt and frustration. Sayers (2011 p.37) refers to the work originating by Hegel but later developed by Marx that agriculture no longer relates to nature as a mere given, and it ceases to be entirely dependent on the contingencies of what is immediately present. Marx identifies that agriculture actively arranges the natural environment to meet it needs, but by doing this we are freeing ourselves from passive dependence on natural contingency (Sayers 2011).

Marx suggests that a human alone is capable of consciousness, and that her "life-activity is motivated by nothing more than the need to create, to express one's self, to give oneself external embodiment." (Schacht 1972 p. 78). Schmidt (1971 p. 21) summarises this as "he who separates thought from the senses, the soul from the body, is incapable of grasping the connection between the content of culture and the sphere of material production." This summation can be re-interpreted through the way people live their lives; the decisions they make are disconnected with sensuality and instinct, moving them closer to the attainment of things but further away from self-fulfilment.

In *The Economic and Philosophical Manuscripts of 1844* Marx differentiated between free human production and animal nature. It is from this standpoint of comparison, the term species-being is used. "Conscious life-activity distinguishes man from the life-activity of animals. Only for this reason is he a species-being" (Sayer 2011 p. 16). Marx explains that while alienated labour alienates nature from man, and man from himself, it also alienates the species from man. It turns his species life into a means towards his individual life (McLellan 2000 p. 90). Humans live with nature and they look at themselves as living species, as universal and free beings. However,

alienated labour takes away their species' life. Since it transforms free and self-directed activity into a means to life, it transforms the species' life of human beings into a means of physical existence.

> Conscious vital activity differentiates man immediately from animal vital activity. It is this and this alone that makes man a species-being. He is only a conscious being, that is, his own life is an object to him, precisely because he is a species-being. This is the only reason for his activity being free activity. Alienated labour reverses the relationship so that, just because he is a conscious being, man makes his vital activity and essence a mere means to his existence. (McLellan 2000 p. 90)

As nature is turned into a mere means of production, so also the human part of nature becomes mere means (Law 2011). Labour is estranged from its own human nature, or 'species-being'. Human society is not external to nature, rather it is a distinct part of it. The separation of the work process and the end product disturbs Marx's sense of human nature. Mandel (1973) states that man's estrangement of nature occurs when natural objects, regardless of their variety, function not for self-satisfaction or cultural fulfilment, but merely as material means for profitable production. The greater control of nature that farmers, industrialists and alike have, the further removed society as a whole becomes from the environment which surrounds them.

Nature

When worker find themselves disconnected from the natural environment they are said to be alienated. Nature is a broad and complex term. Castree (2014 p. 3) defines nature as something we could not live without because it provides us with the materials required to satisfy our basic needs for shelter, warmth, food and clothing. Castree (2014 p. 3) shows that "we try to control nature in order to derive benefits." Agricultural techniques are used overcome nature, which offers historical conjunctures to mechanization, chemical innovations, genetic modifications and structural changes in farm labour.

> It [nature] seems to be a large and diverse phenomenon that is literally everywhere – in us, as well as around us… nature is assumed to be a thing unto itself. It is variously, something to be investigated, protected, properly understood, tamed, restored or modified. (Castree 2014 p. xxii)

Uneven Development (Smith 1984) and *From Farming to Biotechnology* (Goodman, Sorj and Wilkinson 1987) both comprise a substantial corpus of theoretical and empirical work on the capitalist production of nature. Goodman, Sorj and Wilkinson (1987) state that the question of specific social relations in the countryside does not go to the heart of the matter. Rather, the central problem is the industrial erosion of the rural, with the key variable being nature and the degree to which biological production systems are reproduced in the industrial context. Focussing on the hybridization of crops such as corn, their work demonstrates how capitalism has corrupted

the natural reproductive qualities of seed through genetic engineering in the pursuit of corporate profit.

Farm production can be arduous, reiterative and unforeseen. Extreme seasonal conditions, such as heat waves, drought, and floods, can make work more challenging than the planned seasonal and/or routine workload. According to McLellan (2000 p. 87) the "worker can create nothing without nature, the sensuous exterior world." And the more that the worker appropriates this exterior world of sensuous nature by his labour, the more he deprives himself of the means of subsistence (McLellan 2000). Modern farmers are deprived of the means of subsistence at the opportunity cost for profit. The concepts of bulk commodity product support these ideas. Goodman, Sorj and Wilkinson (1987) demonstrate that the organisation of rural production is obviously determined by agro-industrial capitals, and the supposition of a peasant-dynamic in the early twenty-first century is increasingly implausible.

Nature was regarded by Marx as the reactive object and humanity as the active subject. Marx conceived labour as a metabolic interchange between humanity and nature, a process in which humanity (re)creates both itself and society (Nimmo 2010). Similarly for Young (1991) labour is neither culture nor nature, but their matrix.

> Labour is, first of all, a process between man and nature, a process by which man, through his own actions, mediates, regulates and controls the metabolism between himself and nature. He confronts the materials of nature… he acts upon external nature and changes it, and in this way he is simultaneously changes his own nature. (Marx 1967)

Labour is the key mediating moment of the subject-object dialectic at the centre of Marxist thought, at once historically, epistemologically and ontologically (Nimmo 2010). For Marx, social history as the subject has emerged out of natural history, the object, yet represents a fundamental departure from it. Marx insisted that historical materialism alone gave due recognition to the historical significance of the human existence as a species of natural and physical beings, compelled to produce the means to satisfy their material needs (Nimmo 2010).

Marxian theories suggest that the productive forces that take place under capitalism provides the means to reduce the domination of nature to insignificant proportions and to increase human freedom, proportionately. But this extent of domination over nature is not measured. Environmental accounting formulas cannot be agreed up at a political level, and the level of human coercion is disguised. Today, agriculture's reliance upon nature is measured using economics and trade accounts.

The Peasant Question and Capitalism (Amin and Vergopoulos 1974, in Goodman et al 1987) offers that the modernisation of the family farm is a response to the lack of control over the agricultural production process. It claims that due to the predominance of natural conditions,

higher levels of productivity provide a defence against market fluctuations in output and prices. Technical progress in agriculture becomes the condition of survival for farmers, precisely because the rural production process is dominated by nature (Goodman et al 1987). This resonates with our understanding of how Wimmera Southern Mallee farmers relate to nature by actively re-arranging it to meet their productivity needs, and to overcome their exploitation in the commodity chain.

Irrigation

Politics in irrigation provides a pertinent example of where farming manipulates nature for capital gain. It is also where regulations, irrigation infrastructure, rural communities, science, technology, and climate change all culminate into ideological battle. The Wimmera Southern Mallee is part of the artesian system of the Murray Darling Basin. This enabled the Commonwealth buy-back of water licences of Wimmera irrigators and prompted the completion of the Wimmera Mallee pipeline in the early 2000s. Irrespective of this infrastructure and policy reform that has taken place this century, the irrigation remains relevant to the concept of farmer-alienation because irrigated agriculture can be considered as an important for farmer-identity, farm productivity, technology, and political economy.

To summarise, irrigation reorganises and redistributes water for agricultural productivity. It is a farming method whereby artificial applications of water are applied at controlled intervals to water crops. A range of factors influence the use of water on individual farms, including changes in seasonal conditions, water availability, the mix and type of irrigated enterprises and trade in seasonal water allocations and permanent water entitlements (ABARES 2017b). Australia is the driest inhabited continent in the world and renowned for its highly variable climate (Doolan and Hart 2017). Irrigated agriculture makes an important contribution to the Australian economy and regional economies (ABARES 2017c), which prompts the qualitative social question of whether decommissioning the irrigation system in the Wimmera was in fact ideal.

Doolan and Hart (2017) discuss the reforms in water management for the last 30 years, noting that regardless of the firm foundation for water resource management by the 1980s a number of new issues were emerging. These issues included large government debt, poor pricing policies, service delivery challenges and widespread environmental damage (Doolan and Hart 2017). “Water allocation systems were put in place that were meant to reflect the actual water availability at that time.” (Doolan and Hart 2017 p. 5).

> There is increasing awareness that the management of water resources must be considered in a social, cultural, ecological and political context. Gone are the days when it was only the hydrological aspects of water resources that constituted water resource management. (Hart 2017 p. xix)

Since the River Murray Waters Agreement was signed by NSW, Victoria, South Australia and the Commonwealth Governments in 1914, it has evolved through 15 iterations to the current Murray-Darling Basin Plan. This is possibly Australia's longest standing intergovernmental agreement (Hart 2017). The Basin Plan determines the amount of water that can be extracted or taken annually from the Basin for consumptive urban, industrial and agricultural use (Murray Darling Basin Commission n.d). The volume determined is called the long-term average sustainable diversions limit, or a volume of extraction that will not have a negative impact on the natural environments and the functions of the rivers, waterways, groundwater and wetlands of the Basin (Murray Darling Basin Commission n.d).

Political conflicts and legislative iterations are not new to the irrigation sector. The history of the irrigation trusts and schemes clearly demonstrate the differing policy priorities and ideologies of politicians, selectors, and agencies from the 1880s onwards (Barr and Cary 1992, van Veldhuisen 2001). In 1885 Minister for Water, Alfred Deakin ordered a Royal Commission into irrigation, relinquishing his role as Minister and appointing himself as the Royal Commissioner "to ensure it produced the right answers" (Barr and Cary 1992 p. 212). A confident future for irrigation was reported, and a new irrigation Bill was presented to Parliament in 1886. "It allowed major irrigation works to be designated as national works with government paying the infrastructure costs. The costs of other works were to be paid by landholder trusts authorised to take government loans and levy rates on participating landholders" (Barr and Cary 1992 p. 213). The prospect to irrigate spurred the applications for weirs and supply channels, and as a result of this flurry, farmers were dissatisfied with the service and delays in construction. Barr and Cary (1992) highlight that even in the early development that "it was clear there was not enough water to go around" (p. 213). The legacy of limited resources, environmental flow policies, flow targets for South Australia, and unlimited desires, remains today.

As a consequence of these differing ideologies, coupled with varying inflows, irrigators have been in a position of regulatory and water delivery uncertainty from the very inception of the trusts. Irrigation is more than redistributing water along channels for farm delivery. Water is a tradeable commodity unbundled from land, providing licence holders with opportunities to sell water permanently or temporarily, rather than use it for plant production. Water storage management, water allocations, and environmental flows together with uncertain rainfall, all influence competition and pricing.

> Farmers in irrigation areas of Australia have their own culture, their own way of seeing themselves, possibly their own political party. Although it is the irrigators' culture today, it is not a culture that irrigators developed. Irrigators have merely maintained and adapted beliefs that had their roots in the stand of the Eureka miners, the selection movement, the squalor and depression of the eighteenth century urban life and the patriotism of the First World War. (Barr and Cary 1992 pp. 206-207)

Irrigation can be viewed as a tool for farmers safeguard against limiting rainfall, or a commodity to hedge funds and speculate. Either way or somewhere in between, Barr and Cary (1992) and van Veldhuisen (2001) recognise the cultural significance of what water brought to the selectors of Victoria. What is missing from this historiography is an interpretation of the consequences of the iterations to policy upon the farmers, especially in the Wimmera Southern Mallee where irrigation has been decommissioned. Farmers' histories were connected with orchards, paddocks of Lucerne and seed production. The increasing presence of the service sector in the irrigation districts that seek farmers to invest in irrigation technologies and precision farming systems to improve their water use efficiency may be contributing to the condition of alienation. The services sector profits from political reform and community pressure on farmers. Nevertheless, irrigators continue to pay for their water licences regardless of the percentage of water allocation they may receive. The dialectical relationship between farmers and water has changed over time, adding the environment as a new key stakeholder, and capitalism as the policy driver. Historically water was a resource, today it is a sector.

Agricultural sustainability

Agricultural sustainability and regenerative agricultural practices are examples where farmers may defy the wider assumptions of their exploitative ways upon nature. The Wimmera Southern Mallee demonstrates its interest in agricultural sustainability through active Landcare groups, the Wimmera Farming Network and the Victorian No-Till Farmers Association, all non-for-profit groups with farming members. Medium to low rainfall prompted many grain growers to change techniques to conserve available soil moisture. Farmers increased crop productivity by using chemical weed control instead of ploughing, and sowing their crops using narrow knife-points or discs on seeders to minimize soil tilth. Over the last twenty years, soil and soil health have been research and extension priorities for the Wimmera Southern Mallee. No-tillage cropping has become an identity for grain growers using this system.

The term sustainability does not have an agreed definition. It can be described "as a set of issues about how we view and interact with the world" (Ramsey 2015 p. 1076). Sustainability is thus perceived as much bigger than farms or agriculture as an industry alone. Ramsey (2015) identifies that as a result of the social nature of its meaning there are no essences to concepts, and because there are no essences the meaning of the concept has to be set by social practices. That being, the lesson for sustainability is that we will not be able to define our way to clarity, rather, we will have to rely on how we go about doing and performing it (Ramsey 2015). The ideas of soils and sustainability are synonymous in the Wimmera. According to the Wimmera Catchment Management Authority (2020) sustainable management of soils is critical for maintaining Victoria and Australia's economy and providing national food security.

Barr and Cary (1992) describe sustainability as an abstract idea over which few disagree, but in the context of production it is an adaptive process to the Australian landscape. Vanclay (2004 p. 215) defines sustainability as staying on the farm. Wu (2006) defines the science of sustainability as the dynamic interaction between nature and society. Barr and Cary (1992) offer that because it doesn't have readily measured properties, it be expressed in a multiplicity of forms and values.

Based on values and ideology, "there is a wide range of perceptions regarding the care of the land on contemporary Australian farms … The management of farms and the use of land is a series of complex trade-offs. If we only focus on a single purpose we can lose the full understanding of what drives a farmer and direction decisions about land use" (Barr and Cary 1992 p. 3). Culminating from these perceptions of farm management, environmental economic and accounting argues for more rigorous environmental protection and uniform indicators to measure status. Using the Environmental Kuznets Curve theory, evidence shows that as incomes rise as a society, we become more willing to pay for improved environmental conditions (Barr 2009).

Over the past two decades farmers have experienced public and political pressures to restrict their activities in return for improved environmental outcomes." (Barr 2009 p. 108). Examples of such restrictions on production include tree clearing and timber harvesting. Beneficiaries versus polluters is a common argument but the argument is never resolved. Barr (2009) asks the question of who pays for the loss of production. Farmers, as the users of the natural resources, believe that the beneficiary, being the wider public should pay compensation for their loss of income. Equally, the environmental interest groups believe that the polluter, or resource user, should pay for the cost of their activities (Barr 2009). But the market signals are not clear because political economy is not structured with environmental accounts. Barr (2009) eludes to the underlying issue that challenging the practice of a resource dependent industry, such as farming or forestry, actually challenges the values and the value of those working in the industry. Sustainability becomes more about culture than simple economic loss.

Although the use of the term clean can often be justified to refer to food safety, such as pesticide residues, farmers are in a less favourable position to justify the green part (Seymour and Ridley 2005). This implies that food is safe, but perhaps not produced in a manner to meet these environmentally-friendly expectations. Consumers' consciousness is unpolitical and until they acquire the collective awareness necessary to articulate an effective challenge to the production system (Goodman and DuPuis 2002). But farmers don't have an interest for political consumers. They seek support for how they grow crops and raise animals in volatile environmental conditions without subsidies. A mutually beneficial outcome is consumers' awareness of the provenance and sustainability of how food is grown and a widening consumer consensus to move away from homogenous products of globalised agro-food. But according to Jansen (2015) it

becomes impossible to produce outside a capitalist sphere because of the deep penetration of capitalism in the sphere of production which makes farmers compete for resources.

Agriculture is the oldest way in which humans interact with natural systems, particularly through the alteration of land for crop and livestock production and the redirection of energy, nutrients, water, or biomass flows towards human consumption (Dale et al 2013). In Australia, early attempts to recreate England were marked with endless barriers and farming had to be relearned (Barr and Cary 1992). As a result of modifying the landscape for production, the major environmental issues faced by Australian agriculture are salinity of which some areas are beyond reclamation, loss of biodiversity, soil erosion, soil acidification, and soil structural decline (Seymour and Ridley 2005). Farmers tend to address issues that directly affect productivity and which occur on-farm, such as soil fertility decline and acidification (Vanclay and Lawrence 1994). Off-site issues affecting the landscape, beyond the farm, often do not relate to short-term profitability so are not usually within the farmers' immediate needs or financial capacity to be addressed (Vanclay and Lawrence 1994). Examples of off-farm issues include pest animal control, un-vegetated rainfall recharge zones, and water catchment issues such as drainage and flood risk. Seymour and Ridley (2005) state that these "off-site issues often cause the most serious long-term problems for farmers and society." But Dale et al (2013) argues that an agreement on more sustainable pathways is often viewed as being unattainable because the issues are so large, complex, value-laden, and context specific.

But under the condition of alienation, where does the issue of sustainability leave Wimmera Southern Mallee farmers? The balance of past, present and future agricultural practices in the region can be seen through today's silo art trail. The Wimmera Southern Mallee has a long history of grain production. As a collective, value is held in landscape icons such as the antique Murtoa grain stick shed, no longer used but maintained for memorial and historical significance. Community capacity to address sustainability has been long demonstrated through inaugurations of the Wimmera wheat-breeding centre, the Wimmera Conservation Farming Association, the Victorian No-Till Farmers Association, the Grains Innovation Park, the Grains Centre of Excellence, and most recently the data farm at Longerenong College. Sustainability will continue to evolve as long as the term is inclusive and allows for technological change and adaptations.

The greatest challenge is suggested by Barr (2009) in the forecast that farmers will become a novelty. "The farming lobby will no longer be in a world where it influences the agenda of society, but a world in which it must respond to society's agenda" (Barr 2009 p. 95). Archer et al (2008) identify that agricultural systems do not operate in a vacuum, rather they are situated within social and political environments that influence the way in which they operate. Identifying farmers' barriers to adopt sustainable practices, the social, political and cultural context of agriculture has often been ignored (Vanclay and Lawrence 1994, Archer et al 2008).

Indeed, with regard to sustainability, the environmental and economic indicators are well established, but what is lacking is an awareness of the social issues (Vanclay 2004).

MARXIST ELEMENT OF ALIENATION: DISCONNECTION FROM OTHERS

People

Alienation is defined as the condition where individuals find themselves disconnected from other individuals. Through labour the worker creates multiple relations which are both abstract and almost illusionary to describe their inner tensions and feelings about their labouring satisfaction. Alienation relegates the worker as a commodity that produces other commodities in order to consume more commodities. This is a cyclical process where the cycle of compulsion can only be broken by ending alienation itself, not simply abolishing private property or wages (Law 2011).

This element of alienation is a critical concept specifying that labour alienates workers from other workers. Set in the factories during the industrial revolution this is a socially constructed theory that is based through practical and real relationships to other men. Workers could see themselves in others, repeating the same task as they did, but at the same time they lost their individualisation and free thinking. Workers alienated themselves from those who were similar to them. In *The Economic and Philosophical Manuscripts* in 1844 Marx wrote:

> Through alienated labour, then, man creates not only his relationship to the object and the act of production as to alien and hostile men; he creates too the relationship in which other men stand to his production and his product and the relationship in which he stands to these men. (McLellan 2000 p. 92)

Farming can be geographically isolated and be a lonely occupation, but the concept of alienation is not concerned too much with spatiality. This element of alienation is more like an internal mirror for self-reflection. Alienation exists when farmers reflect on their own work processes and labour, when they see their operations mirrored on the farms of others'. Within the Wimmera Southern Mallee, operations and farming systems, such no-tillage cropping, controlled traffic farming, variable rate technology and soil moisture probes, can be depicted as responsible for these relations. This culture of long-standing, and sometimes silent, inter-farmer contestation includes achieving the highest crop yield, buying the biggest and newest farm machinery, and having the winning bid at land auctions. Referring to the words of Marx "in the situation of alienated labour each man measures his relationship to other men by the relationship in which he finds himself as a worker." (McLellan 2000 p. 91). This also explains the distinctly different relations of grain growing farmers in the Wimmera Southern Mallee with graziers, dairy farmers, orchardists or any other primary producer. This is even more so when other farmers are from different catchments in Victoria, inter-state or in another country. When grain growing farmers cannot see their labour in others' operations, they are not alienated from them as farm workers.

Alienation is a consequence from the industry as agriculture perhaps forgets that people are involved, preferring to focus on productivity gains rather than focus on who is responsible for the intended practice. Vanclay (2004) identified that what is lacking is an awareness of the social issues that support farmers. "Agriculture is farming, and farming is people" (Vanclay 2014 p. 213). Farmers also participate in off-farm roles, like the Country Fire Authority and sporting clubs, not just in isolation on the farms. The survival of agriculture is dependent on the survival of rural communities (Vanclay 2004).

Agricultural ethnographers who find themselves at the farmhouse kitchen table have tended to avoid relation-based questions. Asking farmers to define their relations with others such as their spouse, neighbours, friends, relatives and offspring, or seeking farmers' personal preference to either be social or alone, remains under studied. Jansen et al (2010) conducted social research on a group of dairy farmers in the US who were considered to be hard to reach. These farmers did not participate in farmer-groups. This study found that of the farmers they interviewed, a quarter were categorized as 'reclusive traditionalists'.

> This group of farmers was very inward oriented. They did not like the interference of others on their farm. They had few contacts with other farmers and did not feel the need to compare their farm with others'. The interviewed farmers did not seek alliance with other farmers. They stated that they tried to prevent visits from veterinarians and other advisors as much as possible because they thought that these people had a hidden agenda to make money. They did not like exchanging information with others because they felt uncomfortable when others had access to their farm data. (Jansen et al 2010 p. 1302)

Such intention–behaviour discrepancies have rarely been studied in the agri-industry (Dernburg et al., 2007, cited in Jansen et al 2010). This comes as no surprise because field trials of crops and animal health are much easier to research than human responses. "Farmers are also part of a wider social context and are being influenced by many institutions, legislation, and common law, henceforth, farmers' motivation to work—or not to work— … depends on many external factors" (Jansen et al 2010 p. 1302).

The central argument for this element of alienation is about farmers and their relations to others under capitalism. In the situation of alienated labour each farmer measures their relationship to other farmers by the relationship in which they find themselves placed as a worker.

> A direct consequence of man's alienation from the product of his work, from his life activity, and from his species existence, is the *alienation of man* from *man*. When man confronts himself he confronts *other men*. (Marx, 1967 p. 295 original emphasis)

Marx insisted that private property ownership drove human estrangement. Capital accumulation is often polarizing between individuals and groups of similar individuals. Hoggart (1990) asks a

broader question of how established practices of capital accumulation alter the fundamental relationships of civil society. Perhaps an agricultural disaster such as an animal disease outbreak or an intense pest plague, where all farmers equally share its effects, individuals will not be separated from each other for during this time.

Family

The people who matter the most on family farms are indeed the family themselves. Family farms do not conform to the laws of political economy which makes them challenging to analyse. They are embedded in a dualistic conceptual framework which counter-poses family and economy, reproduction and production and assumes that, under capitalism home and work represent two functionally and spatially separate realms (Whatmore 1991 p. 2). Family farms cannot be explained like a wage-paying factory. Yet the condition of alienation is likely to exist for those who labour with minimum control and for minimal wages under the conditions of the family farming unit in the Wimmera Southern Mallee and beyond.

Parental control of the family farm could certainly have alienating effects upon the labouring offspring especially under the duress of unknown inheritance. It is likely this could lead to a loss of spirit for the young farmer, or even the older farmer working for the elderly farm owner who continues to control the family trust. Family labour is distinct from wage labour by drawing an analytical line between family and capitalist production (Whatmore 1991). This is defined in *The Economic and Philosophical Manuscripts* as "the relationship of the worker to his own activity as something alien and not belonging to him". But despite the family farm resisting the tradition of political economy, the consequences of labour remains when it continues unrewarded. But it is not only the youngest working farm labourers that experience minimalist conditions; many farmers do not take drawings from their business nor pay themselves superannuation. Rather, they sacrifice an alternate lifestyle of travel and material luxuries to keep the farm business operating.

In the Wimmera Southern Mallee farms can be a place of controversy and complex human relations. They can involve multiple people in the day to day management and the financial affairs, whilst they all live together in one household. Family labour still constitutes an essential resource on many farms (Andersson 2017). Traditionally, the family labourers work for the farm with minimal wages to build equity. This allows the oldest generation to retire and the younger generation to cope with the debt that succession brings. Often it is only the non-family labourers who receive wages or an hourly casual pay rate. Vanclay (2004) declares that there is no firm evidence but it has been suggested that succession issues are responsible for much rural suicide.

Questions about how capital is socially organised within the farm sector are both politically and theoretically significant (Weller et al 2013 p. 129). Weller et al (2013) argues that

theorisations of family farming can and should give more prominence to the role of business regulation. “A more nuanced appreciation of the ways in which farm families’ commercial and lifecycle aspirations are navigated through the intricate terrains of commercial, legal and taxation regulation should inform expectations of the fate of family farming in advanced financialized economies” (Weller et al 2013 p. 130).

Most farmers want to pass the farm on to their children in a better condition than they themselves received it (Vanclay 2004). This motivation exceeds any rational economic decision about the level of care to invest in improving the farm because it makes any investment of labour, effort and money, worthwhile (Vanclay 2004). Improvements include improving soil fertility, addressing land degradation issues, tree planting, and maintaining and improving infrastructure. It could be argued that Vanclay overlooked the immediate consequences of farm hand-over. Empirical evidence offers that when the retiring generation declares succession, the farm business enters austerity mode, and profit is not re-invested into machinery nor improvements. Indeed parents’ desires to have children remain on, or at least return to, the farm are powerful expectations that can cause strong feelings of obligation in farming families, especially when the farm may have been in the family for generations (Vanclay 2004). New relationships can often create tension and unearth wealth distribution issues amongst farming siblings. In Australia it is estimated that just 10% of farm successors are daughters (Brumby 2020).

Many farms cannot support two families, at least not at the level of some people’s disposable income level (Vanclay 2004). The changing structure of agriculture, especially with greater demand for off-farm income to support the farm and an increasing diversity of on-farm activities, means that the role of women is changing, creating new opportunities and also new problems (Vanclay 2004). Marriage remains the main pathway through which women enter farming (Barr 2009). Dual careers in relationships is leading to new patterns of migration, as motivated farmers alter their routines to accommodate the needs of their family members. Barr (2009) identifies that dual incomes are the norm for most Australian middle-class families, yet most farms have not grown to match this new income expectation. Barr (2009) also uncovered that it is not as predicted that the smaller, and less productive farms are most commonly sold. The farms being sold were those with dissatisfied women in the business arrangement. “Marital and family dissatisfaction can lead to a divorce settlement in which the farm is broken up and sold” (Barr 2009 p. 80). The disposable income generated from farms commensurate with most people’s income expectations is uncommon (Barr 2009; Vanclay 2004).

Vanclay (2004) highlights that the feelings of commitment and obligation can mean keeping the farm in the family, against all economic reason. Vanclay (2004) also highlights that farming in marginal conditions is structural, and generating profit from the farm will remain challenging. An example of this are freight costs; all inputs and all outputs costs have higher transit fees in rural and remote areas as they are further from the port.

> Farmers who are now regarded as marginal were in the past regarded as having a viable land holding…While many of them continue to survive by having a reduced need for income, it must be remembered that they are not marginal because of any personal failure or become a lack of management skills; they are marginal because they were structured to be marginal. (Vanclay 2004 p. 216)

There are many structural challenges for modern farming families living beyond commutable distances from regional business centres. There is an expectation of dual careers for equality and to be able to generate disposable income that equates to dual income households. There is an underlying fear of farmers who are yet to receive the transfer of land titles that the undertaker will be the farm succession facilitator. The rural language of farming wives as they refer to themselves as the 'tractor widow' or suggest their spouse is 'married to the farm' both infer modern interpretations of alienation.

Community

Alienated labour alienates the self from other human beings. The connections between community, capitalism and the quality of rural life is dependent upon the social organisation of agriculture and its attendant occupational structure (Buttel, Larson and Gillespie 1990 p. 146). In a comparative study of rural communities it was found that the district with more farming families with greater variation in occupations, income and recreation had less adverse implications than the district that was occupied corporate farms and wage labourers (Buttel, Larson and Gillespie 1990 p. 147). This correlates to this element of alienation to explain the economically diverse rural district having fewer social issues than the less diverse community where many shared similar jobs. Day and Murdoch (1993) suggest that social science has had a tendency to down play the significance of place and focus on relationships, or be so immersed in time and place that very little general interest can be found in their work. The differences that Warde (1985) observed is:

> … the dominance of mainstream social science of two competing 'paradigms', Marxism and modernization theory, which despite their many differences share one crucial assumption; namely that modern societies are becoming more and more homogenous, either via the onward march of capital or via the spread of science, technology and the general superiority of the Western 'good life.' (Warde 1985).

Homogenous communities are likely to experience greater alienation than heterogeneous and diverse communities. Coupled with this, larger sized farms, whether they be family or corporate, equates to fewer farmers and their families. This means that over time populations in farming districts and rural communities not only decline but they become uniform. A larger farm means the value of fixed production costs, such as interest, can be shared over a greater area of land. The quest for farm expansion can be a strategic objective of farm businesses. Barr (2009) identifies that there can be no end to this race. Barr (2009) suggests that communities are being reshaped by

the quest for farm expansion. The consequences upon those who remain in the de-populated farming districts remains both under-studied and of significant interest to this doctoral study.

> Poor farm management, farming or personal misfortune, inability to partner, infertility or descendants with aspirations other than farming – all are potential long-term opportunities for neighbours. (Barr 2009 p. 10)

In each farmer's working lifetime, the number of farms will halve (Barr 2009). Agricultural competition is multifarious; it is not just a competition for production against the terms of trade, but a competition between farmers for expansion. Marx necessitates that private property ownership drives human estrangement.

> For this narrative to take shape, the destruction of community is fundamental. Marx saw this clearly when he identified as the necessary condition for capitalist production the separation of the mass of labourers from their means of labour. This so-called primitive accumulation is nothing else but the destruction of pre-capitalist community, which, in various forms, had regulated the social unity of labourers with their means of production. (Chatterjee 1993 p. 234).

According to Chatterjee (1993) capitalism is universal therefore community becomes universal. Those who do not participate effectively are deemed undeveloped by the rest of the world. Comprehending Chatterjee's observation of colonialism in rural districts, farmers with high equity operating a quasi-subsistent business, are most likely seen to be undeveloped by their neighbours. As a consequence, community in the narrative of capital, becomes regulated (Chatterjee 1993). Liberal economics suggest that the market will decide which farmers remain and continue to expand and which farmers sell their land. According to Chatterjee (1993) capitalism is a social evolution at the cost of freedom for progress to begin.

Studying community and defining boundaries, people, institutions and structures, has its challenges. Day and Murdoch (1993) examine how the social sciences have attempted to combine the uniqueness of place with general social processes. The concept of community has been seen as inherently bound up with discredited functionalism, which resulted in a reified concept of community as an active social entity (Day and Murdoch 1993). Subordinating groups and individuals to communities to which they were said to belong, ignored or played down the existence of social disagreements and conflicts (Day and Murdoch 1993). Actor network theorist, Bruno Latour states 'there is no group, only group formation' (2005 p. 27).

> While the use of the term [community] may have been misconceived, it had been aimed towards the comprehension of some features of social organization which had genuine significance. One was that people's location within particular places tended to be an important aspect of their lived experience - what they might, for example, refer to as 'neighbourhood' - a major resource drawn upon for many purposes. (Day and Murdoch p. 84)

Lived experiences that are shared among those within a locality may include the landscape, the scent of native vegetation, the weather, the distance travelled to access the CBD or the conditions of the roads to the school bus stop. In a study in the Ithon Valley in Wales, Day and Murdoch (1993 p. 108) concluded that "participants recognised that they have to live together within a confined physical and social space, which compels them to continually interact and negotiate with one another." Australia's farming landscape may perhaps offer more space, yet farmers' roles within their communities requires them to interact socially for sport, CFA, and kindergarten and school-related matters. But regardless of this spatiality, human estrangement in farming communities seems to be overlooked in literature since the inception of Marx.

Labour supply

Population decline and dispersal in rural areas of Australia is accompanied by a sweeping structural supply in labour. Finding an available and experienced farm labourer to work on a farm in the Wimmera Southern Mallee region can be challenging. Experienced farm labourers are often deemed an expensive fixed cost. Inexperienced farm labourers are seen to require constant supervision to avoid accidents to machinery and themselves. Accommodation on farm may be required by back-packer workers or young farm labourers if they do not qualify for a driver's license. Housing for farm workers can also be limited. With these conditions, farmers are forced to re-evaluate how they run their business. Larger machinery is often the first strategy to alleviate labour needs which is deployed by many farmers in the Wimmera Southern Mallee. For some farmers however, encouraging their offspring to return to the farm, or even stay home from secondary school, becomes a valid option. This results in exploitative labour conditions for family members and it becomes normalised in the sector.

According to Farmsafe, there are approximately 20 farm fatalities of children in Australia every year, mainly from quad bikes and tractor related accidents (Brumby 2020b). Child labour on farms is exempt from the Child Employment Act 2003. Children working on farms is considered to deprive children of their childhood, their potential and their dignity, and harmful to their physical and mental development (Brumby 2020b). However, children are source of inexpensive labour during peak season activities and when labour cannot be sourced.

Another source of farm labour is the older generation who may live on the farm or travel from the town each day to continue to help with the farming tasks. The average age of Australian farmers is 56 years (ABARES 2019b). Unfortunately, statistics show that most injuries and farm deaths occur to males, with the likelihood of accidents doubling for those aged 55 years and older. Older farmers are susceptible to poorer eyesight, slips, trips and falls, difficulty in changing work practices and reduced access to services to manage their health (Brumby 2020b). Family farm labour supply can be sourced from both children and the elderly, both of whom are high risk groups for farm accidents, to get the farming tasks done.

As well as children and the retiring generation, women make up a significant proportion of farm labour. Globally, more women are active in agriculture than men with 600M women working as farm labourers in India (S. Brumby, personal communication, February 24, 2020). Tens of thousands of women farmers get excluded from data globally because they are not considered as farmers, or they have multiple roles on and off the farm, so their occupation as a farmer is never recorded (S. Brumby, personal communication, February 24, 2020). Women on farms are perceived as farmers' wives, when in reality they are likely to fulfil equally important roles to men on the farm as career farmers and farm business administrators. Research with sugar farmers in Queensland shows that some farming women choose to hide their on farm contributions (Pini 2005 p. 5).

PART 2. Labour theorists

The aim of Part Two is to provide three differentiating views of labour to create a meaningful narrative of the historical, economic, political and cultural influences pertaining to wage labour. To offer a wider theoretical grasp beyond the writing and interpretation of Marx, Part two draws on the work of Karl Polanyi, Hannah Arendt, and Georges Friedmann for a comparative debate of the constituency of labour in political economy. The purpose of this part of the literature review is to seek others' interpretations of whether labour is a job for economic gain or a lifestyle, or a combination of both pertaining to the identity of the farm labourer which goes against the traditional rationalisation of political economy.

The humanistic effects of farming have been overlooked. This doctoral study offers a new way of thinking about farmers and their relations through farm systems. This literature review looks at three major lines of inquiry from renowned labour theorists to re-consider what farming and farm labour means under the critical concepts of exploitation, alienation and agency.

Karl Polanyi

Published in 1944 by European intellectual Karl Polanyi, *The Great Transformation* reveals the social and political upheavals that took place in England during the rise of the market economy which tool at the end of the eighteenth century. Polanyi's writing is an important contributor to this doctoral literature review because he explains how communities and societies functioned prior to the commercialisation of land and labour. Does Polanyi offer insights into the pre-alienated condition of the worker? I argue that indirectly, yes he does. Polanyi explains the conditions for societies to function in the times before individuals could own property.

Polanyi was an educator and a social philosopher. The problem that he addressed throughout his work was the place of economy in society. He perceives that economy is an instituted process or a social construct and there are a great variety of ways to organize economic livelihood in a modern technological society in accordance with the geographical, historical, and cultural attributes of diverse regions, peoples, and countries (Polanyi-Levitt 2012). Polanyi insists that market economy consists of all elements of industry, including labour, land and money.

Polanyi wrote that the self-regulating economy involves relations between economy and society, and how systems or reforms affect individuals' relations to one another. This concurs with Marxian alienation. But Polanyi interprets it that social relations are inter-changeable with the term social capital. He argues that economic upheaval and disaster brings with it unemployment, poverty and crime which affects social cohesion. Polanyi identifies that economic

policies can lead to a break-down in social relations, and it is these social relations which have adverse economic impacts. This is distinctive from alienation, as his focus remains on the effects upon economic development rather than the effects on humans. Polanyi's model was organically formed on the existing organisation of trade unions that represented workers, consumer cooperatives that represented consumers, chambers of commerce that represented employers, and democratically elected municipal authorities. This was neither a market-less economy nor an economy without money (Polanyi-Levitt 2012).

Polanyi's adversity to rely on historical hypothesis for "man's predilection for gainful occupation" (2001 p. 46) demonstrates visionary nonconformity. Polanyi states the differences existing between civilized and uncivilized peoples have been vastly exaggerated, especially in the economic sphere. Polanyi refers to the work of Max Weber as one of the first modern economic historians. Weber questioned the motives and mechanisms of civilised societies and concluded from his study of early society that it is "the changelessness of man as a social being. His natural endowments reappear with a remarkable consistency in societies of all times and places; and the necessary preconditions of the survival of human society appear to be immutably the same" (Polanyi 2001 p. 48). With this work of Weber, Polanyi concludes that it is humankind's economy which is submerged in humankind's social relationships. Humans do not act to safeguard their individual interests in the possession of material goods. Instead, they act to safeguard their social standing, their social claims, and their social assets. Humankind values material goods only as they serve a need. Geographical and industrial influences create community diversity however every economic system is run on non-economic motives.

Considering Polanyi's interpretation of the history of economic development, the question is not at which point in civil development did labour become a key element in the mechanism of the economy, rather how did wage-labour change the social relations? How long was alienation a condition for the wage-labourers before Marx wrote about it in 1844? Polanyi writes of functional roles of farming, bartering, exchange, local and external trading, hunting and expeditions. He highlights that these tasks of responsibility and accountability do not always lead to the establishment of markets rather the principles of other economic behaviours prevailed instead.

Up until the end of the feudal system in Western Europe, the economic system was organised on the principle of either reciprocity, redistribution, house-holding, or some combination of the three (Polanyi 2001 p. 56). Reciprocity and redistribution ensured the working of an economic system without written records or administration. Reciprocity facilitated the patterns of symmetry, lending itself to the pairing of give-and-take. This is a thought-provoking behaviour, markedly different to the patterns of asymmetry displayed in today's agricultural commodity chain. Redistribution originated with the tribal headperson managing the storage of food for feasts and gifts to tribal neighbours. Economically, this demonstrates existing systems of

division of labour, foreign trade, taxation and defence provisions (Polanyi 2001). Societies which functioned with non-economic motives required necessary labour-power for these production and distribution processes. Tasks to drive the community collective would still be arduous however the cultural and traditional motivations would are assumed as self-satisfying to maintain or advance these individuals in social positions without monetary reward. Individuals would act in compliance with the knowledge that their participation is for societal benefit.

Aristotle insisted on production for use as against production for gain as the essence of house-holding. Yet the surplus production for sale on the market needed not to destroy self-sufficiency of the household. His theory recognised that gain was a motive that was particular to production for the market, and that money introduced a new element into these exchanging situations. Nevertheless, as long as money and markets were mere accessories to an otherwise self-sufficient household, the principle of production for use could operate (Polanyi 2001). These principles of reciprocity, redistribution and house-holding were institutionalised with the help of a social organisation which made use of patterns of symmetry, centricity and autarchy. Production and distribution was orderly as goods were secured through diverse individual motives disciplined by the general principles of behaviour. Personal gain was not a motive, and custom and law, magic and religion cooperated in inducing individuals to comply with, and ensure the economic functioning of the system (Polanyi 2001).

Under feudalism and the guild system land and labour formed part of the social organisation as money had hardly been developed. Land was the basis of order, for military, judicial, administrative and political systems as its status and function were determined by legal and customary rules (Polanyi 2001). Institutional regulations dictated the possession, transfers, and purpose of land use. Under the guild system, and systems prior, labour's motivation was embedded in the general organisation of society. The relations between master and apprentice, and wages and work day length, were all regulated by the custom of the guild system and town (Polanyi 2001).

The pre-condition for a market economy was the commercialisation of land and labour. Craft guilds and feudal privileges were abolished in France in 1790. In England the Statute of Artificers was repealed between 1813 and 1814, and the Elizabethan Poor Law was repealed in 1834. Not before the last decade in the eighteenth century was there the establishment of a free labour market or a concept of a self-regulating market (Polanyi 2001). Mercantilism took for granted this traditional organisation of land and labour, and pushed for full employment and maximum use of resources for trade and commerce. But the transition to a democratic society and political representation involved a complete transformation. This significant change from regulated to self-regulating markets at the end of the eighteenth century represented a complete reorganization in the structure of society.

Polanyi explains how regulation and markets develop together. Human behaviour to maximise money gains was a result of a market economy controlled, regulated and directed by market prices and the self-regulating mechanisms of production and distribution. A market economy also assumes the presence of money to facilitate exchange, together with the supply of goods and services available at a price equal to the demand at that price (Polanyi 2001). Self-regulation implies that all production is for sale on the market and that all incomes are derived from such sales. Accordingly there are markets for elements of industry, not just goods and services, but also for land, labour and money. These are referred to as commodity prices, rent, wages and interest.

Polanyi asserts that land, labour and money are essential elements of industry and must be organised in markets, and these markets form an absolutely vital part of the economic system. However, he argues that land, labour and money are obviously not commodities. "Land is only another name for nature, which is not produced by man" (Polanyi 2001 p. 75). Polanyi states the commodity description of labour, land and money is entirely fictitious but actual markets for these fictitious commodities are organised. However, to allow a market mechanism to be the sole director of the fate of human beings and their natural environment, it would result in the demolition of society (Polanyi 2001). In a Marxian-forewarning Polanyi argues that nature would be reduced to its elements with landscapes defiled, rivers polluted, military safety jeopardized and the power to produce food and raw materials destroyed.

For labour-power, as a fictitious commodity, cannot be used indiscriminately or even left unused without affecting the individual. The transformation to capitalist system requires a new way to value work, and the value of human needs, as well as the value of nature. Polanyi argues that economics must to return to some very basic questions of use value and exchange value, especially in the valuation of services. He argues that some socially useless services are grossly overvalued while essential work, such as bedside care of elderly humans, is accorded little or no value. "People do not like to be valued and respected only for the income that they can earn and to be totally disrespected if they are not able to earn income for whatever reason" (Polanyi-Levitt 2012 p. 14). This can be used to explain why some farmers are less fixated on commodity prices and but would like greater appreciation for their work of feeding others.

Labour is the human beings themselves of which every society consists and land is the natural surroundings in which it exists (Polanyi 2001). To include land and labour in the market mechanism means to subordinate the substance of society itself to the laws of the market. Polanyi's cautionary words of the dire consequences of permitting the global self-regulating market to devastate social coherence and the natural environment has assumed new urgency and relevance (Polanyi-Levitt 2012). His concerns with labour and nature hold Marxian sentiments.

Hannah Arendt

Where Polanyi positions economy at the centre of labour, social philosopher Hannah Arendt places humans. Arendt (1958) asks for a reconsideration for the human condition based on experience and fears, with a practical theoretical standpoint of 'what are we doing' (Arendt, 1958 p. 5). Arendt's writings are about what it means to be human, drawing her labour theories from the works of Heidegger, Aristotle, Galileo, Marx, Augustine, Kant, Nietzsche, Jaspers, and others. Arendt proposes the basics to humans are the two functions to think and to act, which differentiates people from animals.

Arendt published *The Human Condition* in 1958 to establish the conditions of how people act in the world and how this has changed over time through transitions in economy. Arendt inquiries of the nature and fate of human experience by presenting arguments to develop a range of conceptual distinctions, that form a web of inter-related concepts. She proposes the three constitutive features of the *vita activa*, 'active living' of labour, work and action. This can viewed as the phenomenological uncovering of the fundamental and basic conditions given to human life as action, existence and experience. All three activities are connected with the most basic human conditions, the totality of birth and death. These concepts are expanded to seek meaning in social relations. This *vita activa* framework provides a model of life and function.

Arendt notes a scarcity of historical evidence relating to labour theories, especially the misnomer that 'labour' and 'work' are synonyms. To begin, labour is the necessary and involuntary activity relating to the biological processes of growth, metabolism, and eventual decomposition. The human condition of labour is life itself (Arendt, 1958). Labour assures not only individual survival but the life of the species. Arendt repetitively draws upon John Locke's use of the expression, "the labour of our body and the work of our hands." Arendt links the capacity for labour with the condition of life. Labour is the capacity for producing things, the consumption of which keeps the life process going, and it is in the nature of such things to be perishable, to have short-term existence and to be in need of continual replenishment (Smith 2019). This means that the objects of labour must be repeatedly and cyclically produced. These features of the product of labour carry over to the kind of activity that produces them. Eating, growing food, cooking, cleaning oneself, human reproduction, child-rearing, and so on are all repetitive and sustaining-life activities that require effort.

Arendt offers dualisms in her traits of labour. She believes the most significant contrast was between productive and unproductive labour within the *vita activa* itself. Arendt related productive labour akin to Marx's *animal laborans* which implies that the urgency of labour was motivated by life.

> Instead, we find first the distinction between productive and unproductive labour, then somewhat later differentiation between skilled and unskilled work, and finally, outranking both because seemingly of more elementary significance the division of

> all activities into manual and intellectual labour. Of the three, however, only the distinction between productive and unproductive labour goes to the heart of the matter, and it is no accident that the two greatest theorists in the field, Adam Smith and Karl Marx, based the whole structure of their argument upon it. (Arendt 1958 pp. 85-86)

If labour produces consumable products, work produces durable products. According to Arendt, work as the second component of *vita activa*, is the activity which corresponds to the unnaturalness of human existence. It is goal-orientated where humans posit and set about something to do. Work makes durable goods happen to provide an artificial world of things, which are different to the all-natural surroundings. Work is action-based to make a product, such as an axe, cart or table, which bestow a measure of permanence and durability in one's life. These goals to make stuff from actions have a finite outcome and fixed timeframe. This means, when the axe is made to fell trees, the human will not continue to make axes as one is enough. The human condition of work is worldliness (Arendt 1958).

And thirdly, action is something that is done freely. This element of *vita activa* is the only activity that goes on directly between men without the intermediary of things or matter. Action corresponds to the condition of plurality, understanding that men live on earth and inhabit the world together (Arendt 1958). Action is about freedom in a public space, as a political experience, as opposed to other spheres of human activity which are private.

Yar (n.d) perceives that Arendt's goal was to propose that action is a phenomenological reconstruction of different aspects of human activity, so as to better discern the type of activity and engagement that correspond to present political existence. Action includes the dialectic of consequences, forgiveness and promises. Action is entirely dependent upon the constant presence of others (Arendt 1958). It means that debates, creative thinking, socially activated outcomes and language are all correlated with the realities of what it means to be human.

The historical relations through language and translation build Arendt's story of human life engaging in activity. Arendt (p. 23) refers to Aristotle's *zoon politikon* by *animal socialis*, which became the standard translation through Thomas Aquinas: *homo est naturaliter politicus, id est, socialis*: "man is by nature political, that is, social." The word social is of Roman in origin and the Latin word *societas* has a clear, but limited political meaning. Both indicate an alliance between people for a specific purpose and a general meaning of a fundamental human condition (Arendt 1958).

The social relations, distinguished from consumer goods and use objects, are the products of action and speech. They are not durable nor more futile that what is produced for consumption. "Their reality depends entirely upon human plurality, upon the constant presence of others who can see and hear and therefore testify to their existence" (Arendt, 1958 p. 95). Poetry, sculpture and books capture speech and action beyond mortality of the talented individual.

> It is language, and the fundamental human experiences underlying it, rather than theory, that teaches us that the things of the world, among which the *vita activa* spends itself, are of a very different nature and produced by quite different kinds of activities (Arendt 1958 p. 94).

Arendt also established two orders of society, the private, referred to as household, and the public or political realms. These systems existed as distinct entities at least since the rise of the ancient city-state (Arendt 1958). English philosopher, Ian St John (video, 2019) expands on Arendt's Greek city state by explaining that labour was carried out by slaves, children and women in the home which allowed men to leave the house to join with other free men in free political speech and debate. Class and gender enforced this division of labour of those who could be active outside the home and those who could not.

> To be free meant both not to be the subject to the necessity of life or to the command of another *and* not to be in command oneself. (Arendt, 1958, original emphasis).

Arendt interprets freedom, not as the ability to undertake activities of leisure, rather be free from the inequalities present in rulership and to move to a space where one is neither ruled nor rules others. This concept is based on the work of Aristotle, stating that life of a free man is better than that of a despot, or denying freedom to the despot as a matter of course. Within the private realm of the household freedom did not exist, for the head of the household was considered free only in so far as they had the power to leave and enter the public realm, where all were equals.

Over time the gulf between private and public, which existed in the middle ages, has lost its significance. The challenge for a modern society was the amalgamation of these political and social realms. Arendt introduces politics as a function of society through the rise of the household into the public realm, resulting in collective concern for economic activity. But the emergence of the social realm, which is neither public nor private was a relatively new phenomenon whose origin coincided with the emergence of the modern age and which found its political form in the nation-state.

An Arendtian-society, consisting of a subdivision of labouring tasks for economic productivity, is a bleak outlook. She identifies that economy is dominated by keeping life going through a constant acceleration in productivity which leads to demise in the world as it is no longer a stable structure. The division of labour, which preceded the industrial revolution as well as mechanisation of the labour process, could never have occurred in the private realm. The privacy of the household is where human excellence is reserved for this space alone. While humankind has become excellent in the labouring performed in public, the capacity for action and speech has lost much of its former quality. The state of social was considered as an impersonal force that had "transformed all modern communities into societies of labourers and jobholders" (1958, p. 46).

Arendt regarded Marx as the most important theorist of labour so it is not surprising that the concept of labour she deploys for the purpose of diagnosing the fate of the *vita activa* in the modern world should emerge by way of a critical engagement with Marx (Smith 2019). Arendt concurs with Marx's belief that labour's productivity is measured and gauged against the requirements of the life process for its own reproduction. Labour is about labour-power rather than the quality of production. Humans are cogs in a meaningless function to make things that are not important and they are inter-changeable with other humans because nothing is specialized. Arendt identifies that the location, function and durability measured by its length of stay in the world, is not taken into account (1958 p. 94). Consumption becomes labour so we can make more stuff (St John 2019)

Arendt sees alienation as a human condition from mass labour. Alienation is marked by expropriation and the labouring poor, and society became subject to new life processes of consumption and production. Based on the work of Max Weber, the discovery about of the origins of capitalism lay in his demonstration that strictly mundane activity is possible without any care for enjoyment, with motivation driven by worry and self-concern. "World alienation" has been the hallmark of the modern age (Arendt 1958 p. 254). Started by expropriation and characterised by an ever-increasing progress in wealth, it can develop even more radical proportions if it is permitted to follow its own law (Arendt 1958 p. 257).

Arendt offers a very different interpretation of labour and work. What she brings to this research is the opportunity to contemplate the complex role of the farmer, living and working on their farm, undertaking tasks for both private and public realms for which they may not even be able to distinguish. The social relations of labour, in consideration to *vita activa* of labour, work and action, could have provided an alternative analysis of alienation for this research.

Georges Friedmann

The writing of French sociologist and philosopher, Georges Friedmann is used to an historical reflection to understand progressive work place functions and divisions of labour. Agricultural practices are becoming increasingly mechanised and automated, which offers inquiry into farmer-agency. Friedmann is used as a labour theorist to validate whether agency is lost as humans fully submitted to machines for their decision-making, or if mechanisation facilitates human agency in their labouring activities.

Friedmann spent approximately twenty years visiting factories, workshops, mines, and offices, to identify recurrent themes and to investigate the way in which enterprises operate. In his studies, Friedmann closely observed the actions of industrial workers to identify the impacts of mechanisation and division of labour. In 1961 at the International Sociology Association (ISA) conference, Friedmann proposed a social policy with appropriate adjustment for technical

change. As the ISA President he stated in his opening speech that "[a]s society becomes more complex and technical change is faster, the need for sociological input increases" (International Sociological Association 2016). Friedmann's sentiments resonate with the purpose of this research for which his book, *The Anatomy of Work: Labour, leisure and the implications of automation* (1962) has been selected for critical analysis.

> [W]hen thinking about labour…. Friedmann often insists of the unity of the labouring individual. The person who labours in the factory is, after all, one and the same as the person who loves, thinks, suffers, has convictions, allegiances, and so forth; the activity of labour affects body, mind and soul, and thus has ergonomic, psychological and moral dimensions. (Nicholas Smith 2019)

Regardless of the location or production from the factories he has toured, Friedmann holds a humanistic view of industrial labour. He examined the range of capacities, social relations, and possibilities of self-fulfilment at stake in each activity. Rather than perceiving a mass workforce collaboratively working to achieve a collective outcome, his observations demonstrate individuality for each person, labouring as a segment. This ability to see individuals, rather than a conglomerate of workers, is demonstrated by his note taking upon worker exceptions based on their differing capacities, personalities and social relations.

Friedmann criticises the division of labour identifying highly subdivided jobs via the process of technology are too limited in scope to involve the workers' personality, intellectual needs and personal ambitions. For the workers, he described them as bigger than their jobs. What Friedmann offers this study is a re-evaluation of farmers. Land, machinery, tonnes of fertilizer and seed, and all of the equipment required to operate a commercial grain farm are large. Farmers in a sense, can never be bigger than their job because they work with large things in a broad production scope. The question remains though – do farmers ever feel small?

Friedmann's critique of labour specialises in automation. Automation eliminates manual work and reduces the length of time to complete a task. Using the terms novelty and fraught in the long run, Friedmann depicts that automation has negative consequences for humankind working in industrial civilisations. But rather than a Marxian critique of working conditions, Friedmann looks at the methods of communication and control in the production, distribution and administrational process in the factory systems. Friedmann (1962) identifies that automation deprives workers of their essential elements upon which their mental health and the possibility of self-realisation have been based. As a consequence, the need to find a new outlet for human development during leisure time has become acute.

Friedmann worked with industrial psychologists and took particular interest in experimental inquiries of unfinished work. He deduces that the division of labour results in the worker's inability to complete a full job which results negatively upon their wellbeing.

> ….the excessive division of labour, which leads to 'diminishing returns' when jobs are broken down and simplified. These economic facts only express quantitatively the subjective reactions of workers performing fragmentary jobs, imprisoned as it were in narrow sector of production, working on a portion of an object or a part, which they themselves will never finish, and chained to an activity which is in fact constantly *interrupted* by the minute subdivision of operations. (Friedmann 1962, pp. 55-56, original emphasis).

Studying a paper published in 1927 by B. Zeigarnik in *Psychologische Forschungen*, Friedmann refers to the theory of job interruption upon workers' memory. The experiment asked subjects to perform a series of twenty tasks each unrelated to work, such as doing a jigsaw puzzle and making a clay animal. The subjects were allowed to finish one half of the tasks but were prevented through interruption, from completing the other half. At the end of the experiment they were asked to write down all they had done.

> The facts show that the tasks that were interrupted were remembered about twice as often as those completed, a result confirmed later by memory tests. In other words, when a task is completed, it is easy to forget it; but when it is left unfinished it weighs upon the mind and may even become an obsession. (Friedman 1962 p. 56)

The consequences of interruption can be effectively reinterpreted in a modern farming context as weather events, machinery breakdowns and unforeseen priorities that interfere with completing planned tasks. Friedmann identified that work possessing definite outcomes was found to suffer less from being interrupted. He also found that workers were more anxious to complete their task when near completion than when interrupted at the start. Similarly, when they were interrupted towards the end, their frustration felt was much greater (Friedmann 1962).

Friedmann also observed workshops of firms enlarging job scope through decentralised structures that encourage initiative, accountability and polyvalence of the worker. It was observed that the attitudes of workers had been completely transformed, because it was said their jobs were filled with variety, responsibility, meaning and interest (Friedmann 1962). These workers were also interrupted less frequently and felt as though they had finished a product.

Unlike Arendt, Friedmann offers critical hope for the worker. His observations do not offer an historic economic and cultural timeline like Polanyi and Arendt to explain the humanism of labour. What Friedmann offers is a meaningful sociological analysis of what it means to be a worker. He individualises people, showing respect for each individual's purpose, their job, and who they work for. He learns to understand what they do and what they work with. Friedmann offers a framework for inquiry for this doctoral study to observe farmers in their workplace, and to learn from them how they manage interruptions, and get their work done by using technology, automation and mechanisation on farms.

PART THREE

PART 3. Agency

Part three acts as conduit between the literature and the methodological approach for this doctoral study. Agency is offered a nuanced, counter-intuitive concept to explain the humanism of farming when alienation is either insufficient as a concept or imprecise to explain situations. At the same time, it's not to say that alienation and agency cannot co-exist. These ideas will be explored throughout the theoretical discussion and the conclusion.

To begin, agency is a property of a collective. Like a contagious disease needing a host organism, unless there is a connection through past events, it can't exist alone. Agency is about moving beyond the notion of conscious action as human agency is dissolved among many. Higgins (2006) shows that agency is a particular constitution, shaped and arranged through farmers and non-human entities during his study of a dairy crisis in Gippsland. He advocates that farmer agency has generally been overlooked in agri-food research. Referring to Farmbiz, a former Victorian state government initiative that supported farmers, the research investigated non-human entities as part of broader interventions for changing farmer practices. Higgins (2006) used Callon's Sociology of Translation as the methodology to demonstrate the significance of non-humans in the success, or lack of success, of programs governing the performance of farmer agency. Forms of agency that may not have previously been thinkable or practicable, such as software and production plans, needed to be considered in new ways (Higgins 2006). This way of thinking enabled material artefacts and the inscriptions that represent farming practices open up pathways of action. This work argues for greater analytical attention in agri-food studies to the centrality of non-human entities in the constitution and governing of farmer agency. "While valuable in exploring the social relations through which farmers acquire particular capacities as agents, political economy and actor-oriented perspectives do not go far enough in examining farmer agency as a relational effect of human and non-human relations" (Higgins 2006 p. 60).

The notion of agency offers a way of understanding and interpreting why farmers do things their way. "[T]he concept cannot be defined through that of intention, as is presumed in so much of the literature to do with the philosophy of action; the notion of agency is taken as logically prior to a subject/object differentiation." (Dallmayr 1982 p. 428). The term agency undercuts or transcends the customary bifurcation between conduct and behaviour (Dallmayr 1982). The implications of agency leaches into many other conceptual domains including that of power. For an adequate account of human agency Giddens (1979) argues that firstly the notion of agency must be connected to a theory of the acting subject, and secondly, it must situate action in time and space as a continuous flow of conduct, rather than treating purposes, reasons, etc. as somehow aggregated together (Dallmayr 1982).

Despite its richness as a general guidepost, the notion of agency unquestionably requires to be translated into a theory of action. Actor networks offers this bridging strategy to examine and explain phenomena such as this. As a post-human, practice-based method actor networks shape the idea of agents and the performativity of agency. Each performative definition of what society is about is reinforced, underlined and stabilised, by bringing in new and non-human resources (Latour 1986). The method focuses on inanimate entities and their effect on social processes (Cresswell, Worth and Sheikh, 2010). Upon this point the notion of power can change, transferring it to the many resources used to strengthen and hold society still; similarly agency seems unable to stand alone as its own entity. Agency and structure, by enmeshing the rules and practices in day-to-day activities in Garfinkel's sense, demands acknowledging the significance of 'ethno-methods' as the means whereby accountability is sustained (Giddens 1979 in Dallmayr 1982). Like power, agency is an effect rather than something to be possessed.

Concluding the literature review and theoretical underpinnings

This doctoral study examines what is at stake for many of its agricultural industry audiences. This research relies upon the semiotics of farming under the Australian commodity chain contexts. It takes into account the performance of roles and rituals of social interaction and the practices by which farmers maintain their legitimacy—not to mention the structural functionalism of rurality and ways of thinking that comes with food production, geographical location, and how farmers are grouped. In what follows, we take up these farming dynamics and move beyond the simply constructed notions of cropping as a lifestyle and farm enterprise choice. This thesis is an analysis of farmer exploitation, alienation and agency through technology.

In the methodology that follows I examine the role of technology that gives agency to farmers and non-humans. The reason for this ethnographic examination is to look beyond what industry expects from generalized job-specific and task-based roles, to look deeper at labour in cropping practices, and to offer a nuanced understanding of how agricultural science plays out on farms. Farmers are multiple, with lopsidedly constructed halves or quarters in forms such as agrarian-engineers, grazier- environmentalist, and harvester- software developers. To shuttle back and forth in their roles we must rely on the notion of translation, or networks (Latour 1999).

CHAPTER TWO

Methodology for the research

Actor network theory (ANT) as a methodological approach is fit for purpose and aligns with the philosophical assumptions of this doctoral study. This chapter introduces and explains this methodology, some of which will be further examined in detail in the theoretical discussion in chapter four.

The goals set down in this thesis are to show the ways that farmers exercise control over their production to overcome the exploitative nature of the commodity chain. This doctoral study reveals farming operations and the relations of farmers through their product, work processes, and their social connections. By observing the sequences of farm processes this research investigates farmer agency in the farming complex.

Actor network theory is a socio-material theory and a method that works from the ontological premise that humans and nature are not separate realms. This is a rejection of epistemology and objectivity, and even a redefining of ontology, to allow for multiple ontologies (Latour 1999, 2005). It is argued that it is not a theory at all because theories tend to try to explain something, whereas this is more of an approach to research which claims things as far as actual empirical consideration allow for particular cases (Law 2015). The methodology is a post-essentialist theory which dismisses the clear-cut demarcation of humans, animals, things and/or technical devises (Seier 2017). In short, this analysis seeks to present the relationships between artefacts, institutions, ideas, things and individuals that form one another. This work aims to verify how farmers use humans and non-humans to re-position themselves in political economy through on farm practices.

Ethnography is a form of qualitative inquiry that creates deep and rich understanding and descriptions of a phenomenon (Niemimma, 2014). Ethnography looks beyond the obvious and ingrained cultural behaviours to facilitate a different way of thinking about how we act. Renown American anthropologist, Margaret Mead said “What people say, what people do, and what people say they do are entirely different things” (Isaacs 2013). Mead’s twentieth century philosophy and observations of humans framed the future for ethnographic research and practice.

Ethnography is an immersive and reflexive research technique. With the intention to observe only, it is synchronously shaped by the ethnographer’s preconceptions. “Ethnographers walk the line between insider and outsider, participant and observer” (MacLeod et al 2019 p. 180). While the researcher will certainly influence the activities taking place the primary ontological principle is that the research setting and the activities taking place remain independent from the researcher. Positioning the researcher within the phenomenon means that researchers actually (re)configure the world under study (Niemimaa 2014).

Farming consists of both social and material elements. A sociomaterial approach, where matter matters, can help ethnographers to explore how cultural groups use things which may otherwise be considered mundane or taken for granted. As a result, the purpose of actor-network theory informed ethnography is to de-couple these agricultural assemblages that evolve and emerge in everyday farming. These material entities include things like yield monitors, tools, debt, plant breeder's rights, and crops. Natural elements like the weather, native vegetation, and soil, are also considered. This sociomaterial approach to ethnography to help explore the under-theorized elements of farming.

The relationships between things that seem as though they are separate entities, with distinct names, bodies, and structures, are of which in many cases constitute non-human things. The relationships or associations which are always in the process of becoming are what everything is made of. The point is that the world is made through relationships otherwise nothing of the world exists on its own. The idea that people act on nature or that there is a dialectic between nature and society is rejected because the two realms are not separate, rather they are constituents in a relationship that produces both simultaneously. The false distinction between nature and society is in part a product of the process and presentation of natural and social scientific research (Latour 1987). Untangling sociomaterial scenarios can offer a novel perspective on a myriad contemporary agricultural issues.

Analysing alienated labour

The theory of alienation offers no physicality thus examining its presence or absence requires a sociology to argue its application. This section explains the search for evidence of this human state. Alienation can be considered as the intersection between the social-structural conditions and psychological orientation (Kohn 1983). The fundamental analysis for this research looks for where workers' lose control over their primary work role. The occupational structure for farmers and their subjective experience of alienation under the conditions of a large-scale capitalist economy offers the particular point for examination. The theory of alienation has been discussed in detail in the literature of this thesis, but in essence what this study is seeking is the evidence where farmers either have control or not, over their production. The state of control is defined as agency as a property of a collective. Agency is about moving beyond human notions of conscious action to an actor network approach where human agency is dissolved among many. As a post-human, practice-based method actor networks shape the idea of agents and the performativity of agency. Each performative definition of what society is about is reinforced, underlined and stabilised, by bringing in new and non-human resources (Latour 1986).

This research does not offer a cross-national comparison between capitalist and non-capitalist economies to depict the conditions of farmers. The intent of this research is an alternative account for the production of science, adverse to the philosophy of causality that 'A'

is said to be related to 'B'. This is a science that allows the actors to assemble themselves to explain the society in which farmers produce bulk commodities in their annual cycles and what or who makes them act. The methodology will trace the establishment of relations, while giving agency to non-humans, in the pursuit of seeking meaning (Mersch 2017 p. 234) in farm labour.

Marxist research is interested in not only identifying features of the social structure that have direct benefits for capitalist commodity production, but also in the methods used to encourage people to live in this way (Bilton et al 2002). The relations of the means of production are used to define the interest of the classes (Law 1986). The crucial aspect of the structural support for capitalism is that people are encouraged to hold ideas and relations that sustain the system. Yet this study seeks to explore how these relations are not only held and sustained, rather it is how they are stabilised, circulated and who or what holds the power.

Actor network theory advises that there is no relevant group such as class that can be said to make up social aggregates (Latour 2005). Analysing alienation using actor networks means that it is not the researcher's duty to decide in advance what the social world is made of. Instead, the method is to follow actors and look for the traces left behind by their activity of forming and dismantling their own groups.

Ontology of actor networks

Ontology, or metaphysics, in philosophy is concerned with what there is, how it is, and forms of being (Aspers 2015). This research methodology is anchored in constructivist assumptions but the actor network constructivism is not the same as social constructivism in the sense used by Crotty (1998) because social dimensions are not assumed or privileged in advance. Latour (2005 p.91) makes a sharp distinction between social constructivism and constructivism:

> …constructivism should not be confused with social constructivism. When we say that a fact is constructed, we simply mean that we account for the solid objective reality by mobilizing various entities whose assemblage could fail; 'social constructivism' means, on the other hand, that we replace what this reality is made of with some other stuff, the social in which it is 'really' built…. For any construction to take place, non-human entities have to play the major role.

On this account, this research partially adheres to constructivism and to a specific ontology which recognises agential capacities when attributing properties to natural and material objects. On critiquing social shaping and social determinism Latour (1999 p. 198) argues that "society is constructed, but not socially constructed. Humans, for millions of years, have extended their social relations to other actants with which, with whom, they have swapped many properties, and with which, with whom, they formed collectives."

Latour states that "[h]umans are no longer by themselves" (1999 p. 190). This ontological approach rejects the boundary between the technical and the social. The social

construction of farming refuses to give a dominant role to either the technical or the social. Instead of understanding machinery and technology as black-boxes with innate qualities, social constructionists seek to understand why particular technologies emerge and how they are adapted. Technologies may also continue to be shaped during their use. Thus, the ontological belief underpinning this thesis is that reality is neither technologically determined nor socially constructed, but a collective of humans and non-humans: a heterogeneous network of human and non-human actors.

Actor network theory offers no pure analysis of one thing to explain. Society is an imbroglio of humans, non-humans and objects, ever moving and evolving in group formation. To achieve a humanist perspective of farming, we must co-join farmers with other entities, such as machines or other humans, to show their relations. To achieve such analysis actor network theory presents a flat ontology neglecting the realities beyond the empirical domain, and it ignores the existence of emergent social structures. Latour (1999) introduces the term collective as opposed to the term society, because it emphasizes the associations between human and non-humans. This means the method converts the dissociation between objective and subjective into one single circulating entity. Therefore the process of collective constructivism is not only social. Everything is constructed in this way, including facts.

Modern farming is a collective construction that is shaped by the actions of farmers which are enabled or constrained by the technological affordance of machinery and technologies. Farming enterprises, farm size, nature, commodities and infrastructure can be shaped by their owners according to their practices and the organisational context in which they are used for production. It also allows the farm services sector, the commodity chain, Australian political economy and globalization to enter the research realm.

Agential capacities can be attributing properties to both natural and material objects. The thesis is to conceptualise farming, according to contextual factors influencing the use of machines, technology and land to gain an understanding of farmers' connection to their product. Bulk commodity producers have a set of characteristics that are strictly dependent on the market, regulations, products and the people in the system. The ways through which farmers make decisions about what they grow and how they manage their crops are embedded in a pattern of antecedent relationships and meanings sustained through a process of socio-technical action, interaction, and negotiated interests. Reality is dependent on the actors that are involved within the farm business.

Epistemology

Despite Latour's rejection of an epistemology there still remains a relationship between the knower and the known. An epistemological stance asks what kind of knowledge can be obtained and what are the limits to this knowledge? The epistemological assumptions of actor

networks are addressed in this work by employing an interpretive approach that stems from the constructivist ontology. The methodology is considered as an approach embracing epistemological relativism (Law 1991). It has an ontological constructivist assumption in that it assumes that the world consists of heterogeneous networks which are socially constructed and of actors who act according to their interests, inscriptions and their interpretations of their environment (Latour 1999).

From my experience of being a farmer and working with farmers through farm forestry, community capacity building, farm apprenticeships, farm economic software development, and practice change consulting, my position for this researcher is an insider. Epistemologically this implies that I am far from being neutral in the research and I play an active role in choosing the boundaries of the actor-network, the events and the developments that are deemed relevant to understanding the subject.

Actors are constituted in a heterogeneous socio-technical network, partially connected by a set of relations, and partly embodied in a range of materials (Law 1991). Actor network theory seeks to highlight the understandings that actors have about their own lived reality (Latour 2005) by allowing actors "to define the world in their own terms" (Latour 1999 p. 20). Actor networks link materials with practice by defining practice as ontologically heterogeneous. Practice enacts and is enacted by the interaction of technologies and human actants.

In the research of technology and agency lived through the experience of breast cancer, Boer and Slatman (2018) point out that if we want to understand the human-technology relationship, we have to distinguish between technological agency and human agency without falling into the trap of a modernist and radical subject-object dichotomy. Actor network theory avoids this trap. These common epistemological dichotomies are rejected by opposing categories such as subject/object, culture/nature, and society/technology distinctions (Spohrer 2017). In other words, actors are partly social, partly technical, partly textual, partly relating to natural materials, objects and processes (Donzello 2014). Actor network theory offers every actant equal rights in a democratic ontology and responsibility is mutually shared.

The role of power is epistemologically embedded in complex socio-technical interactions between humans and non-humans. The process of interaction between humans and non-humans explains the practices of modern farming. Transcribing these interactions evaluates the intimate motivations and logics of how farmers operate as individuals and the concatenations of farming. This is the starting point for a deeper appreciation of what farmers do. Context is inseparable from localized management actions and interactions within actor networks so both have to be analysed simultaneously. Therefore, the empirical examination of the role of associations and material artefacts used on farms becomes not only a technical concern, but a way of understanding and sustaining epistemic and power discourses.

Infra-language

Actor network theory has its own infra-language to allow the analyst to be attentive to the actors' own developed metalanguage as a reflective account for what they are saying (Thought Jam 2009). The approach to study agricultural concatenations brings with it vocabulary including black boxes, *intéressement*, obligatory passages, mediators and intermediaries, translation, diffusion, and associations of power. All of these concepts are deployed to study farmers' relations in this doctoral study. The following section defines these meanings and explains the analytical approach.

Actor

Instead of the word person, Latour uses the word actor in its hyphenated expression as actor-network. Actor refers to something, not necessarily human, that is acting. But even when it is alone it is never clear who is making them act, just like a solo performance on a stage – there are others in the background. Action is borrowed, distributed, suggested, influenced, dominated, betrayed, and translated (Latour 2005 p. 48). To reconceptualise agency the term agents is used, allowing non-humans to have agency.

Network

Network, even though it features in the title of the methodology, it is somewhat debateable and controversial, compelling many actor network theorists to change the term to net-work. A network is a coordinated set of heterogeneous actors interacting towards success or failure (Corrigan and Mills 2012). An actor is made to act by other actors, but actions are not always conscious. Actor network theory shows that behind the premise and consequences there exists a huge gap; a non sequitur (Latour 2005).

Actor networks asks why the agricultural industry is held together by forces that are not of farmers' making. When farmers act, this method seeks to define who else is acting with them. It is this source of uncertainty that this research topic renders visible.

In the Wimmera Southern Mallee region I estimate that at least 150 private non-farming business and government organisations are associated with grain production. But apart from the concept of grain and the spatial context of Wimmera Southern Mallee, we don't really know how these actors are connected. Actor network theory offers a default starting position that all the actors that the research deploys might be associated in such a way that they make others do things (Latour 2005). This is done by generating transformations manifested by the many unexpected events that are triggered by mediators. This is what Latour (2005) refers to as the principle of irreduction, and as such this is the philosophical meaning of actor network theory.

Non-humans and agents

Actor network theory insists on the capacity of non-humans to act or participate in systems or networks or both. This term refers to the vast array of actants and agents that are enrolled in and affect change across different registers of what humans understand as society, or the social (Strengers and Maller 2019 p. 1). Strengers and Maller's (2019) study of non-humans focussed on such things as devices, objects, phenomena, and bodies which appear to have non-human capacity and non-human agency, to re-examine the concept of dynamism.

Mediators and intermediaries

Working with the actors to stabilise or de-stabilise the network are the mediators and intermediaries. There are no preferable type of social aggregates, there may exist endless numbers of mediators and when those are transformed into faithful intermediaries, it is usual that even more mediators are mobilised, which extends the investigative process (Latour 2005). When deploying a network analysis actors only emerge after the event. As soon as the actors are treated not as intermediaries but as mediators, they render the movement of the social visible to the reader. Therefore, through textual or descriptive invention the social becomes a circulating entity. From this, the text is to test how many actors the researcher can treat as mediators, and how far the research can go to be able to achieve a social explanation. This also means that the method allows the reader to critically analyse how things work because actor networks do not blame, rather they describe how networks are held together.

Mediators and intermediaries can form relationships between actors (Latour 2005). The difference between the two is that the outputs of the intermediaries can be predicted by their inputs. Conversely, mediators transform inputs into unpredictable outputs. This means that they can also transform action, making something happen that is not necessarily related to what is in motion (Law 1999).

Black boxes

A black box is a metaphor that allows for the re-conceptualisation of single entities as composites of different elements, such as machines, software and computers. Black boxes act on the assumption of being a self-enclosed entity (Seier 2017). They are an abstract, analytical tool which comprise of humans, non-humans and objects as one unit which generate effects. From an epistemic view, the role of repeatable networks are black-boxed into material arrangements that are taken for granted and remain invisible and unchallenged, which transport meaning or force without transforming the actors (Latour 2005). An example is a John Deere tractor. This machine is a black box of moving parts which functions as a prime mover for the farmer's equipment, but when it breaks down or requires servicing, it rallies people from the local dealership and perhaps even new parts from the USA.

There are varying versions on the complexities and formation of black boxes. According to Higgins (2006 p. 54) certain groups seek to achieve particular sets of goals, therefore their actioned black box is strategic. The ability of this action to achieve its desired effects is made possible only by an intense activity of enrolling, convincing, and enlisting a range of people and things (Latour 1986 p.273). Such alliances are crucial in transforming and translating a diverse range of interests into a black box so that an object of controversy is no longer subject to contestation and dispute (Higgins 2006). Ultimately, a black box is something with lots of components that no one thinks about until something goes wrong or until we question how it was put together in the first place.

Star (1991) focusses on finding voice for non-accessibility for groups of minorities or the oppressed. She demonstrates that to understand the effects of technology it is important to open the black box of science and technology to examine the previous invisible work of others' standardisations and perspectives, especially in an attempt to represent more than one point of view within a network.

Associations and models

For the purposes of this PhD, we want to understand how farmers in the Wimmera Southern Mallee are net-worked through relations and how these relations help them to overcome the exploitative nature of the free market. Actor network theory determines what is associated with what in the course of the inquiry. It is a study of associations rather than the ties between entities that we deem social (Latour 1986, Latour 2005). To be social is the name given to a type of momentary association, when ordinary entities are reshuffled, which is characterised by the way it gathers together into new forms (Latour 2005). Divisions and distinctions are understood as effects or outcomes, and not given in the order of things (Law 1999 p. 3). This view provides the researcher with another analysis tool, giving them the ability to harness the forces that have been mobilised in the human world to explain why it is that we are linked together and that some orders are faithfully obeyed when others are not (Latour 1986). The multiplicity and surprises in the associations are the truth conditions inherent to the methodology.

Society is not what holds us together, it is what is held together. "Social scientists have mistaken the effect for the cause, the passive for the active, what is glued for glue" (Latour 1986 p. 276). The agricultural sector, led by the Minister and their staff do not hold farmers, commodities, trade partners and companies together. Knowledge is incorporated in daily events and activities rather than knowledge articulated in words and images. Practices are privileged over principles. It locates knowledge primarily in activities, events, processes and sequences.

Actor network theory holds that power is an effect of networks rather than of individual actors (Corrigan and Mills 2010). According to Latour (1986) if you have power in theory, you

do not have it. Power is not something you may possess nor hoard; either you have it in practice or not, as others have it. Latour (1986) identifies two sources of power. When someone has power – *in potentia* – nothing happens and they are powerless. When they exert power – *in actu* – others are performing the action and not the subject. Power over something or someone is a composition made by many people (Latour 1986 p. 265) and for farmers, this composition may pre-date their existence given that farms are mostly inherited assets. The amount of power exercised varies not according to the power someone has, but to the number of other people who enter into the composition. This is why the notion of power increases and decreases (Latour 1986).

> …the notion of power is often used [when] something happens. A dictator is obeyed, we say, because 'he has got' power; a manager is able to move his headquarters because, as we like to say, 'he is powerful'; a dominant female monkey is able to grab the best feeding sites because 'she holds' a powerful rank. (Latour 1986 p. 265)

Power may be used as an effect, but never as a cause (Latour 1986). In the past, power has been used as an easy convention to explain farm ownership, obedience and exploitation from internal and external perspectives. This research is not a study of power per se, rather it is about powerlessness that alienation brings. The goals set down in this thesis are to show how farmers exercise control to overcome exploitation through their relations with their product, work processes, themselves and others. By observing the sequences of farm operations and activities this research investigates farmers' capacities to control their farming complex through their association with technology.

Diffusion

The diffusion model is an effective tool to examine relations between farmers and the agricultural services sector in the Wimmera Southern Mallee because it speaks for actions and explains adoption and uptake of innovations and ideas. The diffusion model is used to describe the spread in time and space of a claim, directive, or an order. Using Latour's (1986) metaphor to effectively explain this model, imagine taking a claim and transforming it into a solid ball. If you drop this ball into the centre of an infinite puddle, a rippling effect occurs from the drop location. Apply the principal of inertia and ripples will continue as long as there are no obstacles. In such a model, the movement of the ripples through space and time do not have to be explained unless the ripples are affected by other ripples in the same puddle. These new ripples may have been created from the action or reaction of other people. The model of diffusion thus defines three important elements: the initial force that triggers the ball drop into the puddle which constitutes its only energy, that inertia that conserves this energy, and the medium through which the ripple circulates (Latour 1986). This is used to explain the cause of collective action and how facts are held. This model facilitates an in-depth analysis of farm practices, such as precision agriculture or

controlled traffic farming, to identify what holds it in place, what affects its implementation, and its flow-on effects as a system.

The notion of power is also considered in terms of the diffusion model (Latour 1986). What counts is the initial force of those who have power. This force is then transmitted in its entirety and finally the medium through which the power is exerted may diminish because of frictions and resistance, for instance a lack of communication, ill-will, indifference, populism and so forth (Latour 1986). Such a model can be used to view non-human things such as orders given by a farm manager, attendees to farm events, membership numbers of grower groups, retail sales, and social media followers. The advantage of such a model is that everything may be explained either by talking about the initial force or by pointing to the resisting medium.

Translation

Translation is the mechanism by which the social and the natural worlds progressively take form. The result is a situation in which certain entities take control of others. Understanding what sociologists generally call power-relationships means describing the way in which actors are defined, associated and simultaneously obliged to remain faithful to their alliances (Callon 1986). Callon offers a way to study power from following the actions of distinct groups of actors. His study in St Brieuc Bay, France, involved groups of scallops, fisherman, scientists, and researchers. The sociology of translation starts as an analytical framework that is well adapted to study the role played by science and technology in structuring power relationships (Callon 1986 p. 197). This approach proposes that power entails the construction and maintenance of a network of actors (Grint and Woolgar 1997).

For the translation model the study of society moves from the study of the social, to a study of the methods of associations (Latour 1986). Referring to the previous metaphor, the solid ball can highlight the spread in time and space of everything, such as claims, orders, artefacts and commodities, in the hands of people. Each of these people may act in different ways when they have the ball; bouncing it, chipping it to change its shape, painting it, ignoring it, or losing it completely. There is no inertia to account for the spread of the ball. When no one is there to take up the order or direction, then the ball simply stops. This method is used to show why not every farmer in the Wimmera Southern Mallee uses the same available technologies nor actively undertakes the same cropping techniques to improve their economic position.

To explain further, the movement of the ball was not caused by an initial drop rather it is the consequence of the energy given to the ball as people pass it on, as it does in a game of netball. The first pass from the centre when the whistle is blown, is no more important than the second pass, and the third and so on until a goal is scored. “Consequently, it is clear that the energy cannot be hoarded or capitalised…you have to find a fresh source of energy all the time, you can never rest on what you did before” (Latour 1986 p. 267). Actors do something essential

for the existence or the maintenance of the ball. The chain of actors shape the ball according to their interests, which is why it is called the model of translation. It is important to redefine who is acting and the boundaries of the collective to determine who is doing the action or has agency.

Translation is an encounter between two mediators. This encounter changes both mediators, and together they transport a transformation. Translation is a method for studying how particular arrangements of farmer-agency emerge and how mediators are held together sufficiently long enough to see their effects (Higgins 2006). It is a relation that does not transport causality but induces two mediators into coexisting. The sociology of translation and the diffusion model approaches allows exploitation, alienation and agency to be reimagined through the presence or absence of stable relations.

Group formation

There is constant debate about who is obeyed and who obeys. Society designates the assembly of already gathered actors but it cannot explain the struggle for power. Society is what is performed for as long as it is able to be performed (Latour 1986 p. 274). Society may be utterly chaotic, being made and unmade constantly. Resources can be deployed in order to make the definition of society hold over time. “The whole burden of making society firm has shifted from the society itself, which has become a consequence, to many material tasks that may enforce or reinforce provisional bonds made by the actors” (Latour 1986 p. 274). These material tasks may be sentiments, resources, or rituals, attached to the representations and integral to the actors. Society is not made up of social elements, but of a list of mixed up social and non-social elements (Latour 1986 p. 275).

When the Australian farming sector is made with social elements alone it does not have a stable structure. The industry cannot be solely based on relationships, it also needs infrastructure and physical objects. It needs arable land, machinery, stock, fences, roads, grain receiving sites, stock sale yards, abattoirs, money and digital connectivity. An example of a stable social structure existing without non-social elements is in primatology studies. Primatologist Shirley Strum shows that primates build collective body with their body alone, using no other resources to group them together. Complex social skills are required and as a result there is no stable social structure as the primates recreate their social order every day.

For farmers, what holds the society together is mostly extrasomatic. Each performative definition of what society is about is reinforced, underlined and stabilised, by bringing in new and non-human resources (Latour 1986). A feature of this method is to focus on inanimate entities and their effect on social processes (Cresswell et al. 2010). Upon this point the notion of power changes. Power is now transferred to the many resources used to strengthen and hold still society. Just as a clan depends upon items such as tattoos and rituals to perform its definition, the power of the farmer may now be obtained by her education, grower group subscription, her shed of

machinery, her record keeping skills, the telephone calls with grain brokers, her mobility, and her grain storage capacity. This exact list is not important but what counts is that it is open ended, that the so-called social elements are simply items among many others.

Ostensive and performative frameworks

Actor network theory challenges the notion that society can be the object of an ostensive definition. Within such a framework all controversies including those about the origins of society are only practical difficulties that will be eliminated with more data, better methodology and better insulation from the researcher (Latour 1986). Observing farmers to include their age, farm location, hectares farmed, profitability, commodities produced, distance to markets and family structure; as well as their interactions and behaviours, would fit well with the ostensive definition of farming.

Referring once more to Shirley Strum's baboons and the link between social skills and notions of society, her studies demonstrates that all *a priori* methods of research and past assumptions need to be ignored in order to make new discoveries; only made possible by new methods which included following individually recognised animals over long periods of time. "Soon, each baboon troop under observation diverged from the norm, and variations in its behaviour undermined both the nice species pattern and its evolutionary interpretations" (Latour and Strum 1987). Scientists accepted the idea that both behaviour and society were flexible (Latour 1986). Latour and Strum (1987) summarize that the traditional, ostensive definition of baboon society has been unable to accommodate the variety of data on their social life. As a result, some information has been treated as data and other information as outliers to be ignored. The more recent studies demonstrate that baboons invest a great deal of time in negotiating, monitoring, and interfering with each other.

A performative view of society allows the actors to define the construct of society. A performative view allows everyone's effort to define the group, rather than beginning the research by placing everyone in the group. According to Garfinkel (1984) social actors are transformed from cultural dopes to active achievers of society. There is no hierarchy, rather the order is created by their social activity. This changes the weight from looking for the social link in the relations between actors to focussing on how actors achieve this link in search for what society is (Latour and Strum 1987).

To observe the agricultural sector the very same process that was used to study baboon societies is implemented. The performative framework grants full activity to all social participants in the efforts of negotiation and control. Individually and together they create society and, in theory, they are all equal (Latour 1986). When new asymmetries are introduced actors must enforce their own definition of social bonds and organise others according to their

individual views of what society is. This approach takes into account the types of resources that actors have to create their society.

Moments of translation

The development of social relationships between unrelated groups can be described. Callon (1986) achieved this methodology when he followed researchers, scientists, scallops and fishermen. Scallops are a saltwater crustacean and are a gourmet delicacy in France. They are in high demand by consumers but their population in St Brieuc Bay were depleting. The fisherman were exploiting the resource due to its lucrative attractiveness. Callon back-dated the analysis to a conference in the 1970's where three aquaculture scientists reported of the successful cultivation of scallops in Japan. Using a very specific methodology of anchoring larvae to collectors immersed in the sea, the larvae are transplanted to the ocean floor where they grow for two or three years before harvest.

Callon (1986) followed an actor through the construction-deconstruction of nature and society. The starting point was selecting the three researchers, identified as the *primum movens,* where four moments constituting different phases in the process of translation, during which the identity of the actors, the possibility of interaction and the margins of manoeuvre are negotiated and delimited (Callon 1986). Callon's four moments of translation can be used to re-interpret and describe relations between unlikely actors, which is applicable when explaining unlikely connections in the Wimmera Southern Mallee and the Australian grains sector.

Problematization

The dynamic processes of problematization is perhaps the most valuable rule to determine the movements and alliances that must be forged between actors (Callon 1986). Problematization is one moment in the translation process where an actor or group of actors defines an issue as problematic (Higgins 2006). The problem was the depleting population of scallops and very little was known by the fishermen or scientists about scallops' life cycle. The scientists were unable to critically analyse the potential to successfully cultivate scallops, especially when the scallops cultivated in Japan were a different species to the French scallops.

> No answer could be given to the following crucial questions: does *Pecten maximus* anchor itself during the first moments of its existence? Other questions are just as important to accompany the first. When does the metamorphosis of larvae occur? At what rate do the young grow? Can enough larvae be anchored to the collectors in order to justify the project of restocking the Bay? (Callon 1986 p. 204)

Problematization is the movement of the three scientists which rendered them indispensable in the network. As the phase of problematization shows, it would be absurd for the observer to describe entities as formulating their identity and goals in a totally independent manner. They are formed and are adjusted only during action (Callon 1986 p. 207).

Obligatory passage point

An obligatory passage point is defined where others must pass through to meet their own interests as well as the interests of the network builder (Higgins 2006). The scientists did not limit their written documents by the questions they could not answer, instead they established themselves as an obligatory passage point in the network of relationships that they were building (Callon 1986).

Displacements

Displacements can happen during the processes of problematization, *intéressement*, enrolment and even the final stage of dissidence. During the scallop cultivation research project the fisherman changed their usual objective to fish and followed the scientists to learn about restocking the bay. This is called a 'displacement'.

Intéressement

The term *intéressement* is when technical devices are deployed in order to impose roles and identities upon other actors which were previously defined during the problematization phase. Callon (1986) refers to the etymology of the word *intéressement* meaning to be in between or inter-*esse*. Callon (1986) found from the series of unpredicted displacements that all processes can be described as a translation. The inter-definition of the actors establishes the identities and the links between them.

Enrolment

The success of the two moments of translation, displacement and *intéressement* leads to enrolment which involves the stabilization of the network of alliances. The stable alliances are used to describe the assembly of actants.

Rules for engaging actors

A particular kind of architecture comes with an actor network perspective. In order to scrutinize what is assembled strict rules must exist. There are major types of uncertainty which are used as a cumulative process for the method. This is to overcome the habit of linking notions of society and social factors with an accelerated mobilisation of history to explain structure and power (Latour 2005). Actor network theory is about a careful examination of the types of aggregates that are assembled and the ways in which they are connected to one another.

Sources of uncertainty

After actors have deployed a range of controversies actor network theory is based on finding order. The task of defining this ordering should be left to the actors themselves, not the analyst (Latour 2005 pp. 22-23). These five sources of uncertainty are followed to find uncertainty:

i) there exists many contradictory ways for the nature of groups to be given identity;
ii) in the course of action actors can barge in an displace original goals;
iii) the types of actors participating in the interaction remains wide open;
iv) the links of natural science with the rest of society seems to be source of disputes;
v) v) good sociology has to well written, if not the social doesn't appear through it (Latour 2005 p. 125).

These instructions are embedded in the application of the models of diffusion and translation to observe the sequences of farm processes and investigate farmers' capacities to control their farming complex.

Agnosticism

Social scientists are required to extend their agnosticism towards all sciences, including the social (Callon 1986). The researcher must be impartial towards the scientific arguments used by the protagonists of the controversy, and abstain from censoring the actors when they speak of themselves or the social environment. Refraining from judgement, giving no privileges to views, and ensuring that no interpretation is censored, are the sub-texts to this first rule. Star (1991) reminds us that we need to agree in principle that all points of view are important. Each perspective is important, but challenged when adopting a network analysis. Considering the multiplicity of a farmer, their perspectives are traditionally underrepresented, therefore a model which changes the point of departure from a human to a non-human may be suitable for the heterogeneity that occurs within these juxtapositions.

This means that in a farming environment the researcher needs to be aware of the agricultural sciences, natural resource sciences, social sciences, technological and information sciences and ready for interpretation at every moment. It is the researcher's role to forgo these ontologies and listen to the participants, or actors, as well as the other actors they mobilise, in the study.

Generalised symmetry

Farmers are frequently deemed as loyal and faithful to their alliances which is why the sociology of translation offers hope to understand these relationships. This method is symmetrical and results in a flat narrative of a complex process involving social and natural entities. Callon (1986) suggests that it is the sociologist's role to explain conflicting views using a single repertoire knowing that controversies are a mixture of both society and nature. The translation repertoire is provided for the reader rather than a repeat of the analysis provided by the actor being studied. Sociologists must act impartially and refer to the differing protagonists in the same terms, regardless of their effect upon others. The sociologist attributes the actors

with neither reason, scientific method, truth nor efficiency because these terms denote the actor's success without explaining the reason for it.

It is at the researcher's discretion to select the description and explanation of the conflicting views and actors involved. This is important for this study which seeks to explain the position of farmers in political economy. Ensuring that nature, farming, farmers, machinery, and farm services are equally respected and that registers are not changed as the researcher moves from technical to social aspects is indeed an important rule to consider.

Actor network theory allows for an analysis of agriculture, using farms as micro-assemblages that related to other micro-assemblages in a certain way. The conclusive understanding of how farms work may be jeopardized unless the *a priori* assumptions are removed of how farms are constructed, and the asymmetry that exists between farmers and the farm services sector.

Free Association

The researcher must abandon all *a priori* distinctions between the natural and the social events (Callon 1986). There is no boundary that separates the two. It is the role of the researcher to consider the entities which are mobilized, and the relationships between topics of discussion and every element by which participants explain and build their world.

Rejecting the concept of a boundary is challenging for researchers in agriculture. Boundaries are what farmers and the farm service sector use to define their identity and the space in which they work. Boundaries can exist as fences, roads, districts, catchments, climate, regions and states. The agricultural sector too frequently cites groups and group formations through memberships, farm systems, enterprises, and rainfall zones. The researcher must reject these pre-defined zones as hypothesis for the boundary.

Valuing time

The translation model requires a value of time, which can be related to the origins of society. Callon's research using the sociology of translation is back-dated to 1972 to a scientific conference in Brest where scientists and the fishing community assembled to examine the possibility of increasing the production of scallops through cultivation (1986). The stored energy from the original associations of the controversy require a value of time. Farms in the Wimmera Southern Mallee, and beyond are all reservoirs of time.

> When we apply the translation model we simply have to understand that the origins of society are still with us today and that debates about how it all began are still shaping our behaviour here and now. If we make such a hypothesis, then all the debates about what holds society together stop being endless and fruitless; instead they themselves become *one of the ways* of holding society together and enrolling enough people to constitute power. (Latour 1986 p. 270, original emphasis)

Power does not have to be explained if it is something that has been provided by prior existence of society, because it is the explanation for the behaviour of everything else. Alternatively, if power is something that has to be obtained by enrolling many actors then neither power nor society are used as explanations. These arise out of the modifications that are made to the developing definition of what society is about (Latour 1986).

Speaking for nature

For farming, nature is taken as the spatialized form of the landscape. Nature is an ontologically equal actor. Castree (2014) offers that a prudent and sensible approach is to look for shared meanings that humans attribute to nature as phenomena. Nature by itself is not in a position to establish consensus because it cannot speak. It can create controversy, therefore it is the analyst's responsibility to speak on its behalf and listen for those who speak for it too.

Actor network researchers view the nature-culture dualism as unsolvable and therefore unproductive heuristics. To dissolve the distinction between nature and society, Castree and MacMillan (2001) use actor network theory in their social constructionist argument to think beyond the binaries that nature-culture offers. Binarism in farming can look like arable/non-arable, productive/limited, flat/undulating. "Actor network theory argues for an amodern ontology in which we recognise the hybrids or quasi-objects that litter the world we inhabit" (Castree and MacMillan 2001 p. 211). This is important when we begin to think about farming as an identity, behaviour, ideology and science.

The study of science on a continuous commercial cropping farm facilitates the need to emphasize the term field in this methodology. The relationship with nature as a spatial concept requires transformation to connect the field to a written report. Grain growers do this when they use technology to map their harvest yields. The fieldwork process requires the researcher to be aware of what they gain and what they lose as they are immersed in the field with the subject (Massey 2003). This means that in isolation a farmer's yield map would be meaningless. "It replaces without replacing anything" (Latour 1999 p. 67). The map is a transversal object, truthful only on condition that it allow for passage between what precedes and what follows it. Latour (1999) explains this as circulating reference. This model is used in this research to examine farmers' fieldwork as practitioners of agricultural science, just as Latour examined soil scientists' research of vegetation variances in Brazil.

Each stage is a matter for what follows and what precedes it, separated from the other by a gap as wide as the distance between of what counts as words and of what counts as things (Latour 1999). In the instance that words and the world is separated by a chasm but related by correspondence, one can use circulating reference minus all mediations and intermediaries, to find the connections. Maps reduce work in nature. The global positioning system (GPS) coordinates act a spatial reference, a word that comes from the Latin *referre*, which means to

bring back. Reference is not simply pointing to a particular yielding zone on a map, rather it is an actor network way of keeping something constant through a series of transformations.

> Our philosophical tradition has been mistaken in wanting to make phenomena the meeting point between things-in-themselves and categories of human understanding. Realists, empiricists, idealists, and assorted rationalists have fought ceaselessly among themselves around this bipolar model. Phenomena, however, are not found at the *meeting point* between things and the forms of the human mind; phenomena are what *circulates* all along the reversible chains of transformations, at each step losing some properties to gain others that render them compatible with already established centers of calculation. (Latour 1999 p. 71 original emphasis included)

Latour's (1999) pursuit to determine the natural dualism between the forest and the savannah in Brazil, is relatable to farmers' plant tissue and soil tests for crop productivity. For some, a yield map may be viewed as a harvest bi-product, an artefact which is created by the technological and mechanical intermediaries employed in the system, or a decision-making tool for future paddock management. Yield maps are stable, easily stored and can be produced at harvest regardless of the crop yield. The methodological approach using circulating reference allows the researcher to speak for nature.

Objects are integral

According to Saldanha (2003 p. 421) "Serres and Latour, the two main sources of inspiration for actor network theory, have always been vehemently against the dominant literary interpretation of post-structuralism." Serres and Latour ignored the cliché that there is nothing outside the text and extended relational thinking, to materiality (Saldanha 2003). This means that the entities such as laboratories, measuring devices, viruses, journals, notebooks, authorities, blood, lungs and customs, just like text, only come to be effective by virtue of their interactions with other things. All of these heterogeneous actors connect to form a particular network which enables and constrains any constituent's agency.

Anthropologist, Appadurai (1986) plays an integral part in references to commodities stating that a commodity is not one kind of thing rather than another, but one phase in the life of some things. Actor networks offer the researcher to look at an object which is enrolled in the network that precludes all certain knowledge of it. This results in a map-like outcome of technical and discursive practices that together constitute a new project. The benefits of this fractional coherence is that it becomes possible to talk about any sociomaterial entity such as the John Deere tractor, the new weigh-bridge, iPhone X, the condition of the roads, the local schools etc., without implying any essence or necessity. The researcher follows the work done by humans and non-humans that goes into holding the network stable.

The ethnographic and praxiographic observations by Mol (2002) highlight the multiplicity of atherosclerosis. For a patient, atherosclerosis is the inability to walk far without

pain. For a surgeon, atherosclerosis is a stenosis in the femoral artery requiring surgery, and the type of invasion depends on the Doppler reading, ankle/ leg pressure ratio, an angiogram and the patient's history. Mol (2002) wants to steer between social constructionism and objectivism. She demonstrates that disease is socially constructed but only if construction means the interplay between cells, organs, language, hospital wards, insurance, health policy, and bioethics (Saldanha 2002). Artery and person are situated next to one another, rather than being a part contained inside a whole (Mol 2002).

Rather than being one contained inside the other, social relations are obviously more complex. One object may be enacted as part of the other, but that inclusive relationship may also go the other way around. In terms of epidemiological knowledge, the population includes the individual, and in its turn, the individual also includes the population (Mol 2002) because surgeons use this knowledge to help them to make decisions. Mol (2002) identifies that no population makes progress on any scale if no individuals' situations have been altered. A treatment can only be established as good if it brings about a measurable change in a large enough number of people in its target population (Mol 2002).

Considering this relationship between the artery and the person, offers an unlikely but new lens to consider the relations with farmers. Agricultural statistics include farmers, and a farmer also includes the statistics. They use national averages in their decision making; they are part of a macro-network. The importance of understanding the wider context is that any goal to improve the profitability of farming or that of individuals, are goals that are often at odds with one another. Actor networks can be used to look critically at these associations.

Multiplicity is inherent to farming. It is a combination of human and non-human relations. The focus of farming business is production-based, but often there is more to farming than just capital growth. This research explores the associations which connect farmers with the commodities they produce, the services they require and technology. Human and non-human relations will explain the social ties and help to determine which objects influence these networks.

Others' actor networks

Actor network theory engages with the suggestions for conceptualizing the social. It does not provide answers nor offers any justification for contesting the status quo, but it presents to the reader a narrative that gives them the opportunity to critically analyse society. Saldanha (2003) proposes that it's an anti-essentialist, open-ended and resolutely relational way of understanding the world. With the insights taken from science and technology studies actor networks are a broad attempt to study modernity in a consistently symmetrical manner. It forgoes the usual privilege granted to western science's self-conception of the uniqueness of its particular way of knowing, which claims to afford direction and unmediated knowledge (Nimmo 2010).

> The theory of the conditions, constraints and modifications of agency within networks is more like an instance of a wider sensibility in the contemporary human science for the intertwining of 'the human', 'culture', 'language', 'mind' or 'society' with 'the nonhuman', 'nature,' the physical world of bodies, things, artefacts and technology. There is an explicit struggle to reach beyond the impasse, witnessed across academia, between social constructionism and postmodernism on the one hand, and realism and scientific objectivism on the other. (Saldanha 2003 p. 420)

The studies of culture, inspired by semiotics and Foucault, state that no knowledge of the physical world is possible as everything is constructed through language and all signs are arbitrary (Saldanha 2002). Realism believes that the physical and social worlds disclose what it is and can be fully explained if studied well by scientists (Saldanha 2002.) Actor network theory has been the most influential of recent theoretical development in addressing this deadlock between constructionism and realism. It follows Foucault's inquiries into historical conditions and probes into the aspect of modernity, namely the conceptual segregation of the non-human from the human (Latour 1993).

Actor network theory arose primarily out of poststructuralist-influenced science studies (Latour and Woolgar, 1979, Latour 1987) but it morphed with other materialisms such as anthropology, medicine (Mol 2002), geography, media studies (Seier 2017) and the philosophy of science. What emerges from using actor network theory is more-than-human-science (Whatmore 2003). So to describe something like farming, the analyst shouldn't simply exclude engineering, plant, nor soil science, as research should draw on some science in the study of science. This is supported by the work of Mol (2002) in her social study of disease. Building on the theories offered by Stengers, Deleuze and Serres, the materialist philosophers that inspired actor network theory, Mol aims to bridge the gap between the 'human' and the 'natural' sciences. Mol (2002) shows that biology is only relevant for her insofar as it is intercepted by or has an effect on practice. Saldanha (2003) suggests that the interplay between biological processes and interpersonal and institutional relations between humans remains undertheorized. This is where the interface of agricultural science and the humanism of agricultural labour, together with machinery and technology can be reassembled.

Callon's sociology of translation in his study of the scallops and fishermen is widely cited. To challenge the validity of his methodology, geographers Eden, Tunstall and Tapsell (2000) applied the conceptual framework to a river restoration project in southern England. They too identified that humans or agents speak for nature. Gray and Gibson (2013) applied this theory while interviewing 200 Kansas farmers about farming finance, consultants and insurance. The methodology showed that crop consultants speak on behalf of nature and as a result possibly distort farmers' views. Higgins (2006) studied the dairy crisis in Gippsland, focusing on the Victorian State government's former Farmbiz program while specialising in farmer-agency.

To conclude, this research follows the rules of actor network theory, specifically translation and diffusion models, but it represents a slightly different response to investigate farmers' capacities to control their farming complex. This work draws on the use of farm technology rather than trying to problem solve it in an ontological mode by further theoretical innovation. Reflecting the work of Nimmo (2010) and his study of the UK dairy industry, Mol (2002) and her ethnographic study of the social relations of atherosclerosis in a hospital in the Netherlands, and Latour and Woolgar's (1979) observations of scientists in a laboratory, this research is strategically planned to identify the relations between humans and non-humans, commodities and the use of science as the unstable centre of modern culture/nature dualism in a capitalist-driven agribusiness economy.

Reflexive photography to render movement still

The proposal is to seek the actors, and the kinds of relations that exist through farmers as a consequence of farm labour. By identifying the actors in the network this research will be able to show the complex nature of farming and examine the relations that farmers control in order to overcome their exploitation in the commodity chain. Research is the process of knowledge production as an intervention in the world in which all human and non-humans enjoin to act and affect each other (Whatmore 2003 p. 90). Photographs are deployed to support actor network theory and to generate materials to support the researcher to achieve the research aims.

Whatmore (2003 p. 97) draws on the work of Isabelle Stengers (1997) where the invention and production of reliable witnesses is generated by not just letting actors speak, but letting them speak in a way that scientists recognise as reliable. The black and white photographs included in the soil science fieldwork in Brazil by Latour (1999) supports this method. Latour included photographs of soil cores, maps and photographs of the soil scientists at work. The photographs have the effect of making the doing of research present in the text. "The photographs extend the register of what it means to 'generate materials' from one in which only human talk counts, to one in which bodies, technologies and codes all come into play" (Whatmore 2003 p. 97).

Photographs help to render movements visible for the actor network research. Photographs can take multiple forms: historic artefacts for participant photograph elicitation, participatory action research, comparative, or elicit participant preferences to identify subjects. For this project the photographs will reproduce Latour's (1999) soil research expedition method and rely on photographs which are taken during the fieldwork only, with the intention to strengthen the research narrative.

Others' visual imagery

Visual ethnographer, Douglas Harper studied the agricultural communities in mid-USA. He was interested in the issues of how people organise themselves socially and technically to

make milk. Obviously, the biological system of the cow producing milk has not changed but the technology and the machinery people use in this process has altered considerably over time. What Harper identifies is that the advance in machinery and technology take the farmer further away from their production, the land and their neighbours with which they once worked. This change in social relations, to communities, the land, and the animals comes to be seen as an inevitable side effect of what we deem as progress. Harper (2003) has been instrumental in influencing the methodology for this research by advocating the role which photography has to offer.

> The era which followed the changing works system alienated the farmer from his crops as well as his neighbours. I use the term "alienation" in its original meaning to indicate "separation". (Harper 2003 p. 114)

Actor network theory gives objects agency. This methodology allows the researcher to record what, when, how long for and why they come into being, through sequences. Actor network theory is used to see how farmers are associated with the commodities they produce through any kind of movement with their grain such as touching it, marketing, moving it with an auger, storing tonnes in a silo, or trucking it off the farm. The role of the photographs is two-fold. Firstly, the photographs will be used by the researcher to validate physical processes, such as sequences for operating software and machinery. This is independent from the images that will be included in the written text, as it creates material for research purposes. Secondly, the digital imagery which is included with this text provides an account to support the narrative. The photographs will improve the text by showing the farming landscapes, the size of the machinery and promote the epistemological position of the researcher.

Aerial photography

Any photographic framework adds a visual dimension to researcher's texts but aerial photography offer more than just an alternative view to traditional landscape and portrait photography. Aerial photography provides a spatial awareness of the placement of fixed structures from a bird's eye view. Harper (2003) offers that aerial photographs of farms provide a baseline of time and space. Using aerial photographs of participants' farmsteads Harper (2003) has retaken some of the SONJ photos. These photos have allowed him to summarise visually farming decisions sometimes a hundred years in the making (Harper 2003). He has used these pictures to compare commercialisation versus the retention of earlier farming systems, with the farmers telling their own story through photo-elicitation.

For an urban perspective Roca (2015) uses aerial photography over a fifty year time period to research changes in commercial, political and cultural practice in Mexico City. "The pictures created through aerial photography could not have been imagined, for the aerial views drawn and painted by artists envisioned the space in a different way" (Roca 2015 p. 2).

Gender on farms

To study labour, the form of the body requires consideration which is offered by Arendt (1958). Humans are embodied to think, touch, feel, breathe, smell, sleep, and to encounter other bodies (Rose 2003). But how bodies live on a farm, or anywhere for that matter, is not as obvious. Some of the ways in which women's bodies are treated have long been subject to various kinds of feminist protest, for example reproductive technologies, pornography and rape laws (Rose 2003 p. 48). For feminist writing about the body the notion of discourse is used because the body is placed firmly inside the workings of language (Rose 2003). Feminism is a way of knowing, an epistemology, assuming that what can be known is framed in some way by what is already known.

This thesis posits that women's labour on farms is equally valued to men. There are many ways to refer to women who undertake farm labour and/or reside on farms, so the phrase women on farms is an encompassing noun to umbrella women whose livelihoods are dependent upon farm productivity. Women on farms are by no means homogenous but it is accurate to acknowledge their multi-positionality. Women's work identities vary, influenced by their individuality, locality, and the prior experiences they bring to the farm. How sexual specificity matters to this ontological framework is addressed through the symmetry that actor network theory and visual imagery data offers.

Gender and actor networks

Gender, age, ethnicity or generation of farm ownership, is not required to be exclusively addressed unless it triggers a movement or becomes a mediator. "Actor network theory is perfectly aware of the politicisation of the body by especially feminists, but its wariness of the 'grand narratives' of modernity stays away from engaging with the politics of identity and difference" (Saldanha 2003 p. 126). Actor networks do not scrutinize as such. This research provides opportunities to compare relations through males and females in both paid and unpaid farm labouring and farm service roles.

Gender division exists in farm labour. The introduction of technology and mechanisation of agricultural practices has been cast as the reason for excluding women from farming and it said to have contributed to marginalising their role in the farming enterprise. Empirical evidence, mostly shown through images in the rural media, suggest that women in dairy, wool and meat production enterprises potentially play a more physical, or paddock-based role compared with women in cropping businesses. Perhaps women are more akin to animals than machinery, or cropping businesses rely on greater physical strength to connect equipment, handle chemicals, move augers and undertake basic mechanical maintenance. Actor networks will assist to clarify these assumptions by identifying the actors and seeking meaning through the effects that they generate.

An example of applying actor network theory is the feminist case study of Air Canada. This work contributed to an understanding the methodology's potential and limitations in explaining the remarkable resilience of masculine dominance within organizations. Corrigan and Mills (2012 p. 251) argue that "using ANT in a critically historicist way allows some for the barriers between ANT and feminism to be broken down." They synthesised an approach to observe gendered organisational processes, identifying the human and non-human actants that encourage people to act, to produce gendered effects such as ongoing discriminatory practices.

> Actants (i.e. things that act on people and things) in a network of gender discrimination at Air Canada may include the staid railwaymen that founded the company, stewardesses with tight-fitting uniforms, advertising copy showing only men as pilots, the phallic fleet of airplanes, company newsletters celebrating heroic managers, the Second World War and human rights laws. (Corrigan and Mills 2012 p. 255)

A trademark of actor network theory is that research has to follow the actors and learn from them as to how an order has been assembled. An actor is something or somebody that is made to act by others. Agency assigned to non-humans is part of the action. Actor network theory follows things that may not be bound to each other yet become allies in a meta-stable state (Corrigan and Mills 2012). Feminism is an actant in this Air Canada masculinity story.

This doctoral study is not seeking gender-bias, nor offers a feminist methodological approach as demonstrated through Air Canada, but it highlights the importance of historical views. Corrigan and Mills (2012) show that actor networks can increase the richness of the discussion by uncovering multiple interpretations of the past from the points of view of various actants, thereby revealing multiple sources of knowledge of how the past was created. Actor network theory may also recuperate the voices of actors that have been marginalized.

Women and photography

Feminism plays a role in the photographic research. According to Pink (2007 p. 25) the "consideration of gender and other aspects of identity has implications for ethnographic research with images." It is highly unlikely that sexualised farming photographs will be unearthed but it is anticipated that gender asymmetries are likely to be found during fieldwork. Considering the work of Pink (2007) and images used by Harper (2001) the fieldwork is likely to find three types of feminine imagery artefacts. Firstly, the female reflexive photographer capturing the images both past and present, as women may be more involved in the image-production rather than the feature. An example of this are mothers taking photographs of their younger children in farm landscapes in either the presence or absence of the male farmer. In this the subjects in the photographs are children, farm animals and innate farm icons which represent the rural idyll. The feminist farm-photo perspective is depicted by familial happiness, appropriately-clean farming

clothes, healthy stock and farm infrastructure that maybe shares history rather than safety or functionality. But the women behind the camera are omitted from the record.

Secondly, women can be the subject in the photographs. Harper (2003) identified that the SONJ photos showed farm life's mundane realities and the tasks of daily life and gender roles on farms.

> The assignment of tasks on the basis of gender meant that the men's and women's identities evolved as gender roles changed. For example, the mechanisation of agriculture removed women from meaningful productive roles. But during World War II, when many male farmers and most hired men were absorbed into the war effort, women were redefined as mechanically competent and responsible for previously male responsibilities. (Harper 2003 p. 192)

The historic occupational structures on farm is effectively demonstrated through photographic imagery. "Material and cultural factors combine in any given system to create a division of labour with specific gender differences" (Harper 2003 p. 190). Harper (2003) argues that while certain case studies highlight certain elements, it is most useful to consider their contributions to understanding given situations.

Thirdly, some farm photos may have no trace of femininity, rather they are masculine in style and subject. Photos taken by male farmers which are shared on social media platforms, such as Twitter, generally show mechanical faults, home-innovations, or landscaped still photographs of machinery in the field either prior to commencement or at the completion of the season's activity.

> The gender-based division of labour in dairy agriculture … wider context includes gender roles in other agricultural systems and the question of how productive technology – generally run by men- has a complex, often competitive relationship with domestic technology – generally run by women. Change in either the domestic or the productive technology affected the other, in often unanticipated ways. (Harper 2001 p. 183)

Researcher's position

Researchers should be aware of abusing the licence to commit or omit items from the past as well as their engendered perspectives and reflexivity of social research (Corrigan and Mills 2012). As a researcher I declare my own feminist subjectivity and epistemological positioning. I am female and I identify as female. I am an only child of divorced parents, raised solely by my mother. I spent much of my childhood on a mixed farm in the western district of Victoria with my grandparents while my single mother studied, mature-aged, at the regional university. I grew up watching my maternal grandmother take good care of my grandfather. She took responsibility for the all of the domestic chores. She had raised four daughters as her primary role, and she was an active member of the local community and the Uniting church.

During my childhood years her role in the farm business was limited to indoor tasks and gardening. She cooked for the shearers and delivered meals to my grandfather at harvest. My formative farming experience is that women serve and farming men take care of farm work and the financial wellbeing for the household.

Method

The role of the actor network researcher is to observe how local networks are ordered and re-configured over time with the purpose to explain how farmers exercise control through their production. Writing the accounts of what happened is part of the actor network method. The data collection process is supported by aerial and digital photography to recall farmers' processes and sequences. Hand written field notes obeyed the conventions of the actor network formula to segregate research purposes and keep thoughts separate in notes. Four notebooks were used to keep track of the moves "because everything is data":

i) the logbook for conversations, activities and broader observations;
ii) detailed notes of chronological orders, sequences and practices that farmers undertook in their day to day activities;
iii) *ad libitum* writing for an outlet of thoughts;
iv) a register of effects to check if an account plays out (Latour 2005 pp. 133-135).

The sample size was twenty participants from farming and the farm service sector, who represented machinery, finance, seed, grain-trading and grain logistics roles. Three farm extension events coincided with the period of fieldwork, with a population of over 100 farmers and farm services representatives present at these gatherings. Countless objects are disclosed in the theoretical discussion, to demonstrate the complexity and agencies of networks at work. Geographically the participants represented a local farming community, the Wimmera Southern Mallee, western Victoria, and national grain buying interests. One participant represented international trade interests, as he was visiting from India.

This doctoral study is structured as two textual accounts, written as case studies that craft chapter three. The first case study followed the social life of a canola crop. The crop is a genetically modified (GM) canola variety. The second case study followed how technology and software is used for three different combine harvesters and the farm labourers' activities during harvest. Both case studies required data gathering on farms by observing participants while they undertook both planned and unplanned operations.

At all times during the fieldwork a camera was available. It was only on weather permitting days that the drone was deployed to take aerial photographs.

Research ethics

For this research, perspectives of translations were relied upon as an ethical methodology. This research builds upon the sociology of science and technology, specifically actor network theory where a heuristic flattening of differences between people and machines was required in order to understand the way things work together. This research project, assigned as university project A18-104, was granted provisional approval by the Human Research Ethics Committee (HREC) on the 7th of September 2018 (refer to Appendix A). I replied with a rejoinder to the HREC, and commenced fieldwork (refer to Appendix B). The final project report was submitted to the HREC on the 26th of August 2019 (refer to Appendix C).

In summary, nineteen participants were directly involved in this study. Each participant agreed to participate in the research by signing a consent form and obtaining a Plain Language Information Sheet about the project after both forms were read aloud and discussed with them. The information sheet was prepared by the researcher and her Principal Supervisor and it was approved by the HREC prior to commencing the fieldwork. As the researcher, I took all of the photographic imagery using my cameras. This justifies the reason why no recognition is given to photographers in any of the captions under each photograph.

As demonstrated by Callon (1986) when providing his view to narrate the experience of a scientist, but a much less from the view of a laboratory technician, and still even less than the cleaner of the laboratory, one needs to be reminded that we need to agree in principle that all points of view are important. Nevertheless, non-farmers may suspect that omissions of information are not accidental. Farmers may reflect on the inadequacy of the available material collected during the fieldwork. There were no principle analytic barriers to this work because non-humans were given agency.

Accumulated materials

The materials collected from this research include handwritten field notes of sequences and points of casual conversation, two yield maps as digital files, a printed copy of the canola specifications from the Footscray canola crush plant, two bottles of high oleic acid canola oil, factsheets about high oleic acid canola oil, and 210 digital images from three cameras: an iPhone 6, an Olympus DSLR and a DJI drone camera.

Analysis and writing

Writing the written account is part of the actor network theory method. Walter Benjamin worked in Paris in the 1920s and 1930s and he is associated with the Marxist Frankfurt School though he was never a formal member (Crang 2003). As a social researcher he is renowned for his interpretations of taking of what seemed common and unexceptional and putting in it a new context – alongside other unremarkable events and information – that you could reveal

previously hidden dynamics (Crang 2003 p. 135). Benjamin identified that linear writing styles inhibited multi-directional and complex linkages in analyses. He advocated a writing practice that sought to engage with what he saw as a fragmented and objectified world by using material in the same style – through fragments and moments (Crang 2003 p.136).

This is how this thesis offers its analyses in the theoretical discussion. The results in chapter three are written as lineal accounts, stepping the reader through the seasons, paddock operations and the experiences on three headers. However the theoretical discussion in chapter four defies chronological order, presenting to the reader the unexpected from predictable farming operations.

Wimmera Southern Mallee: an overview

The research is set in the Wimmera Southern Mallee (WSM) of Victoria, Australia. Located west of Melbourne and bordering South Australia, the region covers just under 34,000 square kilometres with a population of 47,000 (WSM Regional Partnerships 2017; refer to figure 1 below in the purple lift out map). The region has a projected estimated growth rate for the period of 2016–2031 of -0.6% (Regional Growth Plan 2014).

Figure 2. Map of the Wimmera Southern Mallee region.
(Map sourced according to copyright laws from Regional Development Victoria)

The landscape is diverse encompassing the mountain ranges of the Grampians National Park, Mount Arapiles, and the Black Range State Park. The heritage listed Wimmera River flows inland terminating at Lake Hindmarsh. During exceptionally wet periods, Lake Hindmarsh overflows into the ephemeral Outlet Creek and on to Lake Albacutya, a Ramsar-listed wetland (Wimmera Catchment Management Authority 2018). The Wimmera River is part of the

ephemeral artesian system of the Murray Darling Basin. The region features the Little Desert National Park and the Big Desert, both of which are nationally significant. Other landscape assets include lunettes, pink salt lakes, freshwater and saline wetlands and marshes, indigenous sacred sites, threatened species and nationally listed remnant vegetation.

The agricultural sector accounts for 25% of jobs in the WSM and 47% of all businesses (WSM Regional Partnership 2017). Agriculture is agreed to remain the largest employer in the region into the foreseeable future. However, agriculture is not predicted to be the fastest growing employment sector. The other industries in the top five of businesses in the regional include construction (9.2%), real estate (6.9%), retail (5.6%) and financial and insurance services (4.8%).

The Gross Regional Product of the region is estimated to be valued at $3.0 billion whereas the Gross State Product is estimated to be valued at $337.6 billion (WSM Regional Partnership 2017). The WSM is a major producer of Victoria's grain, and home to an estimated 20 grain buyers. In 2012-13 the gross value of Victoria's grain production was $2.31 billion (WSM Regional Partnership 2017) however this total could not be segregated into regional contributions.

The agricultural networks that support and service the farming population is significant. The Victorian State Government funds the Grains Innovation Park in Horsham where pulse breeding and seed gene storage and management takes precedence. A multinational organisation, Bayer Crop Science has a wheat and oilseed breeding site at Longerenong. The Birchip Cropping Group is a long established non-for-profit grower group applying science in field to support farmer adoption of risk management strategies and increase farm efficiency and productivity. Longerenong College offers TAFE and vocational and educational training in dryland farming and agronomy. Machinery dealerships and manufacturers are widely distributed across the region in the townships of Horsham, Warracknabeal, Birchip, Nhill, Ararat, Rupanyup and Donald. This list overlooks the other entities, such as health services, schools and retailers, and local government services for rubbish collection and road renewal, that support the existence of family farms beyond their principal production role.

Mobile telephone and digital connectivity have been identified as a key issue contributing to the loss of productivity (WSM Regional Partnership 2017). As a result, innovation potential, competitiveness, streamed entertainment, emergency management and educational services using ICT have been identified as compromised in comparison with urban environments (WSM Regional Partnership 2017). Mobile coverage shows over 400 mobile blackspots in the Grampians region with plans to fund some of these locations over time through the Fixing the Digital Divide - Connecting Regional Communities Program (Department of Economic Development, Jobs, Transport and Resources 2018).

A study of remote data use in agriculture showed that 70% of farmers were using smart technology, which was above the national average in 2013. The results also showed that 76% of

the respondents use some form of precision agriculture, such as remote sensing, in their operations (WSM Regional Partnership 2017). Given the out-datedness of this research in technology empirical evidence would suggest an increase in the use of smart technology, but potentially not remote sensing such as GPS, because the farmers likely to adopt the technology would have done so prior to 2013.

The main site for the fieldwork is in the southern Wimmera, in the Horsham Rural City Council local government area. Two farms in Telangatuk East, covering approximately 2100 ha, is locale for the majority of the research. The water catchment for these farms is the Glenelg River which terminates at Nelson on the Victorian south west coast. Field research also takes place in Horsham, Vectis, Kewell, St Helen's Plains, and Dunkeld.

Concluding the methodology for the research

This chapter commenced with a broad overview of the social research theory of an actor network approach. It explained the research theory rules for the fieldwork and the rules for the analyses. The purpose of this chapter was to justify actor network theory, which originated in the field of technoscience, is fit for purpose as methodology for this ethnography of farm technology in the Wimmera Southern Mallee. Actor networks, supported with digital imagery, will analyse how farmers use technology for competitive positioning in socio-political economy. The following chapter explicitly follows these rules of actor network theory, and transports the reader to the research setting, to generate reliable data for analysis. Turning to the next chapter will take you cropping in the southern Wimmera, in both words and pictures.

CHAPTER THREE

Case studies

This chapter offers two farming narratives. The first narrative shares the social life of a growing crop of hybrid canola. The second story follows three headers and a chaser-bin to examine the role of technology and machination at harvest time. These two case studies highlight the interactions of farmers with members from the farm services sector, as well as machinery, staff and land, to shed light on the structures and dynamics of family farms. These results draw on extensive fieldwork, interviews and industry knowledge and have been presented to demonstrate the relations that provide for farmers' continuity under the capitalist mode of agriculture.

The results are presented as textual accounts with visual imagery to support actor networks. Tables are used to summarize the paddock operations and machination required for grain production. These narratives and tabled summaries are designed to help the non-agricultural reader understand the social processes between humans, non-humans and objects in farming. The theoretical discussion in chapter four is crafted from the findings in this chapter.

Pseudonyms are used to protect the identity of humans, registered canola varieties and organisations. Frontrunner®, GBA Ltd, Intercont©, Discoverer©, Wisdom, CropCo and Greenlands are pseudonyms. Pseudonyms are marked with an asterisk (*) in the first instance to help the reader. Role-related titles are also used as pseudonyms to protect individuals and to remind the reader of their job. Government-funded organisations, such as Agriculture Victoria, National Variety Trials and Grains Research Development Corporation are not pseudonyms as they do not require anonymity. All machinery and equipment, including combine harvesters are referred to with their make and model. Genetically modified Roundup Ready™, publications, localities and units of measurement are all valid because they support the narrative and give meaning.

Case No.1 Social life of the canola crop

Canola means different things for different people. For those who cook, canola is a plant-based cooking oil (refer to Appendix D for details about the oil). For farmers, canola is crop, a commodity, a break from cereals on cereals in paddocks, and it is used to overcome herbicide resistance. It also comes with a higher production risk than cereals, especially in a low rainfall year. Canola carries with it the name of a singular plant or a crop of millions of plants sown in lines in the paddock. The purpose of the plant is to make cooking oil for humans and canola meal for stockfeed, but equally in the Wimmera Southern Mallee especially after a frost, canola is cut for hay production. Some long season canola crops are dual purpose. Sheep can graze the crop

without killing it, as it re-grows, flowers and it produces seed for harvest. Canola carries with it a long genetic history from rapeseed, and has become a technologically advanced agricultural plant. As a sustainable and ethical product, it rivals palm oil. For this case study, canola is a mute yet important actor. It developed an actor network on a farm in Telangatuk East in the southern Wimmera.

This fieldwork commenced just prior to full flowering. For a non-agricultural person, this is late September or October, because flowering canola dictates farmers' actions. The hybrid Roundup Ready™ Speciality Oil Frontrunner® F6789RR* (GM) canola was sown in a 30 hectare paddock. A grain buyer, Jack* had organised a local canola-specific field day and he called his farming client to look at a few Frontrunner® varieties in the Wimmera. Tony, the owner and the grower of the canola crop, accepted Jack's invitation. During this phone call he told Jack how much growing season rainfall he had received, and offered his thoughts on how his Frontrunner®* crops looked.

Tony was a Frontrunner® grower. This research requires tracing the seed to find out how it came to be grown on his farm, its social life during the growing season, and it concludes at the processor. This case study explores Tony's shared goals with a multi-national corporation called Intercont©, and what was required of Tony as a farmer, through his machinery, products, lease, labour, weather and sequence of operations, to be part of this complex. The theoretical discussion in chapter four provides more detail, but these results are necessary to elucidate the data.

This case study is presented in three chronological events, using the sub-headings of before sowing, growing season and harvest.

Before sowing

This first section of the case study pre-empts the cropping season which lies ahead. The greatest challenge is that the translation model requires a value of time which collides with the concept of continuous cropping. This research could be back-dated to when Tony's grandparents moved to this farming district from the Mallee in the 1950's, or even when Tony and his father, Trevor, sold all of their sheep in the late 1990s to transition to a continuous cropping enterprise. Instead, this section explores the sequences that went into planning for this crop for the timeframe. This case study begins at the start of the calendar year with a mention of the machinery and equipment that was already available, and how controlled traffic farming practices comes into the narrative in this farm business.

The landowner

The paddock under investigation was leased by Tony. The landowner, Fred, was a single retired farmer who remained living on the property. Tony direct deposited the lease payments to Fred every six months to farm approximately 400 ha of arable land. Prior to this year Tony was share-farming approximately 250 ha of Fred's property. The paddock was heavily grazed by

Fred's sheep after each harvest, resulting in soil compaction and Shepherd's Purse and Wild Radish weeds. Leasing had given Tony more control over his paddock management. Tony had permission to use Fred's hay shed and silos in his machinery yard.

Canola margins

Due to the presence of weeds, a canola crop was best suited for agronomic management. Tony did not retain canola seed because he preferred the vigour that hybrid seed offered. Hybrid seed cannot be farmer-retained to plant a subsequent crop. Hybrid canola is a financially unattractive crop for many farmers because retained seed reduces their input costs at sowing time in the following year.

For the non-agricultural reader, in the Wimmera Southern Mallee canola is planted at between 1.5 to 2.5 kilograms of seed per hectare. Retained open pollinated canola seed cost around $6/kg whereas non-genetically modified Clearfield specialty hybrid is about $27/kg and the cost of the hybrid Roundup Ready™ variety canola is $28/kg plus $10/kg as a technical fee to Monsanto. This seems significantly different but the cost of growing a retained open pollinated canola can be higher because of the additional herbicide and fungicide applications. Genetically modified (GM) canola growing costs ranged from $320 to $400 per hectare before windrowing or harvest.

The cost of canola seed was not an important actor for Tony because the agronomic benefits that a break-crop like canola would provide outweighed his alternative option of battling the weed problem in a cereal crop.

Crop variety knowledge

In February 2017 Tony found that the canola seed company, Discoverer©* had sold all of their canola stock. He turned to the 2016 Victorian Winter Crop Summary to find an alternative seed supply knowing that this was a reliable resource to find another variety and a source of supply. Agriculture Victoria use the National Variety Trial results, with funding from the Grains Research Development Corporation (GRDC), to annually publish information about every crop variety. This publication led Tony to the Clearfield Specialty Hybrid (see table 2) because this particular variety had the traits that he was looking for.

Table 2. Clearfield specialty hybrid canola details from the 2016 Victorian Winter Crop Summary

CLEARFIELD SPECIALTY HYBRID
NEW Frontrunner® Specialty Oil - Frontrunner® 1234CL
Late maturing specialty hybrid. High yield potential and oil content. Blackleg rating R-MR.
Released 2017. Bred by Intercont©. Marketed by GBA Ltd under contract.

Tony contacted GBA Ltd to find that they had seed stock available. Jack, a grain buyer for GBA Ltd, told Tony about the incentives that Intercont© was offering to grow their canola varieties (refer to table 3). The incentives, specifically the ability to pay for seed after harvest,

aligned with Tony's goals of cash flow management. He ordered the seed required to sow three paddocks to the Clearfield specialty oil variety. This commenced the business relationship between Jack from GBA Ltd, the parent-company Intercont©, and Tony.

Table 3. Incentives to enrol growers into the Frontrunner® program

	Non-GM Frontrunner® program	**Roundup Ready™ Frontrunner® program**
Tonnage premium	$15/t above market price	$60/t above market price
True Flex traits	N/a	For release in 2019
Pod shattering traits	Being included in the global research for speciality genes for all hybrids	
Sclerotinea tolerance		
Black Leg resistance	No canola is resistant yet. Frontrunner® is included in the national rating system and updated data is available.	
Seed payment plan	Seed cost can be held by GBA until after harvest to help growers manage cash flow	
Contract agreement	Finite number of contracts with growers. The oil production is capped so there are no oversubscriptions.	
Unused seed	Return seed, no cost	Return seed, no cost
Grain delivery options	Unable to deliver to normal installation	Unable to deliver to normal (GM) installation
	Non-GM days allocated for crush at Footscray (400 – 500 t per day)	GM days allocated for crush at Footscray (400 – 500 t per day)
Grain storage	Grower is paid $4/t per month to store canola on farm until delivery	
Crop insurance	Growers can claim up to $250/ha if the crop does not emerge	
Payment terms	Direct deposit of payment 14 days from the end of the week that the grower delivered canola to the crushing plant or to any other designated grain receiving installation site.	

Machinery and technology

Tony owned all of the machinery and technology that enabled him to sow his crop. Tony bought a combine harvester, referred to as a header in Australia, during the fieldwork. Farm machinery brings with it relations from past business deals, services and mechanical repairs. Machinery also carries insurance and registration, which continues to enrol actors each year, even if it isn't used that often. Many farmers have a connection with their machinery that is more than just financial. This list of machinery (see table 4. below) shows machinery makes,

years, specifications, technology and the controlled traffic farming (CTF) configuration. Table 4 shows the non-human actors that Tony enrolled to sow the canola crop on his farm.

Table 4. Summary of machinery and technology aligned to plant, manage and harvest the canola crop

Machine	Model (year of make)	Specifications	Technology	CTF configuration
Tractor	JD335R 8R Series (2013)	335 horsepower	Greenstar GS3 GPS: Monitor, implement steering, autosteer 2cm accuracy, rate controller, hard drive for data collection, JD Link, 3G modem for data transfer for technician problem solving remote access.	Cotton reel kit added in 2017 for 3m wheel width
Tractor	JD8100 (1996)	200 horsepower	No internet access; implement controllers in cabin only	Axle extension kit in 2002 for 3m wheel width
Air Seeder	JD1890 (2015)	9 meter, 12 row units, disc opener	Greenstar GS3	27 metre
Commodity cart	JD1910 (2015)	2 x bin (150 bu; 200 bu) Trailing	4 x cart cameras and monitor	Factory standard 3m
Boom-sprayer	Goldacres (2005)	5000 litres Trailing	Raven 450 SCS spray controller	27m boom 3m wheel width
Spreader	Vicon (2017)	4 tonne, linkage	Greenstar GS3	27m spread with a vein kit to spread 36m
Header	JD STS690 (2015)	Self-propelled Class 9 harvester on tracks	Greenstar GS3 Weigh cells for accurate yield calibration	12m front 3m wheel width
Truck	Ford Thames (1962)	Medium rigid, tip truck 5.5t Gross Carrying Mass (GCM)	None	N/a

Host trial site

Discoverer©* is a seed production company. They compete with Intercont© and other seed companies. Each year they trial hybridized canola under different geographical conditions on private farm land. As a former host, Tony agreed to another year of trials on his farm. A one

hectare research trial site of randomised plot design featuring different varieties of hybridized canola was located in the same paddock as the Frontrunner® canola crop.

Tony did not want to create a new set of headlands around the trials, so he discussed this contention and he asked that the trial plots be configured for a controlled traffic farming system. The plots were specifically designed to fit 3m wheel tracks for continuous spraying and spreading in the crop surrounding the site. Figure 3 shows the wheel tracks through the plots, and the headlands at the top left of the images near the road.

Figure 3. An aerial photograph of the host trial site demonstrating the CTF layout.

Controlled traffic farming

Controlled traffic farming (CTF) as a system on the farm, has a much longer history on the farm than the crop of canola under the study. About twenty years ago Tony commenced implementing controlled traffic farming, when he was farming with his father, Trevor, and younger brother, Jimmy. Tony identified that compacted soils were limiting their crop production. After a bus tour with a grower group to outback NSW to meet a CTF farmer, together with expert knowledge from the soil scientists from the University of Queensland, Tony gradually introduced CTF to his family farm business. The process started by moving the tractors' axels out to 3m spaces and matching the width of the seeder to the width of the combine harvester's front. He removed fences and some paddock trees for easier traffic-ability and to reduce the interference with the GPS signal.

At the same time CTF science and farmer-case studies were being regularly published for a farming audience. The scientists spoke on behalf of mute actors such as residue, soil microorganisms, plant roots, rainfall infiltration and soil air pockets. The CTF farmers spoke on behalf of their costs, machinery, quicker returns to the field after rainfall, and crop health. While modifying his farm and his farming network, Tony had access to new CTF knowledge, some

basic farm soil data, a record of their annual yields, and a membership to a grower group. The detour for this farmer to change his cropping practices was his drive for change. By enrolling a number of agents from the farm services sector who too shared his goals, the fields were transitioned to CTF so that machinery could only drive up and back on the same invisible lines across the fields, indefinitely. Controlled traffic farming is used in the theme, specific to the notion of agency, in the theoretical discussion.

The agronomist

An agronomist was brought into the farm business at the beginning of the year for decision-making support. The purpose of an agronomist is to provide industry validated recommendations on herbicide, insecticide and fungicide applications for plant health to maximise profit for the farmer.

A local branch of a multi-national corporation, Greenlands* offered agronomic consulting on a fee for service basis. The company was managed by a branch manager who receives a wage from Greenlands plus a percentage of profit from chemical sales. The branch manager also owned a consulting business, CropCo* and employed other agronomists. Tony paid Greenlands $4/ha plus GST per year for the agronomist's services, but he was not committed to purchasing the agricultural inputs that they retailed.

Pre-sowing operations

Farmers make decisions about what they grow or how they use their paddocks each year. This list of operations for the 30ha paddock summarises the farm labour and the machinery that was required before the crop was sown. The paddock operations for the Frontrunner® commenced when Fred moved his sheep from the paddock (refer to table 5).

Table 5. Summary of pre-sowing paddock operations using machinery, technology and labour

Date	**Paddock operation**	**Machinery & Technology**	**Labour, product source and human interaction**
1 April	Removal of landowner's sheep	Utility vehicle (farm ute)	Tony talked to Fred Fred moved sheep
5 April	Raked bean stubble into windrows	JD8100 tractor V-Rake	Raked by Leo V-Rake hired from a local farmer
7 April	Firebreak ploughed around paddock	JD8100 tractor Trailing off-set disc plough (3 metre)	Leo
7 April	Applied for permit to burn paddock	Downloaded form on PC Emailed to Horsham Rural City Council	Tony
9 April	Burned stubble	3 x farm utes (2 fire units on trays) Firelighter	Tony, Leo & Trevor
12 April	Ploughed paddock	JD8335R tractor Grizzly discs (6 metre)	Trevor and Leo Discs hired from local farmer
13 April	Grader-boarding (2 passes over paddock)	JD8335R tractor KB grader-board	Leo
29 April	Herbicide and insecticide spray (pre-emergent)	JD8100 tractor	Tony Product supplied by Greenlands

Growing season

This second section of the case study explores the sequences of operations specific to growing the crop. It summarizes the social life of the canola from when it was planted to pre-harvesting operations to examine how farmers' relations may change throughout a cropping season.

Weather Station

Each day during the fieldwork Tony used the internet from his mobile phone to check the recorded weather observations by the Bureau of Meteorology for the Kanagulk Station (Site No. 079097). Tony measured rainfall in his gauge for a local comparison to the station. He stored the data on AgWorld software and the iPaddock Yield app on an iPad. These rainfall records in millimetres are shown in Table 6.

At the time of this research the Wimmera and Southern Mallee region was not declared drought-affected but it was experiencing a year of below-average rainfall. The monthly rainfall and temperatures below zero at flowering and pod filling time both influence crop yield.

Table 6. Recorded monthly rainfall totals, the mean high and low temperatures, and monthly high and low temperatures

	Rainfall (mm) from farmer's gauge	Mean low temp °C	Mean high temp °C	Lowest temp °C	Highest temp °C
April	14	8.9	24.3	2.8	38.4
May	70	7.7	16.1	0.8	24.7
June	49.5	3.0	13.4	-1.7	16.8
July	71.5	3.8	13.3	-3.5	17.9
August	76	4.2	13.9	-1.1	18.1
September	13	3.7	16	-1.3	25
October	24	7.3	20.5	0.3	27.4
November	30.2	8.5	22.5	1.3	34.3
December	47.5	12.1	28.7	5.9	41

(Source: Bureau of Meteorology website, monthly climate summaries)

Growing season operations

The interaction of farmers with their machinery and technology sheds light the structure and dynamics of farms. In the WSM the sowing window opens around the 10th of April and closes at the end of June. This means that farmers have a discrete period to sow their crops to effectively manage the varietal maturity of each crop type to avoid frost, maximise flowering times and allow them to dry-down for harvest later in the year. During the sowing window farmers can be in their tractors for long hours each day, week after week, depending on the size of their farm and the number of staff they employ. Tony planted the Frontrunner® on the 28th of April 2018 (see table 7).

Table 7. Summary of machinery, technology and labour for the growing season

Date	Paddock operation	Machinery & Technology	Labour, product source and human interaction
28 April	Sowing	JD8335R tractor JD1819 disc drill, trailing JD1910 commodity cart	Farmer started, Farmer's worker took over, Farmer finished paddock. Seed supplied by Intercont© Fertilizer bought from Wisdom*
15 May	Post emergent herbicide spray	JD8100 tractor Goldacres trailing boom-sprayer	Tony
25 May	Liquid fertilizer application	JD8100 tractor Goldacres trailing boom-sprayer	Tony Product supplied by Wisdom
26 June	Second post emergent herbicide spray Trace element application	JD8100 tractor Goldacres trailing boom-sprayer	Tony Product supplied by Wisdom
May - July	Cockatoo deterring and eradication	Utility vehicle Shot gun and ammunition	Trevor
28 June	Liquid fertilizer application	JD8100 tractor Goldacres trailing boom-sprayer	Tony Product supplied by Wisdom
14 Aug	Fungicide and trace elements spray	JD8100 tractor Goldacres trailing boom-sprayer	Tony Product supplied by Greenlands
18 Aug	Satellite imagery (NDVI)	Satellite, Precision Agriculture* software program to combine new and old data sets	Greenlands Precision Farm* (the Agronomist and PA representative)
22 Aug	Provision of variable rate prescription (map) for fertilizer	Precision Farm* software program	Agronomist
25 Aug	Spread granular fertilizer	JD8335R tractor Vicon 3.5t linkage spreader	Tony Product supplied by Wisdom
3 Oct	Fence line herbicide spraying	Toyota Landcruiser Ute Pump, tank and fence line boom	Trevor Product supplied by Wisdom

Canola field day

This canola field day specialised in securing seed origination for Intercont©, the multi-national agri-food corporation. Jack, the grain buyer, and his team communicated the benefits of

becoming part of their closed-loop canola growing group. Jack had three other members from the canola team: a plant breeder, a consulting agronomist and a seed marketing specialist. They each spoke on behalf of the Frontrunner® program and the flowering crops during the day.

Figure 4. Photograph of a field of canola at St Helen's Plains, taken during the canola variety field day.

Jack wore a GBA Ltd logo on his polo-shirt, representing a company that holds a long history of grain trading. GBA Ltd was acquired by Intercont© to increase its global investment and involvement in Australian agriculture and food services. Intercont© invests in plant breeding technology to achieve a high-grade canola oil (see Appendix E for specifications on high oleic canola). As a company Intercont© aims to be a corporate leader by providing an alternative to palm oil for the fast-food sector in Australia.

The field day connected the grain buyer with growers, promoting Frontrunner® to be part of farmers' their crop rotation. The company needed farmers to grow Frontrunner® to meet the contracts with their food industry clients. To achieve this they offered farmers multiple incentives to join the program (refer back to table 3 for incentive details). The field day consisted of crop inspections and paddock-based discussion (see figure 4). They were clear on their message, that Frontrunner® was available in two traits; a genetically modified (GM) seed featuring the Roundup Ready™ gene, or a non-G.M Clearfield variety of canola.

One prospective grower voiced their scepticism about the program because of GBA Ltd's incentives. Their concern was that if incentives were required, the crop obviously doesn't yield as well as other open pollinated or non-hybridized varieties. Other concerns from prospective growers included the ethics of GM crops, delivery logistics, oil percentage and payments for premiums, and chemical resistance. The canola team validated these concerns and used National Variety Trials (NVT) data and the domestic market demand to dissolve participants' contentions.

One Frontrunner® grower was unsure of his crop's yield potential. He was concerned that it would be susceptible to frost, especially during a drought-like year, but he did not want to cut the crop and bale it to make hay. The seed manager from the canola team assured the

participants that Frontrunner® is not harder to grow but identified the machinery, technology and the logistics management that was needed from a grower.

The plant breeder from the team connected the crop to the product. Her narrative included the food service industry's perspective of healthier options and the ethical movement to avoid palm oil (refer to Appendix E). We were told that Frontrunner® is used to bake Arnott's Shapes which is a common snack biscuit consumed by Australians. Each field day participant was given a 750 ml bottle of high oleic acid canola cooking oil as a gift (refer to figure 5). This bottle of canola oil is not available for sale as the label was designed for marketing purposes to engage growers in the Frontrunner® program. The label featured a step by step guide as to how to become a commercial grower.

Figure 5. The step by step guide to growing the canola as a marketing strategy to enrol farmers.

Plant breeder's laboratory tour

The plant breeder from Intercont©, Louise*, had invited the participants at the canola field day to visit the plant breeding laboratory in Horsham. Four weeks later, upon visiting the office, the large shed was no different to the others in the industrial estate. The Intercont© sign was small in comparison with the shed size. The gravel car park ended at the concrete, marking the door to reception. There was no garden, bollards or even an edge to romanticize the purpose of the building. Upon entering I was greeted by a female administration manager, asked to sign into the office, and then given a one-minute emergency evacuation induction before going into Louise's cluttered yet furnished office.

Louise talked about what she did as a plant breeder. She explained that there could be up to 3000 variations before the canola seed is released for commercial use. Her role is to select parent plants, cross pollinate seeds and test the plants for disease resistance, seed oil specifications and agronomic suitability for a range of climates. To release a commercially viable seed it may take five years of research, including National Variety Trials and then bulking seed to achieve quantity for the market.

The tour started in a store room scattered with boxes of unused brown paper bags with labels. A seed counting machine sat on the bench. The machine was used for counting seeds into each bag in preparation for sowing plots, which was usually undertaken at the end of summer in preparation for sowing in April or May. Louise introduced me to the trial plot manager. He said that he managed six sites around Victoria and he was most pleased with the Kaniva and Cavendish sites this year.

Louise unlocked the door to a small sealed room with no natural lighting. Sitting on the bench was a square machine connected to a computer called 'The FOSS'. Louise rummaged through drawers and on her last attempt, she found a slide. This flat disc-like metal and glass container looks something like an Oreo biscuit or make-up compact. It was unlike any slide used under a typical microscope. She explained that canola is placed on the white pad and sealed, and then underneath it is numbered by hand. The number corresponds to plot data. Near Infrared analysis is used, calibrated to record linoleic and oleic acids and the oil percentage within the cellular walls of the seeds.

For Intercont© the oilseed analysis was not outsourced. Their technology, which includes the machine and algorithm software is purchased by from a company called FOSS Analytics. Louise explained that a team of three qualified and experienced employees work a 10 hour shift, followed by another team of three, so the FOSS runs for 20 hours per day. This shift work continues until all of the trial plots have been analysed. The FOSS holds slides in a stack which feed automatically through the machine every 60 to 90 seconds. After the analysis, the slides roll out of the FOSS and are caught in a tray for emptying.

In the shed, farm machinery sat idle. There was a plot sowing drill cordoned off with high-visibility tape and hazard caps. This machine was used to sow the plots. It was a seven-row combine which meant that both seed and fertilizer could be placed in the ground in the one operation, just like a farmer's drill. But this sowing drill was relatively simple and small. Rather than an air compressor it only relied on gravity to shift the seed and fertilizer from the boxes into the hoses and into the boot for planting.

Louise talked about the challenges for Intercont© and other seed breeding organisations that they share in trying to achieve the best possible planting and germination from a trial plot combine. She talked about seed bounce when they used an air seeding drill, but not enough pressure could be released before the seed reached the ground due to the short hose length. She also said the time delay from box to boot, resulting in staggered trial plots rather than precise plot design. Even though her livelihood did not exist from good cropping techniques, her career depended on best practice in cropping systems to trial her canola breeds.

Returning to her office to reconvene dialogue, Louise's personal story included a detour from veterinary science to plant science. She explained that she became a plant breeder from her love for simultaneously reading and walking which was perfectly suited for walking and scribing

as she viewed trial plots. The plant breeder demonstrated a strong commitment to her primary school-aged children and their educational needs. She expressed genuine guilt for being overseas on her son's birthday. She was panicked to be hosting his birthday party on the weekend before driving to the airport motel in the evening for an early international departure the following day. Sharing the personal expectations to care for her family highlighted the humanism behind her plant breeding expertise as well as her juggle of professionalism and the engendered structures of motherhood.

Agronomist

Returning to the canola crop, the agronomist inspected the Frontrunner® three times during the growing season. He gave recommendations on timeliness of operations and input rates. The agronomist identified aphids in the tips of the Frontrunner®, but recommended that Tony did not apply insecticide due to the predatory wasps feeding on the pests. The agronomist estimated that the crop would yield 4 tonnes per hectare, which is an above average district yield. The agronomist asked Tony whether CropCo could visit this crop on their annual crop tour for their farming clients.

Pathologist

The pathologist, Andrew, visited Discoverer©'s canola trial site throughout the growing season of the crop. His job was to monitor plant growth, reproductive phases, and inspect for insects and disease. On one of Andrew's visits, Tony, his agronomist and I met with the pathologist to request his commentary on the performance of the Frontrunner®. Andrew looked for evidence of Black Leg disease, a fungal infection which is easily spread to living plants through wind-borne spores. He searched for hyphae in the leaves as spores are found where the first leaf grows from the stem. Andrew pulled a plant from the ground, and using his secateurs, he cut the plant stem above the roots. He looked closely at the cross section of the cut. The dark patch indicated that the disease was present in the vascular system of the plant, but at very low levels. Andrew, the agronomist, and Tony collectively decided that the disease found was negligible in relation to how many weeks Tony was from harvesting the crop. The disease they found would only result in a low penalty to the overall yield potential (see figure 6).

Figure 6. The agronomist, pathologist and the farmer inspect the cross section of the canola stem and discuss the level of disease and threat to crop yield.

Finance

Just prior to harvest commencing, Tony met with his rural lender, Charles*. They toured some of the crops around the farm in Tony's car, and they talked about the potential yields for each commodity in relation to the current grain prices. These conversation between Tony and Charles were significantly different to the other conversations that Tony had had with people visiting his crop in the last months.

During this visit, Tony and Charles talked about the farm business' financial position and amount owing on the deferred merchandise account. Charles talked about interest rates and the likelihood of rate drops in relation to Tony's overdraft and the mortgage, and whether he would consider locking in a fixed rate. Charles talked about taxation avoidance through the redrawing facilities the bank offered and he asked if Tony had any ideas about potential expenditures for the farm for the next two years. Charles mostly wanted to know Tony's cash flow projection and his commitments owing.

In the paddock of Frontrunner® Tony offered agronomic training to Charles. He was honest about not knowing a lot about cropping, so he was happy to learn. Tony explained that longer heads of canola, positioned close together along the stem, was how to estimate the crop's yield potential. Tony searched for some physiological signs of frost damage. He found a couple of pods that were mis-shaped and coloured lime yellow. While he was in the paddock he pointed out the Discoverer© canola trial and he explained why he liked private research taking place on his farm. Tony talked briefly about his own fertilizer strip trials to see the variations in yield at harvest, to work out optimal application rates for growing season rainfall.

Tony advocated to Charles the benefits of participating in the Frontrunner® program, in particular the incentives to store grain on farm. Charles was supportive of his client, and encouraged him to work towards increasing farm grain storage capacity, but not for this harvest

because prices were so high there would be no benefit to do so. Charles encouraged Tony to spend money elsewhere to improve the farms' productivity.

Crop tour contention

This sub-section offers analytical scope for gender in agriculture. The research sets out to find the relations that exist through farmers as a consequence of farm labour. This section serves to demonstrate the social farming phenomena of gender in agriculture to illustrate the laws of agricultural development and how agents align to enact agricultural science. These results are discussed in length in the final theme in chapter four.

Greenlands and CropCo host professional development events for their cropping clients. The agronomist invited Tony and myself, as the researcher of the canola crop, on the day trip around the Wimmera and northern Grampians region to look at trial sites and crops. It was a bus tour with lunch and all-day alcoholic drinks. The event was planned to conclude in the evening at the Dooen hotel, just north of Horsham.

As a researcher and grain grower, I asked the agronomist when their more inclusive information day would be delivered. I pointed out in my email that the bus tour was not engaging those who needed to care for children, in particular, women because it started before the school day commenced and finished late in the day. In my email I shared the opinion that farm business decisions are generally equal between men and women. The agronomist did not reply, instead he forwarded the email to the branch manager.

The branch manager replied to me via an email. He dissented my questioning of the format for the day. He reasoned that one full day was necessary as school hours are too restrictive to deliver the content and that his growers do not want to spend multiple days off farm. The branch manager validated that all of his events are family-friendly and that he has never needed to use the term 'equal opportunity' in his invitations.

> Never once in the flyer has it or did it state that [it's] only exclusive to men and again it wasn't written "this is an equal opportunity day for men and women" as our clients are very aware of this already. All our growers know that they are more than welcome to attend our events... I would actually consider it improper if we did state that as I would see it as degrading [to] the fact that if this had to be stated and not just assumed that we consider all as equals.

The branch manager commented that obviously I did not know his business well enough to ask such a question. He validated his gender non-bias by recounting females he has employed over time.

> Last season we had a female graduate as part of our GRDC project from QLD who has stayed on and taken a position with the department as a research scientist and completing a doctorate. [She] still calls in often and catches up with us as we have still an excellent relationship. [Three] years ago we gave a young girl an opportunity

> to work with us for 6 months [as] part [of the] program we created to encourage more women into the industry, she then moved away with her boyfriend… again we catch up very often and she still thanks me for giving her the opportunity to enter the industry. [M]ore recently we have another young girl studying from Longy doing work experience with us who is wanting to become an agronomist. This season no other female got the opportunity that we had provided for up and comers to experience what the job is about …. I consider us to be leaders.

I left a message on the branch manager's mobile telephone voicemail and sent him an email requesting to discuss his email further, but no further communication was received. I made a decision to not progress tracing this association.

The written correspondence from the branch manager, who considers his business to be an industry leader, infers that women are intermediaries in his actor network. Their participation as clients or staff are predictable, inter-changeable and that they are based on a one-way relation where the branch manager does not gain from them. Women are in a position to learn from him, not the other way around. As stated, gender in agriculture is discussed in more detail as a theme in the theoretical discussion.

Agronomist resignation

Farming business relations can change. It has been awkward for Tony ever since I had emailed the agronomist about the bus tour. Shortly afterwards, and just two weeks prior to harvest commencing, the agronomist called Tony to inform him that he was taking twelve months leave. He and his girlfriend had made plans to travel to Canada. The agronomist encouraged Tony to enrol his replacement agronomist at Greenlands.

For advice as to who he should employ in the interim, Tony sought opinions from farmers from within his farmer network. Where the farmer's relations with his agronomist changed, Tony's relations with other farmers was not affected by his choice of agronomist nor the situation that the agronomist was leaving. There were moments during the growing season when the agronomist's point of view was important for the Tony's actions, however his soon to be absence in the network was not disruptive, rather more of an inconvenience, resulting in the agronomists' role being an intermediary in the network rather than a mediator.

Harvest

This final section of this case study explores the sequences that occurred to harvest the crop. It begins with Tony preparing for the following year by mitigating weed seed set in the paddock, demonstrating the ongoing continuity of operations. This final set of paddock practices demonstrates the last stages of the annual cropping cycle for this crop and it shows the different actors involved with transporting the seed from the farm to the processor (refer to table 8).

Harvesting operations

Table 8. Summary of machinery, technology and labour required during the harvesting period

Date	**Paddock operation**	**Machinery & Technology**	**Labour, product source and human interaction**
1 Dec	Crop top weed set	JD SP sprayer (hired)	Tony, Weed Master DST
4 Dec	Moisture test	Moisture meter	Tony
5 Dec	Harvest	Header JD8100 tractor Finch chaser bin Trailer for comb front Ford truck 18 m 25hp Westfield auger	Tony, Trevor & Leo
11 Dec	Trial plots harvested	Trial plot harvester Truck for carrying harvester Weigh cells Bulker bag	All machinery and staff from Discoverer. Oil content metre in harvester.
12 Dec	Loaded in carrier for delivery to crush plant	2 x Kenworth heavy combination semi-trailers (44 t GSM) 12 m 37hp Finch auger	Hendy's Transport trucks and drivers Tony

Nozzles

Tony's trailing Goldacres boom-spray was too low to clear the fully grown canola. Since dividing the equipment during their farm succession a couple of years earlier, Tony's brother, Jimmy* was allocated the self-propelled boom-sprayer. Tony hired one from another neighbour, Paul from Wonwondah, who shared the same 3:27 CTF configuration.

When Tony prepared Paul's SP sprayer he found that 5 of the 54 nozzles were different. This meant that the chemical droplets would not be uniform across the boom. Tony called Paul about this dilemma and Paul's response was that this difference in droplet size was un-noticeable. However, for Tony any difference in droplet size, and hence chemical efficacy, was not acceptable for his farm practice. It was Saturday lunchtime and Tony could not do as he had planned.

Upon business hours on Monday morning, Tony made three calls to sprayer part retailers to find if they stocked the same nozzles as a majority of nozzles that were already fitted to the boom. Matching nozzles were found in Warracknabeal. Tony's father, Trevor, drove over 200 kilometres in a round-trip to collect them. Tony fitted the replacements and commenced his spraying.

This nozzle incident brings meaning to the labour theory and the notion of agency. Similar to Friedmann's uncompleted work challenge, this nozzle interruption extended a common farm operation for three days, which was much slower than what Tony had anticipated and that

he planned for. Even weeks later into the fieldwork Tony reflected back to the time he perceived that he had lost chasing nozzles. This is also example of farmer-agency, where Tony ensured that his farm chemical applications were deemed best practice. He made contact with retailers seeking the same fittings, and then an urgent and long car drive was required to collect the parts. There was no evidence of Tony just accepting the different nozzle configuration and the actors that Paul had pre-aligned in the network.

Desiccation versus crop-topping

Canola plants need to be dry to harvest and feed into the header, otherwise they jam the feeder-house and the threshing mechanisms in the machine. Farmers can cut the crop into windrows to facilitate the plants to dry-down in swaths, or they can be desiccated as a standing crop. Desiccation is an application of herbicide to hasten the plants to cease living in a uniform manner. Roundup Ready™ crops such as Frontrunner® do not require desiccation as they are genetically modified to mature and then stop living. Tony still needed to spray the crop even though the crop was technologically advanced to overcome this practice. Tony had wanted to ensure that the paddock was weed-free below the canopy of the canola. Unlike the canola, the weeds were not programmed to die naturally, so Tony set about to crop-top the Frontrunner®. Crop-topping is the application of a low rate of herbicide over a crop to eradicate weeds so that they do not set seed nor utilise soil moisture.

On commencing crop-topping using Paul's SP sprayer, the Frontrunner® canola was touching the undercarriage (see figure 7.). The sprayer knocked the seed pods causing them to shatter. The lighter coloured seed pods indicated this pod rupture (see figure 8). Tony did one lap of the paddock and he quickly ended the operation. Even though he had sourced a tall machine, and lost three days in making an effort to ensure the nozzles were identical, his goals did not align with the nature of this tall hybrid crop.

Figure 7. The undercarriage of the self-propelled sprayer was equal height to the hybrid canola.

Figure 8. The photograph shows the white appearance of the canopy where pods shattered.

Tony was clearly frustrated that the paddock could not be crop-topped. He blamed himself for the un-timeliness of operations. This un-timeliness was a result from two outcomes, firstly hiring the machine and waiting for Paul who owned the sprayer to finish his work, and secondly the time it took to replace the five odd nozzles.

At the very same time that Tony was in the paddock with the SP sprayer, less than 500 metres away the neighbour Wayne* was baling vetch and oaten hay. They had clear sight of each other operating their machinery, yet no communication was made between them with either the

UHF radio or mobile telephone. The theory where workers become alienated from one another, even when working in close proximity, can be inferred at this point of time.

Moisture testing

Commodities that are delivered to grain processors must conform to industry standards otherwise the grower is penalised. Grain growers complete harvest declaration forms that are given to the truck driver carting the grain. These signed forms legally validate the load from the farm to the receiving end. Each receiving site has an allocated staff member to take a grain sample. The commodity that is delivered must comply with crop-type moisture specifications. Canola will not be accepted unless it is 8.0% or below in moisture, which means its water content. Grain moisture correlates with grain maturity and the humidity when it was harvested.

The Frontrunner® canola demonstrated characteristics of being ready to harvest. The pods had shattered upon impact with the self-propelled sprayer and the crop was turning light beige in colour. Rather than guessing that the crop was ripe to harvest, Tony used his own moisture meter. He filled the tray with seed and crushed the sample to determine whether the crop met the harvest specifications. The test samples averaged 8.5% so he did not commence harvest. Figure 9 shows the moisture meter and sample reading.

Figure 9. The photograph shows the canola test at 8.5% moisture.

New Delhi grain trader visit

GBA Ltd's regional grain buyer, Jack, called Tony and asked whether the head of grain trading from the New Delhi office could visit his farm. Jack was responsible for taking his international colleague on a tour of western Victorian to see harvest in action and to meet the growers who sold commodities to Intercont©. Tony welcomed his guests and soon afterwards Jack, the grain trader from India, Tony, and I, were seated at the kitchen table discussing global grain stocks, hedging, currency exchanges and prices for next year's wheat.

The grain trader was amicable and his English was fluent. He talked about the government subsidies for Indian grain growers and the less-structured market place. He said that the grain markets were like the wool sales in Australia where buyers physically touched grain samples before committing to buy the small tonnage each Indian farmer produced. He offered to meet Tony in India if he ever visited New Delhi. The grain trader found the isolation between farms in Victoria disturbing and described his fear traveling in wide open landscapes. This opportunity and privilege for Tony to meet an executive from Intercont© was a result from his participation as an enrolled grower in the Frontrunner® program.

Header calibration and remote support

Headers are self-propelled machines that are used for threshing grain and separating the stalks from the seed in the head of the plant. The grain is collected in the grain tank and augured out into the chaser bin, truck or field bin. The fronts of headers are detachable and are available in a range of widths. Depending on their purpose to either cut or strip, they take the crop and move the material into the header for thrashing. Some farmers use contractors, or may own multiple headers and header fronts, all depending on how much crop they grow each year.

Tony uploaded the A-B line paddock data into the GS3 software ready operation; the next step was to calibrate the header. This was a once-off action to ensure the width of the front and the size of the header communicated with the GPS software. Tony started the engine, and waited for the monitor to show the GS3 dashboard, but the data processing message remained for too long. Tony turned the header off, and then on again. A different message appeared on the screen.

Tony called a technical specialist from John Deere. He instructed Tony to accept remote support access on the screen. This 2015-model John Deere header was capable of enabling remote technical support. Older machines that do not have internet accessibility cannot be supported in the same way. The remote support officer ask Tony to complete a sequence of tasks starting with turning the ignition off, checking for a particular plug under the console in the cabin, turning the ignition on, and then reading aloud the software serial numbers which the specialist obviously had in front of his computer at the location from where he worked. The header screen changed indicating it was loading the settings. Tony continued with calibrating the header as per the instructions on the monitor. This problem took approximately five minutes to rectify, allowing Tony to resume the calibration.

During this connection with the remote specialist, Tony was told that his header featured experimental software. The header was no longer being used for research, but the former owner had a relationship with John Deere to test their products. The header had its own history. This was the first time Tony was informed about its past beyond knowing it previously harvested rice in the Riverina of NSW.

Direct-heading is harvesting

Harvesting standing canola is referred to as direct-heading. An alternative to direct heading canola is harvesting windrows of crop. Windrowing is the cutting of crop below the pods, and laying the plants in a swathe to dry. Tony direct headed the Frontrunner® (see figure 10) whereas his neighbour Wayne, who farmed over the road, windrowed his canola crop.

Figure 10. The photograph shows the header front harvesting the canola crop.

The canola was cut by the moving knives, and pushed onto the oscillating belts by the reel, to be fed into the feeder house which was just below the cabin of the header. The header fed the material through the machine to thrash the canola from the pods, separating it from the stalks and then internally augered the grain into the tank. The white weight cells in the grain tank that assist in measuring the yield per hectare in real time, can be seen in figure 11.

Figure 11. A photograph of the grain tank filling with canola, taken from the header cabin through the rear window.

In total, 85 tonnes of genetically modified high oleic acid canola was harvested from the 30 hectares, resulting in a 2.83 t/ha average. This was less than the agronomist's prediction of 4 tonnes per hectare.

Storage and transport

Field bins were not used because the silos on Fred's farm were close by to this paddock. The Frontrunner® was augured from the header into the chaser bin and the farm truck alternatively. Figure 12 shows an aerial photograph of the header waiting to be unloaded. Upon finishing the paddock the machinery was moved to another paddock of Frontrunner®.

Figure 12. The aerial photograph shows the full tank of canola seed in the header waiting to be unloaded.

Trial plot

The trial plots by Discoverer© averaged a yield of 2.5t/ha (see harvesting with a trial plot harvester in figure 13). Tony's crop yield averaged higher than the trials. He was given the seed from these plots which he combined with 8 tonnes of GM seed left undelivered from last year's harvest. This small load of GM oilseed was delivered to the grain receiving site at Dimboola that accepted GM canola.

Figure 13. The trial site was harvested after the Frontrunner® crop.

Canola crush delivery

While harvesting the Frontrunner® Tony communicated regularly with the logistics manager at Intercont©. The logistics manager scheduled unloading times for the GM canola at the crush plant in Footscray. Within one week from starting harvest six loads, equating to 236 tonnes, was carted from the farm by a haulage company which was contracted by GBA Ltd. The Frontrunner® from the 30 ha on Schofields Road left Telangatuk East by truck. Each of the truck drivers took possession of two forms completed by Tony; the Frontrunner® F6789RR (GM) Canola Declaration for Growers Deliveries, and the Canola Loading Docket and Declaration.

Tony received a text message from one of the truck drivers. The message was a photo of the grain specifications from the sampling station at the crush plant. The person at the testing stand printed the sample data and stapled to the Canola Loading Docket and Declaration form, allowing time for the truck driver to take a photograph of the details to send to Tony just before tipping the load into the designated hopper.

The canola tested 45.2% oil and 5.2% moisture, reaffirming the Tony's trust in the header's moisture meter. The test also showed 1.4% admixture, which is the count of foreign material such as pods, gumnuts and leaves remaining post-threshing. These are non-human actors in the relations through which Tony connects to his product and the landscape where he worked.

Case No.2 The power of machines and technology

This is a story of two farmers who grow grain. Tony and Wayne are farming neighbours who reside in a small rural farming district called Telangatuk East. They are aged in their mid-40s and were once class mates at the local primary and secondary schools prior to their senior schooling years. They are both volunteer members of the district Country Fire Authority (CFA) and occasionally have a hit of tennis in the local social tennis competition.

Tony went to boarding school in Hamilton before he commenced a farm apprenticeship in the Mallee in the mid 1990's. It was on this 2400 hectare farm where he first experienced low rainfall continuous dryland cropping. After three years he continued his education with a diploma in agriculture, and then he worked extensively in southern Queensland and the Riverina region of NSW laser-levelling undeveloped zones for irrigation development. Wayne completed his secondary education at the state high school in Horsham before he commenced a farm apprenticeship in the western district. Wayne worked on a much smaller, intensive mixed enterprise farm, focussing on sheep production, pastures and high rainfall opportunity cropping.

Both Tony and Wayne returned to Telangatuk East around the same time to farm full time with their parents, but they needed to supplement their farming income with some off-farm work. Over time Tony has undertaken contract windrowing and harvesting, owned a precision-planter and grader board machinery hire business, and managed a consultancy project for a multi-national Malaysian corporation for the re-development of economic land concessions in Cambodia. Wayne continues to operate a canola windrowing contracting business. Both of these farmers have married. They each have two children; all of whom attend the local community school.

Tony continuously crops 1350 hectares, leasing land from another neighbour, Fred, and his parents, Trevor and Sybil*, as part of the farm succession plan. Tony has implemented a full controlled traffic farming (CTF) system. Tony has a farm worker called Leo who helps him at sowing and harvest times. Wayne crops 630 hectares and has over 2000 cross-bred sheep on 450 hectares. He owns half of the land, and all of the machinery, with a profit-sharing arrangement with his parents as part of their farm succession. Wayne does not practice CTF as he runs sheep as part of his mixed farming enterprise, but he is interested in the system. The fieldwork in this study compares these neighbours by tracing their actions.

Structured as four observations, this research shows what farmers do and interactive with, at harvest time. The first three observations took place on Tony's farm and they involved multiple actors. The fourth observation took place on Wayne's farm. The thesis is that farmers' can control their production through relations. Tony's story includes his farm worker Leo and a header demonstration. Observing how these farmers utilise and relate to their software and auto-machination during harvest offers a substantial analytical platform for this research.

Observation 1. Tony's John Deere and GS3

Even though Tony had experienced about 25 harvests in his career, this was his second harvest after farm succession, and his first harvest using his recently purchased 2015 model John Deere S690 header. Headers are the Australian term for combine harvesters. As mentioned, they are self-propelled machines that remove the seed heads from the crop, separating the grain from the plant material. With John Deere finance Tony bought the machine and a new front, with no-trade, for about $380,000.

The morning was exceptionally hot with a forecasted temperature of 40°C with strong wind gusts. The day was declared a Total Fire Ban from the Country Fire Authority (CFA). This meant that Tony had only a few hours to harvest before ceasing all paddock operations. He had harvested a portion of the 125 hectare paddock of canola, finishing at 1 am that morning as the humidity was too high and the crop had become too chewy to thresh.

Before he resumed harvest, he checked his mobile phone. He had sent a text message to Sam, a farmer from Streatham, who was proficient at operating John Deere headers. Tony had asked him about the best set up for maximum rotor capacity because they both owned and operated this model of machinery. Tony had not asked his neighbours for advice rather he actively pursued relations with Sam, who lived well beyond his farming district, for his machinery expertise.

As Tony taxied the header along the harvested stubble stalks on the headlands, his GPS software was failing to find a satellite signal. The monitor was showing red coloured text indicating that GLONASS satellites were found but a connection had not been made. Tony commented 'bloody slow this morning'. He had just started to look at his recent Twitter feed, when two beeps were heard and the GPS was active; the screen changed to field mode.

Shifting his attention to the crop, he aligned the knife and reel of the header front with the standing plants. He then looked to the screen, checking the A-B line and using the touch screen, he closed the concave to reduce the threshing clearance. He returned his focus to outside the cabin and moved the comb up and then back down to ensure that it was level. Tony sat still for a few moments, stating that he was allowing the hydraulic and engine oils to warm up a little more, pointing to an oil temperature gauge so that I, as the researcher, understood his delay. He set the air conditioning to climate control and adjusted one of the six fans in the ceiling. Using his mobile phone for internet access, he checked the daily grain prices.

As he harvested he pointed to the GS3 screen showing the numerical data displaying the current yield, average paddock yield, total weight off field, number of hectares harvested in field, litres of fuel used in field, moisture percentage of crop, hours of harvesting in field, average tonnes per hectare and number of hectares per hour harvested. The load cells in the grain bin calculated yield in real time. He switched the screen to the performance monitor, to show me the real time fuel usage, litres of fuel per hour and the ground speed.

Harvesting through a spoon drain the load sensors on the header front wheels automatically detected the undulation, controlling the hydraulic rams which resulted in the front lifting and lowering in parallel with the ground surface. The crop continued to be cut at the same height regardless of the different contours. There was minimal sway in the machine as the grain tank filled with black canola seed.

Tony's farm worker, Leo* drove the JD335R tractor towing the Finch 22 tonne chaser bin alongside the moving header. Tony pushed a button to extend the auger over the chaser bin and switched it into gear to move the harvested oilseed out of the grain tank. Neither Tony nor Leo communicated on the UHF radio or even bothered with hand signals between the cabins. Their movements were rehearsed. A few minutes later Tony called Leo on the UHF to inform him that it was time to end their harvesting for the day because of the increasing wind speed and subsequent fire risk.

Tony finished harvesting the 111 ha paddock in the day after the Total Fire Ban. I was given a copy of the yield map (see figure 14) from My John Deere. The paddock averaged 2.83 t/ha which is an above average district yield. Tony was satisfied with how much grain he harvested from the paddock. He was concerned that the frost damage would have penalised his yield. He knew the destination for this crop when he ordered the seed 10 months earlier. This canola was a non-GM Frontrunner®* variety; contracted for delivery to the Intercont© crush plant in Footscray for the market price per tonne, plus $15/tonne premium, plus oil percentage bonus.

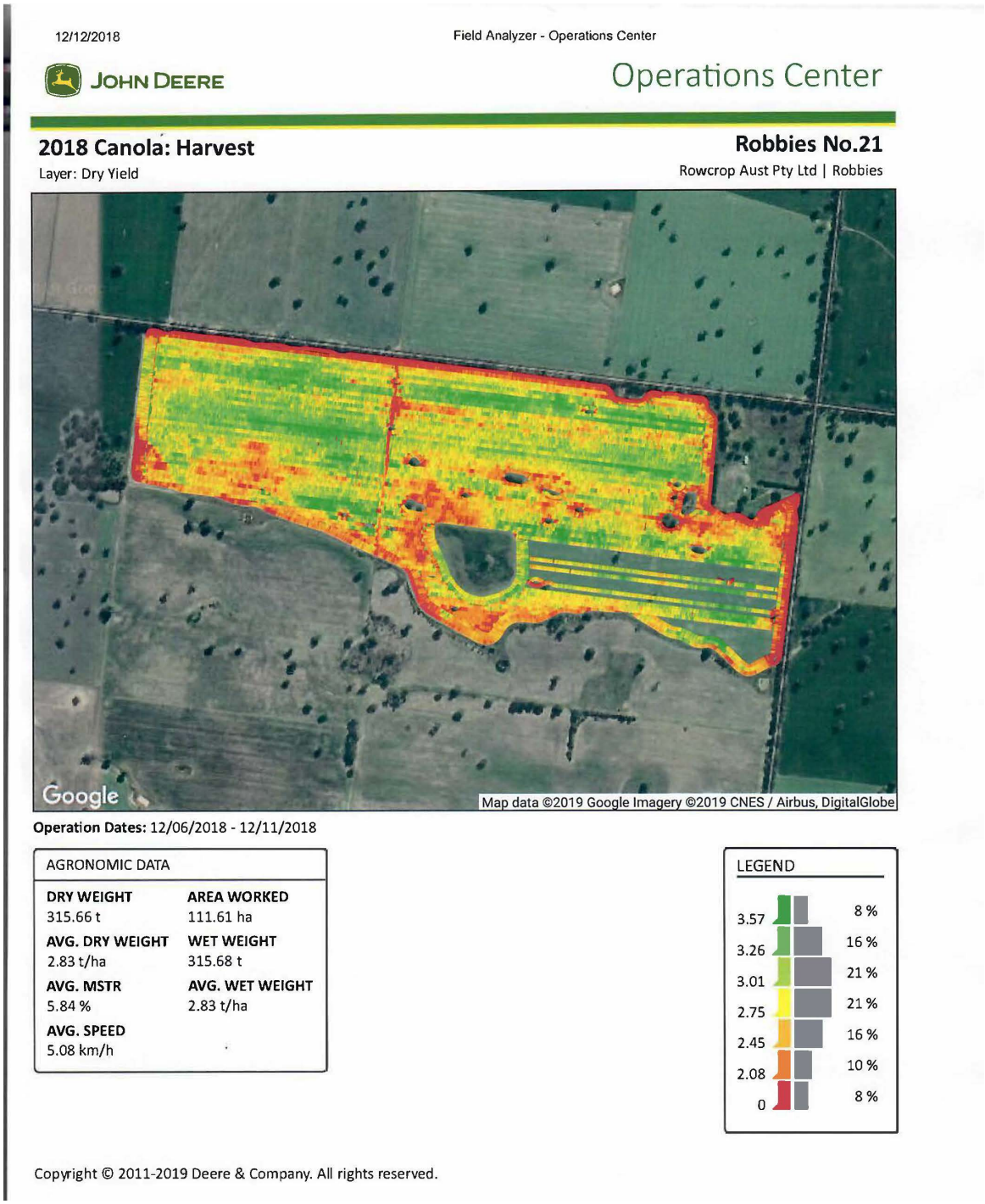


Figure 14. The yield map from the My John Deere program for the 111ha paddock of canola.

Observation 2. John Deere S790 and Gen4 header demonstration at Tony's farm

The relationship between Tony and Walkers* Machinery had lasted long enough to see their header demonstration on Tony's farm as a network relational effect. This sale strategy took place during harvest, a time when all grain growers are exceptionally busy with their labouring and commodity marketing activities. This narrative helps to conceptualize the agricultural political economy. It aims to demonstrate the various roles in the private farm machinery sector, together with the showcased technological advancements, including inter-operability, ITC, and

increased machinery capacities, planned at a time when Tony could personally experience the benefits of the improved automated techniques that the new header had to offer. This narrative also validates farmers' ideological preference for machinery models as the dealership hedged the likelihood that Tony would buy a header from them the next time he chooses to trade his machine.

Walkers Machinery is the John Deere dealership from Horsham which sells new and second hand machinery, parts, and repairs and services machines. The sales manager asked Tony whether Walkers could bring the latest model of header to his farm for a demonstration. Tony asked about the wheel spacing, verifying whether the machine fitted his 3m CTF system. Informed that it did meet his system, he agreed to the proposition.

A few days later, a header front and the header were transported to Telangatuk East. The header was a new John Deere S790; a Class 9 header with the largest engine capacity available on the market at the time. The field service specialist, Scott, prepared the machine for operation by taking a few hours to check the header in its entirety before its virgin harvest.

Together Walkers' header and Tony's header harvested one paddock of canola. The two machines were synced to the My John Deere program, each sharing the screen which showed the colour-coded harvested and unharvested crop. The junior field specialist and the sales manager operated Tony's header, leaving Tony to drive the new demonstration header with Scott the John Deere senior field service specialist. In this time Tony was able to learn about the new updates available for his header, and the new technical features and the productivity benefits that the new model had to offer. Tony and Scott harvested approximately 10 ha of crop.

The photograph in figure 15 shows four of the seven people present at the time of the header demonstration. From the left in the image, Scott and the sales manager from Walkers are together, with Leo the farm worker, and Tony. The farmer's father, Trevor, had taken a truck of canola to the silo and the junior field service specialist was checking the header and was unavailable. As the researcher, I took this photograph.

Figure 15. A photograph from the header demonstration (L-R) with Scott, the senior field service specialist, the sales manager, Leo, and Tony.

Scott welcomed me as a researcher to experience what he referred to as John Deere's harvesting masterpiece, just as he had shown Tony. The header cabin was somewhat similar to the other header, with a few differences in the joystick configuration, foot rest and monitor placement. Scott highlighted the specific features that differed to Tony's header. The Interactive Combine Adjustment application (ICA2) showed how the threshing concaves could be remotely adjusted from outside the header. Scott gave me his phone and opened the app, which he touched to adjust the concave opening from 26 mm to 27 mm. The monitor in the screen informed him that that adjustments had been made by remote access. He accepted the change, but then reduced the concave back to 26 mm on the monitor screen.

Scott then changed the monitor to the live-feed camera called ActiveVision. The screen showed grains of canola, a couple of discoloured seeds, and a small piece of pod in 2D form. He explained that there were three cameras strategically placed in the header; one in the grain elevator to highlight foreign material passing through, another in the tailings and one the shoe, which is the last point in the machine in the top sieve which proceeds the tailings return. All of these cameras were positioned to help the operator to maximise the grain quality on the go, and to make informed decisions when making adjustments to the concave settings.

The screen was changed again showing the history of the machine for the last 30 minutes. The information presented the adjustments made, manually and automatically, detecting crop variations and undulation. The JDLink™ Connect was explained as an automatic file sharing conduit from the machine to the John Deere Operations Centre in Brazil. I was told that the header had a modem to transfer data, but looking around the cabin, there didn't seem anything recognisable as such a thing. JDLink™ allows information sharing with farm advisors and the machinery dealership for repairs and IT troubleshooting.

Scott explained that the Machine-Sync program allowed the header to control the speed of the tractor pulling the chaser bin, to maintain equal machinery ground speeds while using auto-steering guidance. He also pointed to the camera on the auger that helped the operator to see how much grain is in the chaser bin or field bin when unloading. The purpose of this technological upgrade was to overcome machinery collisions and grain spills by eliminating human error. Auto-machination and technologies were designed to replace human intervention.

There were stipulations of which technology worked with which models. This meant that there were not many upgrades available for Tony's current S690 model header that were featured in the new 700 series of combines. Tony would need to buy a new 700 series header for Machine-Sync and ActiveVision. The Gen4 technology had surpassed GS3 Precision Agriculture (PA). However, there was still no technology to sense obstacles, such as trees, or heat detection to prevent roaming bird and small animal fatalities. The field specialist said that he had never been asked about animal deaths through headers before meeting with me.

Scott casually talked about how John Deere owns shares in the agronomic chemical company Syngenta, but he said that to his knowledge John Deere has no intention of providing agronomic support despite being in a position to understand yields and inputs through JDLink™. He was very aware of the ethical considerations for John Deere, and he knew of farmers who had chosen alternative machines to avoid their sensitive data being captured. The field specialist said that the information collected is used to invest into machine performance for increased market share.

The 26 hectare paddock was harvested, and averaged just over 2.6 t/ha (shown in the yield map in figure 16). The data collected from both of the headers was automatically uploaded through the modems. The crop data was amalgamated in the Operations Centre of My John Deere to show the yield map and average speed of harvest. Walkers' demonstration was effective in showing that John Deere designed systems for multiples of machinery.

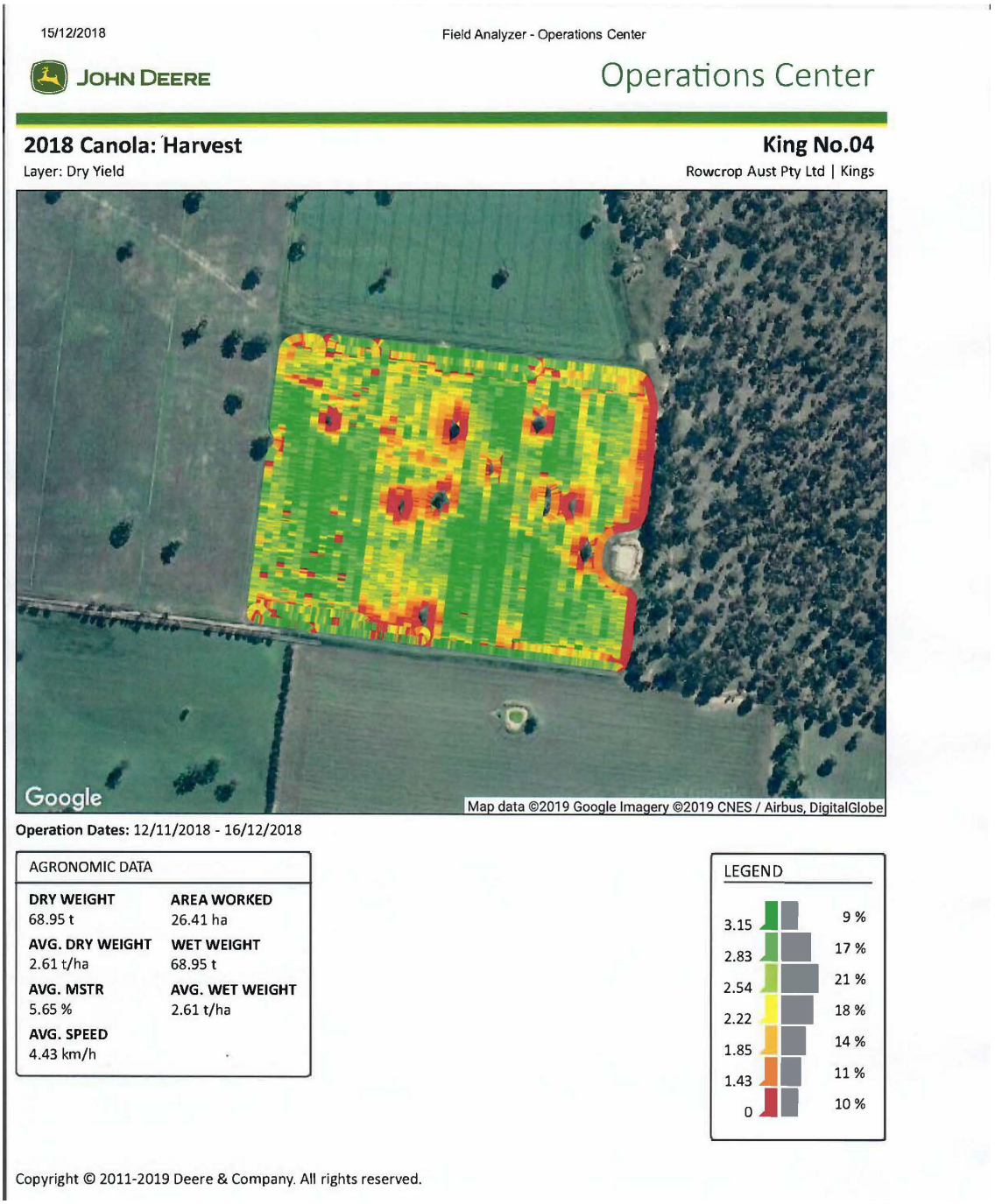


Figure 16. The yield map was produced with data from two headers.

Machinery sales for dealerships in the Wimmera and southern Mallee had been down on previous years because of the low rainfall which had limited crop yields. Tony had bought his header from an alternative dealership in northern Victoria, therefore Walkers were committed to getting this farmer's business next time. The demonstration day was intended for other farmers to visit the new machine in action, but no one else came on that day. The weather was also inclement hastening Tony to harvest as much as possible before it rained.

Observation 3. Tony's farm labourer operating the John Deere 8335R tractor and a chaser-bin

This observation provides the reader with a textual account of the operations involved in towing a chaser-bin during harvest and conforming to the instructions to follow controlled traffic farming, avoiding collisions with standing paddock vegetation and relaying the grain to the field bins in a timely manner. Headers are designed to auger grain into a chaser bin while harvesting to maximize harvest efficiency. The tractor tows the full chaser bin to a field bin or a truck.

Leo* was on chaser bin duty for Tony. He was driving the John Deere 8335R tractor with John Deere GS3 software using RTK 2cm GPS accuracy pulling the Finch 22 tonne chaser bin. This bin was limited in its technology, but remained mechanically sound and robust. It had no technology to support Leo's judgement of capacity, such as weigh cells or cameras to calculate the amount of grain it captured. It just had one window. Leo needed to use his judgment and decision-making at all times rather than rely on technology to guide his actions.

Leo was working with two class nine John Deere headers which are the biggest capacity headers available on the market. Both Tony's header and Walkers' new demonstration header were working together to harvest one paddock of Wahoo canola. It was Leo's job to keep the headers moving and empty their grain tanks for harvest efficiency.

To empty the 22 tonnes of canola in the chaser bin into a stationary field bin, Leo pressed a button that extended the hydraulic ram to engage the bi-fold auger. The auger needed to be fully extended before it was towed over the field bin's hole at the top. The position of the chaser bin auger to the field bin opening was judged by line of sight. There were no sensors to help him. In my presence as the visitor in the tractor, it took Leo more than two attempts to align the auger with the field bin opening.

The weather was transitioning from an intermediary to a mediator in the network. When it rained, harvested would end until the crops dried out to resume again. The dust behind the headers showed the inversion layer. The micro-particles of chaff were suspended in the air which further reduced Leo's visibility when the headers passed him. Even though two headers were increasing the overall speed of harvest Tony was in a hurry to get as much done as possible before it rained, and Leo was under pressure to keep the headers operating.

The role of nature was more evident from Leo's perspective. There were ten remnant Eucalyptus trees standing in the paddock. Two of the trees had recently dropped limbs (see figure 17 for a detailed photograph). Leo navigated around these fixed obstacles as well as the two headers, while abiding by the controlled traffic configured GPS guidance. Figure 18 shows a photograph which captures Leo's view of the trees and moving headers.

Figure 17. The photograph shows the fallen limb and the suspended particles in the air behind the header prior to rain.

The fallen limbs from the paddock tree interfered with the CTF system by increasing the area for Leo and the header drivers to steer around. This meant that longer times were spent overriding the guidance, as well as the increased likelihood of gumnut and leave contamination in the grain sample and loss of harvestable area where the limb fell.

Figure 18. The photograph captures two headers in operation, standing remnant trees, fallen limbs, stubble and standing canola.

The controlled traffic farming (CTF) system was in transition to a wider width. CTF is a science which minimises soil compaction for improved water infiltration and optimal plant growth, which will be discussed in more detail in the theme of agency in the discussion. The machinery is aligned as a series of widths, to create wheel tracks for every paddock pass. Harvest was the first pass for the new wider system. This meant that the headers were not driving on the established tracks from seeding and spraying passes rather they was creating new wheel tracks.

Figure 19. The photograph shows the tractor driver aligning the chaser bin with the field bins to empty the grain.

Tony had instructed Leo to remain on the new wheel tracks that the headers left behind in the stubble. Leo drove along the headlands and watched the two combines; from a distance they were hard to differentiate. The chaser bin had to be positioned on the combine driver's left side, on stubble only. Leo followed the combine, staying on the new wheel tracks before disengaging the auto-steer software. He had to steer the tractor straight, avoiding the combine on his right side, but staying close enough to collect the grain (see figure 19). He had to use his judgment of where to drive. He then set the speed on the control stick, and steered the tractor over to the combine and into a safe zone to fill the chaser-bin. Over his right-hand shoulder he watched the auger swing out from the combine. Over the bin, the auger poured grain out and the bulk commodity crept up the window. Once the header was empty, Leo moved back onto the wheel tracks. He re-set the auto-steer to guide the direction of the tractor, and he slowed down as he no longer had to keep up with the header. He taxied to the end of the row and stopped on the headland again. He sat in the cabin preparing to repeat the exercise with the other combine.

Leo wasn't abiding by the CTF system. His hand movements were discrete; he switched software off and on, and he pushed the accelerator forward for speed and pulled it back to slow down. The GPS guidance and auto-steer system were over-ridden. He merged the tractor about 1 metre towards the combine to collect the grain while in transit. Leo was utilising his own relations with machinery and guidance software by operating the tractor manually. Considering a network approach, the actors were all present however he was over-riding the agential capacity which the CTF assembled collective brought. Leo wasn't being negligent, disrespectful to Tony, nor sceptical of the CTF system – if he had remained on the CTF wheel tracks as he had been instructed to do, the grain would have fallen on the ground.

Observation 4. Wayne's Case IH 2388 header and Trimble software

This observation sets out to look at Case IH machinery and Trimble technology to identify the actors in a mixed farming enterprise during harvest. This multi-generational farming family operate a mixed farming enterprise. Their land is shared but businesses are separate between the two generations. Bert and Robina, the eldest generation own a merino sheep enterprise, and their son Wayne and his wife Janine, have cross-bred sheep, cropping machinery and grow crops. They have school-aged children who are not yet participating in farm work.

Wayne was the Telangatuk East CFA Captain. It was a hot morning and he kept looking at his mobile phone for weather updates. The following day was planned to be declared as a Total Fire Ban, but a cool change was expected to follow. He told me who was available to crew the truck in case there was a fire today or tomorrow. Wayne was going to harvest a paddock of barley located not far from his house and sheds.

At the same time Bert was patching holes in an antiquated, but well maintained, grain shed. Wayne said that Bert and his father had built the shed decades ago, and they used it every year to store cereals. Wayne wanted to store fertiliser in it rather than grain but Bert didn't agree. Bert was working independently with determined purpose, having cut a 40 cm x 40 cm corrugated iron square to glue and tech-screw over two pin holes in the iron. Bert had an angle grinder, cordless drill, screws and a tube of 'liquid nails' to repair the holes.

When the patch was finished, Bert and Wayne slotted the pine boards into the designated vertical tracks made from steel reminiscent of railway, to create a dividing wall in the shed. The work was physically challenging; lifting each board on an angle to slide into position, with the top board extending Wayne onto his tip-toe. Then thin strips of timber were wedged between the boards and the tracks to complete the fit. A mallet was used to force the bowed strip into the gap; Wayne slipped with the mallet, semi-grazing and crushing his finger. Blood streamed from the open sore, which he washed and bandaged.

In the paddock Wayne turned on his 1996 model 2188 Case IH combine harvester and allowed the engine to warm up while he walked around the machine pumping grease with a specialised gun into the nipples. He did the same to the chaser bin auger. He pulled at some of the remaining Planet barley straw left wedged in the knife along the front of the MacDon flex-front.

The crop looked thin. Soil could be seen through the stalks and tree seedlings had germinated which indicated a less than perfect crop stand and a reflection of low rainfall over the spring. There were 30 standing remnant trees in the 25ha paddock of Planet® barley. The combine front width was 9 m which allowed Wayne to move his twenty-something year old header between most of the tree trunks. Stopping the machine, he got out of the cabin and manually adjusted the concaves to make the threshing clearance smaller. Recommencing harvest he said that he 'is looking forward to a new header so I don't have to do this.' He explained that

he had recently installed a new top sieve but grain loss from the combine didn't seem to be his priority. The dial that showed grain loss never moved even after the manual modifications to the settings, which suggested it was ineffective.

I enquired further about the concave settings and how grain loss is monitored. Wayne pointed at a dial; its pendulum hand fixed to left, showing that grain loss was minimal. He referred to two hardcopy documents that he followed 'as best as possible'. Wayne said they came from a mate who had sold his Case IH and he did not need them anymore. The photograph in figure 20 shows the well-used cardboard sliding tool. The tools helped Wayne to identify the rotor speed, concave setting, and fan speed for each crop type, with a trouble shooting advice on the reverse side, to help maximise harvest efficiency.

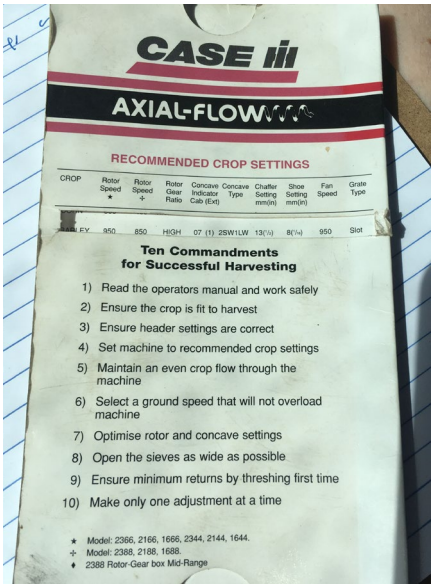


Figure 20. A photograph of the manufacturer's harvesting settings which are presented as a sliding tool for the operator.

Wayne made a comment that he wanted a clean sample for his friend, Jake*, who was coming by later to get a trailer of feed. Both Jake and Wayne were feeding barley to their sheep, but the cleanliness of the grain sample didn't seem as important to Wayne. If it wasn't for Jake he had no other interest to modify the header settings to create a cleaner sample. Wayne talked about his concerns of transitioning to larger equipment and the subsequent need to remove some of the standing vegetation in his fields. He mentioned the state legislative requirements to get a permit for native vegetation removal.

Wayne handed me his iPhone showing me his Back Paddock app that he used for spray data and records, paddock rotations and paddock plans. His farm map was outlined on topographic map that could be zoomed in and out, to open paddock details. Any data added on his phone was stored until he had access to mobile data is then it was uploaded to the cloud, giving him access to it on the PC in his home office. He said that he likes using Back Paddock. He can use the app to order chemical inputs from his farm merchandise dealer, and it enabled

him to get a discount and secure products. His agronomist had access to this data as well. This was the first time that Wayne demonstrated how he gained power in the commodity chain. Wayne's app allowed him to forward order, which gave him an economic advantage through discounted crop inputs.

In discussion about high falling numbers in wheat, a measurement of rain-sprouted grain at grain delivery sites, Wayne talked in general about his lack of risk-appetite to forward contract grain. He chatted about the role of his rural lender, perceiving his influence as very low in the decisions he made. In contrast however, he was proud that he influenced Jake and Jake's parents to change banks on principle to work with Wayne's representative for borrowing finance. Alienation between workers measures their relationship to other persons by the relationship in which they find themselves placed as a worker. Wayne and Jake have embraced their work-likeness and have a very close relationship. How they relate to each other, by trading grain and advocating rural lenders and similar interest rates, is very much a non-alienating characteristic.

Wayne owned his aged combine harvester. He wanted to buy a new second hand header in the coming year with newer technology than his current machine, but at the same time it had to be compatible with his Trimble GPS system. He explained that wanted to keep the MacDon header front in order to make the change-over cheaper because his wife was not in favour of trading their Case IH. He also disclosed how much the annual subscription to the base station costs. With no financial repayments owing on his combine and the purpose to feed the barley to sheep, Wayne had a less complex arrangement of relations. Wayne demonstrated agency by planning to buy a new combine harvester and introduce new relations into his business through finance and technology, but until this takes place his agency remains relational to how he currently operates his business.

Even though Wayne was not using a CTF system he relied on GPS guidance and auto-steering at harvest and sowing. He disengaged the auto-steering software to avoid the trees. He didn't always resume the auto-steering after by-passing the trunk; Wayne manually steered the combine around upcoming trees rather than re-engaging the software. Wayne had not paid for a subscription to unlock the Trimble software to monitor his crop yield. He had no way to map his yields despite his alliance with Trimble technology. The combination of paying for a yield monitoring subscription and the fall-back position that his grain will be fed to sheep, demonstrated a different set of actions than Tony showed, to effectively monitor his crop production.

Wayne's father, Bert drove the John Deere 8220 tractor towing the chaser-bin (refer to figure 21). This chaser-bin was an older model which had been modified resulting in an ambiguous form of grain weight measurement. To unload, Wayne used his UHF radio to call Bert. Bert drove tractor out from under the shade of a tree and lined up next to the moving combine. Wayne's auger extended over the bin and emptied the grain tank. When this was

finished Bert pulled the tractor to a hard left and returned to his place in the shade. Wayne counted how many times Bert took the chaser bin down the road to empty the barley into the grain shed. This was his method of measuring the average crop yield.

Figure 21. The photograph shows the chaser-bin extension in a contrasting colour to its factory-made size.

Wayne wasn't anti-CTF. He knew how to implement the system to gain production benefits yet with sheep as part of his farming enterprise, CTF made less sense for Wayne than for Tony. In relation to the translation model for CTF, Wayne had not changed or passed the ball on, rather he never caught it. But he is aware of the ball and that other farmers around him are playing with it. This is discussed further in Chapter four.

Bert's random paddock driving, reluctance to re-engage the auto-steering after every tree, and not unlocking the available yield monitoring technology, demonstrated that Wayne's agency was relational to humans more so than relational to non-humans for crop production.

Concluding the results

The purpose of this chapter was to bring order to farming practices and to demonstrate where technologies were found. This chapter purposefully presented all human actors, non-human actors and objects through textual sequences. The case studies purposely slowed down the pace and regulated the events. This was used to help demonstrate actor network enrolments where multiple things which were working at once, together generated an outcome.

The key findings are that both of the farmers, and the people from the farm services sector, each have individualistic intentions at the root of their role. Every human who was traced during the fieldwork was engaged with agriculture for either production profit, wages or commission payments through what they did. They were also engaged with technology which mediated these relations. During the fieldwork, no volunteering nor civic mindedness was found, except for the two farmers who were both CFA volunteers.

These results enable the examination of how technologies are used by farmers. The results facilitate sociological rationale of why farmers are different and how they achieve different crop yields. Various technologies were unearthed that will be now brought into the rigorous scientific discussion by turning to the next chapter.

CHAPTER FOUR

Theoretical discussion

This chapter presents five themes that were found during the fieldwork in the Wimmera Southern Mallee. The material has been shaped and juxtaposed to reinterpret the results by applying the sociological methodologies to fit the ontology. This chapter is non-linear, and it defies fragmentation because it breaks down the structural writing constraints of sequences, seasonality, enterprises and the division of concepts and materials to produce new interpretations.

The central argument that technology enables farmer-agency is woven through the themes. It serves to reproduce the social farming phenomena to illustrate the laws of agricultural development and how agents are held to explain the agricultural sector. An actor network approach only claims things as far as actual empirical consideration that particular cases allow (Law 2009). This analysis presents the relationships between artefacts, institutions, ideas, things and individuals that form one another in a farming complex.

In this chapter the sociology of translation, the model of diffusion and the concept of circulating reference, which are located in actor network theory are used to examine the labouring activities that famers undertake to position themselves competitively in the commodity chain in a total free market. Intermediaries and mediators are discussed to examine power as a social construct.

Theme one: Unfolding a yield map

Crop production is a scientific practice. Agricultural science and economics underpin many farmers' set of decisions. The purpose of this theme is to understand the reality of science in practice. The purpose of this theme is to deconstruct and re-construe the power of a yield map. A yield map is a product which is achieved through technologies and machination at harvest. This research addresses farmers' relations and how they exert control over their production to overcome their exploitation in the commodity chain. Yield maps, or rather the information they hold, offers farmers the ability to do this; to re-position themselves within political economy. The findings are that yield maps can be used to reproduce social farming phenomena.

The sociological question that the philosophy of science attempts to ask is "how do we place the world into words?" (Latour 1999). This theme sets out to illustrate the laws of agricultural development by understanding how agents align to enact science by calling on Latour's social re-interpretation of soil and vegetation classifications in Brazil in Pandora's Hope (1999). This is a study within the discipline of agricultural science specifically that of farm technology which is used to explain crop production.

Paddock to map

Three different models of farm machinery software were identified: GS3, Gen4Technology, and Trimble. Despite the John Deere software differing in release dates and model names, and the Trimble not being utilised at its full capacity, they remained sharing common features. The software consisted of empty forms set up behind the phenomena. This allowed the farmers to manually enter paddock names, commodity type and machinery widths. During operation, the software found satellites for GPS guidance. The John Deere headers collected yield data by using either calibrated mass flow sensors in the clean grain auger or weigh cells in the grain tank. Afterwards, this was able to be recalled and re-used from the stored paddock information. The data collected by the John Deere headers was transferred via modem to the cloud to the My John Deere application. For farmers like Wayne who use Trimble, the data could be downloaded on a USB flash drive for installation on a PC.

The GPS software relied on satellites to navigate evenly spaced swathes across the paddock at 2 cm accuracy to avoid overlapping or underlapping operations. The widths of the machines, whether it was the header front, the boom spray, the seeder or the fertilizer spreader, were actors for the software's function. It was the software that defined when paddock operations were completed, through the GPS and sensors on the implement. The monitor in the cabin colour-blocked completed zones, similar to a colouring-in picture using a wide felt tip marker. At harvest, the difference in colour between the harvested and non-harvested crop was manifest. The

random elliptic shapes represented the unharvested spaces giving freedom to remnant paddock trees and rocky outcrops; symbolic of the physical avoidance of damaging farm machinery.

A significant advantage of the header's data was the real time digital indicator of crop productivity. Paddock yields were collected and relayed to a scale depicted by transitioning colours, so that variations could be simultaneously visible. Harvest was interrupted by rain and Total Fire Bans. But regardless of how long it took to harvest a paddock the data was extracted and synced to the location. The paddock was transformed from a physical paddock of dead plants holding seed in the heads, to an abstract arrangement of coloured yield performance on a map. This was a transition; the artefact was graspable because of the relations between the software, GPS and calibrated grain flow devices in the header.

The data recorded by the software in each John Deere header took the form of a shape file. According Latour (1999 p. 49) "[i]n science studies, we are ambidextrous: we focus the reader's attention on this hybrid, this moment of substitution, the very instant when the future sign is abstracted." According to actor network theory, it is not about moving from the crop to the idea of cropping. A continuous monoculture can be abstracted as a discrete file containing coordinates and contour data to demonstrate variations in the paddock and subsequent zonal plant performance. The farmer's movement of substitution by which the real paddock of crop became data would support the ongoing farm management decisions. It was this data which directed Tony's or any other farmer using this technology, for their actions to improve drainage, soil amelioration, soil testing and crop rotations into the future.

There was however noticeable gaps between matter. By using science studies, these gaps became more visible. Not every plant was measured for grain production, but it was harvested. The stages of calibration which required human interaction and operations were rendered visible but the mechanical function that was hidden behind a chassis and safety guards. The software was installed behind a monitor with leads plugged into sockets. These black boxes were visible yet at the same time, when they worked as expected, they were invisible. The longitudinal gaps were undeniably hard to trace without the researcher being glued to the farmer for subsequent cropping seasons. Nevertheless, data maps and aerial photography could be used to help to render those movements visible even if the research was expanded to include multiple harvests. The stages were made traceable.

Map to service sector

The yield map was a transformation, a movement, a deformation, an invention and a discovery (Latour 1999). By refocusing from the paddock to the file, farmers immobilise their land. The paddock changed state from a tract of soil growing plants and physical support for the transit of machines, to a paddock that could travel through space and time without further alterations. The paddock could be shared with agronomists to discuss performance, and with the

soil testing contractor to develop a variable rate (VR) prescription for lime and gypsum. The paddock became sharable, comparable and manageable.

So the question remains, was the yield map that was generated by the software in the header abstract or concrete? It was abstract as it represented a miniscule fraction of dryland cropping land located in the Wimmera Southern Mallee that was influenced by human preference of colours and scale to represent yield zones. However, it was also concrete as it could be printed and held as a piece of paper, or emailed and shared with industry experts to seek advice on inputs. It exists and in the process it created conversation. The map was socially constructed by the labour of the software developers and the sellers who fitted the monitor to the cabin, and the farmer when he utilised the technology to map the data. The map did more than resemble. It took the place of the original situation which could be retraced through the sequence of paddock operations and inputs.

Circulating reference

Latour (1999) seeks to explain that there are no gaps between the two ontological domains – nature and language; rather there is an entirely different phenomenon that he refers to as circulating reference. In isolation the yield map would be meaningless. "It replaces without replacing anything." (Latour 1999 p. 67). The map was a transversal object, truthful only on condition that it allowed for passage between what precedes and what follows it. Latour (1999) explains this as the concept of circulating reference. The map reduced the work of the farmer. Tony's long term efforts in soil amelioration, drainage works, native vegetation removal, pest management, machinery upgrades, controlled traffic farming, time, decision-making with his father and brother, as well as his physical labour, were reduced into a standardized file with relative universality. The GPS coordinates acted a reference which is a word that comes from the Latin *referre*, to bring back. The numbers could be used repetitively to solve a problem in the paddock after being pointed to on map. The farmer's name and the paddock number gave it some identity but only meaningful to Tony and those that he associates his business with, who can identify who, where and what it means.

Yield maps shrink the paddock to the size of a page. This allows farmers to look at one map and then another, from obliviousness to certainty, from weakness to strength, from inferiority from the header cab to domination over the whole farm by the human eye. Yield maps offer power through the set of decisions it offers the farmer who knows the power it can give them.

Latour's sociological question remains, do the sciences speak of the world? The agricultural services sector will tell you that they do. But, the sciences do not speak of the world but rather construct representations that seem to push it away and also bring it closer (Latour 1999). Farmers want to know how to increase their cropping yields, or reduce their inputs, or

both concurrently to maximise profit through improved soil health and economics. This theoretical discussion is about understanding how at the same time science can be realist and constructivist, immediate and intermediary, reliable and fragile, near and far. But when farmers and advisers look at yield maps, to what does the spoken word refer (Latour 1999)?

The yield maps featured in the results chapter were printable and manageable versions of the scale of the paddock's crop productivity performance. Extra information was available about the averaged harvesting speed and wet weight of the grain. The header, GPS and software had extracted, classified and coded the yield as per the calibration by Tony and Scott the field service specialist from Walkers. The crop yield belonged to an origin of coordinates; it was removed by fast moving knives in the header front and abstracted by software. There was a movement where the grain transformed from seeds in a plant head to a reference number, plus a bulk commodity in the header grain tank which would be sold. There was an unbroken series of well-rehearsed elements, each of which played the role of a sign for the previous zone of heads of plants harvested and the zonal heads of plants in front of them.

The yield map was saturated with data which allowed algorithm patterns to emerge. According to Latour (1999) invention almost always follows the new handle offered by a new translation or transportation. The most incomprehensible thing would be for the pattern to remain incomprehensible after such rearrangement. It should be noted that reference is not simply pointing to a particular yielding zone on a map, rather it is actor network theory's way of keeping something constant through a series of transformations. "Knowledge does not reflect a real external world that it resembles via mimesis, but rather a real interior world, the coherence and continuity of which it helps to ensure" (Latour, 1999 p. 58). Therefore, is harvesting a monoculture of plants such as a paddock of wheat, sacrificing resemblance to settle again and again on the same meaning, which remains intact through sets of rapid transformations? Unlike Latour's (1999) pursuit to determine the natural dualism between the forest and the savannah in Brazil, cropping is an enterprise to maximise grain production from nature using sustainable methods. The map may be deemed a harvest bi-product, or an artefact which was created by the intermediaries employed in the system. Alternatively, the concept of circulating reference highlights that the map had more value than initially considered. The map was a precursor for future paddock production. It was stable, easily stored and could be produced at harvest regardless of the crop yield. It also showed that there is no distinct start and end dates to a continuous cropping enterprise.

Powers of transformation

Reference is a way of keeping something constant through a series of transformations. The acts of reference were assured since they relied on regulated farm management practices. "A thing can remain more durable and be transported farther and more quickly if it continues to

undergo transformations at each stage of this long cascade" (Latour 1999 p.58). A grain flow device supports farmers' reference. These are a small, concealed device that when it was calibrated to the manufacturer's guidelines, it measured the flow of the grain through the header. Wheat, canola and beans each differ in volumetric weight. The device was calibrated by weighing one litre of grain which was entered in weight form into the software, together with the selected commodity type, and header comb width. The software was connected to the machine to read ground speed, which resulted in a yield of tonnes per hectare. Any un-threshed grain that passed through the concaves at the rear of the header was never calculated.

Since paddocks cannot be taken to the agronomist's office for advice, yield was transformed to a number. Yields could be compared as they were universal. Formally discussed as volumetric bags per acre, yield was measured and discussed in metrics. At this moment, standardisation allowed the threshold between local and global to be crossed instantaneously. The challenge for farmers was recognising when errors existed in the calibration and/or mechanical threshing to transform the crop to a number. A rupture existed between the operation of harvesting a high yielding paddock zone, and the low yielding paddock zone, to result in an average yield. Humans were not capable of memorizing a yield map and the colour differentiations that denoted the high performing areas and the low performing area, hence a large area of land was generally under simplified as one number.

The results chapter displayed two yield maps. These maps represented about 10% of the farmer's total land under crop and about 50% of the land sown to canola in the 2018 season. Calibration, location, operation, reduction, compression, and standardization were the steps that counted in the creation of the yield maps. No step could replace the one that preceded it, but at the end of harvest, the maps spoke of the world.

Harvest was about collecting seed from the dead plants. Grain as a bulk commodity was representational of the growing season and paddock operations. The yield was an abstract number which represented the average tonnage of grain per hectare collected from the paddock. The yield was meaningful in one sense but not in others. It gave no blueprint for the grains' use, nor its financial value. To attest to and guarantee what we say, there is a much more reliable movement – indirect, crosswise, and crablike- through successive layers of transformations (James [1907] 1975 in Latour 1999). From one step to another there were indeed transformations, which also included processes of selection, cleaning, lubricating, adjusting, controlling, monitoring, communicating, comparing, negotiating, reviewing, agreeing and contracting. Actor network theory has effectively achieved a description of the political order of things, both human and non-human.

Gains and losses

Harvest and harvesting technologies showed the importance of recognising that matter at one end formed matter at the other end. The dialectic of gain and loss was a sequence of transformations. Latour's (1999) reversed isosceles triangles can be used to represent this harvest transition. What was lost through the process of harvest was the locality, origination, and rationality, to the point that all that was left was a yield map, a paddock of stubble and field bins full of canola. This is what Latour refers to as reduction; it is only the tip of the triangle that counted – the lowest denominator of the paddock and the farmers' decision making performance. The triangles also demonstrated that not only reduction had taken place, but with equal representation, there were gains. Greater compatibility, standardization, calculation, text, universality, transferability and circulation resulted inside the map which was produced from the paddock. The map made permissible the explanation of the crop's performance. In summary, trade-offs existed between what was gained referred to as amplification, and what is lost, referred to as reduction, at each information producing step of agricultural science (see figure 22).

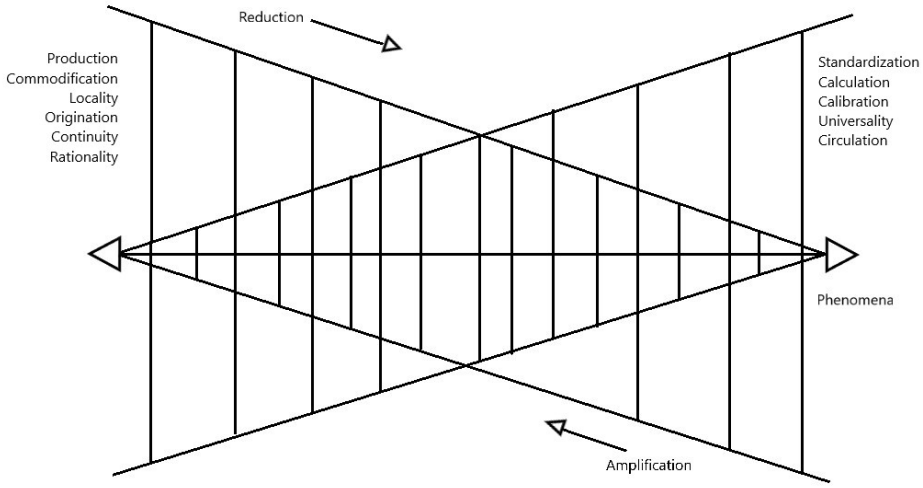


Figure 22. The transformation at each step of the reference may be pictured as a trade-off between what is gained and what is lost at each information producing step (Latour 1999 p.71).

The study of how Tony deployed technology and his relation to productivity gains on a continuous commercial cropping farm in the WSM has been explained by using Latour's concept of circulating reference. Each stage was a matter for what followed it and what preceded it. Harvest marked the end of the growing season, but at the same time it wrote the map for the future in traceable sequences of stages. Latour (1999) shows that the philosophical tradition has been mistaken in wanting to make phenomena the meeting point between things-in-themselves and categories of human understanding. "Phenomena, however, are not found at the meeting point between things and the forms of the human mind; phenomena are what circulates all along the reversible chains of transformations" (Latour 1999 p.71). This theoretical discussion has

identified the actor network that allowed Tony to overcome the exploitative-ness of the agricultural commodity chain through relations with yield mapping technology that enhanced the knowledge of the world.

As a concept circulating reference explained the reality of science in practice. The results compared Tony's My John Deere program, with his neighbour Wayne and his Trimble. Wayne's header did not measure the yield nor relay information to his software to gather paddock data. This offers the counter argument: What happens when no map is produced? In Mol's (2002) study of atherosclerosis, she shows that biology is only relevant insofar that it is intercepted by or has an effect on practice. This theory aligns with farmers' utilisation of plant, soil and animal science in their farming practices. Cropping without a yield monitor and mapping software is still within the realms of agricultural science and farming but as a farmer, Wayne is not intercepting the science. Wayne assembled different agents with technology and the reality of science. Figure 23 shows Latour's reversed isosceles triangles as a comparative theoretical analysis whereby Wayne (right) has less transformations than Tony (left) to explain the crop's performance.

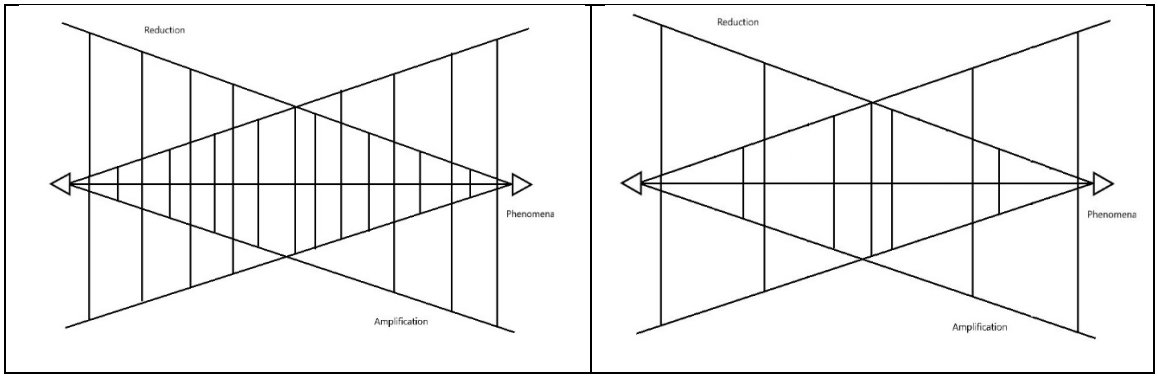


Figure 23. Adapted from Latour's (1999 p.71) reversed isosceles triangles for a comparison between transformations in relation to available technologies. The figure on the right shows that Wayne has less stages of transformation.

The question then emerges of how does the farm service sector talk truthfully with farmers when their paddocks have not been metamorphosed into an average yield, or a map with GPS coordinates and contours showing high and low yielding zones? There are less stages, or matter for form, that have been transformed by growing crops with less technology. It signals that the plant growth phase is not reliant upon the calibration of the grain flow device, but phenomena still circulates across the order of sequences for crop production. Grain growers, like Wayne, experience less through the reduction of their transformations. These farmers may join the conversation of standardisation, but as capitalist landholders and managers of their own entities, it is not mandatory that they share the same compatibility, text, calculation nor calibration in the reality of science.

Conclusion to theme one

This theme deconstructed and re-construed yield maps. Farmers in the Wimmera Southern Mallee not only harvest their crops, but they also harvest data. Farmers' position in political economy can be re-positioned by their ability to explain a crop's performance through a transversal object. Imagining phenomena as something that passes along reversible transformations enables farmers to exert control over their production. A yield map also offers farmers a connection to their product. It is a non-alienating non-human source of reference. In the Wimmera Southern Mallee, and for all grain growing farmers Australia-wide and globally, yield maps remain as an historical and stable artefact of production that remain with the farmer after the delivery and sale of the paddock's bulk commodity.

Theme two: Farming networks

The purpose of this theme is to offer a conceptual explanation of networks in order to explain how farms are held together as individual assemblages. This theme specifically argues that the way in which relations exist and become stable on farms is a result of farmer-agency. Drawing on the hybrid canola case study, specifically Tony's relation with Intercont©, this theme shows how farmers operate in regional and rural locations whilst having relations with multi-national corporations.

Actor network theory states that techniques have meaning. In turn, these techniques modify the matter of expression as well as the form of expression. The Frontrunner® canola growing program is used as the example for this theory. There were variable ontologies that existed for this genetically modified crop. Firstly, Intercont© offered farmers incentives to participate as a grower in a closed-loop supply chain for the Frontrunner® canola, to enable the company to meet their food industry clients' oil contracts. Secondly, grain growing farmers wanted a crop which met their agronomic needs, to reproduce the tonnage per hectare they expected from their operational standards and rainfall, with a market, to enable them to make a profit.

Tony, the canola grower became a Frontrunner® grower. The canola seed belonged to a collective, referred to as the Frontrunner® program, whereby various actors attempted to achieve their goals simultaneously. This theme defines the meaning of technical mediations located in actor networks, to explain network formation.

Interruption

The sociology of translation relies on observations and artefacts. Farmers' motives are not really known but they can be inferred by what remains behind. Latour (1999) defines the program of action as a series of goals to undertake operations. Grain growers' series of goals may begin by determining the crop types and variety based on the paddock rotation, choosing a crop with market demand or a high market price, balancing nitrogen inputs against the climate outlook, using retained seed, and keeping production costs low. Mixed farmers' goals may be similar but with consideration to achieving ample stockfeed for their farm animals, with any surplus commodities available for the grain market.

This section is about programs of action together with the concept of interruption. It argues that mediation is caused by artefacts which explains how networks hold. Interruption is a technical mediation that sociologists can use to explain how relations hold when there is nothing else to turn to.

To demonstrate this concept, when Tony found that the seed company Discoverer©* did not have any Clearfield canola in stock his initial goal changed. This was an interruption. This mediation was caused by an artefact, because there was no other reason why Discoverer© would not want to supply the farmer with seed. Figure 24 shows Tony as Agent 1 whereby his action was disrupted, creating a detour. He sought a particular seed variety; one suitable for the existing carry-over residue and herbicide group rotation in the paddock. Tony referred to the 2016 Victorian Winter Crop Summary. It was in this publication where he came across the 'New Frontrunner® Clearfield Specialty Hybrid Canola' by Intercont©. As an artefact, the 2016 Victorian Winter Crop Summary mediated the new goal. The Frontrunner® GM canola had been plot tested through the National Variety Trials (NVT) permitting the results to be published. Intercont© were seeking growers for its Frontrunner® program.

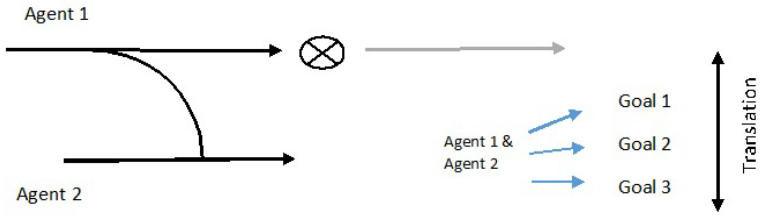


Figure 24. Based on Latour (1999 p.179) the "Meaning of Mediation: Goal Translation" Tony's original goal has been changed to a composite goal with Intercont©, to grow a high oleic acid canola crop.

Tony called the grain buyer about the possibility of growing the specialist seed. Mutual goals between Intercont©, who was seeking growers for the high oleic acid oil, and Tony, who was seeking a GM canola to grow in a specific rotation, were achieved. Upon this agreement the farmer became different through his relations. Actor network theory forces the abandonment the subject-object dichotomy. What was true of the subject, the farmer, was as true as the object, the hybrid canola. When the propositions were articulated, they formed a new proposition; they become someone/something else (Latour 1999). The sociology of translation redefined Tony as a Frontrunner® grower because Intercont© carried with it the weight of many associations, which modified Tony. This translation was symmetrical.

Intercont© was multifarious. This company bred plants to produce high oleic acid seed and secured food industry-end users to buy the crushed and processed food grade oil. This composition of goals were forged with incentives to support farmers to buy their seed and grow a productive crop for delivery. The responsibility for action was shared among agents. Achieving crop yield was a mutual goal; the growing canola was an intermediary. It was neither the farmers nor the plants that grew GM Frontrunner® canola seed because responsibility for action was shared.

Both Tony and Intercont© had a program of action to achieve their goals. Tony's goals to grow a particular seed variety was first interrupted. The interruption then generated a new effect, where Intercont© and Tony shared mutual goals in the Frontrunner® program. Mediation was

caused by artefacts, such as the writer of the Winter Crop Summary, the Agriculture Victoria, the printing company, GRDC funding for NVT crop trials, incentives for growers, a phone number, and residual herbicide in the soil, which were all used to explain how this network came to be stabilised.

Discoverer© did not offer any incentives to farmers who bought their seed. If Tony had not been interrupted and if he proceeded as he planned, the relations through this farmer and Discoverer© would have been present but less stable. Goals would have been achieved by both agents, but not shared goals because the end product, or Tony's canola harvest, is not in Discoverer©'s interest; they just want to sell him seed so they could profit. There would not have been the process of translation.

Composition

This type of group formation concerns the technical concept of composition. This form of mediation looks for the prime mover of a new action, and how it is distributed and nested in a series practices. The series of practices is what Latour (1999) refers to as subprograms. This topic argues that action is the property of associated entities. It shows that science can only be enacted on farm through a composition of embedded subprograms.

In this section composition is demonstrated by offering two examples: Intercont© delivering food grade oil to the food industry, and controlled traffic farming, both of which can demonstrate how relations generate action.

Macro-level

The commodity chain is not a single entity. Intercont© and their growers shared a common goal which was the successful production of Frontrunner® canola. It was in this organisation's interest to secure growers for the Frontrunner® seed so that they can supply a sufficient tonnage of grain to the crush plant for high oleic acid canola oil. The incentives offered by Intercont© to enrol farmers to join the program highlighted how this corporation changed its relations to form a stable network.

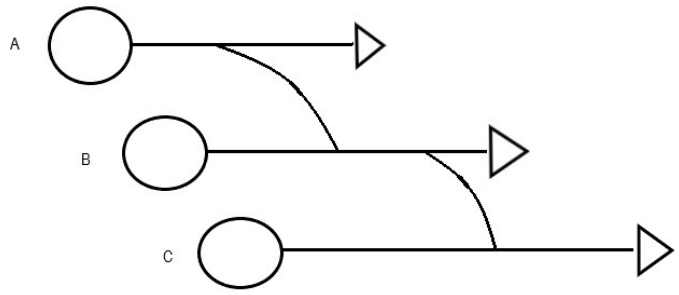


Figure 25. Based on Latour (1999 p.181) the "Meaning of Mediation: Composition", if the number of subprograms in increased, then the composite goal becomes the common achievement of each of the agents bent by the process of successive translation.

According to actor network theory, Agent A is allowed, authorized, afforded and enabled by Agent B and Agent C (figure 25). This conceptual frameworks shows the action of Intercont© purposefully breeding a technical high oleic acid canola (A), enrolling growers through incentives (B), and together the canola is delivered and crushed for the end-user food industry (C). This achieves the food industry's goals to repetitively deep fry in a stable cooking oil. These subprograms are translations in a process. Intercont© is not able to grow the canola by removing farmers from the chain because of the micro-level subprograms which exist (Agent B in figure 25). This next section drills down on these micro-level subprograms which underpin the macro-level commodity chain composition.

Micro-level

The sequence of transformations can help to explain how farmers produce the same varieties of bulk commodities but by using varying techniques. Farms differ in size, machinery, enterprises, labour units, climate, technologies, and so on. The compositions of these objects, humans and non-humans vary. Compositions can be one thing or multiple things put together to act as one. Farm labour can be replaced with hired labour, or larger machines and newer technology which allows farmers to reduce the composition of farm labour. Actions can disperse actants, or actions can eliminate actants to count for nothing such as fencing to moderate pest and stock behaviour. Compositions which lead to transformations are used to explain farm relations.

In the results, the Frontrunner® crop averaged 2.83t/ha. This value is not enough to understand crop production and farming relations. Farming operations were subprograms that achieved the overall yield. This is conceptually expanded in figure 26. The prime mover was Tony. As an agent he brought others, humans, non-humans and objects together through technical mediation to form the composition. Cropping is an example where human-to-human connections or object-to-object connections are rare, rather they criss-cross from one to the other. Tony spent most of his time with machinery rather than with humans to grow the crop.

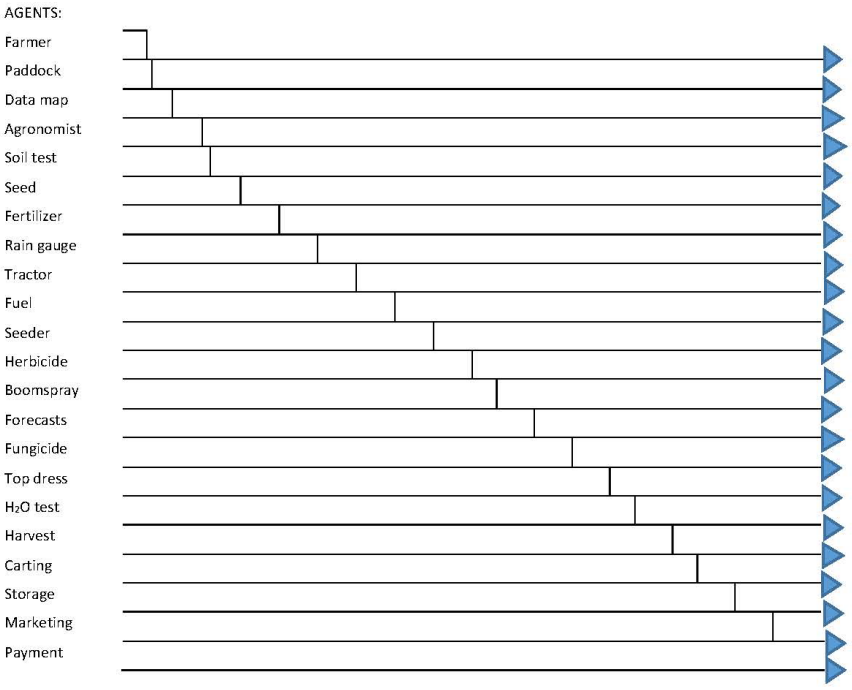


Figure 26. Adapted and expanded from Latour (1999 p.181) the "Meaning of Mediation: Composition" shows when the number of subprograms is increased demonstrating the imbedded subprograms, and the composite goal remains as the common achievement of each of the agents bent by the process of successive translation.

Within this composition of action, to produce the 85 tonnes of canola, another subprogram composition was further embedded. This was the controlled traffic farming (CTF) system that is a science created by experts and engineers to improve crop productivity. Controlled traffic farming is a system that was created from a combination of facts, machines, GPS guidance, scientists, ideologies and after-market parts to support farmers' implementation. It was implemented on the farm two decades prior to this study commencing. It was a composition, in that action was not simply a property of Tony but an association of actants (Latour 1999).

Controlled traffic farming was a technique in the sense that it was specialised. Tony considered that his farm's soil condition was a limiting factor to his production, so he pursued CTF to improve his soils by following the scientists and the other CTF practitioners to gain knowledge. Tony was the prime mover, but his agency did not weakened the other entities. The attribution to one actor in the role of the prime mover in no way weakens the necessity of a composition of forces to explain the action (Latour 1999). Tony was not able to undertake the CTF transition alone. He needed to generate the new composition by priming the sub-programs and resetting the goal with associated actants, human and non-human. CTF was implemented with the assistance of the farmer's brother, Jimmy, and his father, Trevor, both of whom committed days of labour to make the mechanical alterations. This was a process of negotiating goals with humans and non-humans to achieve the system (see figure 27).

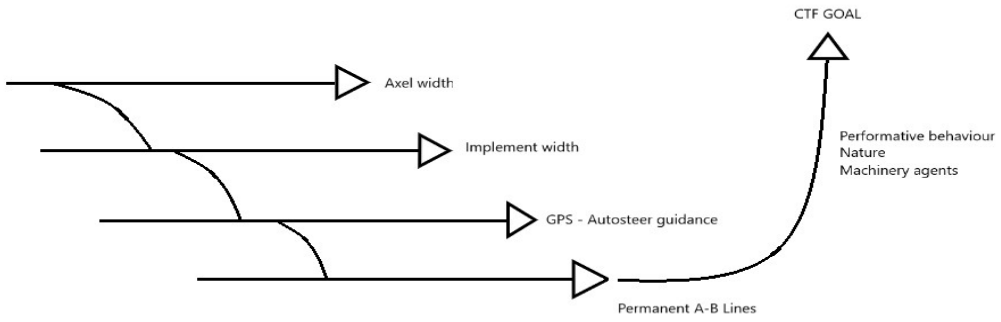


Figure 27. Based on Latour (1999 p.181) the "Meaning of Mediation: Composition"; Controlled Traffic Farming is a composition of many subprograms. The goal becomes the common achievement of each of the agents, human and nonhuman, bent by the process of successive translation, in the presence of performative behaviours, nature and available machinery dealers capable of sharing the goal through technology.

As a technique CTF was referred to multiple times in the results, such as when Tony hired a self-propelled boom-spray from Paul, Discoverer's trial plots, Walkers* demonstration of the new JD header, and the transition to the 12m system that gave Leo a challenging time on the chaser bin. These moments remind the actor network theorist that CTF is about making groups. These groups brought a performative definition in that they were made to exist by the various ways and manners of making and re-making the social by drawing attention to the means that were necessary to ceaselessly upkeep the group formation.

Composition, as a technical mediation was used to explain how CTF science was enacted on farm amongst other subprograms to grow canola to deliver to Intercont©. This was an example of a composition which was part of a broader commodity chain which consists of subprograms which formed the agricultural political economy. Composition was used to show how subprograms are integral to the overall composition to explain farming relations and how agents are held together.

Tony, Charles from the bank, and the agronomist from Greenlands, were each sure that the Frontrunner® canola would yield well over 3 tonnes per hectare. The agronomist went further and estimated that the crop would yield 4 tonnes per hectare. According to these mediations each stage was a matter for what followed and what preceded it, separated from the other by a gap as wide as the distance between that which counts as words and that which counts as things (Latour 1999). The difference in the world of words and the world became apparent though when the canola did not reach its predicted yield. The grain flow device and the receipts from the crush plant both revealed that the crop averaged 2.83 tonnes per hectare. Tony was disappointed. The agronomist remained mute. But the question remained: where in that composition was yield lost? Or, was that yield never attained in the first place?

Composition explains how the quality of agents that are enrolled is relative in the effects produced by the assemblage. For example, if both Tony and Wayne grew Frontrunner® canola, planting the same kilograms of seed and fertilizer per hectare, on the same day and received the

same growing season rainfall, the paddocks would not yield identically. It is because translation, as the meaning of mediation, consists of multiple actors, even ones that are invisible such as slope, paddock history, and soil microbiology. It is in this assemblage where certain entities control others, but identifying these entities can be challenging unless the black box is opened at the beginning.

Black boxing

Black boxes are an abstract, analytical tool which comprise of humans, non-humans and objects as one unit which generate effects. Similar to a black box found in an aeroplane, unless something goes wrong, their presence is likely to remain overlooked. Actor network theory seeks controversies to open black boxes, to look inside to identify the actors that are embedded within and to understand the relations which held it closed as a functioning unit.

This theme constructs the hybrid canola as a black box. By using the sociology of translation which is located in actor network theory this theme examines the relations that the canola enrolled. This methodology allows for an exploration of how objects, non-humans and humans, all connect through a miniscule but technologically advanced seed.

Closed loop grain marketing

The purpose of using a black box analysis is to demonstrate the technical mediation that took place when Intercont© enrolled farmers in a closed-loop grain marketing system. It could be suggested that unless farmers or anyone else from the grains industry is aware of the Frontrunner® canola program, and the incentives that these growers are offered to grow the crop, then few would know about it. This is one characteristic which draws a parallel with the black box analogy.

Callon (1986) coined the term *intéressement* – the process of translating the concerns of one world into that of another, and then disciplining or maintaining that translation in order to stabilize a powerful network. This theme demonstrates the manoeuvre of this multi-national corporation, where Intercont© re-defined the properties and the identities of their grain growers.

The field day was a moment when a black box opened. This event was designed for prospective and enrolled Frontrunner® growers. This field day deviated growers from the physical crop, to the background of the seed breeding process and the genetic traits, as well as the marketing incentives that were joined with growing the seed. It was a black box in that it opened up access to the canola team, and an invitation to participants at the field day to tour of the laboratory, and for free agronomic advice from Intercont© consultants. At the end of the event the black box closed, and the field day participants resumed their normal course of action. As a researcher, I kept the black box open when I accepted the invitation to tour the laboratory in Horsham and meet personally with the grain breeder to learn more about the seed, company, machinery and technology that they needed.

Hybrid canola

The canola seed was a complex imbroglio. The genetic material stored in the seed was un-activated until it was planted in April and received rainfall to trigger its germination. In its non-growing state, the genes of the canola were always there, held in the lipids and proteins behind the seedcoat. The canola carried with it the invisible work of the geneticist, research field and laboratory staff, greenhouse technicians, pathologists, funding, licences, the board of directors, managers, administration processes, packaging, fertilizer, farm machinery, bulking, import agreements, AQIS approval, and marketing. The plant was a vessel for the genes to translate seeds to become the holders of oil for the end-use clients and their customers in a long chain of commerce. Frontrunner® was a black box. Farmers follow a sequence of paddock operations, taking for granted that their canola crop was present because the seed was determined by its function.

The hybrid canola seed held weaker ties for Tony and Intercont©'s international presence until the moment when Jack brought the Intercont© grain trader from India to Tony's farm. They were all part of the black box, because Tony became enrolled in the Frontrunner™ program through *intéressement*, and the series of translations had unfolded to integrate him inside the global corporation.

Farms

Farms, as entities, are also black boxes. There are no shop windows displaying their wares nor slogans offering clues as to what they do. Quarantine signs at the gates of intensive animal production sites are the only regulated signage that farms need to have. Farms are one the interesting places where science, health, commerce and politics all collide. Passing any farm in the Wimmera Southern Mallee, it is nearly impossible to know how many farm labourers, mechanics, software technicians, grain brokers, and machinery sales people would materialize if it were to be site of an actor network examination.

Over time, farms leaves traces beyond their boundary fence. Family lineage, trade receipts, memberships, business records, former machinery ownership, and CFA maps are obvious artefacts. Farms can travel though the social life of the commodities they produced. Latour (1999) asks the actor network researcher to return each of the entities that went into crushing the high oleic acid canola oil, to imagine a time before the farmer read the Winter Crop Summary.

John Deere

Technical mediation could be used to explain the rationale behind the popularity of John Deere machinery. There is evidence of *intéressement* through detours and interruption within the case study of Walkers* demonstrating their newest S790 header. They intentionally disrupted Tony during his peak period to show him what his harvest could look like with new technologies.

John Deere is a black box. As an entity it can generate effects but only staff and clients have access to open it. By owning a John Deere machine farmers can see beyond the company's website. They effectively buy their access to the structure of the global company, through the dealerships in Australia, parts books, logins, and software. But most of these non-humans are only needed when something goes wrong. Farmers open the John Deere black box when their machinery or software does not work. This was demonstrated when Tony called for remote access support while he was calibrating the header.

There are seven steps to understand how to open black boxes and slow down the movement to identify compositions in the farming sector. Transitions may be visible until they are freed again from any influence of others (see figure 28).

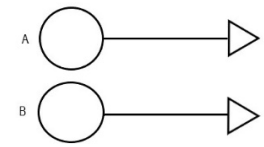
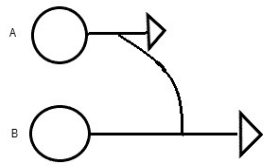
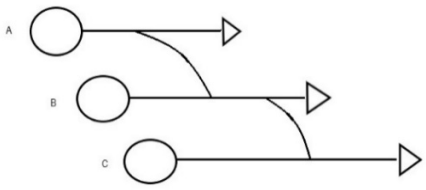
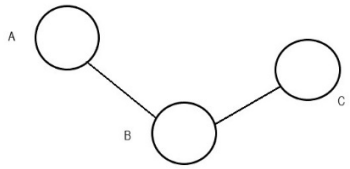
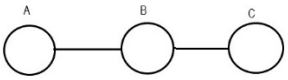
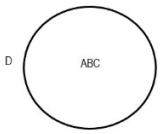
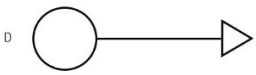
Conceptual design	Title	Research example
	Step 1. Disinterest	Tony plans to sow the canola variety from Discoverer™ (A). The Intercont© Frontrunner® Program (B).
	Step 2. Interest (interruption, detour, enlistment)	Discoverer™ do not have enough seed stock to supply Tony, so he selects Frontrunner® as a variety to suit his cropping needs.
	Step 3. Composition of a new and shared goal	Tony (A), and Frontrunner® canola and Intercont© incentives (B), produce high oleic acid canola for the food sector (C).
	Step 4. Obligatory passage point	The canola is GM. It cannot be delivered to any other grain elevator or to any other buyer due to its genetic traits and end use design.
	Step 5. Alignment	Trade aligns the entities; cartage, travel time to Footscray and the delivery schedule at the crush plant aligns actors.
	Step 6. Black-boxing	Intercont© black boxes the growers.
	Step 7. Punctualization	One agent. The high oleic canola oil used routinely for deep frying at fast food outlets is composed of multitudes.

Figure 28. Based on Latour (1999 p.184) the "Meaning of Mediation: Reversible Black-boxing" to demonstrate assemblies of artefacts, which can be moved up or down through the succession of steps depending on the crisis they go through; what may be deemed as one step may be composed of several steps.

Shifting expression

Technical mediation demonstrates that expression can be shifted. A detour was presented when Tony was required to source a different canola, but shifts in meaning can be more significant in explaining how networks are formed beyond agents simply sharing mutual goals. This science reinforces the structures of political economy. It shows how farmers comply with

regulations to participate in trade. It supports the theory that farmers are alienated in the lack of freedom that bulk commodity production offers, but at the same time agency is required to comply with regulations and remain profitable. The purpose of this theme is to show where boundaries are crossed from policy, myths, and signs into practice.

In managing his paddock hygiene Tony shifted his goal from his paddock management to compliance, which is defined as a change in the matter of expression (Latour 1999). Shifting expression is a form of technical mediation and it offers an explanation of farmer- compliance. Introduced in the results, crop-topping is a broad acre treatment of herbicide to a mature crop to avoid weed seed set in the following year. The agricultural application of herbicides, as well as pesticides, fungicides and insecticides, are strictly regulated in Australia. To buy farm chemicals, a valid farm chemical users' permit or ACUP license is mandatory. All labels on chemical containers are a legally binding agreement. Upon every grain delivery to a receiving site, a sample is collected for reference. If any beach to an MRL is found, the samples can be recalled for testing to determine the farm of origin. Farmers' identification, banking details, levies and End Point Royalty fees are managed through their National Growers Registration (NGR) number which is linked to their delivery samples.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) sets MRLs for agricultural and veterinary chemicals in agricultural produce, particularly produce entering the food chain. These MRLs are set at levels that are not likely to be exceeded if the agricultural or veterinary chemicals are used in accordance with approved label instructions. Instead of signs and warnings the APVMA use compliance, which is invisible but at the same time present. The APVMA's program of action is articulated through compliant farmer behaviour.

It could be suggested at this point that alienation exists at this imbroglio of delegation. Latour (1999) mentions the term reification at this point of delegation. This is different from but similar to the Marxian terms alienation and commodity fetishism. This implies an all-powerful human agent imposing their will on shapeless matter, because matter matters. However non-humans, like chemical labels also act and displace goals. This is the juxtaposition where sociologists can begin to explain the human behaviour of conformity. This is also the point where it can be shown why farmers do the things they do when they work in an environment with minimalist human to human contact.

In the context of crop-topping, Tony's goals were to use the most cost effective weed management tool to reduce weed emergence over summer. Tony applied 2.5l/ha of Weedmaster™ DST, a glyphosate product specifically registered for pre-harvest use. His goal was translated from avoiding seed set to the goal of abiding by the label to avoid maximum residue limits. These two goals are far apart; Tony's first goal was paddock management related, profit-driven and labour efficiency-based to minimise weed emergence, maximise soil moisture

retention and decrease the need for subsequent sprays. Tony's second goal appealed to his fear of non-compliance.

Tony believed that if anyone contaminated a whole bunker, for example 30,000 tonnes of canola, they would be financially liable for its entirety. Therefore, he modified his behaviour through the mediation of his NGR (see figure 29). This mediation also explained why Trevor drove 200 kilometres to collect five new boom-spray nozzles and ensured that the herbicide efficacy was achieved through the best possible known and available spray technology.

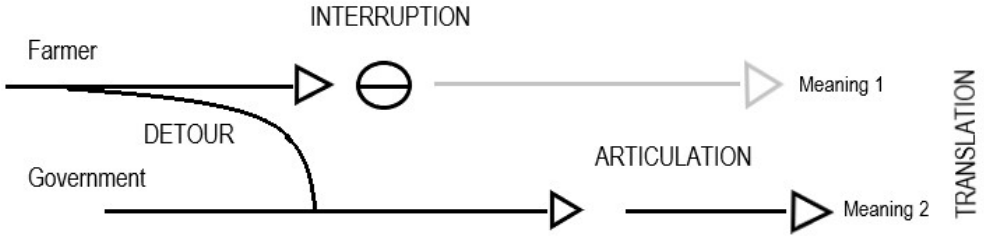


Figure 29. Based on Latour (1999 p.187) the "Meaning of Mediation: Delegation" is when we introduce a second agent, in this case, the Australian Government through the APVMA which implies a process of translation but the shift in meaning is much greater since the nature of the 'meaning' has been modified. The matter of expression has been changed along the way, to explain the concept of conformity.

Delegations and detours

Actor networks considers technology as congealed labour. Mol (2002) supports this theory in her study of clots in atherosclerotic legs. There are a multitudes of different cells types, doing different jobs, with different meanings, for an overall purpose. The atherosclerosis cannot be seen until a cross section is cut and presented on a slide under a microscope; but it is there. Just as one cannot see the data storage administrators in Brazil ensuring that the large cloud storage space is always working for their client John Deere farm machinery.

Agriculture consists of detours initiated by various actants in the production of bulk commodities for domestic use and export. Hybridization of past events and acts, which allow plant breeders, agronomists, mechanics, financial lenders, precision agricultural specialists, earthmovers, transport operators, internet providers, grain traders, auto-electricians and so forth, all disappear while also remaining present. Farming encounters hundreds of absent makers who are remote in time and space yet simultaneously active and present (Latour 1999). Through such detours political order is subverted since farmers rely on many delegated actions that they make them-self do things on behalf of others. Some of these others are no longer on the farm nor have never been, or never will, in the course of whose existence this research does not dare dream to retrace.

Mechanical and technical artefacts, such as the MyJohnDeere and Trimble software, hide the human labour that stands behind cropping. A grain farm may look like one farm owner with one or two farm labourers, but hidden behind the machines, equipment, software and inputs that make this farm operable, may lie thousands of detours and agents sharing goals. Alternatively, a

grazing farm could look similar but they could have twenty farm labourers across shearing, mulesing, crutching, feeding stock and fodder production. Grazing farms may not share the larger machinery but there is still congealed labour beyond the farm gate in technology, stock genetics, fodder production, and data management. This comparison of tracing technological and technical artefacts between farming enterprises would offer another level of inquiry into mixed enterprise farms. These farms combine cropping and grazing; actions and actants are multifarious across both animal and plant production. This can be used to potentially explain the complexity of detours and delegations and the challenges associated with shared goals with a broader range of agents. I offer that the technical mediation of compromise may be an internal subprogram of translation, where shared goals for the farmer are achieved but with a cost to the farmer at the same time because stock and plants effectively compete for paddocks, as does grain production because animal feed competes with market value and cash payment.

Actor network theory argues that humans are no longer by themselves. Our delegation of actions to other actants that now share our human existence have developed so far. It is at this point that technical determinism requires consideration. Determinism acts as a theory that guides reform and is a hidden force not seen by contemporaries but discovered later by analysts (Perdue 1996). Perdue (1996 p. 171) argues that under appropriate conditions peasants do transform their societies by adopting new seeds, new field formations, or even leave the farm given the right incentives. Perdue (1996) refers to the single-factor method using the research by Lynne White Jnr (1964) exemplifying the introduction of a new heavy plough to northern Europe that increased both agricultural production and population density. White (1964) argues that the plough was revolutionary in its outreach of commerce yet he asserts that it is not this one factor that determined everything else. Perdue (1996 p. 178) uses White to show when populations and technology spread together, neither determine the other. What the WSM experiences is limitations in technology with a declining population. Critics may believe that technology is the sole driver, however unravelling actors and looking into black-boxes when they are periodically opened, the determinist must concede that there is more to the complexity of agriculture than just technology. According to Perdue (1996 p. 178) Marx was not a technological determinist but a class-struggle determinist. In arguments about agricultural development, three alternatives are offered: population, class structure and the market (Perdue 1996). Actor network theory argues that these theories suffer from the same flaws of technical determinism and single-factor theories may be appealing but limit explanation.

Latour (1999 p. 190) argues that we cannot fall back on materialism either; artefacts and technologies do not imprint chains of cause and effect onto malleable humans. The GM canola seed is ultimately not made of lipids and proteins behind a seedcoat; it contains plant breeders, regulators and a multi-national corporation with integrated commercial interests in the food sector. These people co-mingle their story lines with farmers, tractors, seeders, fertilizer,

agronomists, spray applications and headers. Similarly, the Material and Safety Data Sheet (MSDS) on every Agvet chemical container is ultimately not made of paper, rather it's full of chemical review panel members, chemical engineers, and regulators co-mingling with sellers of chemicals, boom sprayer and spray nozzle fabricators, chemical manufacturers and importers, and of course the farmers, to protect Australia's grain trade, human health, the environment and the safety of chemical users. The farmers who grow Intercont's Roundup Ready® GM canola are not the multi-national GM canola breeding company, and the multi-national GM canola breeding company are not the farmers growing the seeds for the crush.

Just as Tony is not the law applying the herbicide limit on his canola, the law is not Tony. The mediation as a technical translation resides in the blind spot in which society and matter exchanged properties.

Conclusion to theme two

This theme offered conceptual frameworks to explain how farming and political economy is constructed. The meanings of mediation, including detours, shifts in expression, goal sharing, black boxing and composition of subprograms, were forms of transitions and translations to explain how humans and non-humans are brought together in group formation to generate effects. When effects are generated by farmers in the Wimmera Southern Mallee, agency exists through the properties of technology such as specialty canola, giving these farmers the ability to overcome the exploitative effects of the commodity chain.

As black boxes, farms function as closed units, although they open for those that share the same goals, including machinery brands, compatible technologies, seed producers, grain buyers, finance lenders, family members, and agronomic support. Farms can be said to be osmotic-like; over time various actors have passed through the membrane and traces may remain. But the relations that remain in place are not always in favour of supporting the farmer. Within the commodity chain artefacts make farmers change their matter of expression when they deliver bulk commodities. This change in matter of expression reduces freedom. The concept of conformity was shown when expression was shifted to abide by the law using top-dressing products.

Tony's enrolment as a Frontrunner® grower in a global agribusiness black box was non-alienating in that he was connected to the product. The Frontrunner® brought with it obligatory passages, such as the time and date of delivery to the crush. Intercont© needed Tony, as well as their other farmers in Victoria, NSW, WA and Queensland to grow Frontrunner® canola. The incentives to grow the canola were aligned with farmers' goals to hold these relations stable. Agency was a property of these relations.

This theme was used to develop and publish a co-authored journal article for the American Anthropological Association publication through Wiley Author Services. The journal article is attached in Appendix F. A small portion of the controlled traffic farming narrative from the results chapter is repeated at my discretion because it remains relevant in explaining this social science.

Latham, A., McDonald, J., & Reeves, K. (2019). Following the invisible road rules in the field: Using ANT for CTF. *Ethnographic Praxis in Industry Conference Proceedings*, (pp. 398-414). doi:10.1111/1559-8918.2019.01296

Theme three: Agency

Scientific farming systems include practices such as zero tillage cropping, variable rate prescription technology, soil moisture probes and precision planting. For agricultural research the typical focus remains on understanding the barriers of farmer- adoption. This analysis shifts the focus beyond binary and hierarchical notions of humans, technology and nature, to insider-research of farming practice, the alliances, and the neighbourly relations to examine how agency makes farmers act. This theme specifically draws upon the precision farming technique of controlled traffic farming. Controlled traffic farming matters to farmers who want to gain the productivity benefits that the science promotes. This theme examines what makes farmers follow the invisible road rules of CTF in the field using the actor network approach.

From informal interviews with farmers, a few years of experience as a controlled traffic farming project consultant, as well as my position as a landholder and grain grower as an insider researcher, this theme begins to examine not what gives ethnographic research its authority but what is at stake for many of its agricultural industry audiences. The research in this theme relies upon the semiotics of farming under the Australian commodity chain contexts; the performance of roles and rituals of social interaction and the practices by which farmers maintain their legitimacy—not to mention the hierarchies, positions, and ways of thinking that comes with geographical location, rurality and the social isolation within the farming landscape. In what follows, we take up each of these dynamics in turn. This theme specifically examines farmer agency. This work examines technology and science that give agency to farmers and machines that enable the invisible road rules of a precision cropping system, controlled traffic farming. The reason for this ethnographic examination to look beyond what industry expects from this farming practice, and to offer a new understanding of how agricultural science plays out on farms.

This theme aims to draw attention to farmers' relations with non-humans, like machines, technology and farming methods. Actor network theory is an approach that focuses on the heterogeneous network of interactions of human and non-human actors such as knowledge, technology, money, farmland, animals, plants, and so forth, and how these interactions depend on

both the quality of the actors and the network context of interaction (Noe and Alroe 2003). This method demonstrates that agency can be interpreted as a collective property of humans, non-humans and objects. It focuses on human interaction with technology and artefacts (Noe and Alroe 2003). This analytical approach seeks to present the relationships between things that form an assemblage of agents. As a heterogeneous product, agency generates effects. The sociology of translation located within actor network theory, is used to show where these effects are found. This theme continues to refer to Tony, Leo and Wayne to demonstrate that farmer agency exists to exercise control within the agri-food structures, but it requires specialized non-human relations and associations to generate such effects. This theme explores these concepts by interrogating farmer agency in the context of machination and technology for crop production. This research is contributes to a global understanding of how agricultural science and technology is adopted and held in place by agency.

What the … CTF?

Controlled traffic farming (CTF) is a science with a group of specialised scientists and CTF farm leaders advocating this practice. The Australian Controlled Traffic Farming Association has over 700 members. Some peer-reviewed CTF research includes the whole farm benefits of CTF (Kingwell and Fuchsbichler 2011), soil emissions of nitrous oxide and methane (Tullberg et al 2018), modelling to estimate environmental impacts (Gasso et al 2014), and estimating annual machinery costs for CTF (Bochtis et al 2010). There seems to be abundant CTF science in fieldwork, simulated and theoretical. Disagreement between CTF scientists is evident, but equally relevant is how this science explains the relations for what it accounts. This theme aims to contribute to the CTF literature about how CTF science is adopted and held in place by agency constructed as a relational collective.

Controlled traffic farming is a science that enables farmers to potentially be more productive by following the same wheel tracks in fields for every operation. The objective of a CTF system is to minimize soil compaction and achieve all the benefits advocated by CTF scientists such as improved water infiltration, mitigation of randomized machinery passes which cause soil compaction, improved plant performance in non-trafficked zones, hardened designated wheel tracks for faster field access after rain, and reduced fuel consumption. CTF is a prescription based precision farming system. It relies on global positioning systems (GPS) for real time kinematics (RTK) auto-steering guidance. The GPS signal together with the software steer the machine to achieve 1cm positional accuracy to ensure that the implement is not overlapping nor underlapping its operation. Axels on the prime mover, whether it be tractors, combines or self-propelled sprayers have the same wheel base width. The implement widths are aligned to a designated ratio to ensure that the machines travel on exactly the same tracks in the paddock for every field operation, indefinitely (see figure 30). In an increasingly automated

world it would be fair to assume that farmers might wholly submit and give over to their fully-automated machines and technology for their decision-making, rather than take into account the agential capacities of their soil type, topography, micro-organisms, and knowledge. But this PhD sets out to challenge that farming is more than just a farmer's set of decisions. This research argues that when we define agency as a property of humans and non-humans using an actor network approach we can explain how technology and science re-articulate the agential properties of farmers, their machines and the other agents that enter the farming complex.

Controlled traffic farming has been used by grain growers in Australia over the last twenty years. However, not every farmer who grows grain has adopted this system. This theme refers to results and re-develops two case studies for a comparative analysis; Tony who has adopted CTF, and Wayne, who has not. Empirical evidence is provided to show how agency is distributed as a collective and performed by farmers, machines and other entities. This theme marshals the results and the methodological approach to analyse the social, cultural, material, natural, human and technological elements at play in these case studies. This analysis contributes to a broader understanding of the complex relationship between farmers, technology and their land.

Figure 30. This photograph captures the straight lines and mathematics of CTF ratios. The image shows the wheel tracks and the 12m swath of canola crop remaining to be harvested, parallel to the operating combine harvester.

Agency in the grains sector

This theme offers a comparative analysis of Tony and Wayne's farming practices to examine agency. These farms are located in the water catchment of the Glenelg River. The landscape is diverse with the Black Range State Park to the east. Remnant paddock vegetation, shallow top soil, creeks, and native pest populations of kangaroos, cockatoos and emus are dominant landscape features. The mean annual rainfall is 550mm. The vegetation density, the undulation and non-arable zones are symbolic of the traditional grazing enterprises. The district population is 50 people.

The CTF farmer

As mentioned in the results, Tony commenced implementing a CTF system about twenty years ago. Back then he was still farming with his father and younger brother. Tony saw that compacted soils caused by decades of grazing, hay production and cropping were limiting their crop production. After a bus tour with a grower group to outback NSW to meet a CTF farmer, together with expert knowledge from soil scientists from the University of Queensland who were publishing widely in farm extension magazines, Tony gradually introduced CTF to his family farm business. The process started with Trevor and Jimmy helping Tony to move the tractors' axels out to 3m spaces and then working to match the width of the seeder to the width of the combine harvester's front. Tony removed fences and some paddock trees for easier traffic-ability and to reduce the trees' interference with the GPS signal.

At the same time farmer case studies of the successful implementation of CTF were being regularly published for a farming audience. Tony was reading as much about CTF as he could. While modifying his farm and his farming network, Tony had access to new CTF knowledge, some basic farm soil data, a record of their annual yields, and a membership to a grower group.

In these published case studies the CTF scientists tended to speak on behalf of the mute actors such as residue, soil microorganisms, plant roots, rainfall infiltration and soil air pockets. On the other hand the CTF farmers spoke on behalf of their costs, machinery, and a quicker return to the field after rainfall, as well as their crop's performance. By enrolling a number of agents from the farm services sector who too shared Tony's goals, his fields were transitioned to CTF so that machinery could only drive up and back on the same invisible lines across the fields, indefinitely.

Two decades later, in spring 2018 Tony was faced with a new problem. He could not find a new or second-hand combine with a 9m front. Committed to the system, Tony decided to change the implement ratio. Tony had been operating a 1:9:27 system, but with limited options he decided to transition to the 12m system. The axels spacing on all of his machinery remained the same; the combine front and his seeder would change to 12m with a 36m boom-spray span to fit the ratio.

Tony purchased a new combine harvester with a 12m front which meant that his span was now 1.5m wider from the centre than how it was originally. From this, a second challenge arose. For a CTF system to work during harvest the auger on the combine needs to be able to extend over chaser bin. The chaser bin is a cart that is towed behind a tractor, allowing the combine to both harvest and empty its grain simultaneously (see figure 31). The John Deere dealership had assured Tony that an auger extension kit on the combine would be long enough for his 12m system. They installed a kit as part of the sales contract but it failed to reach the required length. This meant that the chaser-bin could not be filled while both machines remained

on the CTF wheel tracks. Tony knew that the auger was too short before it was tested in the field and he said that another extension kit would have to be installed before the next harvest; it was too late for this year. He also talked of purchasing a self-propelled 36m boom-spray. He traded his John Deere 1890 air seeder for a new one to fit the changed width. He said that he would need remove more paddock trees to allow for these wider machines.

Figure 31. This photograph captures the header auger extended over the chaser bin and unloading the canola while in transit. One person is in each cabin operating the machine. The drain was previously cut by an excavator to shed paddock water, and it divides the paddock of canola from the paddock of wheat.

Tony's commitment to CTF and the science behind the productivity benefits, was evident. CTF is an effect of humans, machinery, nature and technological agency which when put together as a collective enacts the benefits of the science on the farm. When Tony could not find a suitable combine front he was positioned to make the decision to forgo CTF. He could have chosen to be flexible in his choice of machination, but he chose to implement a new ratio based on his cultural experience of this scientific assemblage of agents.

Soil, micro-organisms, native standing vegetation and rainfall are all agents in CTF. Tony did not view standing paddock vegetation as a contributing agent to the collective, rather he viewed it as an obstacle in achieving the desire effective that CTF offers. Controlled traffic farming brought with it a collective action which holds power. Agency is a property of the farmer, the machines, the technology and the CTF scientists. Together they work to control nature, even though nature is an agent as well, by improving rainfall infiltration in non-trafficked zones, to help in producing higher yielding crops. This allowed Tony to profit and effectively participate in the structures of political economy, through collective agency.

The farm worker

Leo, Tony's farm worker, was towing the chaser bin. He was driving the John Deere 8335R tractor with the GS3 software using RTK 2cm GPS accuracy to pull the Finch chaser bin. Leo had guidance to auto-steer the tractor along the same wheel tracks as the combine harvesters. The chaser bin was limited in its technology, but remained mechanically sound and robust. It had

no technology to support Leo's judgement of capacity, such as weigh cells to calculate the tonnage, nor cameras to show how much grain was pouring into the bin. It just had one window. Leo mostly needed to use his judgment by sight and his decision-making rather than rely on technology to guide his set of actions in the CTF system (see chaser bin alignment with the field bin in figure 32).

Figure 32. This photograph captures the tractor and chaser bin aligned with the field bins. The farm worker is auguring the canola from the chaser bin into the field bin with his judgement of sight for accuracy.

Leo was working alongside two large capacity John Deere combine harvesters; Tony's S690 and Walker's demonstration-model S790. Both headers used the My John Deere software to harvest the 30ha field of Wahoo canola. The software was synced to create one shape file from the headers to produce the yield map for post-harvest reference (refer to theme 1). But Leo didn't have access to the harvest software. He could not see the real time yields or capacity of the grain tanks that the header software shared. The paddock was heavily timbered with 10 remnant Eucalyptus trees. Two trees had dropped limbs which increased the area of the fixed obstacles. Leo was busy keeping up with the two headers and ensuring he didn't collide with fallen limbs and standing trees.

Tony had instructed Leo to remain on the new wheel tracks that the headers left behind in the stubble. Leo drove along the headlands and watched the two machines. From a distance they were hard to differentiate except Tony's header had tracks rather than wheels at the front. The chaser bin had to be positioned on the header driver's left side, on stubble only. Leo followed the header, staying on the new wheel tracks before disengaging the auto-steer software. He had to steer the tractor straight, avoiding the combine on his right side, but staying close enough to collect the grain. He had to use his judgment of where to drive. He then set the speed on the control stick, and steered the tractor over to the combine and into a safe zone to fill the chaser-bin. Over his right-hand shoulder he watched the auger swing out from the header and over the bin. The grain crept up the window. Once filled, Leo moved back onto the wheel tracks. He re-set the auto-steer to guide the direction of the tractor, and slowed down as he no longer had to keep

up with the header. He taxied to the end of the row and stopped on the headland again. He sat in the cabin preparing to repeat the exercise with the other header.

It was from this point of observation it could be noted that Leo wasn't abiding by the CTF system. The GPS guidance and auto-steer system were over-ridden. He merged the tractor about 1 metre towards the header to collect the grain while in transit. Leo was utilising his own relations with machinery and guidance software by operating the tractor manually. Considering a network approach, the actors were all present however he was over-riding the agential capacity which the CTF assembled collective brought. Leo wasn't being negligent, disrespectful to Tony, nor sceptical of the CTF system – if he had remained on the CTF wheel tracks as he had been instructed to do, the grain would have fallen on the ground.

The non-CTF farmer

Wayne was undecided about whether he liked stock more than cropping in his farming system. He had employed a new agronomist during the year, terminating his former agronomist, to employ an old friend to help him with crop products and application rates. Wayne said that he looked to his neighbour Tony for cropping advice, and to Jake, his best friend and a farmer further along the road, for his stock advice.

There were 30 standing remnant trees in the 25 hectares of Planet® barley where Wayne harvested on this hot day. This variety was relatively new to Australia, with end point royalties to Seedforce for the intellectual property rights to sell the grain. However, Wayne wasn't selling this grain; it was allocated as his stock feed. Wayne made a comment that he wanted a clean sample for Jake who was coming by later to get a trailer of the grain to feed out. Both Jake and Wayne were feeding this barley to their sheep, but the cleanliness of the grain sample didn't seem so important to Wayne. If it wasn't for Jake he had no reason to adjust the header settings to create a cleaner sample.

The 9m header front allowed Wayne to move his aging twenty-something year old Case IH 2188 combine harvester between most of the tree trunks. Stopping the machine, he got out of the cabin to manually adjust the concaves to make the threshing clearance smaller to reduce the amount of grain which was un-threshed and scattered from the rear of the combine onto the ground. Recommencing harvest he said that he "is looking forward to a new header so I don't have to do this". He explained that he had recently installed a new top sieve. Regardless, for Wayne the total grain loss from the combine didn't seem to be his priority. The dial showing the measure of grain loss never moved, even after the manual modifications to the settings, suggesting it was ineffective.

Wayne fully owned his combine harvester. Wayne spoke about his concerns of transitioning to wider equipment and the subsequent need to remove some of the standing vegetation in his fields. He mentioned the state legislative requirements to get a permit for native vegetation removal. He talked on behalf of the trees and the waterways. He wanted to buy a

newer second hand New Holland combine in the coming year. He wanted more modern technology, but at the same time it had to be compatible with his Trimble GPS system. He explained that wanted to use his existing MacDon front from his windrower and then purchase an adapter for a New Holland combine in order to make the change-over cheaper. His wife was not in favour of trading their Case. Janine was content with the older machine and she did not see the value in updating what they had. Wayne also disclosed how much the annual subscription to the GPS base station costs. Financial commitments were relational to Wayne's network.

Wayne did not follow a CTF system, even though most of the machinery axels were 3m widths. He relied on GPS guidance and auto-steering at harvest and sowing. He disengaged the auto-steering software to avoid the trees. He didn't always resume the auto-steering after by-passing the trunk. Instead Wayne manually steered the combine around upcoming trees rather than re-engaging the software. Wayne had not paid for a subscription to unlock the Trimble software to monitor his crop yield. He had no way to map his yields despite his alliance with Trimble technology. The combination of paying for a yield monitoring subscription and the fall-back position that his grain will be fed to sheep, demonstrated a different set of relations to monitor his crop production.

Wayne's father, Bert was driving the John Deere 8220 tractor towing the chaser-bin. This chaser-bin was an older model which had been modified resulting in an ambiguous form of measurement. To unload, Wayne used his UHF radio to call Bert. Bert drove tractor out from under the shade of a tree and lined up next to the moving combine. Wayne's auger extended over the bin and emptied the grain tank. When this was finished Bert pulled the tractor to a hard left and returned to his place in the shade. Wayne was counting how many times Bert took the fully loaded chaser bin down the road to empty the barley into the grain shed. This was Wayne's method of estimating the average crop yield.

Wayne's arrangement of relations with agents acted as a collective. Through this collective he monitored his farm management performance and reproduction of farming systems. His relations with nature and technology moved beyond the binary notions of dualisms. He did not use yield maps for his reference, nor had no financial commitments on his header. In this field his purpose was to grow grain for his sheep. His agency was an assemblage that generated a collective effect: sheep, sheep feed, finance, family, land, machinery, technology, cropping inputs and advice were translated for production.

The culture of the Australian grains industry

Political economy enables farmers to produce near-identical bulk commodities. The agricultural political economy is also known as the commodity chain. Farming practices are moderated by others even when connections within this chain seem implausible. Modern farmers continue to change and modify their agricultural techniques to keep up with the terms of trade in

the global economy. Increases in crop yields, decreases in production costs, management of risk and/or improvement in work efficiency are key ways in which farmers attempt to maintain competitiveness. Higgins (2006) states that the agency of farmers is the subject of ongoing conceptual and analytical debate in the critical studies of agriculture and food. The culture of the Australian grains industry, and the structures of the commodity chain, contextualise why farmers refer to science and technology such as controlled traffic farming for profitability and productivity advances.

Farmers are legally required to meet extensive quality standards set by regulators and as a consequence many actors are aligned to safeguard production. Levies are deducted at grain sales and this is matched with government funding to finance the peak industry body, the Grains Research and Development Corporation (GRDC). Australian farmers participate as individuals in a colloquially-named 'global playing-field'. They are not subsidized; their inputs and grain prices are influenced by the value of the Australian dollar and global supply and demand. Grain grown from using a controlled traffic farming technique is not segregated, penalised, nor rewarded; it remains a bulk commodity subject to standard commodity grades.

Competition exists within the farm services sector to undertake agronomic field research. Controlled traffic farming research is competitive under the governing structures of the industry. Grain grower levies can be directed to CTF research when scientists and grower groups are successful in their competitive application. Farmers also compete with other farmers for available land to buy, lease and share-farm. These behaviours, from all agents who are farming and non-farming, contribute to the market-driven economy. At the same time agriculture places nature at the background. Political economy is constituted by human capacity by using biological, mechanical and chemical engineering to overcome the natural obstacles of production.

Farmers' actions are rooted in economics as much as they are ideology. Grain growers increasingly look to technology and science to enhance their productivity. This is the precursor for the uptake of farming methods and techniques such as zero-tillage cropping, the use of variable rate technology, the implementation of soil moisture probes, post-harvest seed destruction methods and controlled traffic farming. These are different ways that farmers can buffer against the terms of trade. Automation, data management and large-scale efficiencies are key management strategies advocated to Australian grain growers by governing politics. Farmers spend long hours producing bulk commodities therefore a comfortable, modern environment with technological support structures is generally preferable than manual labour. It is unlikely that younger generations of farmers could oppose the forces of neo-liberalism and seek alternative practices unless new markets opened. As a nation, global competitiveness comes by supplying high quality grain compliant with the stringent market conditions. Farmers feel coerced and powerless to challenge political conditions under which they operate, hence they rely on new production techniques. To apply these techniques, agency is a requisite.

Conclusion to theme three

This work utilises some of the frameworks from within ANT to examine agents' associations and to explain from an insider perspective how agency is distributed as a collective and performed by farmers, machines and other entities. This is achieved by following the movement allowed by an actor network approach. Hierarchical social orders are also flattened, working from the ontological premise that humans, non-humans and objects are not separate realms. This is founded on the rejection of epistemology and objectivity, by redefining ontology to allow for multiple ontologies (Latour 1999; Latour 2005). This approach shows the role played by science and technology in structuring power relationships. It is clear that certain entities control others but by remaining agnostic, the power dynamics between humans and non-humans becomes visible. This means that in a farming environment the insider researcher needs to be aware of the agricultural sciences, natural resource sciences, social sciences, technological and information sciences ready for interpretation at every moment. It is the researcher's role to forgo these ontologies and listen to the participants, or agents, as well as the others that they mobilise, in the study. Giving generalised symmetry to actors implies that the researcher must act impartially and refer to the differing protagonists in the same terms, regardless of their effect upon others. Describing the way in which actors are defined, associated and obliged to remain faithful to their alliances is how we determine performative agency.

Agency is a property of a collective and can be distributed among many. Agency is about moving beyond human notions of conscious action to an actor network approach where human agency is dissolved among many. As a post-human, practice-based method actor networks shape the idea of agents and the performativity of agency. Each performative definition of what society is about is reinforced, underlined and stabilised, by bringing in new and non-human resources (Latour 1986). The method focused on inanimate entities and their effect on social processes (Cresswell, Worth and Sheikh, 2010). Upon this point the notion of power can change, transferring it to the many resources used to strengthen and hold society still.

An actant is an entity that 'performs' in network relations with other actants (Noe and Alroe 2003). The term actant replaces the term actor since the latter implies only human agency (Higgins 2006). Higgins (2006) defines agency as a property of humans and non-humans through the arrangement of relations, not just those which are social relations. Agency is performative in that it is constituted in and by these relations (Higgins 2006). The ways in which actants perform in an actor-network is framed by the actor-network – meaning that among all the ways in which an artefact, or actant, could be performed such as a zip tie or fence, limits the possibilities that are actualised within the particular actor-network. The notion of 'translation' is characterised as the transformation of objects as they are enrolled into the network and mobilise actants of the network (Noe and Alroe 2003).

Approaching these farms as actor-networks there were many elements that were translated and enrolled into the objective of crop production. There were the farmers, tractors, combines, chaser bins, technologies, mobile phones, satellite signal, land, crop, sheep, remnant vegetation, soil, family, farm labour, grain, market prices, knowledge, skills, values, time, stress and so forth, depending on the heterogeneous strategy of each enterprise. The outcome of the sequence of operations required to undertake the practice of farming resulted in the interactions in the actor-network.

Controlled traffic farming as a translation took the form of a black box. Using the actor network infra-language a black box is the term used to describe an alliance for transforming and translating a diverse range of interests so that an object of controversy is no longer subject to contestation and dispute (Higgins 2006). This is not to suggest that controlled traffic farming is a controversy, rather an actor network analysis identifies black boxes at moments when they open and expose the parts which hold them together. The parts were exposed when the combine auger did not reach the chaser bin, forcing Leo to over-ride the GPS auto-steering guidance system and manually drive beside the moving combine. Black boxes are a consequence of agential capacity of human and non-humans when the relations between these materials hold and generate an effect. Controlled traffic farming demonstrates the agency between the farmer, and his machines, nature and technology to generate effects on soil and crop yield, which allowed Tony to be competitive as a grain grower in the Australian grains sector.

The relationality of entities is that the entities enrolled get their forms and performances through the relations in which they are located (Law 1999 p. 4). This explains why farm productivity differs between farms even when climate and enterprises seem to be the same. To explain further, if Tony planted Trojan wheat in a field, and the following day Wayne borrowed Tony's John Deere disc air seeder to plant this same variety of wheat on his farm, and theoretically both crops were sown at the same seed and fertilizer rates and received the same rainfall during the growing season; the fields will not average the same. To begin, Tony's wheat is translated into a controlled traffic farming network, where different entities are enrolled to produce the crop. Wayne's crop is translated into a mixed farming enterprise, where sheep as an entity are immobilised in the network and generates a different effect. The same kind of difference can be explored for the other entities enrolled such as farm size, software, grain marketing strategies, rural finance and so forth.

The actants enrolled in the networks on the farm can be actor-networks themselves, e.g. controlled traffic farming, GPS auto-steering technology, prime lamb production, John Deere, Walker's Machinery, Trimble, and Telangatuk East. The networks also enrolled entities not limited to the physicality of the farms. Actor network approaches bring with them a value of time and a stored energy from historic associations. The CTF scientists, farm succession, the labour by Tony's brother and father, the trip to outback NSW to visit a farm with a grower group which

Tony no longer subscribes to, all add to complexity of the heterogeneous network. External entities are enrolled and mobilised as actants into the farming processes: seed, machinery dealerships, John Deere's data storage facility in Brazil, education, work experience, and weather forecasts. The kind of entities and actors that are enrolled or not enrolled into the network and how they are enrolled is characteristic of the enterprise (Noe and Alroe 2003). Comparing Tony and Wayne's education, technical training and cropping work experiences prior to their move home, together with the implementation of CTF and yield monitoring references, the difference in the number of relations in each network can be used in 'summing up' that Tony's average crop yields will be different to Wayne's average yields.

The sociology of translation relies on observations and artefacts. Farmers' intentions are not really known but they can be imagined through what remains afterwards. Tony and Wayne's goals may have begun by determining the crop types and varieties based on the paddock rotation, market demand and price, balancing nitrogen against the climate outlook, using retained seed, and/or keeping production costs low. Wayne may have considered achieving ample stockfeed for his sheep, with surplus grain to sell to Jake.

Social research on farms typically seeks the barriers of adoption suggesting that farmers have limited choices in their actions. Noe and Alroe (2003 p. 6) oppose this idea, offering that actor networks are built on choices, but there is no master plan prescribing the mobilisation of the network and there is no platform for making these choices rationally because the network must establish its own schema of rationality. They interpret this as when you ask a farmer why the farm is organized in the way it is, the researcher will often get the answer that it is because it is the only rational way to do it, because of … etc. And the argument leads to a place where there was no choice (Noe and Alroe 2003). Only through a reflexive communicative process of the actor-network, the fact of choice becomes visible (Noe and Alroe 2003).

Latour (1986) states that society is not what holds us together, it is what is held together. "Social scientists have mistaken the effect for the cause, the passive for the active, what is glued for glue" (Latour 1986 p. 276). The Australian agricultural sector, led by the Agriculture Minister, do not hold farmers, commodities, trade partners and companies together. Practices, as an act of doing, are privileged over ideas. So rather than assuming that structures exist or actions will occur, associations locate knowledge in activities, events, processes and sequences. Power is not something a human may possess nor hoard; either they have it in practice or not, as others have it. Latour (1986) identifies two sources of power. When someone has power – *in potentia* – nothing happens and they are powerless. When they exert power – *in actu* – others are performing the action and not the subject. Power over something or someone is a composition made by many people (Latour 1986 p. 265) and for farmers this composition is extended to their machinery and technology. The amount of power exercised varies not according to the power someone has, but to the number of other people who enter into the composition.

Controlled traffic farming consisted of a composition of actants. Power over something or someone is a composition made by many (Latour 1986). Controlled traffic farming had power as it made Tony, Leo and the staff from Walker's Machinery abide by the invisible road rules in the field. Wayne knew that if he wanted to implement a CTF system he would have to remove some trees. As a performative behaviour, it gave Tony identity, and it made Walkers strive to translate his farm in their own network strategies by demonstrating the new combine in the aim to make a sale. Controlled traffic farming enrolled the GPS guidance, software, farmers, machinery widths, machinery manufacturers and made them follow the system even during a period of transition; there was little room for creativity and self-expression. Only momentary decision making occurred to disengage from guidance to steer around the remnant paddock trees to avoid collision and turn at the end of the paddock during operations.

Like power, agency as a composite produces an effect. Controlled traffic farming is a pre-determined system created by others for farmers to follow through modified machines and utilisation of technologies to follow. Agency is what has to be explained by the action of others who enrol. This is evident by the memberships to Australian Controlled Traffic Farming Association, the diversity of CTF research projects, the financial risks to farmers to adopt CTF, the factory standard machinery to fit CTF multiples, and the after-market axel and auger extension kits to keep the system alive. All of these effects support the hypothesis that CTF as a collective assemblage of actants that have agency.

The glimpse at the remote control app to override the driver of the combine demonstrated that agricultural robotics is nearby, removing farmers from their machinery and placing them elsewhere in the network. It's predicted that farm operations will be undertaken by swarm-like micro-machines. This theme demonstrates that farmer agency will not be lost when robotics become normal practice. The assumption that farmer agency disappears as technology replaces manual work is not correct. Creativity and freedom in open fields may decrease, and research and development may be left to the experts, but farmer agency, when we understand this in relational terms as a collective assemblage to generate effects, will always remain.

Theme four: Nature

Grain production co-mingles with the landscape calling on this theme to specifically explore the role of nature in farming practices. According to Latour (1998) all forms of political thinking and action must have an environmental dimension for the spaces of nature cannot be confined to a few fast-shrinking pristine sites (in Castree and McMillan 2001). Farming has never been a pristine site and nature is not confined, but consideration to the politics of nature in farm production makes for a rigorous analysis. This theme contributes to the studies of science and technology to explore the critical synergy between nature, humans and technology in farming practices.

Nature is not ontologically separate to farming because the methodological approach shows that translation constantly remakes the entire network. This actor network perspective includes the spaces where grain growing farmers' are said to oppose nature, such as standing paddock trees and compacted soil. These jumps between humans and objects are both hybrid and real.

Theoretical approach for nature

Critical human geographers' approaches to nature are well cited. They trespass over the non-human world and the grounds for understanding it, claiming that nature is not at all, or simply natural but in fact a human construction (Castree and McMillan 2001 p. 209). In the past, geographers and others have imagined nature as the anti-thesis to society, whereas recent geographers recast nature as indeed social. Moreover in farming, truth is defined by farmers' ideas about the physical environment and how it actually is on their land.

The idea that nature is a social construction suggests that even if there were an ontologically independent real world our empirical observations of it would still be biased by our socially constructed preconceptions of it. A natural realist may argue that farming is a process that works with nature to grow food sustainably and ethically. A social constructionist may argue that farmers are actors which change nature to conform to their image of farming efficiency and environmental stewardship. Farmers' construction of nature is relatively unknown, but it may be related to other things that they can use to overcome it for farming productivity. Each of these positions shares an inability to imagine human-natural relations in a non-dichotomous way (Castree and MacMillan 2001 p. 210). Actor network theory moves the researcher past this impasse and to think beyond this nature-culture dualism.

Binarism refers to the habit of understanding the world in terms of conceptual dichotomies (Castree and McMillan 2001). Agriculture and farming are laden with these examples. Soil classifications such as arable/non-arable and productive/ un-productive are used,

together climatic classifications such as high, low and medium rainfall zones. These binary terms are generally contextualised with land – a networked imbrication but still limiting in its notion. Tony, the farmer said that "if he couldn't shoot it, he'd cut it down, and if that didn't work, he would paint it". This was a jovial and somewhat crude interpretation of what he thought of nature and his actions to improve its condition.

Farmers and agronomists define weeds as plants growing in the wrong place. Weeds are viewed asymmetrically. Yet any growing plant has the potential to enhance soil microorganisms, attract beneficial insects, and photosynthesize. In the Wimmera Southern Mallee, and other cropping regions around Australia, the re-generative farming movement of cover cropping is currently challenging this asymmetric view. These farmers are growing multi-species crops post-harvest to improve soil health through root biodiversity. Nature is used to overcome nature, which in most cases supports to the constructions of farming sustainability – drilling bio-char, deep ripping, clay-topping, zero-tillage cropping, perennial pastures, spreading animal manure, carbon sequestering techniques, multi-species cropping, revegetation, native pastures, and stubble retention, are referred to as regenerative farming practices. Nature remakes nature, as a tool for agricultural sustainability, and as a force it overcomes farmer-vulnerability through improved soil fertility.

Actor networks are a modern ontology which recognises hybrids such as animal DNA in plant materials. This ontology of not-quite-natural/ not-quite social entities rejects the pure transcendence of binarist thinking and urges us to see them as outcomes that illicitly compartmentalise a disordered and heterogeneous world (Castree and McMillan 2001 p. 211). Actor networks are useful in re-conceptualizing the social life of the GM hybrid Frontrunner® canola. Tony became a Frontrunner® grower; buying and sowing the seed re-cast him as a hybrid and it enclosed him in the Intercont© growers' program black box.

The issue for agriculture as a natural production system remains hidden behind ideologies. The modern commercialisation of the family farm, together with the growth of the farm services sector, offers a dynamic structure that is determined by the degree and form of the industrialisation of nature. Contention exists when farmers feel the need to overcome nature to merely maintain and improve their position in political economy. Deforestation, draining and sowing wetlands to crop, rock crushing, and levelling lunettes, may each be environmentally destructive methods to farm but they are also indicators of the conditions for farmers to participate in the free market.

Based on the growth of the farmer services sector and the government stepping back from agricultural extension, is it fair to deem farmers as those solely responsible for exploiting nature? Perhaps political economy encourages farmers to exploit nature to overcome their vulnerability. I argue that farming relations should not be explained only in terms of capitalist relations. Removing this binary-thought from this debate shows that nature is nothing, and neither

is trade, money, land, farmers, services sector and so on, if it is not defined in relation to other things. Actor networks let us pick at the stitches that holds cropping practices together.

In what follows, nature is allowed to tell its own story through its relations. Nature was embedded in a range of non-humans and objects and these places offer the reader a somewhat dis-joined, yet meaningful analysis of farmer-agency. The following five sub-headings are discrete and inter-related. They look for where technology and nature collapse binaries and the hierarchical notions of agriculture and nature by advancing relational materiality.

Trees and soil

Wayne's paddock of barley was scattered with over 30 standing native trees. One hectare in the north east corner was densely timbered. It was hard to know the origin for this small forest. It could have been natural revegetation from a few ancient trees, or a rogue farm forestry plot left unattended for twenty plus years. This space was too dense for any significant under growth of grasses. It forced the paddock operations to work around this site leaving the paddock shape resembling a sandwich with a bite taken from its corner.

Wayne was considering transitioning to wider machinery but he was concerned with the subsequent need to remove some of the trees in the paddock. Rather than being co-shaped by technology, in this moment Wayne demonstrated that he was co-shaped by nature.

In terms of soil, Wayne said that he did not own anything below the top 10 cm of the soil. This included the standing remnant eucalypts with their long roots implanted in the soil. Wayne believed that they too were not really his trees do to as he pleased. He spoke of the legislative requirements to obtain a permit for clearing the trees in his paddocks. He mentioned the names of farmers nearby who choose not to comply with the law. As per Callon's review of scientists' and fishermen's attempts to conserve the scallop population in St Brieuc, the scientists spoke for the scallops (Callon 1986). This was because nature cannot speak for itself. Like these scientists, Wayne spoke on behalf of the Victorian government and native vegetation clearing regulations. For Wayne, nature translated as rules and regulations which co-shaped his language, actions, beliefs and culture.

Yet Wayne he did not speak for the soil in the same way that he spoke for the trees. For Wayne, soil as an actor didn't carry with it a network that included regulations. Wayne did not practice soil conservation practices to enhance soil fertility and conditions. The photograph in figure 33 reflects this and offers a story of the paddock's history. In the photograph there is a minimal amount of last year's straw remaining on the ground, which means that there is extreme sunlight exposure leading to soil moisture loss. The parallel lines remain from sowing in autumn that year. The seeder cut trenches during seed placement and the plant emergence was poor. This could have been due to blunt discs on the seeder or Wayne was simply sowing too fast. Most of the photograph is plant-free, indicating that there is limited nutrient availability and severe soil

compaction about 20 cm from the surface. This photograph also shows the reality of nature by the growth of the native tree seedling on the bare soil. It confirms that nature recreates itself through the process of regeneration.

Figure 33. Regenerative seedling of Eucalyptus camaldulensis (River Red Gum) emerging in the barley crop.

On Tony's farm while I was in the header cabin with him, he pointed out which of the trees in the paddock he thought he may need to remove. This was part of the controlled traffic farming transition into the wider machinery. Twenty years ago, when Tony first started CTF many trees were limiting their machinery manoeuvrability. With his family, they worked out which standing paddock trees were the priority to cut down to maximise the straight lines in the paddocks. Now, shifting to a wider CTF ratio, Tony was faced with needing another 3 m between some of the trees and fences that were less than 12 m apart. He was no longer working with his family for additional labour to help with the vegetation removal. In this, Tony didn't talk of this task with joy or pleasure to overcome nature, rather he indicated that clearing standing remnant trees was an onerous and intensive clean-up job. Much of his time would be absorbed by directing contractors which trees to knock over, and where to move and stack the limbs. When the bulldozer and loader were finished, Tony would then need to stick-pick the smaller branches by hand and burn the piles of timber in time for sowing.

In words, Tony did not speak on behalf of the soil but by enacting CTF he spoke for it through this farming method. Controlled traffic farming minimises compaction, increases micro-organisms, and improves rainfall infiltration, and in concert with other production-related actors, crop yield is increased. The CTF science and technologies became a force for Tony to control nature. Tony acted to remove trees to enable the efficiencies of his CTF system by following the CTF scientists. This CTF science and technology enabled farmer-agency to control nature. In

doing so, it re-positioned Tony's business in socio-political economy through increased grain production and farm productivity. Technology mediated nature through farmer-agency.

Even though technology became a force for Tony to control nature, nature too held power in when it was in a group formation. A plantation, or a cluster of trees, are black boxes on Tony's farm. Together they produce an effect such as a windbreak, wildlife habitat, and salinity mitigation. The Landcare movement of the 1980's had spurred Trevor and Sybil to plant trees and fence off the waterways on their farm. They also planted shelterbelts for stock. Tony liked the plantations of trees in places where it did not interrupt his cropping. The purposefully-planted trees in the plantations along laneways and in the fenced-out and meandering creek lines created the roadmap for his CTF. These natural assets set the A-B lines for his GPS. Very few of his paddocks were parallel because natural assets distorted the shape. Nature held power over technology when trees, fences and waterways were collectives of objects. Individual paddock trees held less power unless they were hollow and protected by government regulations.

Seed technology

Seeds naturally self-produce. They are a public good which farmers, horticulturalists and even gardeners use for free by retaining the seed. Capitalism has found its way into this naturally reproductive farming economy. Scientists remake nature conceptually and physically in the pursuit for profitability through the products they commercially release (Castree 2001). Mendelian genetics explain plant heredity. Any single crop is made up of strains but by inbreeding a crop the hybrid vigour is greater than a non-hybridized variety. These hybrid crops produce un-reproductive or reproductively-challenged seeds. If these seeds were to be planted they would not yield nearly as well as the crop from which they originated. Considering plant science, farmers' actor networks are altered by the crop varieties they choose. The origination of the seeds that are enrolled by farmers offers insight into the strength of network ties. As previously discussed, the incentives offered to farmers by Intercont© to participate in the Frontrunner® program resulted in an extensive, internally strengthened and stabilised network based on the science in the seed. Seed became the vehicle for capital accumulation for both the breeder of the seed and the farmers who chose to grow it.

Two years earlier, during the distribution of farm assets for farm succession, Tony's brother Jimmy was allocated the farm's SP sprayer. Tony kept the original, aging, trailing Goldacres sprayer. Tony, the actor network hybrid Frontrunner® grower, needed to desiccate and crop-top each year regardless of his limited machinery. The Frontrunner® canola was far too tall for his tractor to tow the boom sprayer over it, so Tony was forced to decide to hire a SP boom sprayer or employ a spray contractor. Successfully enrolling actants to spray his crops prior to harvest came down to finding an available agent.

The Frontrunner® canola averaged 1.75m in height. Tony hired an SP sprayer from Paul but even then it was still not quite high enough to clear the crop. There was minimal clearance between the crop canopy and the undercarriage of this machine. Seed pods were damaged by the machine when Tony applied WeedMaster™ DST glyphosate. Seeds were knocked from the dry pods, landing on the ground and decreasing the potential yield.

Tony blamed his work inefficiency as the cause for this interruption. Collectively it took a sequence of many days from the time of waiting to hire the sprayer, sourcing nozzles, picking them up from Warracknabeal, and actively fitting the new nozzles on the boom. Tony thought that if he had been more timely with the spraying operation the crop would not have been as tall, allowing the sprayer to clear the crop.

This sequence of activities offered controversy between nature and technology. Translations and mediations were taking place simultaneously but it wasn't until after Tony knocked pods from the crop that the actor network could be effectively analysed. This network approach could be back-dated to different points in time. Firstly, canola was traditionally windrowed. Windrowing nullified the need for desiccation and crop-topping. It was only since new canola varieties became technologically advanced with anti-pod shattering traits, that Tony started direct heading standing canola. Secondly, since farm succession and the division of assets, Tony was without the technology of an SP sprayer to pass over the heads of the standing canola before they grew too tall.

Intercont©'s genetically engineered hybrid canola was taller than the under carriage of the John Deere's sprayer. Tony's detour was to purchase the tallest available John Deere model SP sprayer to clear the next crop in 2019 and beyond. The seed technology was mediating Tony's investments in machinery and technology because this Frontrunner® technology aligned with his capital interests. In this moment, the John Deere SP sprayers became the more like an intermediary, because for Tony they were predictable in their cost, size and output as a crop protection tool. And together, the SP sprayer, tall hybrid canola crop, and Tony, were agents in the crop-topping sequence in the actor network.

Nature at work

Nature does not stop at the farm boundary. Rain, run-off, pest animals, air-borne diseases, soil and vegetation types, sunlight and weeds were all part of a dynamic ecosystem that existed on a catchment-based scale, and were actors in these farm networks. It's when these natural entities deployed controversy, is when actor networks began to appear.

The shortcoming of actor network theory is that it's somewhat problematic to observe and analyse humans and non-humans shaped by nature through movements and enrolment. It is even more problematic to see how nature naturally acts from human activity. Nature can be shaped by humans, both deliberate and indirectly, often with a time lag. On farms the obvious

and visual movements include vegetation removal, quarrying, laneways being made, earthworks, property boundaries, species eradication, monocultures, and re-vegetating by planting trees. Some movements immediately lead to public prejudice. The field observations throughout harvest included visual assessments of the soil, tree density, dust, rainfall and so forth. No additional scientific methodologies were deployed because even though soil science drives true knowledge, scientific knowledge is objective in the sense that it is not based on subjective belief but on an objective observation of an independent reality. If actor network theory was used to treat the farms as soil science laboratories, the thesis offers subsequent limitations because nature challenges the authority of scientific knowledge.

Figure 34. Predatory wasps feeding on the aphids in the canola tip.

The photograph in figure 34 shows that even when a human is not in the paddock, the canola remains social. The dark-coloured colony of aphids can be seen in the tip of the plant. To the right of the stem, a small wasp is sitting on seed-pod, indicating that there is a presence of wasps feeding on the pest aphid larvae.

Tony viewed these aphids as pests that threatened his productivity and potential profit. It was a binarist, asymmetrical view. He looked for nearby experts to share his interest, so he contacted the agronomist for his advice. The agronomist became Tony's obligatory passage point to direct him. The agronomist provided feedback based on his *a posteriori* experience. He confirmed that aphid populations were in the tips, but he recommended that Tony did not apply insecticide due to the predatory wasp population feeding on the pests.

This is an example where nature created the movement as the mediator in the network. In a moment of time, the power dynamic shifted from the farmer to the agronomist. The agronomist held power to immobilise the farmer to enrol more agents, such as the sprayer, insecticides and the chemical re-sellers in Horsham, to overcome this aphid infestation. Even

though the agronomist could have instructed Tony to buy insecticide and hire a spray contractor to help others profit from his pest problem, the agronomist did not mediate these actions.

Similarly, Black Leg disease was an actor in the same crop. The pathologist looked for the fungal infection which is spread to living plants through wind-borne spores. Firstly he searched for hyphae in the leaves. The pathologist then pulled a plant from the ground and used his secateurs to cut the stem above the roots to inspect the cross section (see figure 35). There was evidence of disease in the vascular system of the plant, but at very low levels. The pathologist, the agronomist and Tony collectively decided that the disease would only result in a low penalty to the overall yield potential because it wasn't far off from being harvested.

Figure 35. Cross section cut of the canola plant shows Black Leg disease in the cellular plant structure.

The standing gum trees (*Eucalyptus camaldulensis*) and grey box trees (*Eucalyptus macrocarpa*) together with their fallen limbs in the crop were another example of nature rearranging itself without humans. The humans had to negotiate these natural obstacles using the machinery and technology they were operating. As research artefacts, both the yield maps and the aerial photographs demonstrate interruption as a meaning of mediation.

Bulk commodities are linked back to the farm

The relations between institutions and farmers must always be mediated by someone – or something like technology, regulations, Acts of Parliament and so on. One of the mediators between nature and capitalism was the National Growers Register (NGR). This may seem an unusual place to offer this structural and bureaucratic mechanism for trade, but it's a network that mediates the gap between grain delivery and the payments for bulk commodities. In respect to this theme, the NGR also helps to regulate how much nature can be associated with grain production before farmers are penalised.

To begin, when farmers deliver their grain to the receival site a sample is taken, tested and often stored. The NGR enables these movement. This is a database of farmers' business and contact names, and their bank account details. Grain payments are direct deposited to farmers and the NGR facilitates this information exchange. The NGR gives farmers a card that states their unique grower registration number. Every delivery of grain to a trading corporation or grain storage warehouse requires these details. When Tony trucked Frontrunner® to Footscray, each load was recorded with his NGR number and the registration of the truck that made the delivery. They were grouped together as a record of where the grain came from. Humans and non-humans acted on behalf of the commodity. Within 14 days of delivery Intercont© paid Tony for the canola because they had his trading details though his NGR.

The NGR connects subscribers to farmers. Subscribers, such as grain buyers like Intercont© can access farmers' details and payment records when they are given authorization. Farmers also need to supply this identifier every time they buy seed. Farmers are invoiced by the seed company when they sell the grain they grow, so that the plant breeder can collect End Point Royalties (EPR) for the intellectual property of the seed. The NGR number is linked to the mandated percentage of production farmers pay as a levy to GRDC. Some farmers are member of political lobby groups, like the Victorian Farmers Federation, where their annual fee is linked to a production percentage and facilitated through the NGR. Farmers may also choose to make voluntary payments to registered charities, such as football clubs or hospitals. All fees and levies facilitated by the NGR is automatically deducted as a percentage of the delivery value. These levies, facilitated through the NGR, are uncapped and aggregate with the grain sold.

Actor network theory supports relational thinkers in that phenomena do not have properties in themselves but only by virtue of the relationship with other phenomena. The red and white plastic NGR card with a barcode, the grower number, plus a name do not mean much upon face value. However this object is the mediator between capitalism and nature. It links phenomena far beyond the truck tipping-off the grain at the receiving site.

Farmers are at risk of being penalised by grain buyer for nature's presence in the grain. The Footscray crush plant measured the admixture percentage at 1.4% in the Frontrunner®. This was the percentage of foreign material in the grain sample originating from nature: gumnuts, leaves, bits of stick, and snail shells, are a few examples of what can be found in grain. Exceeding the limit placed on the sample by Australian grain quality regulators generally results in a financial penalty for cleaning the tonnage delivered, or the refusal to have the truck unloaded at the delivery site. Some of these constraints remain socially constructed. Technology will continue to give farmers power over these threats to price as headers advance in their threshing to reduce admixture over time. These natural limitations will determine the pattern and trajectories of appropriation.

Canola seed network comparison

Seed technology enrols different actors into farmers' networks. In 2018, canola grew on both sides of Schofields Road in Telangatuk East. The crops were sown on the same day and they flowered at similar times. For any person driving along the road, not many differences could be seen except that one crop was taller and denser than the other.

The tall, dense crop was Tony's genetically modified hybridized Frontrunner® canola that had been bred by Intercont© and distributed by GBA Ltd. The crop on the opposite side of the road was Wayne's Bonito canola. This was an open pollinated Triazine Tolerance (TT) farmer-retained canola bred by Nuseed (see Wayne's windrows of canola in figure 36). These varieties enrolled different actors in their networks as shown in figure 37 and figure 38 below. These diagrams illustrate that even when neighbouring farmers both grow canola, their networks can be very different based on the technology of the seed.

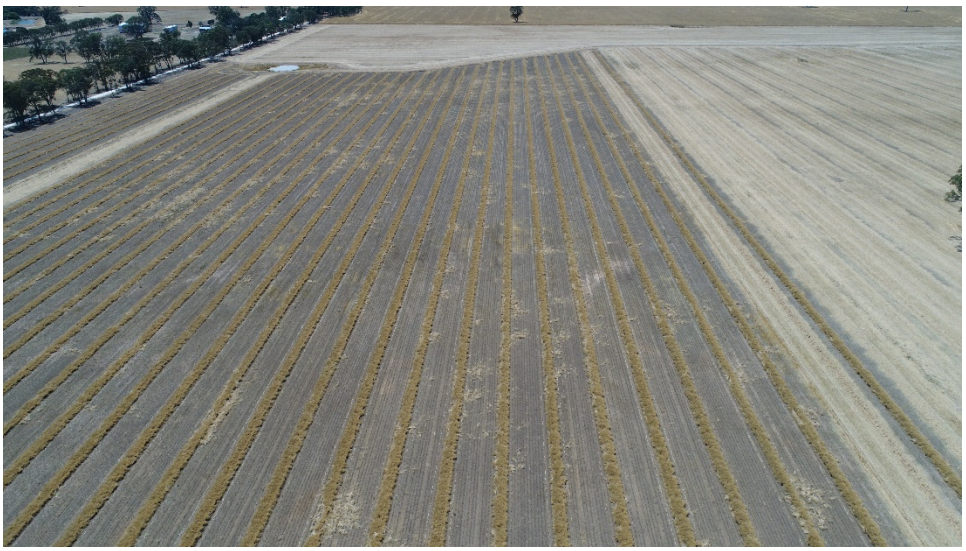


Figure 36. An aerial photograph of windrowed canola, with the paddock partially harvested to the right hand side of the image.

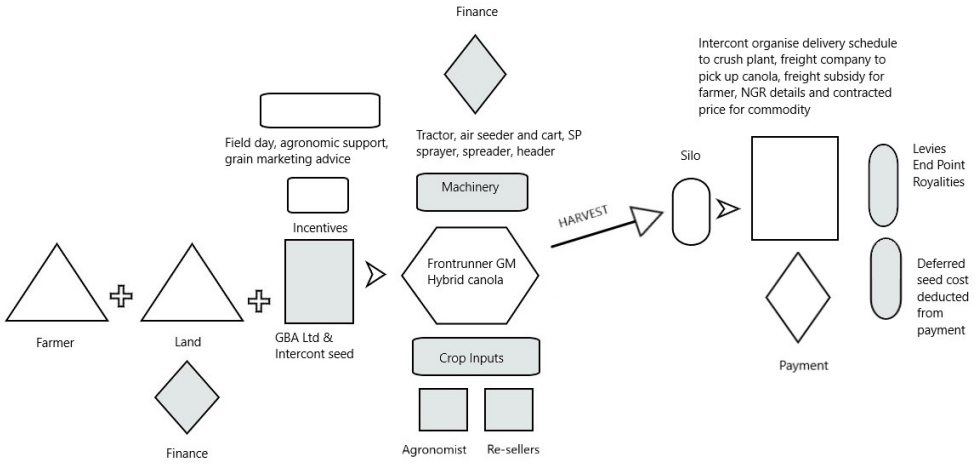


Figure 37. The hybridised seed does not permit retention of seed, creating a chain of actors in the farmer's trade of the commodity. The shaded shapes show what farmers pay for.

When farmers choose GM seed as they are biologically guaranteed to buy new seed stock the following year. With which company the new seed stock is sourced from is not guaranteed though. Intercont© as a black box, stabilised the actor network for Tony and other Frontrunner® growers in the closed-loop marketing system to deliver the seed to the crush plant in Footscray. This seed could not be retained nor sold anywhere else based on its speciality oil traits. Tony's inputs were relatively structured. The delivery schedule of date and time for the canola to be tipped off at the crush was arranged by Intercont© as well as the haulage contractor that carted the grain from the farm to Melbourne. There were more actors in this network than in a retained seed network. Many actors shared the same goals to produce the crop to result in the end product of a refined high oleic canola oil for the food industry (refer to the diagram in figure 37).

The politics of nature was the multi-national corporation that enrolled farmers to plant GM seed with a corresponding prescription to ensure optimal plant growth, so that the farmers reflect success as their own. Hybrid GM canola seed are the coalescence of power relations. For one growing season the farmers spoke for the crop, then they relinquished their entire Frontrunner® production to the company of seed origin. Intercont© spoke for the farmers. The company held their NGR details, their canola, payment details, and their deferred seed cost. Through genetic engineering nature was recast as a corporate commodity.

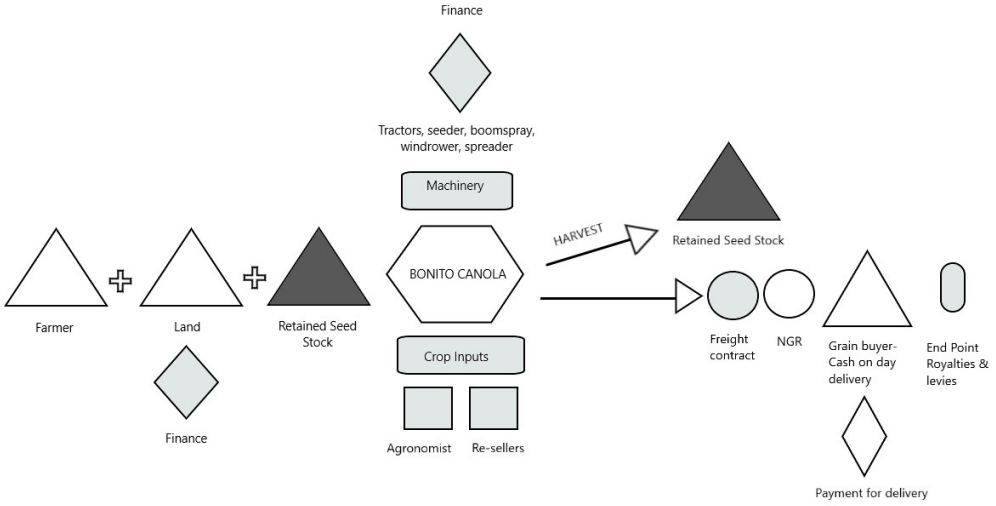


Figure 38. The retained seed is shown in the dark grey triangle. The shaded shapes show what this farmer pays for.

Wayne was not biologically guaranteed to buy new seed stock because he used a variety that can be naturally reproduced. All of his crop varieties were farmer-retained. He and Burt were anti-GM crops. Effectively storing seed became an additional operation for their farm practices to ensure a reliable germination the following year. It also meant that Wayne did not need to pay for, or defer the payment, for his seed. Wayne does not use forward sales contracts either. At harvest he calculated the tonnage of canola to sow the following year, and then he deducts this sum from his final harvest. This allowed him to cart the remaining grain to the closest receiving centre for a cash contract. Freight, EPRs and levies were deducted. Wayne's actor network was relatively simple with his GRN. He retained all of his barley for sheep feed. Wayne is a network, but less actors are enrolled.

Conclusion to theme four

Nature is inherent in dryland broad acre farming. The landscape of the research setting was present as an actor in the results. The farmers' relations to their landscape where they worked, and to nature as a whole, was modified by capitalism. Technology could only go so far until constraints were recognized through fertility, reproduction, climate, land, space, and genetics. These findings demonstrate that nature is nothing if it is not defined in relation to other things. It re-conceptualised the socio-natural imbrications. Using agnosticism and overcoming binarism, these findings gave symmetry to nature and farming practices. Above and below the ground nature was remade but defined only in relation to other actors.

An actor network approach traced the actors, showing that cropping is not dictated by the natural elements of the landscape but by the actual relations between the changing actors within the network. There was no uniform entity that caused trees to be removed to increase arable land for Tony. By setting aside a binary ontology, and finding that different associations were woven

together, grain production phenomenon in the Wimmera Southern Mallee is explained. This research also highlighted post-human actor networks that were mediated by non-humans including end point royalties, plant breeders rights and GM seed. It showed where capitalism infiltrated nature in political economy to ensure that farmers' profitability was shared with others.

Theme five: Gender and agriculture

Women and farming are a long standing and politically sensitive topic. The concept of women on farms is founded upon opposition between political economy and domestic economy, which such forms of production confound (Whatmore 1991). Marxism reduces gender relations to a binary argument, embedding families and women to reproduction, and farming and men to production; two different spatial and functional roles. When we seek a Marxist analysis of human-to-human relations in the farm business narrative these social relations are different in their analysis because the concept of petty commodity production in political economy excludes families and households. The daily capacity to reproduce family labour and the generational capacity to reproduce family property are posed as important and distinctive features of petty commodity production (Whatmore 1991 p. 30).

The purpose of this theme is to offer an understanding of how farmers reposition themselves and exercise control to overcome exploitation through their relations. Actor network theory works to overcome the binary Marxist arguments of women on farms. A main tenet of this theory is that society is an achievement of people engaged in producing a variety of associations of human and non-human elements (Lagesen 2012). This work has sought to understand the actors in farm networks, and how they come to be stabilised or generate effects as an assemblage of agents. This theme specifically explores women in networks and how they may generate effects as a collective. Actor network theory can be used to overcome the asymmetrical treatment of women. It may be used to recuperate the voices of actors that have been marginalized. It is this space where the theory offers an interesting possibility for perceiving both gender, machinery and technology as heterogeneous and malleable objects.

Lagesen (2012 p. 444) suggests that it is helpful to be most specific about what it actually means to do gender, and how to analyse the role of technology and machines in the doing of gender. Actor network theory claims that doing gender is an on-going movement where associations with bodies, norms, knowledge, interpretations, identities, technologies, and so on, are made and unmade in complex ways (Lagesen 2012). Given that the process of translation constantly remakes the entire actor network, gender is fluid and flexible because new associations are established, while old ones are dissolved. A widely acclaimed example of a feminist co-constructionist analysis of gender and technology is the study of the microwave oven by Cockburn and Ormrod (1993, in Lagesen 2012). Microwaves are associated with cooking and food preparation as gendered roles.

> [A]t first, the microwave was designed to be sold as a masculine ‘brown good’ along with televisions, videos and hi-fi systems. It was marketed to men,

> assumed to be single and not particularly keen cooks. Thus, the microwave was developed and advertised as a high tech, 'masculine' gadget to reheat pre-prepared food. However, this marketing failed, and the producers decided to change the microwave and its configured users. The new targeted group was women, and the microwave was redesigned for 'serious', versatile, feminine cooking. It was then sold as a 'white good' among products such as conventional ovens, fridges and freezers. (Lagesen 2012 p. 443)

This theme presents gender as a re-assemblage with a focus on machinery and technology through the relations of farming. In this work thus far, the people who have primarily produced a variety of associations have been men. Very few women were directly traced in this study. As a consequence this theme specifically questions whether women as a gendered concept and their relations subject to gender, are fit to interpret assemblages based on this low sample. The purpose of this theme to find a gendered meaning through re-positioning farms in political economy. This work offers new opportunities to use actor networks to study women in agriculture.

Lagesen (2012) uses the actor network example whereby a woman's life may change by being trained as an engineer. When new objects are made part of a woman's life, new relationships are made, to other humans as well as to non-human entities. Latour (1987) proposes that the next step, after new uncertainties or controversies have been analysed, is to study how involved actors become in working to overcome those uncertainties and to stabilize the controversies. This can be made to happen by finding new routines or standards. Thus, the doing of gender changes (Lagesen 2012).

This research tells the story of three women in agriculture. Two of these women came in direct contact with the research as participants. Firstly, Louise, the plant breeder from Intercont© and secondly, Wayne's mother, Robina. These contacts were meaningful as they offered their perspectives and demonstrated their roles in connection with crop production. These analyses provide a comparison of a younger, corporate, and highly skilled wage labourer with an elder, unpaid, domestic farm worker who was caring for her labouring son. The third woman in this theme is myself. As a feminist reflexive researcher, my personal and gender-biased experience plus my *a posteriori* knowledge brings meaning and strengthens this discussion. This is the final discussion theme for this thesis, and it is specific to women in farming networks.

The traditional farmer's wife

Wayne's parents, Robina and Burt live 500m from Wayne's house, just beyond the woolshed and stock holding yards. For Wayne and his wife Janine, farm succession has meant that they own approximately 600 hectares of land, all of the cropping machinery and 2000 cross-bred sheep. Burt and Robina continue to farm some of their own land, they maintain their own merino sheep flock, and they have a share in the crop production. Their business arrangement is

complex. Wayne also has two brothers who Burt and Robina will consider in their estate. Over recent years there has been an active generational process of reproduction in terms of the transfer of capital through social institutions of kinship, filiation and patrilineage. Wayne and Janine live in the house that was formerly Burt's parents' home. In the last few years Robina commenced her first off-farm paid job, casually cleaning and cooking at the Wilderness Resort on the Glenelg River.

Robina continues the tradition of cooking for the shearers. One week every September, she is responsible for cooking the hot lunches for the shearers, the rouse-about, Wayne, and Burt, who all work in their shed for five or six days continuously until all the sheep are shorn. Janine makes the morning tea and afternoon tea each day, with dissent. The members of the district are all aware of Janine's dislike for shearing during the school holidays. But Burt and Robina have always shorn sheep during the September mid semester break, seeing no reason for change. The shearers are booked for this shed at this time each year. Janine requested a change to the date, but it was denied by Wayne, Burt and Robina. Janine, as the younger woman in the farm business could not de-stabilise and re-stabilise this traditional shearing network which enrolled contract shearers, wool staple length, and stock husbandry schedules.

During the fieldwork Robina brought sandwiches and fruit to the header for Wayne. She drove the farm utility vehicle with two dogs in the front of the cabin. She checked on her son with genuine interest and care, asking him about the crop and how the header was going. Robina had made an effort with her appearance with neat hair and clean clothes. There was no expectation for Robina to interact with the machinery and technology nor the physicality of harvest, such as opening field bin lids. Her relation to the machinery was through the provision of food to Wayne and Burt. Food preparation was Robina's role. She kept the machinery moving by ensuring that her family did not have to stop the operations. Doing gender was doing the lunch and afternoon snacks for the men on the farm. Robina's agency was a property of roles in relation to Burt and Wayne's activities, their location, time of day, and having supplies in her kitchen to prepare something to ensure farming could be performed. Robina did not need to operate the header nor drive the tractor that was towing the chaser-bin because her family was capable of fulfilling these operations. Rather, Robina mediated timeliness and efficiency. She was necessary in her family and farming network that performed the harvest.

Janine was not at home at the time of this fieldwork. She had taken their children camping at a local reservoir with Jake, his wife and their family. Janine has driven the chaser bin during harvest in the past. She also completes the quarterly Business Activity Statement (BAS) for the Australian Taxation Office. She shares liability with Wayne for machinery and land as a business partner. Janine has part-time casual employment at the local school as the gardener plus a start-up furniture re-modernisation business on the farm. She is an active community member. Locally she plays tennis in summer, and she volunteers for the football club during the winter

season. She holds an executive position for the show society. Her relations with others off-farm are localized, structured and stable.

On this day during harvest, Robina shared Wayne's interest. The goal was to finish harvesting the barley before the Total Fire Ban that was forecast for the next day, as well as move the mob of sheep into that paddock to let them feed on the stubble. At this time Janine wasn't sharing the same goals as Wayne; she was dis-interested in the harvest. Wayne said that he wanted Janine to drive the chaser-bin to let Burt get on with other jobs. The theory of actor networks suggests that negotiations were the precursor to this arrangement.

Technoscience can explain unreliable machines or the co-shaping of humans by technology especially during peak farming seasons such as harvest when detours and enrolments occur frequently and networks are held precariously to complete the operation and protect capital interests. The question is how de-stabilised does a farm business become when an agent, like Janine, who is a mediator through marriage does not share the same goals? Even when she shares a capital interest, the consequences of her being unreliable to share goals in the business network still remain to be seen. This is a limitation of actor network theory as it is best used after events have occurred. However, the binarist argument of presence/absence is overcome through actor network theory where the boundaries of dichotomies are rejected. Janine's disinterest may be momentary, for maybe two days or a week, offering nothing for longitudinal analyses. Yet considering that farms are black-boxes this one opened at the moment that Wayne's mother brought food and replaced Janine's assumed gendered role in food preparation.

The modern corporate agriculture woman

There was one moment during the canola field day that a gendered effect was noted. The plant breeder, Louise* excused herself at the Kewell site and drove her vehicle home in Horsham, about 20 kilometres away. She needed to use the bathroom. The men at the field day were not placed in this position to excuse themselves entirely as they could be discrete for a few minutes and return to the conversation. Toilet-stops were not planned for this tour, until driving through the township of Rupanyup to stop at the public amenities after the lunch break. This was about three hours from the start of the event.

The tour of the Intercont© office provided solid insights into the busy corporate working life of this plant breeder. Louise was aged in her mid-30s. She was married to a farmer who had leased out his farm, and they had two primary school aged children. They lived in Horsham. She talked of her initial passion to study veterinary science due to her love for animals. At university her science course made her detour to plant science. She realised her skills of simultaneously reading and walking was found to be perfectly suited for negotiating crop trial plots. Louise chose plant science as her career, becoming a breeder for a multi-national corporation.

Louise's practice as a plant breeder involved the heterogeneous gatherings of natural, technological, human and non-human actors. She enrolled machinery, software, analytic tools, and staff to determine canola varieties that were fit for trialling. During the tour of her laboratory actors surfaced as she spoke of the series of negotiations required to assemble genetic viability in canola. Plant breeding was not a matter of individual human skill or cognition. Actor network theory shows that the plant breeder was part of a web of humans, non-humans and objects bringing about canola varieties that were suitable for commercial release with the end product being the high oleic acid canola oil, which was the hybrid networks' goal.

Louise expanded her agency and her roles in relation to many other people, including her family, Frontrunner® growers, Frontrunner® team members, laboratory staff and Intercont© canola breeding staff domestically and internationally. In the five-week interval from the canola field day and the tour of the Intercont© laboratory in Horsham Louise had been involved in other canola field day tours, conferences and field research in Narrabri in NSW. The week after this tour, she was flying to Chile to select parent material. Louise shared an insight into the complexity of her career and her role as a mother. She was the mediating agent bringing the canola's genetic knowledge into the network; she led the FOSS analytics machine after the trial plots had been harvested. The ways Louise assembled canola gene traits as a part of her doing gender appeared as pent-up and pressured. This is an example of the way of doing gender and technology by the way of associations.

The feminist insider researcher

The final example is from my experience of a woman in farming. Here I use the work of Donna Haraway (1991, 2004) with her critical concept of the cyborg which she used to dissolve and subvert gender binaries. Haraway is a contributing pioneer to actor network theory through her insistence of heterogeneity and the focus on practice including human and non-human elements. To achieve this, my analysis focused on material semiotics to altercate essential differences by insisting on the performative character of relations and the objects that are constituted in those relations. These experiences are drawn from my three month period of fieldwork, and it refers to two industry-led events and one very inappropriate email.

The multi-national agricultural re-seller Greenlands, launched a new software program called Upperkut* in Horsham on Wednesday 5 September 2018. It was an information night for their clients to demonstrate the competitive advantage of buying this agronomic prescription system. Upperkut was a brand and a hybrid. It relied on farmers' yield data, sourced seventeen years of Normalised Difference Vegetation Index (NDVI) data from a database, and created an algorithm which resulted in a variable input rate map for their clients' paddocks. It was not a new concept, rather it was about welcoming another company in this market that prescribed crop inputs through technology.

More than 60 people were in attendance and only three of these participants were women. I was one of the women, present as a researcher with my notebook. The other two women were agronomists from Greenlands who were both expected to attend the event as staff.

The Upperkut representative, Jay*, addressed the audience by asking everyone to take a seat at a table. Jay was not married and aged in his early-30s. This was the third agricultural company he had worked for in the last three years. Jay validated the company, demonstrating the merit and history of the organisation. He gave some product details and used digital yield maps to demonstrate his paddock practice knowledge. Jay's presentation concluded with a video clip by British comedian John Cleese about a woman in labour. Cleese played the role of the incompetent-doctor, delivering the baby and then he ushered all of the nurses with the newborn out of the room. The clip ended with the perplexed new-mother left alone and restrained in obstetric stirrups, baby-less and surrounded by exaggeratedly large chrome technical machines. The audience did not laugh but no one spoke in disagreement either. Most of the men in the room were fathers thus had experienced the reality of childbirth.

Jay found the clip very humorous. He concluded his presentation appealing to the audience that sometimes we all feel overwhelmed by technology. Jay's message was that Upperkut will help you to understand what the technology means. Jay had deployed a range of actors to present his speech: yield maps, software screen shots, and an audio visual clip for his metaphor of feeling overwhelmed by technology. This was all in the hope to enrol farmers to subscribe to the program for Greenlands' profit. Considering the model of diffusion, Jay dropped the ball in a puddle to create a ripple effect, and he was hoping that this room full of farmers would keep its inertia by relating to his presentation, commit to the technical program and give Upperkut, and himself as the representative, power.

Actor networks attempt to dissolve asymmetries in the treatment of gender and technology. Yet this confident young man from the services sector, engendered fear. His point of reference was to re-assemble the feeling of being overwhelmed by technology and he related it to women. He did gender by endorsing to his audience a narrative that women and technology are vulnerable. He offered his service as a saviour to the men, ensuring them that he works for his clients so they never have to feel the way that woman did after childbirth, left alone and surrounded by technology that she didn't understand.

I left during the event while the branch manager, Tobias*, continued to talk about his business and what he does for his clients. The event was advertised as dinner. On the tables were a few party pies and as assortment of crackers. I interpreted these small centre plates as an entrée; but I was incorrect. No meals were brought out from the kitchen. The entire event was organised by men. The projector, laptop, cabling, screen, loud microphone, digital clip and presentation slides were all in order. But there was no food offered around the clustered standing farmers or brought to the tables when everyone was seated. I was famished by the time I arrived home.

Latour (2005) calls that the source of uncertainty in group formation is found by tracing what is left behind by actors' activities of forming and dismantling groups. For this group of farmers and services sector on this night, something was never there in the first place. The gender imbalance, and the limitation to this particular actor network analysis shows that there were no women from farms to trace. This absence offers a great insight for social scientists to begin to understand what the social world in the grains sector in the Wimmera Southern Mallee is, or rather, is not made of.

Continuing my experience of the branch manager, Tobias, a controversy was initiated by an email from the agronomist inviting me to attend the CropCo and Greenland's annual crop tour. I replied by email, typing less than three lines, declining the invitation based on the timeliness of the crop tour because it was either side of school hours that made it too hard for carers of children to attend. I also questioned the need for alcoholic beverages on the bus and a hotel stop as part of the professional development structure. The agronomist did not reply to my email. He forwarded my email to his supervisor. Tobias sent me a long rebuttal email. The agronomist had become an intermediary – if my email was a ball he passed it on to his supervisor, Tobias, without modification. Referring to Callon's scallops in St Brieuc Bay, like the scientists speaking for nature, Tobias spoke on behalf of the agronomist. He did not want his junior staff member to negotiate, nor respond to my email. Tobias demonstrated that the agronomist of was not powerful enough in his network and that my email was something that he needed to control.

Aged in his 40's, Tobias is a senior agricultural leader, a business owner, a divorcee, a son, a partner, father and a manager of six staff. He does not hold any tertiary qualifications. He has lived in the Horsham district his entire life. The year prior he was hospitalised following a heart-attack, offering some insight into his weight, stress levels and sedentary lifestyle. It was this lengthy and detailed personal email from him that offered insights into the oppression of women in the sector. The results chapter does not include his entire letter. It was aggressive, yet it offers significant detail through material semiotics to begin to understand his assemblage of agents which enables him to hold power. This is was one paragraph relating to gender inclusivity:

> 'Never once in the flyer has it or did it state that [it's] only exclusive to men and again it wasn't written "this is an equal opportunity day for men and women" as our clients are very aware of this already. All our growers know that they are more than welcome to attend our events... I would actually consider it improper if we did state that as I would see it as degrading the fact that if this had to be stated and not just assumed that we consider all as equals.'

Tobias interpreted my email as an equal opportunity issue. Equal opportunity stems from job fairness and the elimination of discrimination, sexual harassment and victimisation of employees in the workplace. Equal opportunity isn't necessarily applicable for farming clients who pay his company for agronomic services and retailed products. He used the term 'degrading' to his whole

client base, but inferred it to women. He perceived that he would insult to his clients if he had dared mention women or gender in his invitation, overlooking the structural impediments of the event format. This is a most patriarchal explanation of both acknowledging a societal issue, which is gender discrimination, while at the same time admitting the need to not mention it. His action is an authoritarian email to a woman, persecuting her for challenging the status. The terms women, female and family were used sparingly as he had chosen masculine nouns, like growers and clients to refer to people. Tobias concluded the letter by praising himself for employing women in the past, and how some of them remain in contact with him and they continue to be grateful for the opportunity he has given them.

The actor network of Greenlands and CropCo, with Tobias as the branch manager, the agronomist and his other staff, hold power. The Upperkut software launch demonstrated their regional reach of farming clients. The notion of power is constructed and explained by elements that enable the inertia. The Upperkut representative, Jay, together with Tobias can be socially reproduced to explain how men in the agricultural sector, farming or wage labourers, have not challenged the elements that give this organisation its masculine momentum. Rather, a de-stabilising effect such as my email, was immediately acted upon and stopped. Tobias used email to demonstrate how I was incorrect in my assumptions of how he ran his business. There were no negotiations to modify the inertia. Tobias held power in the way his business operated so there was no desire for any change or mediation. My email translation was Tobias's reaffirmation of his success and a disinterest in my request to reconsider the hours of the field day. Our goals were not shared.

Corrigan and Mills (2012) feminist study of Air Canada illustrates that actor network theory can increase the richness of the discussion by uncovering multiple interpretations of the past from the points of view of various actants. Revealing multiple sources of knowledge of how the past was created offers a critical historicism to break down the barriers between feminist thought and actor network theory. This allows the structure of the crop tour and the Upperkut launch to be reconciled historically through human and material factors that encourage people to act. These actors work together as a network to produce a gendered effect, such as cultural behaviours and discrimination.

Using the method by Corrigan and Mills (2012) it can be argued that the farm services sector is operated similarly to that of the traditional Australian Rules football club structure. Football clubs enrol more males than females. When playing, there are 18 men on football field, and only 7 females on a netball court. The material elements of these clubs include memberships, players' and club members' jackets and beanies, team colours, pies, sausage rolls, men-only post season football trips, women serving in the canteen, and men serving beer in the bar. Successes and failures are shared as team, uniting the club through group formation, enrolment, symbols and stability.

Similar to a farmer, Tobias is a hybrid and a network. He has an assemblage of agents who share his interests. His business's farming clients and his employees maintained the disinterest of women participating in the events. Despite Tobias's lack of formal education, he maintained the inertia by enrolled agents by sharing their interests to produce mutual goals. This explains how men hold power in the industry; the leaders start the process and the actors keep their directive in motion with limited modification to the historical method.

Since the crop tour and the email, the agronomist and one younger female agronomist have both voluntarily ceased working at Greenlands. Actor network theory could be deployed to recuperate the voice of the female agronomist. What remains open is the opportunity to trace further the historical views and determine the actants beyond the structural responsibility of domestic duties that impede on women's participation in the sector, as well as female agronomists.

In a last attempt to trace associations I attended a GRDC Update for advisors on the Thursday 28 February 2019 in Dunkeld. This was an industry networking event with approximately 70 farmers and industry representatives in attendance. It was a fully catered day-time conference. The presentations were of high quality with allocated speaking times compared with the Upperkut information night where Jay and Tobias talked without limits of how long they held the audience. I attended this event to challenge some of my assumptions about how science crosses the boundaries of farms, and yet it also provided a valuable insight into gender in agriculture.

The farmers were most engaged with the presentation and visual imagery of straw choppers and weed destructor technology as add-ons for headers. It was evident that their relation to machination was far stronger than the prior presentations about the benefits of deep ripping bio-char or the APVMA standards for grain delivery.

Of all these attendees, less than 15 were female. This was an improvement on the gender balance from the Upperkut event. The younger females wore company logos to represent their employer. The current gender practice was to dress androgynously. So, were they cyborgs? Were they morphed woman-agronomists, who had changed as a consequence of their relations with farmers, soil, plants, crop data, and farm chemical products? On an exceptionally hot day where I wore a dress, why were these young females wearing work boots, men's shirts and shapeless work shorts, each devoid of make-up or anything symbolic of femininity? We were in a newly renovated air-conditioned conference centre. Their return to paddocks to inspect stubble at 3pm during the afternoon heat was highly unlikely. Enrolling the work ute, men's leather boots, collared cotton half-button shirt, shades of blue, and pony tail hair styles; these young women were doing gender by dressing as men.

Conclusion to theme five

Feminism in farming scholarship has played a significant role in challenging assumed gendered roles. The orthodox concepts of labour, while exposing the family as an important site of exploitation and struggle, has allowed feminist researchers to explore women's experiences (Barrett 1980 in Whatmore 1991 p. 3). Even though the conceptual framework for this research was not structured for gendered questions, an actor network approach revealed that women are important for family and farm work. Robina did not have to be in the cabin of the header or the tractor to perform harvest. Her relations to harvest were through food, food preparation and mobility as the property of agency for the machine operators. She was part of the network. She was a mediator in operation efficiency and a contributor to overcoming their farming positions in political economy through timeliness of operations.

Louise, the plant breeder demonstrated her agential capacity to actively engage humans and non-humans to produce canola with performance traits suitable for Australian grain growers. Even though she had a capital interest as a wage earner, her role was to breed canola to support Frontrunner® growers overcome their position in political economy through the incentives that Intercont© offer. Technology facilitated this grain breeder's agency.

From my experience, seeking to improve my agronomic knowledge, my agency to challenge Greenlands', by using email to respond to what I deemed as an archaic structural professional development event by elucidating the gendered barriers for participation, did not work for me. However, I have the capacity and knowledge, as well as other networks, to work around this dis-interest with Greenlands to seek equally valuable professional development in crop production elsewhere. New relations will be sought, new group formation may take place, and new effects will be generated. Email as technology facilitated my agency to challenge the status quo.

These findings, particularly from my insider research, show that the agricultural services sector is a masculine assemblage of humans, non-humans and objects. Machinery and technology were engendered masculine, epitomizing women's capabilities in professional farming forum. The order of the male dominated services industry is secure, with a long standing existence supported by the materiality of men's clubs, and the symbolic of fleet of farm utility vehicles, navy and stone coloured cotton work shirts, rugged leather boots, mobile phones and peaked caps. Women may join the network during the day, but they may not de-stabilise the structure.

This work has drawn on Lagesen (2012) arguing that actor networks show how women do gender with machinery and technology. This was effective in comparing Louise and Robina and their interaction with technology in their places of work. Latour's (2005) notion of following the actors to see how networks are formed failed, based on the situation that women were more or less absent at the beginning of the investigation. Corrigan and Mills' (2012) critical historicism was useful in seeking meaning from past material and human factors that worked together to

produce a gendered effect. Seeking sources of uncertainty through an actor network approach would provide valuable feminist scholarship by tracing the established women in agriculture networks. Perhaps these network exist because women do not feel welcomed or included in the traditional information sharing forums. The re-vamp of the Victorian State Government's Rural Women's Network, Partners in Grain, the annual Women on Farms Gathering, and the effects from AgriFuture's Australian Rural Women's Award all come to mind to look for analytical strategies that avoid binaries and dissolve the asymmetries in the treatment of women and farming.

Concluding the theoretical discussion

This chapter of the thesis presented the social science of farming in the Wimmera Southern Mallee. The theories within the actor network approach were used to re-organise and re-conceptualise the results. By applying these sociological methodologies to yield maps, farming group formations, science on farm, nature, and gender discrimination in agriculture, this thesis now offers fresh, rigorous, and tangible analyses of farming phenomena through technology.

Five themes were chosen because they were re-current notions and concepts found throughout the results, making them pertinent and applicable for intensive discussion. However, before concluding this chapter there is one more theme that I would like to briefly discuss.

The weather, as the natural element, frequently re-appeared as an actor in my sequence of notes taken during the fieldwork. It was recorded as a topic of conversation and discussed as a past event, the immediate moment, and/or the future forecast in various periods of time. Weather made farmers enrol a range of technologies that were captured in the fieldwork. These weather-related technologies generally relied on mobile data. Some of them were new and novel to the user. They included the Kanagulk weather station readings on the Bureau of Meteorology website, Tony's fee for service weather forecasts via email, weather on the CFA app, the rainfall records on iPaddock Yield app, the grain moisture meter, and the screen in the header cabin showing the outside temperature reading. These were all technology-weather hybrids. Enrolling weather forecasting technologies was the physical process of choosing and using the tool, which then facilitated weather data, to help the farmer make decisions of what to do on the farm. Weather-technologies enabled farmer- agency.

As discussed in this chapter, farmers and farms are networks. The Country Fire Authority is also a network, because as an institution it consists of humans, non-humans and objects. The CFA holds immense power when coupled with the weather forecasting technologies, because it enforces farmers' actions, which impacts on other actors in farmers' networks, through a combination of compliance, fear and peer pressure.

On the days of Total Fire Bans, the CFA transitioned from an intermediary to a mediator in farmers' networks. The CFA stopped farmers harvesting. Farmers' power to harvest was

removed, leaving no other alternative, or detour, to maintain usual farming practices. This process of interruption, as shown by Friedmann in the literature review, explains farmers' frustrations. The CFA has been somewhat underplayed in this chapter but it was a significant actor and a worthwhile theme to conclude this discussion. It is a relatable opportunity for future research and socio-cultural investigation for the region.

To conclude, the key findings in the theoretical discussion centred on the power of technology. It was clearly evident that where technology on farm was most prevalent, women were absent. Technology was also expensive in relation to its less technical alternative. According to actor networks, it should be defined as an intermediary through its programmed predictability, but these findings tend to contradict this notion. Technology was mostly a mediating actor in farmers' networks because it changed the make-up of farms. It acted as silent facilitator of farmers' decision making and it gave a reference of past events. When farmers identified this knowledge, technology became a force for competitive advantage in the free market. I also found that technology, in general, improved both farmer safety and marketing safe guards.

This discussion supports my central argument that technology enables farmer-agency. Turning to the conclusion next, I will surmise the thesis and demonstrate my contribution to new knowledge about grain growing phenomenon in the Wimmera Southern Mallee.

CONCLUSION

Tracing farmers' exploitation, alienation and agency through technology

This PhD centred on modern farming in the Wimmera Southern Mallee region, taken to embrace the range of actual farming activities and technologies in specific ways associated with commodity production. Commodity production is a cultural and economic activity. This doctoral study described the way in which the farming enterprises were tied to the wider market by explaining the agrarian commodity chain in such a way that farms and farmers were formed and the marked conditions of their trade that were entwined with it.

In recent decades farming and farm systems have advanced rapidly, along with economic development and globalisation. The problem that this research identified was that our knowledge of how farms operate to be economically competitive in in a global supply chain has not advanced at an equal pace. The concept that farmers work to overcome exploitative effects of the commodity chain challenges the romantic notions of farming as a lifestyle. The research questions were proposed to understand how farmers transformed themselves, cast as the theme of farmer-agency, in the commoditisation process. It has provided fresh understanding of how some farmers change their position in contemporary socio-political economy. The fieldwork and the literature review focussed on the grains industry specifically relevant to the farming enterprises in the Wimmera Southern Mallee.

The strength of this research lay in the re-assembly of farming and the associated network-relations by considering the agential effects of humans, non-humans and objects that were present in the process of grain production. The research was structured on the central argument that technology enabled agency among grain farmers. Technology was positioned both as a tool within the commodity chain that contributed to overcoming alienation, as well as a force that enabled farmer-agency.

To achieve this, the doctoral study marshalled a range of relevant themes. The overarching purpose of this work was to explain intellectual reason for farmers' industry-exodus by gaining a deeper appreciation and a better understanding of modern farming practices. This doctoral research offered a gendered insider-researcher critique using an actor network approach and reinterpretations of the themes alienation, exploitation and agency in a modern farm setting in Australia. The central project was based on the role of technology as the mediating agent between farm labour and production. It constructed a very different view of farmers as private property owners to present their complex activities of farming and the reality of the challenges political economy brings.

Thesis

The on-farm commodity production process remains an important focus as the main impetus for change to overcome the exploitative nature of the commodity chain. Commodity production is a social process whose development is understood as rooted in human agency (Thrift 1983; Whatmore 1991). This doctoral study concludes that farmer-agency is responsible for exerting control over production. Agency is a property of human and non-humans. What this doctoral research offers is meaning to rural sociologists about how agency is enacted on farm through technology.

Technology was the subject that was used to trace farmers' actor networks. A hybrid canola crop and header software were appropriate modern samples of technology found to facilitate farmer-agency. These technologies shaped people and other objects and they unearthed a wide range of actors in the networks to explain the manoeuvres in farming. These technologies had a dialectic approach to life in that it had two sides – farmers used it as a tool and then technology was used by the farmers as a force, the latter which was in opposition to human nature. The latter also worked against nature and natural assets, to make farmers more profitable or in control of their environment. It was technology that made farmers act as capitalists in farming.

This doctoral study found that farmers overcome the exploitative nature of the agricultural economy by how they used technology. Stable actor networks were possible when farmers transitioned technology from a tool into a force. Farmers' awareness of political economy was necessary to facilitate this transition, and further their commodity production, by forfeiting relationships of convenience and loyalty. At the same time, the less conscious the farmer was about the power that lay in technology, the more likely they were to be alienated.

Alienation was a condition tied to the causal powers of the social structures and processes located in class and capital accumulation. Alienation was tacitly the opposite of agency, where alienated farmers were less likely to utilise technology and remain exploited as workers. Alienation was determined by farmers' mediating relations with others through technology to overcome their grain production vulnerabilities. It is the unconsciousness of alienation that maintained many farming relations in the Wimmera Southern Mallee.

This doctoral research validates the necessity for social science in agriculture, and continued innovation and investment in technology for farmers. Recurrent evidence in the Wimmera Southern Mallee shows that farmers have greater control of their farming practices and processes when they can refer back to their histories of paddock operations and activities. A strength of this research was that it showed how power was performed by farmers' knowing and relying on recorded past sequences of actors that performed as a network of objects and non-humans to grow the crop. Technologies, as the tools, enabled these points of reference that gave

farmers connection to their product through transferrable data and replicable blueprints, such as yield maps. By using technology farmers' work processes were constantly related to crop productivity, allowing technology as a force to overcome alienation.

Agency is responsible for generating the effects of technology as a collective assemblage of actors. The field results have showed that the more technical or specialised farmers became, the more agents they required to keep the science and technology in place to generate the desired commodity production. Controlled traffic farming systems demonstrated a network of scientists and experts that promoted a science, and how farmers held these known effects, or facts, in place. Reference to these actants through data validated the agency of the controlled traffic farming network. The actor network approach showed that science and technology remade the network through a series of translations. When farmers changed techniques through technology, previous networks were momentarily de-stabilised, but simultaneously they were replaced with new mediating and re-stabilising agents into the network.

Actor networks demonstrated that through the translation of mediation, when multiple agents were enrolled and they all shared the same goals, they collectively supported farming productivity and reduced farmer-vulnerability in the economy. Farmers were positioned in relation to those actants, human and non-human, that were available to them. Farmers held power through their selection of actants where strong social ties were formed that kept their network stable. They were able to re-position their farm businesses within political economy as producers through available scientific knowledge and adoption of technology. This explained the dryland grain growing and farm services phenomena in the Wimmera Southern Mallee.

Limitations and constraints

From the initial outset, the conceptual framework paired an unlikely combination of theory, methodological approaches and setting. The design took into account the actor network infra-language along with lay agricultural terms to produce a doctoral thesis that was both coherent and comprehendible for a non-farming audience. To achieve this, it was a necessity to bridge agricultural semiotics and the actor network language for the reader. A constraint to this doctoral thesis was the highly technical language to explain ideas. Nonetheless, the concept of alienation was an opportunity for a modern re-interpretation of farmers' conditions of labour. Actor network theory was relevant and timely because at the time of writing no other published example of this method used on-farm could be found. The composition of actor network theory and alienation is likely to remain a brave endeavour based on the quantity of literature available specific to these pillars used within this framework.

The agricultural economy is capitalistic in nature. The commodity chain is structured by farmers' costs and farmers' incomes from commodity production. It could be argued that the Marxian theory of petty commodity production (PCP) may have offered a deeper analysis to

explain agricultural economics, specifically the actors in the cycle of money. As Whatmore (1991 p. 1) states "PCP defines a variety of types of small-scale production based on family, or household, labour and property … it represents a distinctive form of production because it contradicts the tendency toward the separation of capital and labour." Even though this research was not about Wimmera Southern Mallee farmers' economic survival, petty commodity production as a concept would have fitted within the framework for this examination.

Farming relations explained the social particularities of farm labour for grain production. As both a method and a methodology, actor network theory was fuelled by weak and strong ties which were used to explain what holds systems together in alliances. A limitation to the methodology is in knowing the difference between the strengths of ties, as this could not be measured rather only inferred. When relations held science in place, it could be confirmed that strong ties existed. However, for other network relations, alienation was measured through inference. Actor network theory was effective in many ways such as understanding farmers' relations with non-humans, identifying what made farmers act, and the agential properties of actants. However as a methodology it could be argued that it did not offer scope to examine relations pertaining to self-actualisation. As a method actor network theory did not effectively record ideologies, morals, ethics, feelings or any nuances that support our understanding of individuals and their characteristics that were meaningful for this element of alienation.

Literature advises that actor network approaches tend to be constrained by time. This study concurs with these sentiments because it is very difficult to disentangle actors from invisible structures. The longer the time permissible for this actor network study, the richer the contribution to new knowledge and ability to replicate the science it offers to explain our farming society. But despite its limitation in project length, the thesis remains meaningful. This research now offers future scope to study a range of events specifically related to farming and agricultural controversy. As a researcher, I recommend that a longitudinal actor network approach would be beneficial to re-explain our understanding of past events. Studies could include tracing farm succession, gender discrimination within the farm services sector, and the administration of insolvent grain traders. These examples may be considered as confronting, yet they exist in the Wimmera Southern Mallee and they offer opportunity for an advanced understanding of farming, humanism and political economy.

Another limitation to this research was that it did not directly address the causes of farmer-exodus in the Wimmera Southern Mallee. Rather, this approach considered how farmers remain solvent in business through their practices and operations. The approach was to trace farmers' technology, therefore this research did not connect with any former-farmers that allowed an examination of the actual events that led them to selling their farms.

Politically, this research has touched on locally sensitive issues that relate to women in agriculture. Actor networks demonstrates where goal sharing and *intéressement* takes place. Goal

sharing, and transferring the concerns of one onto another to strengthen the joint position, explains how networks are stabilised. This approach was effective in explaining traditional farm business relationships and it highlighted the discrepancy in goals and power using gender theory.

Through actor networks this doctoral study found that the branch manager and his staff working in farm services are un-progressive and un-responsive in acting to achieve gender equality. Since the time when I questioned Greenlands' culture of how they conducted their annual crop tour, my farming husband has been ostracized by all of those who are connected with this branch manager. Retrospectively, ethnography using interviews as the only method with agricultural business leaders may not have collected comparative data that this actor network approach achieved. Through his email, the branch manager perceived that all of his efforts validated women as genuine. He viewed his client relationships were mutually respectful and family friendly. His verbal responses in an interview about gender could have been harder to test compared with his ideologies put into actionable practice using artefacts and tracing actor networks.

Even though this research was never intended as a gender study, it offered a short, actor network examination of women in agriculture in the Wimmera Southern Mallee. Actor networks explain local cultures by trace-ability and connections which bring actors into the networks and shows diversity in humans, institutions, objects and organisations. A longer actor network approach of the farm services sector may help to solve the questions about the void of women and work towards other social issues to address inclusivity of all marginal groups in our farming region.

Contribution to new knowledge

Knowledge gaps of how modern commercial farmers operate in the Wimmera Southern Mallee, with consideration to technology and capitalism, has fallen through the clutches of the agricultural science, human geography and sociology fields. The purpose was not to eclipse farmers and technologies with Marxist preoccupations of capitalism and labour, nonetheless alienation offered a philosophical and an evocative approach. This research has contributed to new knowledge to elucidate the idea that even though farmers may be multi-millionaires through the value of their land, they are subject to the costs of the commodity chain passed on to their businesses. Farmers are private property owners yet they still remain exposed to alienating elements.

The findings reveal that the concept of farmer-loyalty should be viewed as a warning for farmer-exploitation. Farmers who present as connected with other humans from within the commodity chain are most likely to be alienated. This goes against the rationale of the element of alienation that draws on the loss of connection to others. However this research has shown that loyalty to people is indirectly relational to farmer-agency. For example, the ties between farmers

and farm businesses based upon convenience and friendliness are in some cases exploitative. The findings show that the farmers who value friendly business connections may not see the detrimental and exploitative nature of the relations as a consequence of these weak social ties. Actor network theory has demonstrated that stable farm productivity through science and technology requires farmer-agency and strong ties to share goals. The most economically successful farms, with an ability to re-position their business, have mediating agents irrespective of geographical location. To keep farmers' actor networks stable, farmer-agency looks beyond the local and seeks mediating agents to enact the goals of technology regardless of spatiality.

This doctoral thesis has specifically studied labour and associated fields of occupational health. Alienation is an interpretation of workers' well-being and social connectedness, which is most applicable for regional and rural areas. Epidemiologically, alienation can be used to explain farmer health. It sits within the modern realm of mental health and it offers rural health practitioners another explanation for farmer-illness. This research contributes new sociological knowledge about farmer-agency and farming relations that are required by farmers to persevere and sustain the pace of agricultural science, scales of efficiency, farm productivity and globalisation.

Alienation was measured through the relations between humans, non-humans and objects. The field results and the digital images of machinery, crop and the landscape supported these findings. The theoretical discussion, which relied on methods that sat within the actor network approach, marshalled a range of nuanced and meaningful outcomes about how we explain farming. The conclusiveness of this research still remains that farmer-alienation can be defined through the known associations with other things that actor network theory deploys. This doctoral research provides evidence that social research in the grains sector is necessary. There is scope for strategies and investment in programs to engage women in farm technology, re-affirm domestic duties as structural roles equal to the labour of machinery operation, and to support technical specialists in understanding why farmers get different results even when they use the same objects.

At the conclusion of this doctoral study, I remain confident that farmer-exodus from the industry is directly relational with technology. This research stands by the conclusion that technology is both a tool and a force that facilitates farmer-agency. Farmers can most effectively respond to the vagaries of free market trade and globalisation by embracing new and savvy technologies. To replicate these conclusions that explain farming phenomenon in the Wimmera Southern Mallee an actor network study following farming technology remains a rigorous approach to trace exploitation, alienation and agency.

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List of Appendices

Appendix A. Provisional approval by Human Research Ethics Committee

Provisional Approval
Human Research Ethics Committee

Federation UNIVERSITY • AUSTRALIA

Principal Researcher:	Dr Tim Harrison
Other/Student Researcher/s:	Ms Amity Dunstan
School/Section:	**School of Education and Arts**
Project Number:	**A18-104**
Project Title:	**Analysing the associations of farm labour to redefine the socio-political position of the modern farm.**
For the period:	TBC **to** 31/01/2020

Email your submissions to research.ethics@federation.edu.au

Full approval is subject to the following special conditions being met, as stipulated by the Human Research Ethics Committee, according to the protocol listed at the end of this document:

- **Section 11 – Risk Management Procedures:**
  - Page 12 – As no deception is involved with this project, debriefing is not required, please remove.

Please quote the Project No: A18-104 in all correspondence regarding this application.

BEFORE BEGINNING THIS PROJECT

You may not begin this project until full approval has been granted.

PROTOCOL:

- **Return to the Ethics Officer a copy of this Provisional Approval as a response-sheet with your rejoinder to each issue listed underneath, point by point, explaining clearly how each of the matters raised has been addressed.**
- **Include a copy of any amended document; e.g. Plain Language Statements, Consent forms, or advertisements**

Fiona Koop
Coordinator Research Ethics

7 September 2018

Appendix B. Rejoinder to Human Research Ethics Committee

MEMORANDUM

School of Arts	
Project number:	**A18-104**
Project title:	"Alienation: analysing the associations of farm labour to redefine the socio-political position of the modern farm."
To:	Research Ethics
From:	Dr. Timothy Harrison
CC:	Amity Dunstan
Email:	t.harrison@federation.edu.au
Date:	September 13 2018

Full approval is subject to the following special conditions being met, as stipulated by the Human Research Ethics Committee:

Section 11 – Risk Management Procedures:

- Page 12 – As no deception is involved with this project, debriefing is not required, please remove.

Rejoinder from the researcher:

The HREC Application Form has been amended. All of the comments offering debriefing support to participants are removed from Section 11 – Risk Management Procedures, page 12.

Appendix C. Final project report for Human Research Ethics Committee

Annual/Final Project Report

Human Research Ethics Committee

Federation UNIVERSITY • AUSTRALIA

Please indicate the type of report	☐ Annual Report **(Omit 3b & 5b)** ☒ Final Report
Project No:	A18-104
Project Name:	**Analysing the associations of farm labour to redefine the socio-political position of the modern farm.**
Principal Researcher:	Professor Keir Reeves
Other Researchers:	Amity Dunstan
Date of Original Approval:	13 September 2018
School / Section:	School of Arts – Rural Incubator for Social and Economic Research
Phone:	0427 861 891
Email:	a.dunstan@federation.edu.au

Please note: For HDR candidates, this Ethics annual report is a separate requirement, in addition to your HDR Candidature annual report, which is submitted mid-year to research.degrees@federation.edu.au.

1) Please indicate the current status of the project:				
1a) Yet to start				☐
1b) Continuing				☐
1c) Data collection completed				☒
1d) Abandoned / Withdrawn:				☐
1e) If the approval was subject to certain conditions, have these conditions been met? (If not, please give details in the comments box below)			☐ Yes	☐ No
Comments: N/a: Project was not subject to certain conditions				
1f) Data Analysis	☐ Not yet commenced	☐ Proceeding	☒ Complete	☐ None
1g) Have ethical problems been encountered in any of the following areas: **Study Design** **Recruitment of Subjects**			☐ Yes	☒ No

Finance	☐ Yes	☐ No
Facilities, Equipment	☐ Yes	☐ No
(If yes, please give details in the comments box below)	☐ Yes	☐ No
Comments:		

2a) Have amendments been made to the originally approved project?	
☒ No	☐ Yes
2b) If yes, was HREC approval granted for these changes?	
☐ Yes	**Provide detail:** ☐ Yes **Application for Amendment to an Existing Project** ☐ Yes **Change of Personnel** ☐ Yes **Extension Request**
☐ No	**If you have made changes, but not had HREC approval, provide detail as to why this has not yet occurred:**
2c) Do you need to submit any amendments now?	
☒ No	☐ Yes **Application for Amendment to an Existing Project** ☐ Yes **Change of Personnel** ☐ Yes **Extension Request** *** NB: If 'Yes', download & submit the appropriate request to the HREC for approval:** **Please note: Extensions will not be granted retrospectively. Apply well prior to the project end date, to ensure continuity of HRE approval.**

3a) Please indicate where you are storing the data collected during the course of this project: (Australian code for the Responsible conduct of Research Ch 2.2.2, 2.5 – 2.7)
Data (hand written field notes) is stored in a locked filing cabinet in an office at Federation University Horsham Campus. Electronic data (digital images) are stored on a Federation University laptop with security password protection. Data has not been duplicated.
3b) Final Reports: Advise when & how stored data will be destroyed (Australian code for the Responsible conduct of Research Ch 2.1.1)
The data will remain under the management of the project Principal Supervisor. The Principal Supervisor will direct the exact method of disposal after a minimum of 5 years. Incineration of field notes (hand written notes on exercise notebooks) will most likely take place.

Images will not be destroyed. They will be stored on a flash drive (USB) with appropriate image names, and retained by direction of the Principal Supervisor at the conclusion of the project.

4) Have there been any events that might have had an adverse effect on the research participants OR unforeseen events that might affect continued ethical acceptability of the project?	
☒ No	☐ Yes * **NB: If 'yes', please provide details in the comments box below:**
Comments:	

5a) Please provide a short summary of results of the project so far (no attachments please):
The results support that alienation exists under certain farming conditions as a consequence of the relations with human and nonhuman associations. The actor network approach was selected as the methodology to examine these conditions of modern farm labour, drawing attention to science, technology and machination, under the structures of the Australian political economy. The project data consists of hand-written, sequential notes of farmers' operating machinery and technology. Digital images were taken to support this data; some of which will be included in the thesis to help contextualise the topic for the non-agricultural reader. The data led to the compilation of the results as textual accounts. Alienation is a relations-based condition. Alienation was overcome through heterogeneous relations with non-human associations. The models of diffusion and translation located within actor network theory have been effective in explaining how farming practices are held together and generate effects. Farming is a concept, theory and a performance; it could not be touched as a concrete object, rather aspects of it were presented as a black box. In this black box humans, machinery, soil, and plants demonstrated relational properties. More relations were found in the hybrid canola crop and the Controlled Traffic Farming case studies. This work showed that particular farming practices had the ability to organize humans and non-humans. This work contributes to a broader theoretical understanding of how farmers utilize science and technology to pursue productivity gains and actively participate in the grains industry commodity chain.
5b) Final Reports: Provide details about how the aims of the project, as stated in the application for approval, were achieved (or not achieved). **(Australian code for the Responsible conduct of Research 4.4.1)**
Research aims: As stated in the application for approval "the aim of this project is to observe, evaluate and analyse

farm labour. This research aims to offer new scope for defining labour in commercial farm business settings. It also aims to define the connectedness of farmers to their production through human (service industry, staff, family) and nonhuman (machinery and technology) networks".

The research aims were achieved. Farm labour was observed, evaluated and analysed using the sociology of translation located in an actor network approach. Farm labour is defined as relation-based activity using the technology and machination available rather than a manual task. The relations between human and nonhumans created a new scope to analyse farmers' alienation as a consequence of working within the structures of the commodity chain (business, service industry, staff).

This research has been completed effectively because it has achieved a sociological explanation of how alienation exists on commercial modern farms within the structures of the Australian political economy.

6) Publications: Provide details of research dissemination outcomes for the previous year resulting from this project: eg: Community seminars; Conference attendance; Government reports and/or research publications
Presentation: Regional Development Australia – Grampians: What is holding back regional Victoria? Horsham, March 25 2019
Conference speaker and research publication: Ethnographic Praxis in Communities, Providence Rhode Island, USA, Nov 9-12 2019

7) The HREC welcomes any feedback on: • **Difficulties experienced with carrying out the research project; or** • **Appropriate suggestions which might lead to improvements in ethical clearance and monitoring of research.**

8) Signatures			
Principal Researcher:	..... Keir James Reeves Print name: Prof. Keir Reeves	**Date:**	26/08/19
Other/Student Researchers:	..... Print name: Amity B. Dunstan	**Date:**	26/08/2019
	.....	**Date:**	

Annual/Final Project Report

Human Research Ethics Committee

Federation UNIVERSITY • AUSTRALIA

	Print name:		

Submit to the Ethics Officer, Mt Helen campus, by the due date:
research.ethics@federation.edu.au

Appendix D. Canola oil factsheet

The purpose of this appendix to supplement information in chapter 3, specifically the end product of a canola crop.

Cargill®

Canola Oil Factsheet

Canola oil is recommended by leading health authorities because of its health properties, in particular, the low level of saturated fat and relatively high levels of omega 3 and 6 fats. These properties makes canola oil an ideal choice for people wanting to improve their overall health.

High levels of cholesterol in the blood is a key risk factor for heart disease. For this reason, leading health authorities, such as the Australian National Heart Foundation, the American Heart Association and the Heart and Stroke Foundation of Canada all recommend the use of canola oil as part of a heart healthy diet**

Q&A

Q: Why are food companies and restaurants changing to canola oil?
A: Canola oil is nutritionally superior than traditional oils such as palm oil and tallow as it is lower in saturated fats and has a higher amount of polyunsaturated and monounsaturated fats. The National Heart Foundation of Australia recommends that Australians should actively reduce their intake of foods high in saturated and trans fats**.

Q: Does canola oil contain trans fatty acids?
A: Canola oil is virtually free of harmful trans fats as it contains less than 1% trans fatty acids.

Q: What is the benefit of lowering saturated fats?
A: Medical research indicates there is a strong association between a lower intake of saturated fats in the diet and cardiovascular health*. Canola oil has less than one quarter the level of saturated fats compared to tallow or palm shortening.

Q: Is canola oil cholesterol free?
A: Yes, as Food Standards Australia states, "Cholesterol occurs in animal foods such as offal, meats, full-fat dairy products, egg yolks and kidneys but is not found in oils and fats from plants." ***

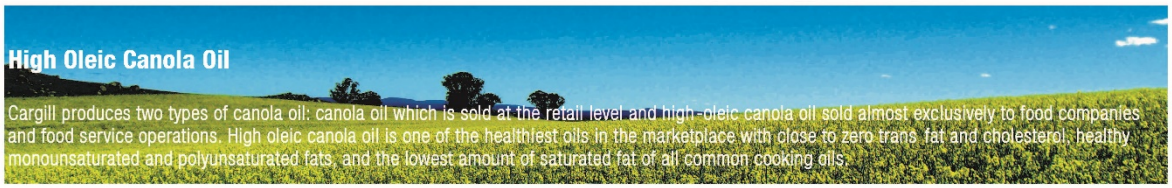
Q: What are Monounsaturated fats?
A: Canola oil is high in monounsaturated fats. Monounsaturated fats are the 'good' fats, and clinical studies have shown them to have a beneficial effect on cardiovascular health*.

Q: How is canola oil processed?
A: Once delivered to Cargill's processing facilities the canola seed is crushed to extract the oil. Our facility is certified by our customers which includes compliance to third party food safety and good manufacturing practice audits.

References:
**WHO Expert Committee (2003) Risk factors in cardiovascular disease. World Health Organisation, Geneva.
**The Heart Foundation http://www.heartfoundation.org.au/healthy-eating/fats/Pages/healthy-fats.aspx
***Food Standards Australia http://www.foodstandards.gov.au/scienceandeducation/factsheets/factsheets2010/choosinghealthierfat5003.cfm
Sinclair AJ. The Good Oil: Omega 3 polyunsaturated fatty acids. Today's Life Sciences 1991;8:18-27; Meydani M. 1995. Vitamin E. Lancet 345:170-175; James MJ, Gibson RA, Cleland LG. Dietary polyunsaturated fatty acids and inflammatory mediator production. Am J Clin Nutr 2000;71 (Suppl):343S-348S.

Appendix E. High oleic canola oil factsheet

The purpose of this appendix is to supplement information in chapter 3, specifically the specialty oil in the case study.



VICTORY® HYBRID CANOLA

Q: How is high oleic canola oil different from normal retail canola oil?
A: High oleic canola oil has been specifically bred for repeated deep frying applications. This oil is high in oleic acid and low in linolenic acid which makes the oil less susceptible to deterioration during deep frying. This stability ensures the performance food manufacturers and foodservice providers need, while delivering the high quality taste and nutritional benefits consumers demand.

Q: Why are food companies and restaurants changing to High oleic canola oil?
A: High oleic canola oil is nutritionally superior than traditional oils used for deep frying (such as palm oil and tallow) as it is lower in saturated fats and has a higher amount of polyunsaturated and monounsaturated fats. The National Heart Foundation of Australia recommends that Australians should actively reduce their intake of foods high in saturated and trans fats**.

Q: Does high oleic canola oil contain trans fatty acids?
A: High oleic canola oil is virtually free of harmful trans fats as it contains less than 1% trans fatty acids.

Q: What is the benefit of lowering saturated fats?
A: Medical research indicates there is a strong association between a lower intake of saturated fats in the diet and cardiovascular health*. High oleic canola oil has less than one quarter the level of saturated fats compared to tallow or palm shortening.

Q: Is high oleic canola oil cholesterol free?
A: Yes, as Food Standards Australia states, "Cholesterol occurs in animal foods such as offal, meats, full-fat dairy products, egg yolks and kidneys but is not found in oils and fats from plants." ***

Q: What are Monounsaturated fats?
A: High oleic canola oil is high in monounsaturated fats. Monounsaturated fats are the 'good' fats, and clinical studies have shown them to have a beneficial effect on cardiovascular health*.

* References:
*WHO Expert Committee (2003) Risk factors in cardiovascular disease. World Health Organisation. Geneva.
**The Heart Foundation http://www.heartfoundation.org.au/healthy-eating/fats/Pages/healthy-fats.aspx
***Food Standards Australia http://www.foodstandards.gov.au/scienceandeducation/factsheets/factsheets2010/choosinghealthierfat5003.cfm

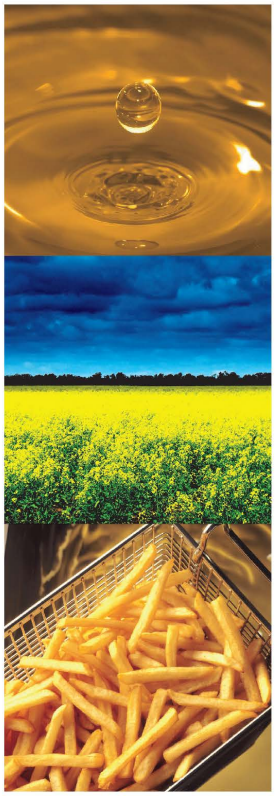
Q: How does high oleic canola oil compare to other frying oils.
A: Some commonly used deep frying oils include tallow and palm shortening that are highly saturated and contain unhealthy trans fats. Cottonseed oil is also widely used for deep frying in both commercial and food service markets. High oleic canola oil is much lower in saturated fat and hence has a much healthier nutritional profile.**

Oil	Beef Tallow	Palm Shortening	Cottonseed Oil	High Oleic Canola Oil
Saturated Fats	48%	53.5%	25.5%	8.6%
Trans Fats	4%	0.5%	0.5%	0.4%
Polyunsaturated Fats	6%	9%	58%	22%
Monounsaturated Fats	42%	37%	16%	69%
Cholesterol	100mg/100g	Nil	Nil	Nil

Q: Where is our high oleic canola sourced ?
A: Our high oleic oil is derived from Cargill's own Victory canola varieties, which have been specifically developed to be grown under Australian conditions. Cargill produces the planting seed and then contracts Australian farmers to grow the crop from which the high oleic canola oil is derived.

Q: How is high oleic canola oil processed?
A: Once delivered to our processing facilities the Victory high oleic canola seed is tested for varietal purity and oil quality. If it meets our strict standards the seed is crushed to extract the high oleic canola oil. Our facility is certified by our customers which includes compliance to third party food safety and good manufacturing practice audits.

Q How does Cargill ensure the quality of its high oleic Canola oil?
A: Cargill Australia is active in every step of the high oleic Canola supply chain. Cargill Australia develops varieties, produces the planting seed, contracts farmers to grow the canola, stores and transports the harvested canola and finally processes the seed into refined and packaged high oleic canola oil. Cargill is in a unique position to be able to control every step of the supply chain, ensuring the final product is of the highest quality and purity.



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- For more information regarding Cargill's Victory high oleic canola program please contact Joshua Gordon on +61 (0) 2 63600019 or your nearest AWB representative
- For Refined Oil enquiries please call +61 (0) 9268 7200 or visit www.cargill.com.au

Appendix F. Published journal article from research