Organisational Readiness for Digital Innovation - The Case of Australian Agriculture

A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

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Declaration

I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed. I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

Monika Streuer

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I was once told that if you have a curiosity about how the world works, a passion for what you do, and a drive to succeed that you can really make something of yourself and contribute to the world. This thesis represents the first of many contributions I hope to make in the world, and it brings so much joy to know that at the end of this long endeavour, I have had the support and guidance of many people.

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Abstract

The demand for agricultural goods is growing due to a growing global population and increased individual consumption. At the same time, climate change and the associated extreme weather events will make it challenging to meet this demand. Digital innovation is seen as an important part of ensuring the global food supply; however, the agricultural sector remains one of the least digitalised industries, lacking readiness to innovate with digital technologies. Despite the academic interest in digital innovation and the urgent need to apply it to the agricultural sector, research on readiness for digital innovation, especially in this sector, is rare.

This thesis investigates how Australian farmers become ready for digital innovation. Specifically, it identifies and defines key factors influencing family farms' readiness for digital innovation, and explains the process of gaining such readiness. Building on relevant readiness literature (innovation readiness, e-readiness, readiness for industry 4.0, digital readiness and change readiness) and family farm literature, blended with research on family businesses and Small to Medium Enterprises (SMEs), this thesis builds a conceptual framework of organisational readiness for digital innovation in the context of the Australian agricultural sector.

Embracing constructivism, this thesis employed a qualitative approach. Semi-structured interviews were conducted with managing farm owner(s) of 19 representative farms in Australia and 6 subject experts active in the field of digital agriculture. To ensure academic rigor and research trustworthiness, the data collected were coded manually and using NVivo 12, and analysed applying thematic and content analysis. The thesis findings identified that the factors Strategy, Managing Farm Owner(s), Management, Resources, Digital Technology and External Capacity influence the readiness of Australian farms to innovate with digital technologies and further defined each of these factors by specifying their constituent attributes. To date, no academic enquiry has explored factors influencing the readiness of family farms to innovate with digital technologies, therefore this finding is significant to the concept of organisational readiness for digital innovation. This thesis identified and explained changes in focus in regard to the key factors when advancing along the readiness spectrum, which is yet to be addressed by the readiness research.

Investigating the process of Australian farms gaining readiness for digital innovation, for the first time to date, it was discovered that each key factor became relevant in a specific order, starting with Managing Farm Owner(s), followed by External Capacity, Strategy, Resources, Digital Technology and finally Management. Furthermore, this thesis identified both enabling and reciprocal relationships between the key factors, which provided significant insights into

the dynamics and complexity of the process, and on which hitherto no readiness research exists.

Consequently, this thesis builds upon and extends the readiness theory, specifically the concept of organisational readiness for digital innovation in four aspects: 1) it captures the complexity of readiness for digital innovation on family farms in a holistic framework, 2) it identifies and specifies the factors influencing family farms' readiness for digital innovation, 3) it articulates the process of gaining readiness for digital innovation and explains its underlying mechanisms, and 4) it provides insights into the context-specific boundaries of organisational readiness for digital innovation.

Translating the findings into practice, this thesis provides policymakers, technology providers and family farms with actionable knowledge. Such knowledge can help guide 1) policies that enhance digital innovation, 2) digital technology design for a wider and quicker technology uptake, and 3) farms' transition to becoming digital innovators, consequently contributing to meeting the global food demand.

Chapter 1: Introduction

1.1 Objective

This chapter provides the thesis overview. It introduces the background of this thesis, its objective and the research questions guiding it. This chapter includes an overview of the research methodology and the theoretical scope of the thesis. Finally, the structure of this thesis is explained.

1.2 Introduction

The organisational readiness literature, so far, only offers one publication on organisational readiness for digital innovation (Lokuge et al. 2019). This research investigated organisational readiness for digital innovation in a global, industry-generic context, limiting the transferability to the context of Australia's family farming. Related readiness concepts that have received more academic attention, such as innovation readiness, e-readiness, readiness for industry 4.0, digital readiness and change readiness can shed light on the topic to some extent. However, their explanatory power in the specific context of digital innovation can be questioned, as they do not capture the specific case of digital innovation.

Management practices differ between countries (Ajiferuke & Boddewyn 1970; Storey 2004; Teagarden, Von Glinow & Mellahi 2018), and innovation follows industry-specific patterns (Hirsch-Kreinsen 2015; Malerba & Orsenigo 1995; Ryynänen & Hakatie 2014; Świadek et al. 2019; Tether 2002). Hence, an investigation into the specific context of the Australian agricultural sector can shed light and provide knowledge on family farms' organisational readiness for digital innovation.

A research inquiry into readiness for digital innovation in the specific context of family farms in Australia can contribute to the increasingly growing research on digital innovation in general (Kohli & Melville 2019), and specifically with regard to antecedents. While the antecedents of innovation have been subject to academic interest (Curado, Muñoz-Pascual & Galende 2018; Popa, Soto-Acosta & Martinez-Conesa 2017; Wan, Williamson & Yin 2015), there is still a lack of understanding about the prerequisites for digital innovation. So far, the scholarly focus has been on exploring the implications of digital innovation (Nambisan, Wright & Feldman 2019); however, as these can only be experienced once organisations are ready to innovate with digital technologies, it is central to gain an understanding of readiness as a prerequisite for digital innovation.

Moreover, understanding what influences the readiness for digital innovation of family farms in Australia and how it is gained is highly valuable for farmers, policymakers and technology developers. Providing farmers with actionable knowledge on how they can gain readiness for digital innovation can enhance the scope and effectiveness of Australian farms innovating with digital technologies. Policymakers with an understanding of the prerequisites required by family farms to be ready for digital innovation can focus their efforts on offering more targeted and precise support. Technology providers profit from such knowledge too, as it allows them to offer digital technologies which are adopted more broadly. Consequently, an advanced understanding of readiness for digital innovation can contribute to enhancing digital innovation on Australian farms, and potentially help farms react to the changing sector conditions and ensure the supply of agricultural goods.

1.3 Research Objective

This thesis sets out to investigate organisational readiness for digital innovation on family farms in Australia. The research objective of this thesis is to investigate how Australian farms become ready for digital innovation. The research undertaken in this thesis is multidisciplinary, bringing together existing management, information systems (IS) and agricultural research on family farms, and an empirical investigation into the Australian agriculture sector.

1.4 Background and Research Rationale

Agriculture worldwide is currently facing major challenges. Climate change (Mulla et al. 2020; Wiebe, Robinson & Cattaneo 2019) and related extreme weather events (Iizumi & Ramankutty 2015; Li, Y et al. 2019; Vogel et al. 2019) have caused decreased production volumes of agricultural goods (Lobell, Schlenker & Costa-Roberts 2011; Van Meijl et al. 2018). A decline in agricultural labour force and limited land suitable and available for agricultural expansion (Bryan et al. 2013; Pardey et al. 2014; Roser 2019) further threaten the global food supply (IPCC 2014; Siddig et al. 2020; Van Meijl et al. 2018). The current global COVID-19 pandemic and the measures taken to stop its spread have had a negative impact on production volume and reliability as well (OECD 2020a, 2020b, 2020c).

At the same time, due to increased individual consumption and the global population growth, the agricultural sector must produce over 70% more goods by 2050 to meet global demands (Lutz 2013; World Population Review 2020). Hence, the sector is in urgent need of innovation to ensure the global food supply. Digitalisation is seen as a breakthrough and an important trigger of innovation in the sector (Ciruela-Lorenzo et al. 2020; Salam 2020). However, global studies have identified that the agricultural sector is the least digitalised (Blackburn, Freeland & Grätner 2017; Gandhi 2016). In Australia, which is the context of this thesis, agriculture has likewise been ranked the least digitalised sector (Blackburn, Freeland & Grätner 2017).

Various initiatives to drive digital innovation have been put in place globally, as well as in Australia (Bacco et al. 2019; European Commission 2017; US Department of Agriculture 2014; Victoria State Government 2018). Crucially, however, research has pointed out that organisations must first be ready to adopt and innovate with digital technologies before being able to do so successfully (Snyder-Halpern 2001; Williams, I 2011). Despite the importance of understanding readiness for digital innovation, academic research and guidance on the topic is scarce (Lokuge et al. 2019), especially in the agricultural context. Insights into readiness for digital innovation in the specific context of family farming can provide: 1) farmers with actionable knowledge on how they can gain readiness for digital innovation, 2) policymakers with an understanding of the prerequisites required of family farms to be ready for digital innovation, and 3) technology providers with knowledge on design-related expectations about digital technologies, which can in turn enhance the scope and effectiveness of Australian farms innovating with digital technologies.

1.4.1 Research Questions

To date, the literature on organisational readiness only offers one publication on organisational readiness for digital innovation in a global, industry-generic context (Lokuge et al. 2019). Related readiness concepts that have received more academic attention, such as innovation readiness, e-readiness, readiness for industry 4.0, digital readiness and change readiness can shed light on the topic to some extent. However, their explanatory power in the context of digital innovation can be questioned, as they either do not take into consideration the peculiarities of organisational digitalisation, which is the case with the innovation readiness literature (Agostini 2017; Appio et al. 2018; Nambisan et al. 2017), or they fail to capture the specific case of digital innovation.

Management practices differ between countries (Ajiferuke & Boddewyn 1970; Storey 2004; Teagarden, Von Glinow & Mellahi 2018), and innovation follows industry-specific patterns (Hirsch-Kreinsen 2015; Malerba & Orsenigo 1995; Ryynänen & Hakatie 2014; Świadek et al. 2019; Tether 2002). Hence, only an investigation into the specific context of the Australian agricultural sector can shed light and provide knowledge on organisational readiness for digital innovation of family farms.

In order to make a meaningful contribution to theory and practice, the aim of this thesis is to answer the overarching question:

How do Australian farms become ready for digital innovation?

This umbrella question is expanded into the following two sub-research questions (RQs):

RQ1: What are the key factors that influence the readiness for digital innovation of family farms in Australia?

RQ2: How do family farms in Australia transition from their current practices to digital innovation?

1.5 Research Methodology

This thesis employs the philosophical stance of constructivism, which is concerned with understanding subjective human experiences and views of their own world (Guba & Lincoln 1989), in order to uncover in-depth insights on the experiences and views of the research participants.

To capture and make sense of the underlying complexity in participants' meanings, qualitative research methodology is applied, which allows an in-depth exploration (Creswell, JW 2017) by delving below the surface and providing sophisticated insights (McMurray, Pace & Scott 2004). Specifically,19 semi-structured interviews were conducted with managing farm owners of Australian farms and 6 with subject experts to access detailed information on the topic and explore the research questions thoroughly (Bryman et al. 1988; Minichiello, Aroni & Minichiello 1990; Turner III 2010).

The research design of this thesis, as depicted in Figure 1, consists of five sequential stages:

Stage 1: Extensive literature review on the readiness theory and specific readiness concepts relevant to organisational readiness for digital innovation as well as the research context to position this thesis in the theoretical research space.

Stage 2: Selection of research paradigm and the research method.

Stage 3: First wave of data collection and analysis: Interviews with Australian farmers conducted, transcribed and analysed using Microsoft Excel and NVivo 12, informing the second wave of data collection.

Stage 4: Second wave data collection and analysis: Interviews with experts conducted, transcribed and analysed using Microsoft Excel and NVivo 12.

Stage 5: Reporting and discussion of findings

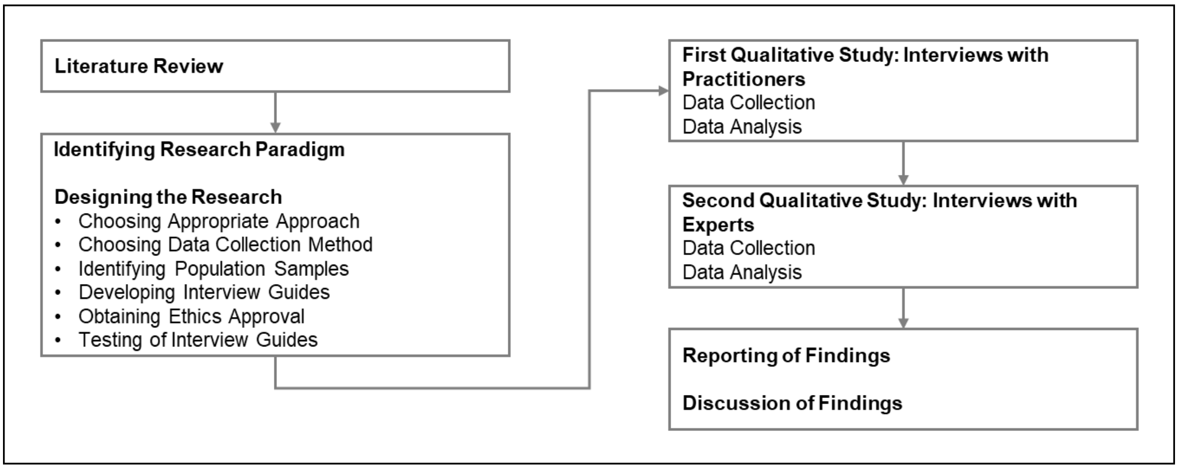

Figure 1: Research methodology process

1.6 Structure of the Thesis

Following the first chapter, Chapter 2 provides an in-depth review of the literature on digital innovation and readiness concepts relevant to explaining organisational readiness for digital innovation. Building upon extant readiness research, a theoretical research framework is developed.

Chapter 3 provides an overview of the global agricultural sector, the challenges it faces and the potential of digital technologies to meet these challenges. The agricultural management literature, outlining the peculiarities of family farms in Australia, is then introduced. Finally, evaluating the extant readiness research in the context of this thesis, the research objective and questions of this thesis are derived.

Chapter 4 details the methodological approach of this thesis. After explaining the research paradigm and approach, the research methods applied are clarified and justified, and the data collection and analysis processes are outlined in detail. Finally, this chapter sheds light on the measures taken to ensure research trustworthiness, referring to research credibility, transferability, dependability and confirmability.

Chapter 5 presents the first part of the qualitative data analysis. Starting with an overview of the farms and experts interviews, insights on the informants of the empirical study are provided. Then, structured around the first research question, the analysis results on key factors influencing family farms' readiness for digital innovation are outlined in detail.

Chapter 6 presents the qualitative data analysis answering the second research question. It details the insights gathered on the process involved in gaining readiness for digital innovation. In this chapter, the analysis results of both research questions are brought together in an empirical framework.

Chapter 7 discusses the major findings under the two sub-research questions. Then, the initial theoretical framework developed in chapter 2 is compared with the empirical findings, leading to the revision of the proposed theoretical framework.

Finally, chapter 8 presents the thesis conclusion. After briefly outlining the significance of the findings of this thesis, it details the contributions to theory and implications for practice, as well as the limitations and avenues for future research.

1.7 Terms and Definitions

This thesis deals with concepts and terms which include innovation, digital innovation, readiness, innovation readiness, e-readiness, readiness for industry 4.0, digital readiness, readiness for change and readiness for digital innovation. These are defined and explained in the respective section of the literature review in chapter 2.

1.8 Theoretical Framework

Due to its multidisciplinary nature, the theoretical underpinnings of thesis are situated in the intersection of readiness and digital innovation literature, as well as literature on family farms, family businesses and Small to Medium Enterprises (SMEs) capturing the organisational peculiarities of family-owned and managed farms. A visualisation of the theoretical positioning of this thesis is depicted in Figure 2.

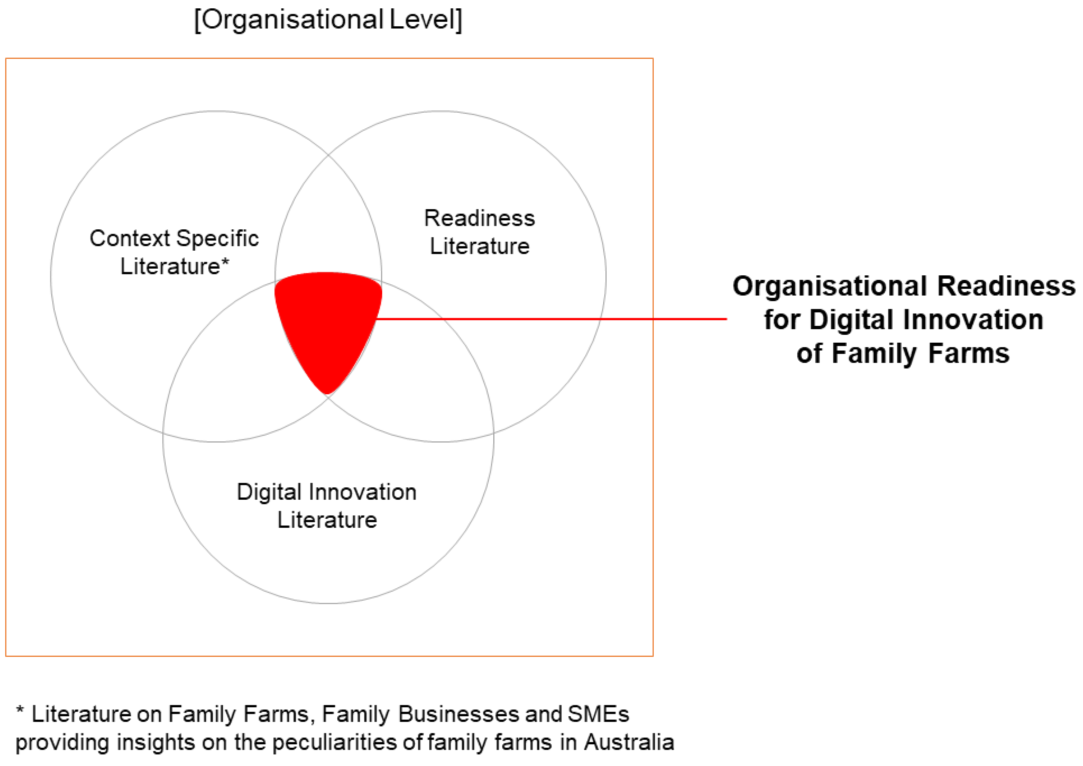

Figure 2: Theoretical underpinnings of this thesis

Literature on digital innovation is used to define digital technologies, innovation and digital innovation in line with the thematic scope of this thesis. Readiness literature is used to generate an initial theoretical framework which serves as a theoretical scaffold for the subsequent empirical investigation. Specifically, the following readiness concepts are considered relevant for providing insights into readiness for digital innovation: innovation readiness, e-readiness, readiness for industry 4.0, digital readiness, readiness for change and organisational readiness for digital innovation.

Bringing together this extant theoretical knowledge, the theoretical framework of this thesis outlines factors influencing the organisational readiness for digital innovation, as well as the relationships between these factors.

Finally, literature on family farms, family businesses and SMEs is used to evaluate the theoretical framework in light of the research context of family farms in Australia and motivate the research inquiry of this thesis.

1.9 Delimitation of Scope

The scope of this thesis is limited as it is specific to the Australian agricultural sector and investigates family farms. Addressing this specific context limits the generalisability of the thesis findings. Furthermore, the explanatory power of this thesis is limited to the organisational level.

1.10 Thesis Contribution to Literature and Practice

Addressing the two research questions, this thesis makes the following four contributions to the existing body of knowledge:

1) It develops a comprehensive framework of organisational readiness for digital innovation for family farms, and offers a holistic perspective on the antecedents of readiness for digital innovation in this context, which has so far not been addressed by research (Lokuge et al. 2019).

2) It identifies and defines factors influencing family farms' readiness for digital innovation, and unveils and explains the relationships between these factors. In doing so, this thesis extends and specifies extant research on factors influencing organisational readiness for digital innovation (Lokuge et al. 2019). Moreover, the findings make a contribution to the body of knowledge on antecedents of innovation (Curado, Muñoz-Pascual & Galende 2018; Davis & Bendickson 2020; Lee, Saerom & Csaszar 2020; Popa, Soto-Acosta & Martinez-Conesa 2017; Wan, Williamson & Yin 2015), explaining these in the specific context of digital

innovation. The findings support extant research on the central role of small business owners in technology adoption as well (Karanasios & Burgess 2008).

3) It clarifies, for the first time, the process of family farms gaining readiness for digital innovation, and extends the body of knowledge on organisational process studies (Langley et al. 2013; Reay et al. 2019), with a particular focus on its theoretical development and integration (Stephenson et al. 2020).

4) It outlines the context-specific boundary conditions of readiness for digital innovation on family farms, contrasts it with the industry-specific boundaries of organisational readiness for digital innovation, and extends the extant readiness literature (e.g. Lou, Lee & Goulding 2020; Nguyen et al. 2019; Pessot et al. 2020)

This thesis generates knowledge which can help guide 1) policies that enhance digital innovation, 2) digital technology design for a wider and quicker technology uptake, and 3) farms' transition to becoming digital innovators, consequently contributing to meeting the global food demand.

1.11 Summary

This introductory chapter has provided an overview of this thesis, set out the research objective and questions, and outlined the research methodology and the theoretical space in which this thesis is situated. It has detailed the motivation for this thesis, its scope, and contributions to both theory and practice.

The next chapter introduces and explains in detail the theoretical underpinnings of this thesis.

Chapter 2: Theoretical Background

2.1 Objective

This chapter details the theoretical perspectives guiding this thesis and critically reviews the literature pertinent to its key concepts. Drawing on management and IS research, this chapter begins with systematically introducing, reviewing and analysing extant literature relevant to understanding organisational readiness for digital innovation. It then proceeds with summarising the key findings in a theoretical research framework.

2.2 Innovation

Innovation has been a long-studied phenomenon in the economics and management literature (Schumpeter 1934). However, the term ‘innovation’ lacks a common definition (Cooper 1998), as it is notoriously ambiguous (Adams, Bessant & Phelps 2006). Generally, innovation is considered through two specific lenses: as a process or as an outcome.

Innovation as a process consists of consecutive phases, commonly classified as (1) idea generation (the development of a design or proposal in regard to the economic and technological environment of the firm), (2) problem-solving (research and development of the proposed idea), and (3) implementation (pilot production of the offering) (Myers, S & Marquis 1969; Swanson 1994). To meet the challenges and seize the opportunities of the ongoing changes in the business environment, the innovation process continuously transforms in terms of its practices, the underlying mechanisms, responsibilities and stakeholders involved (Rothwell 1994).

The result of an innovation process is considered the innovation outcome and it is the focus of this thesis. Viewing innovation as an outcome is motivated by the practical context of this thesis, being the agriculture sector which is currently in urgent need of generating innovation outcomes, in specific processes, products, and organisational and marketing practices. Therefore, the innovation literature presented in the following section is dedicated to innovation as an outcome.

Generally, an innovation outcome refers to the generation of novelty in the organisational context (Schumpeter 1934). More specifically, researchers have identified several types of innovation outcomes, including product, service, marketing, organisational and process innovation (e.g. Drucker 1985; OECD 2005; Wang & Ahmed 2004). Furthermore, the referent of innovation, establishing ‘who’ the outcome is novel to (for example, the organisation, the customers), has been a central element of the scholarly discussion (Davila, Epstein & Shelton 2012). Another key component in the theoretical typology of innovation is the dichotomy of the magnitude of innovation (Gopalakrishnan & Damanpour 1997). Research commonly distinguishes between incremental innovation, describing an ongoing variation leading to improvement of output (Damanpour 1991; Dewar & Dutton 1986), and radical (sometimes referred to as disruptive) innovation, associated with fundamental changes in the incorporated technology, shifting market structures and inducement of changes in user behaviour (Christensen et al. 2006; Urban, Weinberg & Hauser 1996). The last differentiating factor in the conceptualisation of innovation is the level of analysis. Research has considered innovation at both the network and firm level, as well as in regard to processes and individuals (Pittaway et al. 2004).

There are multiple definitions of innovation as an outcome (Crossan & Apaydin 2010) due to the diversity in attributes; the possible level of analysis, which is predominantly organisational (Haar 2018), but societal, industrial, and group and individual level as well (Crossan & Apaydin 2010); and the possible theoretical perspectives, such as institutional theory (Cohen & Levin 1989; Fagerberg, Mowery & Nelson 2005), resource based view and dynamic capabilities (Lei, Hitt & Bettis 1996; Teece, David J 1998), and theory of change (Eisenhardt, Kathleen M & Tabrizi 1995; Von Krogh 1998). Appendix A highlights and provides examples of the contrast between innovation as an outcome and innovation as a process.

For the purpose of this study a definition of innovation as an outcome is needed. However, first, it must be applicable to innovation in agriculture context. Furthermore, it must reflect the full scope of innovation originating from the application of digital technologies. Finally, it must be a commonly used definition to allow the researcher to draw on existing knowledge on the topic and ensure the significance of the theoretical contribution of this thesis.

The most appropriate definition meeting these criteria is the definition provided by the Organisation for Economic Co-operation and Development (OECD). Viewing innovation from a firm level, it refers to it as, 'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations' (OECD 2005, p.146). A product innovation can be based on technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. A process innovation includes changes in techniques, equipment and/or software. A marketing innovation involves product design or packaging, product placement, product promotion or pricing. Organisational innovation describes a new organisational method in the firm's business practices, workplace organisation or external relations.

This definition was chosen as it was generated with the intention of including all sectors (Godin 2002) and hence is applicable to innovation in agriculture. Second, it is considered an adequate definition for most intents and purposes (Amankwah-Amoah, Egbetokun & Osabutey 2018). Third, it accommodates a broad range of innovation types that one may reasonably expect to encounter when speaking about innovating a whole industry sector. Fourth, it is the primary basis of international guidelines for defining innovation activities (Gunday et al. 2011). Fifth, this definition is commonly used in innovation research (Denti & Hemlin 2012; Faems, Van Looy & Debackere 2005; Gault 2018). Sixth, due to its broad scope of outcomes it aligns well with other definitions, as presented in Appendix A. The operationalisation of the adapted definition is, as outlined in the OECD (2009), illustrated in Table 1.

Table 1: Operationalisation of innovation

Type of Innovation	Operationalisation of Innovation
Product Innovation	Introduction of new-to-firm product
	Introduction of new-to-market product
Process Innovation	Process Innovation: methods of manufacturing, delivery or distribution methods
Organisational and Marketing Innovation	New knowledge management system
	Change to the organisation of work
	Change in relationships to other firms, including partnership
	Changes in design or packaging
	Changes in sales or distribution methods

2.3 Digital Innovation

The foundation of digital innovation is digitisation, which refers to converting analogue data (audio, video, text and image) into a digital format (Brennen & Kreiss 2014). Digitalisation (Yoo, Henfridsson & Lyytinen 2010), which according to Bockshecker, Hackstein and Baumöl (2018) describes the state of an organisation concerning its digital development, refers to the application of digital technologies in broader social and institutional contexts (Tilson, Lyytinen & Sørensen 2010). 'Digital technologies' is a collective term comprising a multitude of recently advanced technologies, such as wearables, social media, the internet of things (IoT), business analytics, augmented reality, and blockchain (Lokuge et al. 2019; Sedera et al. 2016; Yoo et al. 2012). Due to digitalisation being the fastest development in human history (Berger, S, Denner & Roeglinger 2018), research on digital technologies has long used the term intuitively (Arthur 2009). However, more recent concerns about the need to structure the field of digital technologies (Bharadwaj et al. 2013), have led to a diverse spectrum of definitions. Focusing on singular technologies, researchers have developed detailed taxonomies classifying, for example, smart things (Püschel, Röglinger & Schlott 2016), big data algorithms (Fahad et al. 2014), mobile media (Scolari, Aguado & Feijóo 2012), and cloud computing (Keller & König 2014).

Considering the wide range of digital technologies, additionally research has developed taxonomies classifying the different existing digital technologies. Fitzgerald et al. (2014), for example, understand digital technologies as social media, mobile, analytics, or embedded devices. The SMAC acronym, originating from consulting practice, differentiates between social, mobile, analytics, and cloud technologies as digital technologies (Evans, ND 2016; Uhl et al. 2016), while its extension, SMACIT, adds the distinction of the IoT (Ross 2014). Yoo, Henfridsson and Lyytinen (2010), comparing digital to earlier generations of technologies, find re-programmability, homogenisation of data and self-referential nature yielding positive network externalities as differentiating characteristics unique to digital technologies. Berger, S, Denner and Roeglinger (2018) view digital technologies as cyber or cyber-physical applications or infrastructure, which serves in a uni- or bi-directional network, creating digital or physical output from either digital or physical input by either collecting, aggregating, analysing or transmitting data with optional human involvement.

This thesis adopts and combines the SMACIT classification and the taxonomy offered by Berger, S, Denner and Roeglinger (2018). These two definitions were chosen for multiple reasons. First, both definitions do not focus on individual digital technologies, as it would not be appropriate in the context of this research which reviews a multitude of different digital technologies applied in the agriculture sector (Menzel 2015). Second, the SMACIT categorisation, coming from consulting practice, is easily applied to digital technologies in agriculture but at the same time has been more widely applied in academic literature (Adamczewski 2016; Stjepić, Ivančić & Vugec 2020). As it is, however, missing a detailed classification specifying the nature of the digital technologies used, it is extended with the classification by Berger, S, Denner and Roeglinger (2018), compensating for this shortcoming. Third, this categorisation takes into consideration the increasing convergence of digital technologies. Originally unrelated digital technologies can either enable the functionality of other digital technologies or be recombined into a new digital technology (Teece, David J 2018; Yoffie 1996). Hence, to avoid omitting a relevant digital technology, which as a standalone technology may not be of interest for this thesis but integrated with other technologies may be a highly interesting object to investigate, this thesis relies on the rather broad definition introduced earlier.

Digital technologies and their application in broader social and institutional contexts, called digitalisation, are often referred to as digital innovation. Digital technologies, such as the mobile internet, are product innovations, being products which are novel not just to an organisation but to the world (Dong & Wu 2015; Lin & Chen 2012). So is digitalisation, transforming organisations' key business operations, products, processes, as well as organisational structures and management concepts (Matt, Hess & Benlian 2015), making it an innovation itself. Digital innovation can refer to generating innovative digital outcomes as well, or both using digital technologies for the innovation process and generating an innovative digital outcome at the same time, considering the complex and dynamic dependencies between both (Nambisan et al. 2017). Other scholars include the business model in their definition too, referring to digital innovation as a ‘product, process, or business model that is perceived as new, requires some significant changes on the part of adopters, and is embodied in or enabled by IT’ (Fichman, Dos Santos & Zheng 2014, p.330).

In this thesis, in line with previous research (Ferràs-Hernández 2018; Nambisan et al. 2017), the term ‘digital innovation’ refers to the application of digital technologies to generate an innovative output. Examples of digital innovations according to the type of innovation outcome are listed in Appendix B. While the various definitions introduced here differ in their object(s) of focus, they all consider digital innovation at the organisational level of analysis, as is the case in this thesis.

Digital innovation is gaining increased attention in the academic community (Nambisan, Wright & Feldman 2019). Scholars have been discussing, for example, how digitalisation fuels new forms of innovation, and how it influences business models and intelligent machine-driven innovation (e.g. Alshawaaf & Lee 2020; Huang et al. 2017; Kakatkar, Bilgram & Füller 2020; Lyytinen, Yoo & Boland Jr 2016).

But, while digital innovation is a ‘hot topic’ in academia, organisations have found it challenging to apply digital technologies for an innovative purpose (Gandhi 2016). A MIT Sloan study reviewing almost 400 globally dispersed companies in diverse industries showed that roughly a quarter of organisations classify themselves as beginners with regard to their digital maturity (Westerman et al. 2012). These organisations are either unaware of digitalisation opportunities, or their utilisation of advanced digital capabilities is very low. Around another 50% of organisations are either heavily experimenting with digital technologies, but not creating value, or are very cautious with their implementation and hence, are missing out on valuable opportunities. Scholars repeatedly highlight the importance of readiness with regard to digitalisation (Snyder-Halpern 2001; Williams, I 2011), which is introduced in the following section.

2.4 Organisational Readiness

Organisational readiness describes the prepared state of an organisation prior to a specific action (Klein & Kozlowski 2000). It ‘… occurs when the environment, structure, and organisational members’ attitudes are such that employees are receptive to a forthcoming change' (Holt, Armenakis, Harris, et al. 2007, p.290). Readiness includes a firm's ability to try new things (Beer & Walton 1987), and is considered a precondition for the planned outcome, which may be innovation, change, etc. (Cunningham et al. 2002a; Fuller et al. 2007; Shirazi, Mortazavi & Azad 2011). Readiness is best conceptualised as a continuum, which indicates how ready an organisation is in this regard (Holt, Armenakis, Feild, et al. 2007).

The concept of readiness has been discussed in various fields such as psychology, medicine, and engineering (e.g. Gou, Lau & Prasad 2013; Issa et al. 2009; Norris et al. 2008), as well as the fields in which this thesis is situated – management and IS (e.g. Armenakis, Harris & Mossholder 1993; Kaplan & Norton 2004).

While the management literature has been predominantly focused on readiness for change (Armenakis, Harris & Mossholder 1993; Spector 1989; Weiner et al. 2020), IS literature has remained broad in its focus, discussing diverse themes such as knowledge management, technology readiness and e-readiness (e.g. Holt, Bartczak, et al. 2007; Molla et al. 2008; Walczuch, Lemmink & Streukens 2007).

Readiness is a multi-level concept (Holt, Armenakis, Harris, et al. 2007), which has been investigated mostly at the individual (Eby et al. 2000; Jones, RA, Jimmieson & Griffiths 2005a) and organisational levels (Siemieniuch & Sinclair 2004; Weiner 2009), but in some cases at the team level too (Chilenski, Greenberg & Feinberg 2007; Fiore et al. 2012).

In this thesis, readiness is viewed as an organisational level concept, motivated by the research context as well as the theory applied to investigate it. On family farms in Australia, which are mostly non-employing (ABARES 2018), the decision-making and executive duties, and therefore the management of innovation, are mostly the responsibility of the farm owner(s) (ABARES 2020). Hence, an investigation at the individual level would not provide any meaningful insights. From a theoretical point of view, scholars highlight readiness at the organisational level to be fundamental for successful innovation in general and in particular with technologies (e.g. Kane et al. 2015; Snyder-Halpern 2001; Wraikat, Bellamy & Tang 2017). Hence, the investigation of readiness at the organisational level best serves the practical purpose of this thesis and is in line with the previous research into the concept.

To capture the extant knowledge relevant to explaining organisational readiness for digital innovation, the following section introduces the concepts of readiness for innovation, e-readiness, readiness for industry 4.0, digital readiness, readiness for change and readiness for digital innovation.

2.4.1 Readiness for Innovation

The concept of readiness for innovation is central to this thesis as readiness for digital innovation, meaning the readiness to generate an innovative outcome by applying digital technologies, requires readiness to innovate in the first place.

To capture a comprehensive and objective view on readiness for innovation, an initial systematic literature review, adapting a scientifically rigorous, transparent and reproducible approach was carried out. Three databases (Scopus, EBSCO and ProQuest Central), chosen based on their prominence in management science, were used to search for the key words ‘Innovation’ and ‘Readiness’ in the Title, Abstract and Keywords. Included in the search were only journal articles, books, conference papers and work-in-progress papers in the field of business, management and accounting, written in English. All of the articles relevant for the purpose of this thesis either develop, discuss or utilise the concept of readiness for innovation. As this thesis focuses on the organisational level of analysis, only articles that contain organisational readiness for innovation were included.

In this review, articles that listed readiness and innovation as key words, but which were non-related to the concept of innovation were excluded. Articles related to industry 4.0 and e-readiness were not considered at this stage of the review as they will be discussed separately later on. Other articles excluded were those on readiness concepts that eventually influence innovation, because they did not directly incorporate the readiness for innovation concept and hence did not provide appropriate insights, definitions or measurements.

This very focused literature search led to a total of 743 potential articles, of which only 14 were identified to be relevant for this thesis. This result indicates that, while readiness is a topic of high interest and repeatedly called to be a prerequisite for organisational innovation, there is little theoretical research conceptualising readiness for innovation. A detailed review of the remaining 14 articles is provided in Appendix C.

Out of these 14 articles only the conceptualisations by Scaccia et al. (2015), Yen et al. (2012), Evans, JD and Johnson (2013) and Yusof et al. (2010) were included in the literature review to ensure the validity and representativeness of this research. The remaining articles were identified as not relevant to the purpose of this thesis as they do not align with the definition of innovation used in this thesis or do not specify their understanding of innovation.

According to Scaccia et al. (2015), motivation, general capacity and innovation-specific capacity are the three components required for readiness for innovation, referring to the implementation of an innovation in a firm, such as a program, process, or policy that is new to an organisation.

The authors define motivation as 'perceived incentives and disincentives that contribute to the desirability to use an innovation' (Scaccia et al. 2015, p.486) and assert that motivation consists of the relative advantage of introducing this innovation, compatibility with existing values, cultural norms and experiences, low complexity of understanding required to use the innovation, trialability of the innovation, observability of the innovation outcomes, and priority of the specific innovation. General organisational capacity refers to the attributes of a functioning organisation and its connections with other organisations and the community, including its culture, climate, organisational innovativeness, resource utilisation, leadership, structure ensuring day-to-day functioning, and staff capacity in terms of their general skills, education and expertise. Innovation-specific capacity, the last component, is defined as human, technical, and fiscal conditions that are important for successfully implementing a particular innovation with quality. This component includes the attributes innovation-specific knowledge, skills and abilities, existence of program champions, specific innovation climate support, and inter-organisational relationships.

Scaccia et al. (2015) assert that these three components must interact and influence each other in the process of achieving readiness for innovation. However, the nature of the dynamic interaction between the components is, according to the authors, dependent on the specific innovation.

A study by Yen et al. (2012), which identifies components of a firm's readiness for adopting service innovation, is relevant to this thesis, as the innovation as an outcome may lead to a new service offering. They identify strategic investment into innovation, risk tolerance, champions, inter-organisational collaboration, innovation and IT experience, all important aspects of organisational readiness for innovation. While the authors do not specify interdependencies between the proposed factors, they stress that innovation occurs in response to a stimulus.

Evans, JD and Johnson (2013) developed a measure of innovation readiness, which is designed to assess an organisation's readiness for introducing an innovation outcome. The aspects considered in this model are finance (sufficient financial resources to successfully fund the new innovation outcome), human resources, legal knowledge, manufacturing adjusted to the innovation, marketing and sales to commercialise the innovation, regulatory affairs (which are not further specified) and developed technology for innovation. As the aspect 'regulatory affairs' is not further specified and therefore not possible to evaluate in terms of fit for this thesis, it is being disregarded in the theoretical framework of this thesis.

Yusof et al. (2010), carrying out an extensive literature review, identified four factors that influence the innovation readiness of an organisation: firm characteristics, resources, external support, and the market. Firm characteristics which could influence or trigger innovation readiness include the firm's size, culture of shared values, its behaviour patterns and set norms, and a structure that is informal, decentralised, and permits flexibility and speedy decision-making enabling the achievement of predetermined outcomes. Resources include assets, capabilities, firm processes, information and knowledge, market, and external support factors. External support refers to the support readiness of the external organisational environment. Market factors describes the ability of the market to absorb the innovation, reflecting the firm's responsiveness to the market.

As many of these aspects, often labelled differently, are mentioned in more than one of the introduced publications, and because some categories may be grouped in a more consistent manner, a summary of all introduced categories is visualised in Table 2 and detailed in the following section. This summary, representing the current theoretical literature on readiness for innovation, is utilised in this thesis to conceptualise readiness for innovation.

According to Scaccia et al. (2015), Yen et al. (2012), Evans, JD and Johnson (2013) and Yusof et al. (2010) the key factors of readiness for innovation are Resources, Strategy, Employees, External Capacity and Management.

In order to be ready to innovate, the authors point out that financial and human resources must be available and ready to utilise. Furthermore, there must be an appropriate strategy and employees with specific criteria in place as prerequisites of organisational capacity. Such a strategy must have (1) a firm structure that is informal, decentralised, and permits flexibility and speedy decision-making, both (2) processes and (3) financial management in place, supporting innovation, (4) information and knowledge relevant to innovation, and (5) an innovation-encouraging environment. Staff, who are the individuals initiating and executing the innovation, require innovation-specific knowledge, skills and experience in IT and innovation, and must perceive change valence and efficacy. Furthermore, as the organisation depends on the collaboration with and support from its external partners, its external capacity influences the organisation's readiness for innovation. Finally, managing leadership has been identified as the last component of readiness for innovation.

Table 2: Factors constituting the readiness for innovation (as an outcome), as applied in this research

Factors of E-readiness	Description of Factors
Resources	Availability and utilisation of financial, human and IT resources
Strategy	Firm structure and processes supporting innovation, strategic financial management, existence of necessary information and knowledge, supportive culture
Staff	Possession of innovation specific knowledge, skills and experience in IT and innovation; perception of innovation valence and efficacy
External Capacity	Inter-organisational collaboration, external support factors
Management	Leadership

As identified by (Scaccia et al. 2015), four of these factors influence each other. Taking into consideration the interrelation of the attributes – 1) motivation, which refers to the factor employees, 2) general capacity, referring to the factor external capacity and management, and 3) innovation-specific capacity, referring to resources – their dynamic nature is summarised in Figure 3. The authors, however, do not specify the influences as they suggest these depend on the specific innovation.

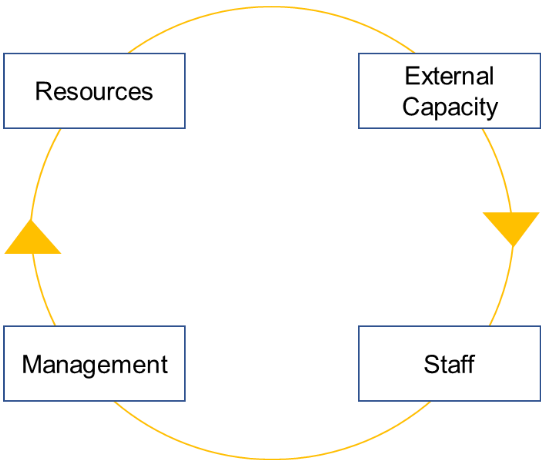

Figure 3: The dynamic nature of innovation readiness (circular arrows indicate mutual influence of all factors)

What remains of interest is why only 14 articles fit the strict criteria of the search. Which other topics are of interest in the theoretical space around readiness and innovation and how are they related to the concept? Attempting to capture the theoretical field around digital innovation, the original pool of 743 potential papers was revisited. The drastic reduction of potentially relevant articles was identified as being due to the loose application of both terms (innovation and readiness), which were not conceptualised or connected to theory but used as key words.

Furthermore, the plurality of meaning embedded in the term innovation led to hits which were not connected to the research topic. Additionally, the majority of the articles using both terms, innovation and readiness, applied these as two separate, not meaningfully connected, concepts. The majority of the remaining articles (48 out of 63) focused on exploring readiness with regard to digitalisation or technology, which is introduced in the following section.

2.4.2 Readiness for Digitalisation

To capture extant knowledge relevant to understanding readiness for the adoption and application of digital technologies, the following section reviews the concepts of e-readiness, readiness for industry 4.0 and digital readiness.

2.4.2.1 E-readiness

The advancement of information and communications technology (ICT) and the rapid rate of internet penetration throughout the world, has been one of the major driving forces for productivity, competitiveness, collaboration, and superposition of resources (Popova, Popov & Dalin 2005), transforming economies and businesses throughout the world into their e-versions, specifically e-economy and e-businesses (Cheng, Law & Kumar 2003; Peters 2001). Consequently, following the call from practice, research around e-readiness has gained increased attention since the beginning of the 21st century.

A wide range of definitions, measurements, frameworks and tools have already been developed to assess e-readiness, predominantly at the national level. Examples are (1) The Readiness Model for the Networked World by the Centre for International Development of Harvard University and IBM, which identifies five categories (network access, networked learning, networked society, networked economy and networked policy) as indicators of e-readiness of communities in developing countries (CID 2000) to assess a country's capacity to make use of its ICT resources; (2) the E-readiness Ranking, measuring a country's ICT infrastructure, and the capability of government, consumers and organisations to benefit from IT implementation by assessing its connectivity and technology infrastructure, business environment, social and cultural environment, legal environment, government policy and vision, as well as consumer and business adoption (The Economist 2009), and (3) The Ready? Net .Go! framework, which assesses a country's e-readiness capability based on its connectivity, e-leadership, information security, human capital and e-business climate (WITSA 2000).

At the organisational level, e-readiness has been and remains a topic of academic discussion (e.g. O'Neill 2019; Rai, Jirli & Singh 2018); however, it is far less studied than e-readiness at the national level, as it was not originally designed to address organisational issues (Lou, Lee & Goulding 2020). Organisational e-readiness is commonly defined as the ability of an organisation to successfully adopt, use, and benefit from information technologies (Fathian, Akhavan & Hoorali 2008; Ruikar, Anumba & Carrillo 2006), and is the stance that will be taken by this research. According to a review by Lou, Lee and Goulding (2020), among e-readiness assessment studies, there are only five known academic organisation-based readiness tools – BEACON, VERDICT, GPIS/NICE, BMI Maturity Matrix and the Technology Readiness Level, which all have different underlying goals and definitions of e-readiness, and apply different measures.

The BMI Maturity Matrix focuses on assessing the readiness of organisations to use BMI, a methodology to manage essential building design and project data in digital form, which in this study is defined as e-readiness. The Technology Readiness Levels, developed by the National Aeronautics and Space Administration, assess the maturity of new technologies (Banke 2010), defined as e-readiness. Both frameworks are not relevant to the aim of this thesis due to the lack of compatibility in the definition of e-readiness. Furthermore, their focus on technology readiness, not organisational readiness, does not provide meaningful insights to the topic of interest.

The GPIS/NICE framework, developed as part of a PhD thesis, is not publicly accessible and can only be viewed upon request to the author. Consequently, it can be assumed that it has not found wide application and has not been part of the academic discussion in the field. Therefore, it is not considered in this thesis.

The remaining e-readiness frameworks, which fit with the definition of e-readiness and can provide valuable insights into the research inquiry of this thesis, are introduced in the following section.

BEACON, developed by Khalfan, Anumba and Carrillo (2001), is a framework that assesses the readiness of organisations to implement and apply concurrent engineering. While congruent engineering is not a digital technology *per se*, it refers to the use of electronic information exchange and communication systems as well as knowledge management systems both within and beyond organisational boundaries (Duke & Anumba 1997), which falls within the presented definition of digital technologies.

This framework is divided into four categories: technology, process, people and project. Aspects of technology regarded as necessary for e-readiness include communication support, coordination support, information sharing, integration support, and task support. Processes require management systems, process focus, organisational arrangements, strategy development, and agility. The people category includes the existence of teams in an organisation, team formation and development, team leadership and management, and discipline. Looking at projects, client focus, quality assurance, and facility design are the highlighted factors.

VERDICT, developed by Ruikar, Anumba and Carrillo (2006), views the adoption and implementation of new and innovative technologies as e-readiness. Analysing benefits, barriers and drivers for e-readiness, this framework considers four dimensions – people, management, process and technology – key to organisational readiness. The people category is concerned with attitudes, outlook, and feelings of staff towards change caused by technology adoption. In terms of management, business strategies must be carefully orchestrated to derive organisational benefits from technology adoption. The dimension process refers to specific actions, rules, ethics and procedures to either incorporate new technology into existing processes or adjust processes to the new technology. The last category, technology, ensures the availability and performance of all hardware and software. Ruikar, Anumba and Carrillo (2006) explain that these factors go hand in hand, influencing and enabling each other; however, the mutual influence is not detailed.

Criticising existing frameworks for being rigid and lacking the possibility to weigh the e-readiness factors according to the organisation's priorities, Lou, Lee and Goulding (2020) developed a framework called ERiC, which allows firms to assess and display each e-readiness component separately. This framework refers to e-readiness as 'a measure of the degree to which an organisation may be ready, prepared or willing to obtain benefits which arise from the digital economy' (Lou, Lee & Goulding 2020, p.3). Adapted from Goulding and Lou (2013), who identified (1) leadership and empowerment, (2) business and information processes, (3) IT shareability and interoperability, (4) change management and (5) policy/strategy/vision as the key enablers for e-readiness, this framework expands each of these categories with a set of constituting attributes. The category leadership and empowerment includes the aspects IT vision, involvement, inspiration, integrity and improvement. The business and information process takes into consideration standardisation, automation, availability, integration, and interchange. IT shareability and interoperability refers to attribute uptake, standards, availability, knowledge and legal framework. Change management consists of a strategic framework, implementation, executive sponsorship, business practice and communication. The policy/strategy/vision includes collaboration, identification, dissemination, empowerment and future technologies.

All three frameworks were developed in the context of the construction industry, mostly within the UK. While collectively they present somewhat varying factors of e-readiness, and each framework is based on a different definition and a different focus, they all represent fairly similar categories of organisational e-readiness. All of the attributes outlined in the above detailed frameworks can be matched with the four categories of technology, process, people and management, which are summarised in Table 3 and detailed in the following section.

Table 3: Summary e-readiness factors

Technology	Processes	Staff	Management
Available and well performing, that is applicable throughout the organisation to share information and which supports automation of information processing. New technologies should be empowered. **IT-support** for communication, coordination, integration and tasks.	Agile, standardised **processes** allowing incorporation of new technology.	Positive **attitude** and perception towards technology adoption **Team** formation and development.	**Project Management** with client focus, quality assurance and facility design. **General Management** should ensure an elaborated business strategy aligned with practice, that implements change. Leadership throughout hierarchies should focus on constant improvement by being involved and collaborative to communicate and inspire the IT vision.

The category *Technology* requires both IT and IT support. For an organisation to be classified as e-ready, it must have an existing well-performing IT infrastructure which is sharable and interoperable with new technology, and has the potential to support automation of processes. In order to capture the potential of IT, however, an organisation must be able to provide support as well, in particular with regard to communication, coordination and integration.

Shifting organisational attention more towards IT, the role of *Processes* gains importance. Processes must be designed with a high degree of agility and standardisation, allowing the integration of new technology.

The introduction of new IT to an organisation, however, does not only influence the technology and process dimension of an organisation but its S*taff* as well. For new technology to be successfully adopted and applied, individuals within the organisation must have a positive attitude and perception towards it. In this context, creating teams is useful.

When introducing and integrating a new technology, *Management* is evidently a key-component. Project management focusing on clients, product quality and facility design, as well as general management developing and implementing a change strategy that aligns with business practice is central for e-readiness. Leadership throughout all hierarchical levels is another core responsibility of management to create readiness for innovation. Empowering innovation can be achieved by continuously improving leadership, which is characterised by being involved, collaborative and which creates and communicates the firm’s IT vision.

As Ruikar, Anumba and Carrillo (2006) suggest that the four factors influence each other, the dynamic nature of e-readiness categories is visualised in Figure 4.

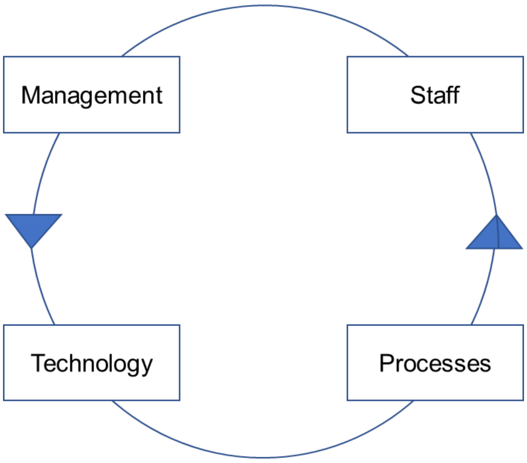

Figure 4: The dynamic nature of e-readiness (circular arrows indicate mutual influence of all factors)

Several studies extend these frameworks with additional categories and attributes (Gichoya 2005; Hourali et al. 2008; Molla 2008; Sanaei 2014). However, for the sake of clarity, structure and academic rigor, which may be compromised due to varying or incompatible definitions, contexts and hence measurements, only the above introduced frameworks are used as theoretical scaffolds in this thesis. Whilst well suited to this research, however, it is important to note that they all have been generated within a construction industry context and therefore cannot be applied directly to the Australian agriculture sector. Each framework must first be evaluated and reviewed to determine which of the introduced categories and attributes of e-readiness constitute the readiness for digital innovation in the Australian agriculture sector.

2.4.2.2 Readiness for Industry 4.0

The term Industry 4.0, originally introduced by the German government in 2011, refers to the current and ongoing fourth industrial revolution (Kagermann, Lukas & Wahlster 2011; Popkova, Ragulina & Bogoviz 2019). It implies a shift towards intelligent and integrated manufacturing systems by connecting the physical and virtual world (Leyh, Martin & Schäffer 2017) via various digital technologies, such as IoT, AI and Cloud Computing (Baena et al. 2017; Roblek, Meško & Krapež 2016).

Initially used as a buzz word for the vision of a digitally connected industry, the term Industry 4.0 is increasingly becoming reality in manufacturing practice. Considered an evolutionary transformation, researchers are particularly interested in the organisational-level readiness for Industry 4.0. Commonly defined as an organisation's readiness to start the development process to implement Industry 4.0 (Akdil, Ustundag & Cevikcan 2018; Mittal et al. 2018), it has become a subject of discussion in multiple research areas such as manufacturing, computer science, management and IS (Leyh, Martin & Schäffer 2017; Liu & Xu 2017; Menon, Kärkkäinen & Lasrado 2016; Vrchota et al. 2020). A wide range of frameworks, models and assessment tools (Akdil, Ustundag & Cevikcan 2018; Colli et al. 2019; De Carolis et al. 2017;

Mittal et al. 2018; Santos-Neto & Costa 2019) have been developed as well, for organisations that wish to assess their readiness for Industry 4.0 (detailed in Appendix D).

Although a number of models have been developed since the term was first introduced in 2011 (Xu, LD & Duan 2019), none of them have become firmly established or widely accepted (Lu 2017; Rajnai & Kocsis 2018). Hence, due to this lack of a dominant model, this thesis relies on a recent systematic literature review by Sony and Naik (2019), who identified and clustered existing factors of readiness for Industry 4.0.

This choice is supported by the ongoing, multidisciplinary academic debate on readiness for Industry 4.0, (Branco 2019; Castelo-Branco, Cruz-Jesus & Oliveira 2019; Colli et al. 2019; Stentoft et al. 2019; Trotta & Garengo 2019; Zaidi & Belal 2019), which implies that readiness for Industry 4.0 is still an emerging research area and therefore requires research on the topic as a whole, not a singular model.

The systematic literature review by Sony and Naik (2019) captures the latest discoveries in the field as well as the diversity of readiness for Industry 4.0 by reviewing literature in the databases Academic Source Premier (EBSCO), Google Scholar, Business Source Premier (EBSCO), Emerald, IEEE Xplore Digital Library, JSTOR, ProQuest Dissertations and Theses, Science Direct, Taylor & Francis, World Public Library, Scopus and Web of science.

Based on their extensive search, the categories Organisation Strategy, Level of Digitisation of the Organisation, Extent of Digitisation of Supply Chain, Smart Products and Services, Employee Adaptability with Industry 4.0 and Top Management Involvement and Commitment are identified as factors of readiness for Industry 4.0. In the following, each of these categories is detailed, while Table 4 provides an overview of the respective literature they are derived from.

Organisation Strategy: Industry 4.0 is expected to cause profound changes in an organisation's strategy. These include (1) more resource efficient and hence sustainable manufacturing systems, (2) inclusion of customers in the manufacturing process, and (3) distributed manufacturing through collaborative processes and human orientation with regard to work conditions and environment.

Level of Digitisation of the Organisation: Industry 4.0 stands for highly automated production, which comes with an increased level of digitalisation. Consequently, integration of cyber-physical assets within an organisation, automated data management, integrating organisation assets and fully integrated IT systems supporting all organisation processes are requirements for Industry 4.0

Extent of Digitisation of Supply Chain: Industry 4.0 does not just affect the organisation itself, but its supply chain as well. The operations of the entire supply chain must be digitalised, integrated with cyber and physical systems, and managed via protected cloud-based data management systems. Processes must become self-reacting and autonomously guided.

Smart Products and Services: Industry 4.0 enables the generation of smart products and services. However, in order to realise their potential, products and services must be integrated with all of the cyber-physical systems in the organisation as well as end customers to create new service opportunities. They must be designed as an integrated offering, and service management principles should be applied to satisfy customers.

Employee Adaptability: While Industry 4.0 comes with fundamental changes for manufacturing, at the same time it affects the working environment and hence the organisation's employees. As a multitude of tasks carried out by employees will be done by cyber-physical systems, smart employee adaptability models are necessary to predict how well staff can adapt to the changes.

Top Management Involvement and Commitment: Top management is highly influential within an organisation. As the transformation towards Industry 4.0 requires changes throughout the organisation, impacting not just processes and products but employees as well, top management involvement and commitment is required to help establish acceptance of industry 4.0 among all stakeholders.

Table 4: Categories of readiness for Industry 4.0 and the respective literature according to Sony and Naik (2019)

Category	Exemplary References
Organisation Strategy	(e.g. Brettel et al. 2014; Erol, Schumacher & Sihn 2016)
Level of Digitisation of the Organisation	(e.g. Bassi 2017; Hofmann & Rüsch 2017; Zanero 2017)
Extent of Digitisation of Supply Chain	(e.g. Douaioui, Fri & Mabroukki 2018; Ivanov et al. 2016; Watanabe et al. 2005)
Smart Product and Services	(e.g. Kagermann, Lukas & Wahlster 2011; Leyh, Martin & Schäffer 2017; Mont 2004)
Employee Adaptability	(e.g. Benešová & Tupa 2017; Lichtblau et al. 2015; Palazzeschi, Bucci & Di Fabio 2018)
Top Management Involvement and Commitment	(e.g. Bauer et al. 2015; Shamim et al. 2016; Wolf et al. 2018)

While Sony and Naik (2019) elaborate on these factors individually, they acknowledge their mutual influence. However, the authors do not provide any information on the nature of the influence.

The majority of the publications reviewed by Sony and Naik (2019) are from Germany (32%); 16% of the articles are from the US, 9% from Italy, 7% each from Austria and the UK, and 5%

from China and other countries (Sony & Naik 2019). None of the publications are based in Australia.

As the factors identified by Sony and Naik (2019) are based on a literature review conducted in 2019, the researcher conducted an additional literature review for the year 2020, following the same methodology. This review identified 117 potential publications of which only one was in line with the definitions used in this research and which provided a meaningful contribution to the goal of this thesis. The remaining 116 publications focused either on the individual or national level, assessed students and the educational space, referred to concepts only related to Industry 4.0 (such as Quality 4.0), or used the term 'readiness for industry 4.0' as a key word without a theoretical foundation or connection to the concepts investigated in this thesis.

The remaining article by Pessot et al. (2020) identified four areas influencing organisational readiness for Industry 4.0, which the authors refer to as the factory of the future: *Strategy*, *Organisation, Management* and *Technology.* Strategy refers to having a clear digital strategy, with dedicated roles for its execution. Organisation refers to communication between all organisational levels and the cultivation of digital skills. Management refers to technology integration and utilisation as well as collaboration with the eternal network. Technology refers to maintaining appropriate IT infrastructure and using technology to achieve flexibility.

A structured overview of all factors influencing organisational readiness for Industry 4.0 is illustrated in Table 5.

Table 5: Summary of factors influencing readiness for Industry 4.0

Factors of Industry 4.0 Readiness	Description of Factors
Strategy	• Clear Organisational Strategy • Dedicated Roles • Level of Digitisation of the Organisation • Smart Product and Services
External Capacity	• Extent of Digitisation of Supply Chain • Collaboration with External Network
Staff	• Employee Adaptability • Digital Skills
Management	• Top Management Involvement, Commitment and Communication with all Organisational Levels
Resources	• IT infrastructure
Technology	• Technology Application for Flexibility

In light of the interdependencies between the attributes Organisation Strategy, Level of Digitisation of the Organisation, Extent of Digitisation of Supply Chain, Smart Products and Services, Employee Adaptability and Top Management Involvement and Commitment, identified by Sony and Naik (2019), the dynamic nature of readiness for Industry 4.0 with respect to outlined factors is illustrated in Figure 5.

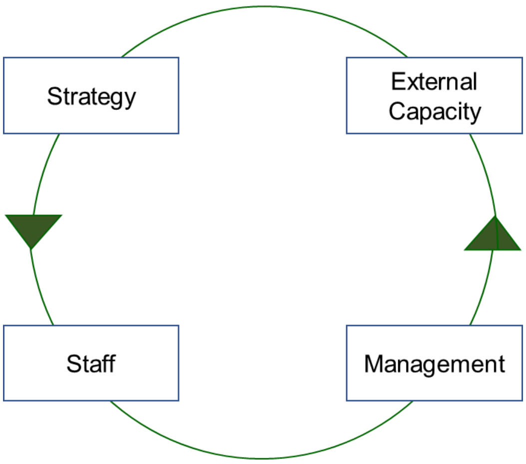

Figure 5: The dynamic nature of readiness for Industry 4.0 (circular arrows indicate mutual influence of all factors)

2.4.2.3 Digital Readiness

Digital readiness is defined by Nguyen et al. (2019, p.3) as, 'the degree to which an organisation is ready to digitally transform the current organisation'. The terms digital transformation and Industry 4.0, detailed in the previous section, are often used as synonyms, or as mutually dependent concepts resulting in their differentiation appearing blurry at times (Oztemel & Gursev 2020; Preindl, Nikolopoulos & Litsiou 2020). In order to avoid omitting relevant literature due to inconsistent nomenclature, digital readiness is included in the literature review of this thesis as a separate section.

Digital transformation is increasingly becoming an imperative for organisations throughout all industries (Andriole, Cox & Khin 2017; Baiyere, Salmela & Tapanainen 2020). Readiness, identified as a prerequisite for digital transformation (Li, L et al. 2018; Warner & Wäger 2019) has therefore attracted scholarly attention in recent years, which has led to increased academic efforts to shed light on the topic of digital readiness (e.g. Bharatula & Murthy 2020; De Carolis et al. 2017; Soomro, Hizam-Hanafiah & Abdullah 2020). While multiple publications have been dedicated to defining and exploring digital readiness, due to the novelty of the research no model exists which identifies antecedents or factors influencing digital readiness. Therefore, this thesis relies on a systematic literature review by Nguyen et al. (2019), which, in line with the definitions used in this thesis, summarises the existing knowledge on the topic and establishes a conceptualisation of digital readiness. This review was conducted using the database ISI Web of Science, searching 11 leading journals in the IS field (*MIS Quarterly*, *Information Systems Research*, *Journal of Management Information Systems*, *Journal of the Association of Information Systems*, *Journal of Information Technology*, *Information Systems Journal*, *European Journal of Information Systems*, *Journal of Strategic Information Systems*, *Decisions Support Systems*, *Information and Management*, and *Computers in Human*

Behaviors), as IS has been identified to be the leading field in digital transformation-related research (Vial 2019). Additionally, a backwards search was performed using the identified articles as a reference. The literature review has led to a total of 32 relevant papers – 27 empirical, 1 meta-analysis and 4 construct development papers.

The review identified three areas essential for digital readiness: (1) digital assets, (2) digital capabilities and (3) digital commitment. Digital assets encompass not only existing digital IT structure, but human assets (employees' digital skills and knowledge) and relational assets (involvement of relevant external parties) as well. Digital capabilities include the aspects of proactiveness and responsiveness, which describe the organisation's ability and willingness to identify, explore and exploit the opportunities of digital technologies. Digital commitment involves managerial and employee commitment to transition to digital practice. An overview of all factors that influence digital readiness is provided in Table 6.

Table 6: Summary of factors influencing digital readiness

Factors of Digital Readiness	Description of Factors
Digital Assets	IT infrastructure Human Assets (digital skills and knowledge of employees) Relational assets (involvement of external parties)
Digital Capabilities	Digital proactiveness and responsiveness
Digital Commitment	Management and Employee Commitment

2.4.2.4 Readiness for Change

The concept of organisational readiness for change elaborates on how organisations can transition into a desired future state, based on their readiness, which indicates being psychologically and behaviourally prepared to take action (Weiner 2009; Weiner, Amick & Lee 2008). Consequently, research on organisational readiness for change focuses on internal change, often initiated by management (Weiner, Amick & Lee 2008).

The concept of readiness for change is relevant to explaining readiness for digital innovation due to the following two reasons. First, innovation and its management require change, as a multitude of management-related publications have uncovered (Dodgson, Gann & Salter 2008; Francis & Bessant 2005; Nelson 2009; Tidd, Joe, Bessant & Pavitt 2005). Innovation is a constant renewal process, where firms change what they offer and how these offerings are created by adapting an adequate strategy (Bessant et al. 2005). Consequently, change is an inevitable prerequisite for innovation (Utterback, J 1994). Second, as noted earlier, digitalisation has major implications for innovation, fundamentally changing how firms innovate. Examples of the changes are less pre-defined agency in the innovation process and continuously shifting spatial and temporal boundaries, which in turn require new capabilities for organising innovation (de Sousa Jabbour et al. 2018; Nambisan et al. 2017). To successfully capture the potential of digital innovation, organisations must adapt to the new nature and requirements of digital innovation, calling for the readiness to change.

Readiness for change has been a topic of interest in a diverse spectrum of disciplines, such as psychology, health and management (e.g. Maness et al. 2019; Miake-Lye et al. 2020; Weiner et al. 2020). Established in the early 1990s, it received considerable attention and remains a highly discussed concept (Holt, Armenakis, Harris, et al. 2007; Roos & Nilsson 2020; Weiner et al. 2020). Consequently, a multitude of definitions and therefore conceptualisations of organisational readiness for change in the business context exist, as detailed in Appendix E. This thesis, which explores organisational readiness for digital innovation in the agriculture sector, requires a conceptualisation at the organisational level in a business setting. Armenakis, Harris and Mossholder (1993) and Weiner (2009) both offer conceptualisations that fit these criteria and are the two most commonly referred to in reference to readiness for change.

Armenakis, Harris and Mossholder (1993) define readiness for change as the beliefs, attitudes and intentions of an organisation's members to make necessary changes, and the organisation's capacity for their successful realisation. They identify Appropriateness, Principal Support, Efficacy and Valence as sub-constructs that influence readiness for change.

Weiner (2009), in line with previous research, identifies three theoretical paradigms as conditions promoting readiness for change: change valence, change efficacy and contextual factors. Change valence, drawing on motivation theory, refers to how organisational members value the change (Fishbein & Ajzen 1975; Meyer & Herscovitch 2001). Change efficacy, reflecting research in the field of social cognitive theory (Gist & Mitchell 1992), captures the organisational members' appraisal concerning whether:

- (i) the demand for executing the change is known
- (ii) the resources for its execution are available and
- (iii) the situation allows the change to be implemented.

Contextual factors summarise several broader conditions such as organisational culture (Adelman & Taylor 1997; Jones, RA, Jimmieson & Griffiths 2005b), flexibility in organisational policies and procedures (Eby et al. 2000; Turner & Crawford 1998), and positive past experience (Armenakis, Harris & Mossholder 1993). This thesis relies on the conceptualisation of Weiner (2009), as it meets the appropriate criteria and purpose. Additionally, it accommodates the aspects identified by Armenakis, Harris and Mossholder (1993) and extends these with categories relevant to the business context. An overview of the change readiness concept according to Weiner (2009) is visualised in Table 7.

Table 7: Organisational readiness for change according to Weiner (2009)

Factors of Digital Readiness	Description of Factors
Change valence	• perceived need for change • perceived urgency of change • perceived appropriateness of change • the anticipated benefits or costs of change
Change efficacy	organisational members appraisal concerning whether (i) the demand for executing the change is known (ii) the resources for its execution are available and (iii) the situation allows the implementation of the change.
Contextual factors	• culture • flexibility in organisational policies and procedures • positive past experience

2.4.2.5 Existent Readiness for Digital Innovation Construct

Despite the growing academic interest in digital innovation (Kohli & Melville 2019; Vega & Chiasson 2019), so far only one publication has been dedicated to exploring the concept of organisational readiness for digital innovation. Lokuge et al. (2019) conceptualise a formative multidimensional construct of readiness for digital innovation at an organisational level. The authors refer to digital innovation as 'innovation enabled through or triggered by digital technologies' (Lokuge et al. 2019, p. 446), which is in line with the definition chosen in this research. Both qualitative and quantitative research methods were employed in their study. First, a qualitative study was conducted to derive a priori measures of the construct. Therefore, 9 cases were analysed, of which 3 were from Australia, 4 from Europe and 2 from Asia. The case companies were a mix of private and public sector, and one non-for-profit. Private sector organisations included logistics, dairy, energy, manufacturing, and telecommunications. The a priori model was tested using a quantitative study, which surveyed 189 CIOs and line-of-business managers of organisations predominantly active in the manufacturing and service industries. The resulting construct consists of seven sub-constructs, including a total of 21 measures, as follows:

(1) Resource readiness – flexible financial, technology and human resources through which digital innovation can be delivered.

(2) Cultural readiness – strength of the core values, idea-sharing and decentralised decision-making that facilitate digital innovation.

(3) Strategic readiness – managerial activities of communicating clear and relevant goals to facilitate digital innovation.

(4) IT readiness – strength of IT portfolio by ensuring stable, up-to-date, and reliable IT infrastructure and enterprise systems as well as access to new digital technologies to facilitate digital innovation.

(5) Innovation valence – positivity of stakeholders towards digital innovation, reflected in motivated employees with the right attitude, and who are empowered to make decisions.

(6) Cognitive readiness – strength of knowledge, skills and adaptability of staff facilitating digital innovation.

(7) Partnership readiness – good relationship with software vendors, management consultants and suppliers to facilitate the organisation's digital innovation.

2.5 Research Framework

Consolidating the extant readiness literature, a research framework of organisational readiness for digital innovation was developed as follows.

When analysing readiness literature relevant to this thesis, Strategy, Management, Technology, Resources, Staff and External Capacity emerged as key factors influencing the readiness of organisations to utilise digital technologies to generate an innovative outcome.

Strategy

There are several aspects that firms must meet in order to achieve readiness for digital innovation.

The first aspect is forming a clear strategic plan which articulates the organisation's goals and the respective actions and resources needed for its realisation (Pessot et al. 2020; Sony & Naik 2019).

Second, the considerable financial investment and changes in operations required for digital innovation demand an innovation-supportive firm structure, financial management and processes (Evans, JD & Johnson 2013; Yen et al. 2012; Yusof et al. 2010). These ensure that there is adequate capital and that it is appropriately invested in technology and infrastructure, as well as agile and standardised processes (Khalfan, Anumba & Carrillo 2001; Lou, Lee & Goulding 2020) which allow the addition and incorporation of new practices.

Third, the level of digitalisation within an organisation reflects its experience with and knowledge of digital technologies, influencing the organisation's readiness to adopt and utilise digital technologies to generate an innovative output (Sony & Naik 2019).

Fourth, the organisation must be open to searching for, identifying and realising opportunities presented by digital technologies, as they are often not apparent and their realisation requires considerable effort and investment (Nguyen et al. 2019).

Fifth, roles must be clearly designated to distribute responsibility and structure the complex processes of incorporating and applying new technology (Lokuge et al. 2019; Pessot et al. 2020; Yusof et al. 2010).

Sixth, implementing, operating and utilising digital technologies to generate an innovative outcome requires information and knowledge on technology as well as innovation. Therefore, another strategic component of readiness for digital innovation is ensuring that specific information and knowledge is present within the organisation (Evans, JD & Johnson 2013; Lokuge et al. 2019; Scaccia et al. 2015; Yusof et al. 2010).

Seventh, the organisational culture plays a role in innovation. To facilitate digitally enabled innovation practice, organisations must establish a new organisational culture supporting and encouraging innovation. Such a culture is characterised by idea sharing, decentralised decision-making and shared values, behavioural patterns and set norms that create a supportive and encouraging environment (Lokuge et al. 2019; Lou, Lee & Goulding 2020; Scaccia et al. 2015; Weiner 2009; Yusof et al. 2010).

The last aspect of strategic readiness is designing smart products and services (Sony & Naik 2019).

Management

The literature identifies multiple management attributes necessary to achieve readiness.

As entering the space of digital innovation is a complex project management endeavour which focuses on clients, quality assurance and facility design must be put in place (Khalfan & Anumba 2006).

The transition process from the favoured conventional farming to technology-based agriculture requires leadership that enforces constant improvement by being involved, committed and collaborative, and communicating and inspiring the IT vision throughout all hierarchical levels of the organisation (Lokuge et al. 2019; Lou, Lee & Goulding 2020; Nguyen et al. 2019; Scaccia et al. 2015; Sony & Naik 2019).

Due to the changes originating from the application of digital technologies and their novel operation to generate innovative outcomes, management needs to ensure the availability of

IT-support for, for example, communication, coordination, integration and tasks within the organisation (Khalfan & Anumba 2006).

Technology

In terms of technology characteristics, the literature suggests that the IT must be available and well performing (Khalfan, Anumba & Carrillo 2001; Lou, Lee & Goulding 2020; Ruikar, Anumba & Carrillo 2006).

Other technology characteristics that influence readiness for digital innovation are the applicability of technology throughout the organisation (Lou, Lee & Goulding 2020), the capacity to enable information sharing and automated information processing, as well as their application to gain flexibility (Khalfan, Anumba & Carrillo 2001; Lou, Lee & Goulding 2020; Pessot et al. 2020).

Resources

The readiness literature suggests digital innovation requires a multitude of resources.

To purchase new technology, financial resources are necessary (Evans, JD & Johnson 2013; Lokuge et al. 2019; Scaccia et al. 2015; Yusof et al. 2010).

Furthermore, existing IT resources, such as computers and smart phones must be available, in order to operate the digital technologies (Lokuge et al. 2019; Lou, Lee & Goulding 2020; Nguyen et al. 2019; Pessot et al. 2020; Ruikar, Anumba & Carrillo 2006).

Finally, human resources are required to install, operate and maintain technology and generate an innovative outcome (Evans, JD & Johnson 2013; Lokuge et al. 2019; Nguyen et al. 2019; Pessot et al. 2020; Scaccia et al. 2015).

Resources must be flexible and add value too (Lokuge et al. 2019; Scaccia et al. 2015; Sony & Naik 2019).

Staff

Individuals in an organisation are one of the key factors of digital innovation as both the decision to implement digital technologies and their utilisation to generate an innovative outcome are executed by these individuals. Therefore, research suggests that digitalisation as well as innovation require employees to perceive change valence (Lokuge et al. 2019; Ruikar, Anumba & Carrillo 2006; Weiner 2009), change efficacy (Weiner 2009), have a positive attitude and perception towards technology adoption (Lokuge et al. 2019; Ruikar, Anumba & Carrillo 2006), and positive past experience with change (Weiner 2009).

Furthermore, they must be adaptable and possess innovation-specific knowledge, skills and IT and innovation experience (Lokuge et al. 2019; Nguyen et al. 2019; Sony & Naik 2019; Yen et al. 2012; Yusof et al. 2010) .

External Capacity

Finally, in order to be ready to apply digital technologies and generate innovative outcomes, it is necessary for organisations to collaborate with external firms (Lokuge et al. 2019; Nguyen et al. 2019; Pessot et al. 2020; Scaccia et al. 2015; Yen et al. 2012; Yusof et al. 2010). Furthermore, as digital innovation does not happen in a silo, the level of digitalisation across the whole supply chain influences organisational readiness for digital innovation as well (Sony & Naik 2019).

A summary of the literature-based framework of organisational readiness for digital innovation is visualised in Table 8.

Table 8: Research framework of organisational readiness for digital innovation

Key factors	Aspects of Respective Key factors	Supporting References
Strategy	• Clear organisational strategy (that implements change) • Firm structure, financial management and processes support innovation • The organisation possesses a high level of digitisation • Processes are agile and standardised enhancing incorporation of change • Organisation is proactive and responsive to digital opportunities • Roles in regard to digitalisation are designated • Necessary information and knowledge exist within the organisation • Organisational culture characterised by idea sharing, decentralised decision-making and shared values, behavioural patterns and set norms that creates a supportive and encouraging environment • Products/Services are, if possible, designed smart	(Evans, JD & Johnson 2013; Khalfan & Anumba 2006; Lokuge et al. 2019; Lou, Lee & Goulding 2020; Nguyen et al. 2019; Pessot et al. 2020; Ruikar, Anumba & Carrillo 2006; Scaccia et al. 2015; Sony & Naik 2019; Weiner 2009; Yen et al. 2012; Yusof et al. 2010).
Management	• Project Management is existent and focuses on clients, quality assurance and facility design • Leadership throughout hierarchies focuses on constant improvement by being involved, committed and collaborative to communicate and inspire the IT vision throughout all levels • IT-support for communication, coordination, integration and tasks is available	(Khalfan & Anumba 2006; Lokuge et al. 2019; Lou, Lee & Goulding 2020; Nguyen et al. 2019; Scaccia et al. 2015; Sony & Naik 2019)
Technology	• IT is available and well performing • IT is applicable throughout the organisation. • IT enables information sharing and automated information processing	(Khalfan & Anumba 2006; Lou, Lee & Goulding 2020; Pessot et al. 2020; Ruikar, Anumba & Carrillo 2006)
Resources	• Financial, human and IT infrastructure resources are available and flexible for utilisation	(Evans, JD & Johnson 2013; Lokuge et al. 2019; Lou, Lee & Goulding 2020; Nguyen et al. 2019; Pessot et al. 2020; Ruikar, Anumba & Carrillo 2006; Scaccia et al. 2015; Sony & Naik 2019; Yusof et al. 2010)

Staff	• Positive attitude and perception towards technology adoption • Employees perceive change valence • Employees perceive change efficacy • Employees have positive past experience with change • Employees are adaptable • Employees possess innovation specific knowledge and skills as well as experience in IT and innovation	(Lokuge et al. 2019; Nguyen et al. 2019; Ruikar, Anumba & Carrillo 2006; Sony & Naik 2019; Weiner 2009; Yen et al. 2012; Yusof et al. 2010)
External capacity	• Inter-organisational collaboration and external support • Extent of digitisation of supply chain	(Lokuge et al. 2019; Nguyen et al. 2019; Pessot et al. 2020; Scaccia et al. 2015; Sony & Naik 2019; Yen et al. 2012; Yusof et al. 2010)

Beyond identifying factors and attributes influencing organisational readiness for digital innovation, the readiness literature used to develop the theoretical framework of organisational readiness for digital innovation suggests the existence of relationships between the identified factors, as illustrated in Figure 6.

Scaccia et al. (2015), referring to innovation readiness, suggest a mutual influence between the factors Resources, External Capacity, Staff and Management. Specifically, the authors propose a relationship between the 1) Resources attributes financial, human and IT-resources, 2) External Capacity attribute Inter-organisational collaboration and external support, 3) Staff attributes of perceived change valence and change efficacy, and 4) Management attribute leadership. However, the authors point out that the relationships depend on the specific innovation, hence they do not provide any details on the nature of the relationships.

Ruikar, Anumba and Carrillo (2006) suggest that the factors Staff and Management influence and are influenced by the factors Technology and Processes in the context of e-readiness. Specifically, the authors propose a relationship between the 1) Staff attributes of attitude towards technology adoption, change valence and change efficacy, 2) Management attribute of leadership instrumentalising digital strategy, 3) Technology attribute of IT availability and performance, and 4) Processes attribute of processes enhancing change. The factor Processes is used in the e-readiness context, however, bringing together the different readiness literature, here it is identified as part of Strategy readiness. Ruikar et al. (2006) do not provide any examples or more in-depth information on the identified relationships.

Finally, investigating Industry 4.0 readiness, Sony and Naik (2019) propose that the factors Staff, Management, External Capacity and Strategy have a mutual influence on each other, but they do not provide further detail. The authors propose a relationship between the 1) Staff attributes of adaptability, 2) Management attribute of involved, committed and communicative leadership, 3) External Capacity attribute of extent of digitalisation of supply chain, and 4)

Strategy attributes of clear organisational strategy, a high level of digitisation and smart products/services.

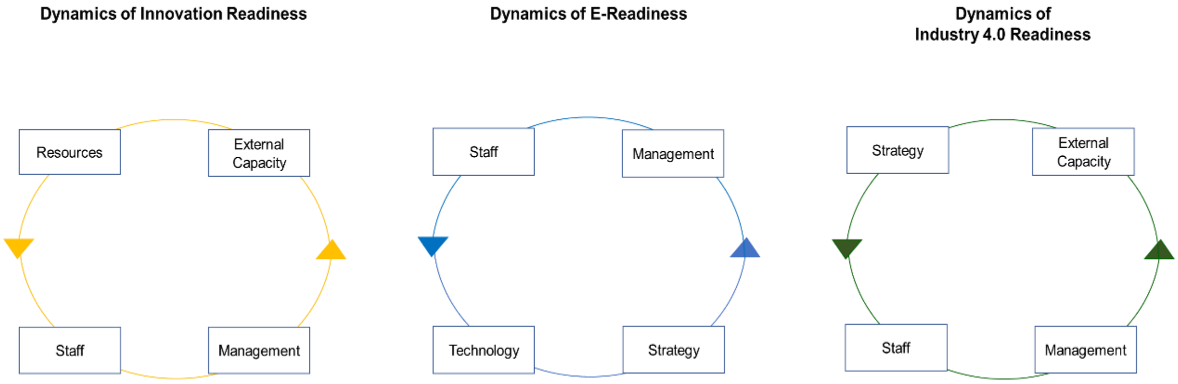

Figure 6: Overview of the relationships between readiness factors suggested by relevant readiness literature (circular arrows indicate mutual influence of all factors)

Bringing together the key factors influencing organisational readiness for digital innovation, as well as the proposed dynamic relationships between the factors, the theoretical framework guiding this thesis is established, as depicted in Figure 7.

The influence of the six key factors (Staff, Management, Technology, Strategy, Resources and External Capacity) on organisational readiness for digital innovation, as suggested by the readiness literature, is indicated by the black arrows. The relationships between these factors are indicated by the coloured arrows. The circular green arrow represents the mutual influence of the factors Management, External Capacity, Strategy and Management, as suggested by Sony and Naik (2019). The circular yellow arrow represents the mutual influence of the factors Staff, Resources, External Capacity and Management, as suggested by Scaccia et al. (2015). The circular blue arrow represents the mutual influence of the factors Staff, Technology, Strategy and Management suggested by Ruikar, Anumba and Carrillo (2006)

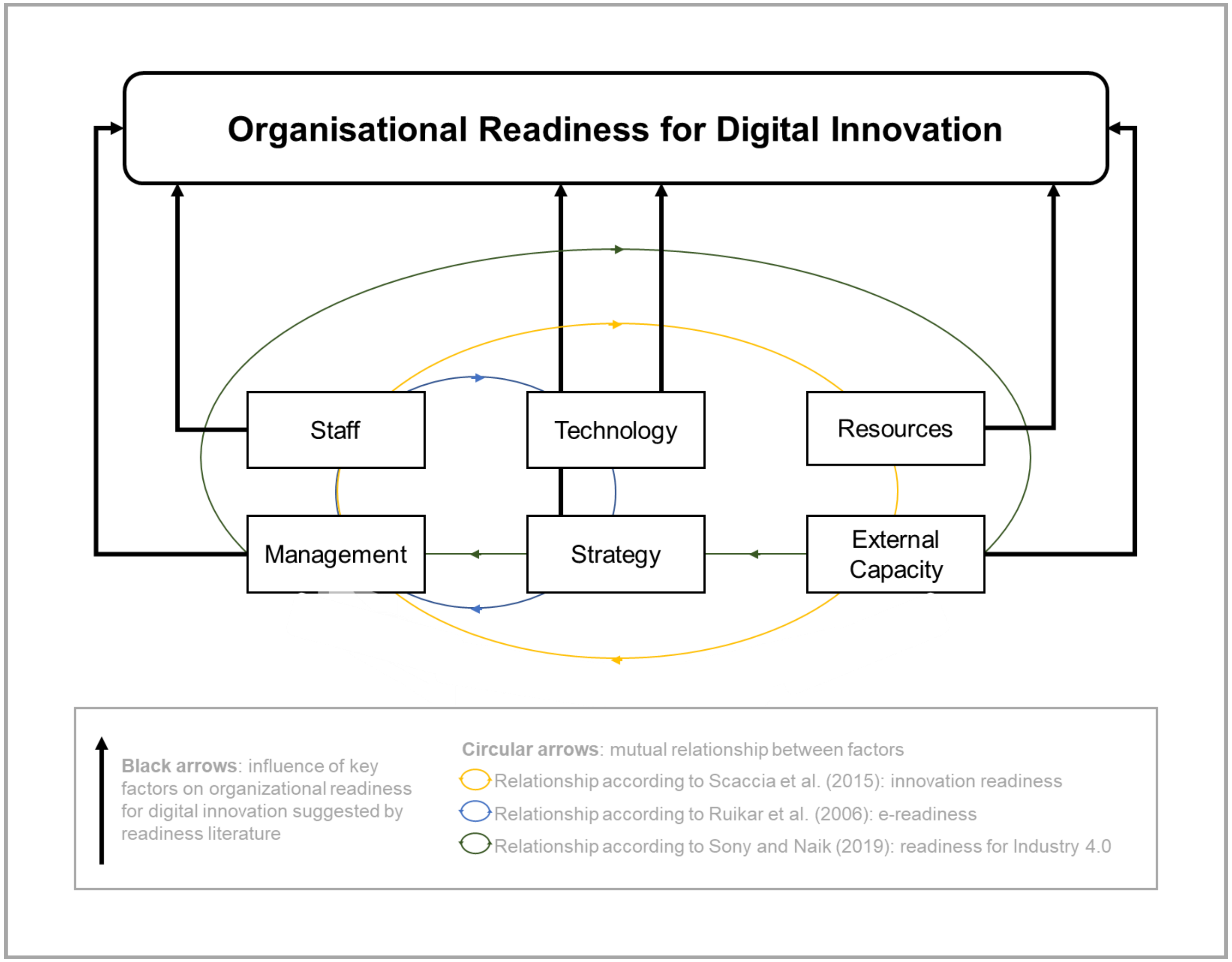

Figure 7: Theoretical framework

2.6 Summary

This chapter has theoretically positioned this thesis, and introduced and critically reviewed readiness concepts relevant to explaining organisational readiness for digital innovation. Building upon extant readiness research, a research framework of organisational readiness for digital innovation was developed.

In the next chapter the research context of this thesis is detailed. Furthermore, the research objective and the respective research questions guiding this thesis are derived.

Chapter 3: Research Context

3.1 Objective

This chapter introduces the research context of this thesis. It first provides an overview of the global agriculture sector, its current challenges and the role of digital innovation in addressing these challenges. It then outlines the Australian agriculture sector and its peculiarities. Finally, the extant readiness research that was introduced in the previous chapter is evaluated in light of the research context, unveiling research opportunities, from which the objective and research questions of this thesis are derived.

3.2 Global Agriculture

3.2.1 Global Overview

The industry context of this thesis is the agriculture sector. It comprises organisations active in the agriculture practice (also called farm business), that combine land, labour, capital and management to generate agricultural products (ABARES 2019). According to the Food and Agriculture Organisation of the United Nations (FAO 2019) there are over 600 million farms in the world, over half of which are in high- and middle-income countries and the remaining half in low-inclome countries (The World Bank 2012). As agriculture requires land use for cropland as well as pasture, agricultural businesses currently use nearly 40% of the world's land – one third as cropland, and the remaining land for pasture (OECD/FAO 2019).

Agriculture is a sector of great importance to the global economy. One-third of the economically active population obtains its livelihood from agriculture (Global Agriculture 2019), almost equally distributed between male and female (The World Bank 2019a). However, the employment as well as the economic importance of the sector varies between regions. Africa has the highest rate of agriculturally involved population, reaching over 60% in countries such as Mauritania and Angola (The World Bank 2019c). In developing countries, in particular, agriculture has been shown to contribute to a surplus of food, labour, raw materials, capital, and foreign exchange, while at the same time generating demand for industrial goods and services, which enhances the country's growth (Tiffin & Irz 2006).

In 2017, agriculture accounted for only 3.4% of the global GDP (The World Bank 2019b). The contribution of agriculture to the national gross domestic in highly developed countries, such as Germany (0.7%), Canada (1.7%) and Singapore (0.02%), is very low (The World Bank 2019b). In contrast, developing countries, characterised by high poverty rates, economic instability, and lack of basic human resources, depend on agriculture, as the agricultural GDP contribution in, for example, Guinea-Bissau (47.46) and Mauritania (44.82%) show (The World

Bank 2019b). Nonetheless, even in some developed countries, such as the USA, there are communities in which agriculture is the primary industry (Kotkin 2015).

3.2.2 Challenges of Global Agriculture

Currently, the agriculture sector worldwide is facing significant challenges. First, due to climate changes, COVID-19-related issues and increased demand for agricultural goods, securing the global food supply is becoming an increasingly compelling problem. Climate change occurs in various forms and leads to a multitude of events, threatening agriculture (Mulla et al. 2020; Wiebe, Robinson & Cattaneo 2019). Varying precipitation patterns make the seasonal yield unpredictable (Fishman 2016; Sam et al. 2020). Droughts decrease yields (Fraga et al. 2020; Iizumi et al. 2014), and extreme weather events such as floods, hail, bushfires and cyclones destroy harvests and can have consequences on the following seasons as fertile land mass may be reduced (Iizumi & Ramankutty 2015; Li, Y et al. 2019). Consequently, the effects of climate change significantly impact global agriculture (IPCC 2014; Siddig et al. 2020; Van Meijl et al. 2018) and are forecast to increase in frequency and severity (Steensland & Zeigler 2018), endangering the global food supply.

The current global COVID-19 pandemic poses another challenge for the agriculture sector and its ability to meet the production volumes needed to feed the global population, especially at an affordable price. Movement restrictions imposed to limit the spread of the virus are limiting the availability of seasonal workers (FAO 2020b). The reliability of the agricultural workforce is decreased as any workers experiencing COVID-19-related symptoms must isolate until testing negative for the virus. In case of an infection, other workers who have been in close contact with the infected individuals must undergo the same procedure (Australian Government 2020). Such labour shortages impact farms' ability to maintain their production volumes (Australian Government 2020).

Preventive measures limiting the spread of the virus cause inefficiencies in agricultural production as well. Social distancing requirements, for example, while packing and grading fruit and vegetables (OECD 2020c), limit the number of workers able to execute the tasks, which in turn translates into more time and hence higher costs for the production of agricultural goods. Continuous disinfection of workplaces is another COVID-19-related measure which not only involves additional costs for antibacterial chemicals, but time and manpower needed to execute this task. These inefficiencies and additional costs for farms are expected to be reflected in the price of agricultural produce (OECD 2020b). Additionally, a price increase is forecast due to high transportation costs originating from limited freight activity and delays due to border closures (OECD 2020a).

While climate change and consequences of the current COVID-19 pandemic are threatening current global production volumes, at the same time the global social and economic developments demand an increase in production volume. Over the last century, the global population has quadrupled. Growing from 1.8 billion people in 1915, to over 7.5 billion in 2020 (Elferink & Schierhorn 2016; World Population Review 2020), it is expected to reach over 9.5 billion in 2050 (United Nations 2019). Combined with an increase in individual consumption, agriculture must produce over 70% more goods by 2050, to meet the global demand (Lutz 2013). Meanwhile, over 820 million people, 11% of the global population, are already suffering from hunger (FAO et al. 2019).

In its current state, the agriculture sector is not able to produce the required volume of goods. A decreasing agricultural labour force as well as limited land suitable and available for agricultural expansion are putting further pressure on the sector (Pardey et al. 2014).

Furthermore, global agriculture has a considerable negative environmental impact. To increase yield, agriculturalists have been applying fertilisers and pesticides, over-irrigating land and deforesting to create more agricultural land, as the current case of over 26,000 forest fires in the Amazon demonstrates (Andreoni & Londoño 2019; Webb et al. 2017). This has led to soil erosion, land pollution, and substantial reduction of CO_2 absorbent flora (Bouma, Montanarella & Evanylo 2019; Brown 2019). Agriculture accounts for 70% of global water use – in some developing countries, up to 95% – causing life threatening water shortages (FAO 2017b). Furthermore, it contributes to 25% of the global greenhouse emissions, significantly impacting the climate (OECD/FAO 2019).

3.2.3 Digital Innovation in Agriculture

To meet the challenges and ensure the global food supply, the agriculture sector is in urgent need of innovation. The increasing number of digital technologies entering agriculture is a promising trigger for innovation in the sector (Ciruela-Lorenzo et al. 2020; Salam 2020). While different reports present a spectrum of digital technologies enabling digital agriculture (Blackburn, Freeland & Grätner 2017; EY 2019; Trendov, Varas & Zeng 2019), Burdon et al. (2017) identify the most promising digital technologies in agriculture to be cybernetics, big data, sensors and robotics. A detailed summary of these digital technologies and their application in the agriculture sector is presented in Appendix F.

The introduction of digital technologies to agricultural practice can enable innovation on several levels. One of the post prominent innovative outcomes induced by digital technologies on farms is process innovation. As tasks such as irrigating, applying fertilisers and herbicides, harvesting and feeding can be automated and executed by robots, the processes on farms can be changed fundamentally with the application of digital technologies. Burdon et al. (2017) provide an extensive overview of process innovations enabled by digital technologies.

These changes affect not just how the farm operations are carried out but how they are organised too. Automated task execution reduces the amount of manual labour required on farms, and consequently the time investment and presence necessary, thereby influencing the organisation of farm work. Moreover, digital technologies enable data-driven decision-making. Knowledge management is therefore not based on intrinsic knowledge and experience-based evaluation, but instead is subject to real time data collection and analysis processes. As the digital technologies enabling these innovations are acquired externally, new business partnerships with technology providers and advisors are formed.

While the application of digital technologies on farms mainly focuses on innovating processes and the organisation, they can contribute to marketing innovation too. An example is the application of blockchain technology. While this digital technology is commonly associated with financial markets (Tapscott & Tapscott 2017), in agriculture it enables producers to place their products into differentiated markets by allowing verification of specific attributes such as provenance (Robertson, M et al. 2018).

Product innovation is the least likely innovation outcome to occur on a farm when applying digital technologies. However, widening the perspective, immense product innovations can be enabled through the application of digital technologies in agriculture (Van Etten et al. 2016). A current, highly discussed example is crop improvement strategies (Langner, Kamoun & Belhaj 2018; Omari et al. 2020). To assess plant genotypes and their performance in varying environments, a wide range of genotypic, phenotypic and environmental data are required, which can be acquired using digital technologies such as drones, remote sensors and connected weather stations on farms (Halewood et al. 2018).

Further remarks on the potential impact of digital innovation on the agriculture sector can be found in Appendix G.

While the innovation enabled through digital technologies has the potential to meet the global agricultural challenges, not all countries have the possibility to realise digital innovation. Farmers in third world countries, living in poor conditions, with low education and subject to political as well as economic instability (OECD/FAO 2019), do not have access to digital technologies. At the same time, the majority of these third world countries report that they do not have the capacity to ensure their population’s food supply OECD/FAO (2019). In March 2020, for example, the food and agriculture organisation of the United Nations (FAO 2020a) recorded 44 countries, mostly third world countries, in need of external assistance for food.

Consequently, the responsibility for ensuring an adequate global food supply lies with countries with a potential production volume exceeding the domestic demand, such as Australia.

3.3 Australian Agriculture

3.3.1 Key Facts and Significance of the Sector

The Australian agriculture sector consists of cropping, horticulture, forestry, industrial crops, livestock and fishery (National Farmers' Federation 2017). As cropping, livestock and fishery account for over 75% of the total gross value (ABARES 2020), this thesis focuses on these three sectors. While this focus allows to gain a representative understanding of the Australian agriculture sector, its diversity enables to identify potential differences in regard to reediness for digital innovation.

Agriculture accounts for 58% of Australian land use (Jackson, Hatfield-Dodds & Zammit 2020) and is a cornerstone of the Australian economy. There are 85,681 farm businesses in Australia, 99% of which are Australian-owned and -operated (National Farmers' Federation 2017). Agriculture accounted for 2.7% of the national GDP in 2016-2017 and for 17% of its exports (ABARES 2020; Thirlwell 2017).

The agricultural sector is a major employer in Australia, providing employment to 304,200 people in 2016-2017 (National Farmers' Federation 2017), with the unique distribution throughout the country, ensuring employment in rural areas (EY 2019). Most people working in agriculture in 2016 were employed as farm managers (59%), farm labourers (25%), and farm technicians and trade workers (4.5%) (ABARES 2018). This is mirrored in the Australian Bureau of Statistics (2016), that identified 71.2% of Australian farms as non-employing and 27.71% as having less than 19 employees. The majority of Australian farms are owned and operated by a family (ABARES 2018; ANZ 2016; Local Farm Produce 2019).

While the Australian agriculture sector is important to the domestic economy, it makes a noteworthy contribution to ensuring the global food supply as well: 70% of agricultural goods produced in Australia are exported (Jackson, Hatfield-Dodds & Zammit 2020), making it the 12th largest exporter of agricultural products in the world (Wyers 2019).

However, Australia is heavily affected by climate change, experiencing extreme heat, persistent drought, and floods in coastal areas (Howden, Nelson & Zammit 2018), reducing yields significantly and threatening the survival of farms (Karp 2019; Loch et al. 2012).

To meet the increasing global demand for agricultural goods and remain a driver for the Australian economy, while limiting the negative environmental impacts of farming, the Australian agricultural sector requires innovation. Digital innovation is regarded as having high potential to meet these goals in Australia (Australian Government 2019; EY 2019; The Regional Australia Institute 2018).

However, with regard to the application of newly emerging digital technologies, ‘Australia is in its infancy’ (Leonard, E et al. 2017, p.1), compared to other countries such as the US and Israel. In a national comparison, agriculture was ranked the least digitalised industry in Australia (Blackburn, Freeland & Grätner 2017; Gandhi 2016).

To unlock the potential of digital innovation, both federal and states governments have initiated and remain heavily involved in fostering digital innovation in agriculture. Examples include investment in research on agricultural technology, on-farm trials, infrastructure programs enhancing connectivity in rural areas, and innovation hubs dedicated to developing digital technologies for the sector (Agriculture Victoria 2019; Food Agility CRC 2019; Government of Western Australia 2019; Pulford 2018).

3.3.2 Context-Specific Factors Influencing Organisational Readiness for Digital Innovation

This section will identify and analyse the peculiarities of family farms (which make up the majority of Australian farms) that may influence their readiness for digital innovation. As family farms are not an autonomous and institutionalised research area and hence lack the breadth and depth of academic debate required to fully capture the context (Suess-Reyes & Fuetsch 2016), the analysis is enriched by literature on family businesses and SMEs, when appropriate.

Family business is a separate research stream which offers a wide body of literature applicable to the context of the Australian agricultural sector (Payne 2019; Sharma, Chrisman & Gersick 2012; Wortman 1994). As the majority of Australian farms are owned and managed by farming families (Watts & Harrison 2015), reflecting the global status-quo where 90% of the farms are run by an individual or a family (FAO 2019), only literature on family-owned and -operated businesses is included.

It is often assumed that family businesses are small (Litz 1995); however, some of the largest organisations worldwide are family businesses, for example Wal-Mart Inc., Volkswagen AG and the ALDI Group (van Rij & Zellweger 2019). As over 80% of Australian farms classify as SMEs (ANZ 2016; Clark et al. 2011) literature on SMEs is included. The particularities of SMEs resulting from their small number of employees and turnover, attracts considerable academic interest and has become a separate research stream (Bocconcelli et al. 2018; Hossain & Kauranen 2016) which can provide additional insights into the Australian agricultural sector.

The relevant research, introduced in the following section, is structured around the six factors (Strategy, Management, Technology, Resources, People, and External Capacity), which were identified by extant readiness literature as influencing organisational readiness for digital innovation.

3.3.2.1 Strategy

According to Sreih et al. (2019), there is a lack of clear strategic planning and communication in family farms. A distinct characteristic of family farms' strategy is their long-term economic orientation (Gasson & Errington 1993), originating from the tradition of intra-family succession (Bell, C 2019; Bohak, Borec & Turk 2010). As the farm capital is provided by the farming family (Block 2012), no short-term results must be reported and justified to external equity holders (Dreux IV 1990), allowing a long-term focus. Sharing equity with non-family members is generally avoided to maintain financial and managerial independence (Sirmon & Hitt 2003; Suess-Reyes & Fuetsch 2016), which in turn leads to limited financial resources and consequently low investment activity.

Family firms, including family farms, have been shown to have the potential and ability to innovate (FAO 2014), particularly because of their long-term orientation which should motivate innovation for a sustainable future (Rondi, De Massis & Kotlar 2019); however, innovation rarely occurs (Duran et al. 2016). Research refers to this phenomenon as the 'ability willingness paradox' (Chrisman et al. 2015). Reasons for this paradox include risk aversion and the focus on risk-minimisation to ensure the existence and value of the family legacy (Aimin 2010; Suess-Reyes & Fuetsch 2016) and to protect the invested private capital (Carney 2005), as well as the family firm-specific goals. Due to the duality of the family business system, family firms simultaneously pursue business and family goals (Binz et al. 2017; Chrisman & Patel 2012), with each influencing the other (Fitz-Koch, Cooper & Cruz 2019). The duality of economic and non-economic goals is discussed as 'socioemotional value' (Berrone, Cruz & Gomez-Mejia 2012; Saleem, Siddique & Ahmed 2019). The emotionally driven goals of family farms include, for example, assuring workplace and financial resources for family members (Alsos et al. 2003), reputation and identity-based goals (Tagiuri & Davis 1992) and the company being a means of personal growth, social advancement and autonomy (Dyer Jr & Whetten 2006). The pursuit of such non-economic goals contributes to low economic performance and consequently limited financial capital despite a high level of productivity (Jakobsen 2017).

3.3.2.2 Management

The governance of Australian farms, in terms of stakeholder rights and responsibilities, is mostly in the hands of the farms owners, as they provide the farm capital (Block 2012). Farm owners/the farm family act as chief executive(s), and operating, marketing, financial, technology and communications officers (FAO & IFAD 2019; Suess-Reyes & Fuetsch 2016), with a distinct lack of clarity between the roles (ANZ 2016). The farm family carries the managerial role due to two reasons: a) the financial investment of the family in the business, and b) the personal principle, which describes the owning manager(s) view of the task as a lifelong duty (Loecher 2000). Their management is characterised as less formal because of the family bond as well as the low number of employees (Kotey 2005).

Balancing sometimes conflicting firm and family goals leads to unique incentive structures, (Anderson, Mansi & Reeb 2003; Randøy, Dibrell & Craig 2009) and a leadership style fundamentally different to non-family firms (Williams Jr et al. 2018). Family firms take pride in their enterprise, identify with it and strongly focus on maintaining its reputation (Berrone, Cruz & Gomez-Mejia 2012; Dyer Jr & Whetten 2006). Hence, leadership is at least partially emotionally governed (Daspit et al. 2017), and focused on corporate social responsibility (Wanzenried 2018). Additionally, leadership in family businesses is characterised by close, long-term relationships and networks that the family firm builds over time (Classen et al. 2012).

At the same time, the farming family's interest in protecting the family business can outweigh the socioemotional leadership motives causing close control and monitoring behaviour (Cassia et al. 2012; Wanzenried 2018). Furthermore, undiversified shareholders' long tenures may lead to rigid mental maps and hence leadership which discourages change (Anderson, Mansi & Reeb 2003).

3.3.2.3 Technology Adoption

As no two owners of any company are the same (De Massis, Frattini & Lichtenthaler 2013) and hence do not think alike (Matzler et al. 2015), there is no universal answer to what is needed for a farm to take up new technologies.

However, an extensive literature review has identified a wide range of elements contributing to farms' adoption of digital technologies, which are outlined in the following section.

First, for a farm to adopt a new technology, the technology itself must incorporate a set of characteristics. Major obstacles to current technology adoption in agriculture include the lack of (1) technological usefulness, (2) a relative advantage, (3) perceived benefit, and (4) compatibility with existing infrastructure (Annosi et al. 2019; Chavas & Nauges 2020; Pathak, Brown & Best 2019).

Second, external feedback plays a central role for family farms. Hence, researchers such as Zangiacomi et al. (2020) and Biegler et al. (2018) stress the importance of communication with external organisations, which encourages collaboration and facilitates the adoption of digital technologies.

Third, the outer context, referring to the socio-political climate, can be decisive as incentives and mandates can motivate farms to adopt new technology.

Fourth, research has found a set of attributes shared among farms adopting technology. Skills, motivation, values and goals reflecting the ability and willingness for technology adoption are characteristics necessary for the adoption of new technology.

Fifth, the structural and cultural features of the farming business, such as pre-existing knowledge/skills base, the ability to find, interpret, recodify and integrate new knowledge, and a risk-taking climate all provide an environment which fosters technology adoption and are therefore system antecedents for innovation (Miller et al. 2019).

Furthermore, the situational aspects of the farming business that relate to preparedness to assess and adopt an innovation are prerequisites for the adoption of new technology on farms.

The last key element identified by Pathak, Brown and Best (2019) is the situational aspect. The timing and nature of the links between the potential adopter and other players involved play a role in a farm's decision to adopt a new technology.

While many studies that look at the influencing factors of adoption of precision agriculture and other digital technologies support the introduced categorisation (e.g. Barnes et al. 2019; Kaler & Ruston 2019; Kountios et al. 2018), recent publications on the topic provide additional insights explaining the reluctance of farmers to engage in digital innovation.

Investigating the barriers preventing the adoption of smart agriculture and the implementation of 4.0 technologies, Annosi et al. (2019) identified that a supportive business environment, in terms of availability of professional services or institutional support, and the organisational capability of knowledge acquisition were both additional prerequisites for technology adoption in the agriculture sector.

Despite the benefits of data collection on farms, as continuously emphasised by research (e.g. Saggi & Jain 2018; Shakoor et al. 2019), farmers are reluctant to engage in big data applications. Newton, Nettle and Pryce (2020), Wiseman et al. (2019) and Kosior (2018) suggest that it is the constraints surrounding data sovereignty and the socio-ethical dimensions of data use that is impeding adoption of big data. Fielke, Taylor and Jakku (2020) make a similar observation, identifying that the different priorities and interests of various stakeholders are challenging as well. Hermans et al. (2019) suggest public-private partnerships as a solution to balance diverging interests.

Moreover, in a study conducted by Kaler and Ruston (2019) farmers repeatedly mentioned time as a crucial component for technology adoption. As farmers are time poor (Boza et al. 2019), finding time for technology adoption is another factor holding farms back.

In addition, a recent study by Salam (2020) identifies the high costs of digital agriculture as a barrier, particularly because digital technology providers mostly target big farms, leaving behind smaller farms with limited financial resources.

Connectivity is another important factor, identified by Virk et al. (2020) and Bacco et al. (2019), as critical for applying digital innovation. At the same time, researchers have identified gaps in connectivity on farms, especially in rural Australia (Fleming et al. 2018; Marshall, A et al. 2019), causing yet another barrier.

Finally, scholars have been calling for the engagement of farmers as co-developers as they can provide a focus on functionality rather than pure technological advancement (Eastwood, Chapman & Paine 2009; Kaler & Ruston 2019). Research identified that digital technologies are not always user-friendly or fit for purpose (Uddin et al. 2016; Wolfert, Sørensen & Goense 2014), and lack accountability from providers (El Bilali et al. 2019), which makes the adoption of digital technologies less attractive.

3.3.2.4 Resources

Farms are commonly a multi-generation workplace, where practical knowledge has been accumulated and diffused throughout the family (Cabrera-Suárez, De Saá-Pérez & García-Almeida 2001; Inwood, S, Clark & Bean 2013). Therefore, farms can potentially have deep firm-specific tacit knowledge (Sirmon & Hitt 2003), which often is a knowledge collective of the individuals engaged on a farm (Thomas, E, Riley & Spees 2020). The majority of Australian farms are operated primarily by a farming family and supplemented by additional labourers (ABARES 2018; Mahto et al. 2020), which lack the know-how and experience related to the application of novel digital technologies (Burton & Riley 2018; Franco, Singh & Praveen 2018) and their value-adding utilisation (Bramley 2009; Franco, Singh & Praveen 2018).

With digital innovation on farms being identified as complex, multifaceted and not straightforward (Zambon et al. 2019), it is considered central to possess high intensity and heterogeneous knowledge (Hund & Wagner 2019; Van Es & Woodard 2017; Vecchio et al. 2020). However, the recruitment of knowledgeable experts is often challenging due to factors such as the exclusive succession on farms, lack of conventional professionalism and limited opportunities for personal growth which discourages highly qualified employees from working for family-owned farms (Covin 1994). Furthermore, economic pressure and past government policies have contributed to increased 'deskilling' of rural labour (Carlisle et al. 2019).

In terms of financial resources, the farm capital in family farms is traditionally provided by the farming family (Block 2012). To keep governance of the business within the family, farms generally forego external funding (Sirmon & Hitt 2003; Suess-Reyes & Fuetsch 2016), which leads to very limited financial means. Moreover, Australian farmers receive the second lowest levels of government support in the developed world (OECD 2019). Consequently, the vast majority of Australian farms hold some form of debt (ANZ 2016).

3.3.2.5 Staff

Individuals on farms in general, and particularly in Australia, are characterised by a set of unique attributes. As Australian farms are mostly family-owned and -operated, flexibility to perform work and extensive working hours are common characteristics of the farming family (Suess-Reyes & Fuetsch 2016).

Additionally, Australian farms are exposed to a highly volatile environment involving, for example, unpredictable climate events (Jackson, Hatfield-Dodds & Zammit 2020). Farm families have been shown to possess a high level of resilience (Hanson, Hessel & Danes 2019; Rathi 2020) and adaptability (Brookfield & Parsons 2007; Nicholas-Davies et al. 2020) which allows them to respond appropriately and sustainably to challenges. Farmers favour and trust practical experience over theoretical knowledge too (Lees & Reeve 1991; Salam 2020). In a study conducted by Moore (1990), farmers named local knowledge, the willingness to work hard and the ability to work reliably and independently as the most important characteristics of a farm manager.

The motivation for farm families, as described before, originates from the goal of ensuring personal and family well-being (Alsos et al. 2003; Barbieri 2010). Hence, financial opportunities are pursued in consideration of the care-based ethic of safeguarding the family wealth (Bohnet et al. 2011; Greiner & Gregg 2011), as well as the farm family identity and the farming culture (Warren et al. 2016).

The farming culture, which authors such as Vayro et al. (2020) call 'a way of living', is defined by the deep attachment to conventional farming practice (Warren et al. 2016) and the significance of peer approval within the network (Greiner, Patterson & Miller 2009). This culture is one of the primary reasons farmers are reluctant to change (Warren et al. 2016), as pursuing established farming practice generates socio-cultural rewards of peer approval, acknowledgment and admiration (Burton 2004, 2012; Burton, Kuczera & Schwarz 2008).

Another obstacle to initiating change is the perception of change requiring new knowledge, unfamiliar expertise and novel machinery (Warren et al. 2016) as well as time and money, which are scarce resources on a farm (Boza et al. 2019).

3.3.2.6 External Capacity

As detailed earlier, family farms have an undiversified workforce and limited knowledge resources (Dunn 1995; Franco, Singh & Praveen 2018). Hence, know-how of new developments, technology, etc., must be gained from outside the family farm.

The acquisition of such knowledge is important to understand the spectrum, potential and application of digital technologies (Phiri, Chipeta & Chawinga 2019; Vecchio et al. 2020). A lack of interaction and collaboration with external entities has been shown to limit the knowledge on farms and therefore are barriers to innovation (Lowitt et al. 2020).

The main external sources of knowledge on farms have been identified by recent publications as (1) the local community, (2) managing institutions and those associated with agricultural policy, (3) the media, (4) peers, and (5) field days (Belyaev et al. 2020; De Haes et al. 2020; Emerick & Dar 2020; Fielke, Taylor & Jakku 2020; Kernecker et al. 2020; Silvestri et al. 2020; Wójcik, Jeziorska-Biel & Czapiewski 2019).

However, research has shown that SMEs are less sufficient and accordingly less beneficial in regard to the acquisition and exploitation of external knowledge (Huber, Wainwright & Rentocchini 2020; Lee, Sungjoo et al. 2010; Spithoven, Vanhaverbeke & Roijakkers 2013). They tend to overemphasise appropriability, reducing efforts to acquire external knowledge through formal partnerships, they do not have the capacity necessary to conduct an extensive search for required knowledge, and they lack capabilities such as multidisciplinary competencies to utilise external knowledge (Huber, Wainwright & Rentocchini 2020; Laursen & Salter 2014).

3.4 Review of the Research Framework in Light of the Research Context

As no research on organisational readiness for digital innovation in the agriculture context exists, the research framework developed in this thesis (see section 2.5) relies on readiness literature not specific to the context of this thesis. Hence, in the following section, the research framework of this thesis is evaluated applying theoretical knowledge on the sector detailed in the previous section.

Strategy: The validity of some attributes influencing readiness with regard to the category strategy is challenged in light of the characteristics of the Australian agriculture sector. While readiness literature suggests the need for a clear organisational strategy to realise digital innovation, family farms have been identified as lacking a clear strategic plan (Sreih, Lussier & Sonfield 2019).

Prerequisites for digital innovation include a conducive firm structure, financial management and processes supporting innovation; however, farms are subject to the so-called ability willingness paradox (Chrisman et al. 2015). While they have been shown to possess innovative potential, their risk aversion (Aimin 2010; Suess-Reyes & Fuetsch 2016), as well as the parallel pursuit of often competing business and family goals, inhibit innovative activity (Binz et al. 2017; Saleem, Siddique & Ahmed 2019).

Aspects such as the farms' governance by a small number of family members and the strong bonds between the individuals of the farm (Mahto et al. 2020; Suess-Reyes & Fuetsch 2016) make the suggested need for agile and standardised processes redundant.

Another attribute of strategic readiness in the derived framework is designation of roles; however, family farms often lack a clear distinction between and designation of roles (ANZ 2016; Suess-Reyes & Fuetsch 2016) and professionalism in business management (Covin 1994).

Furthermore, the framework suggests the need for information and knowledge existing within the organisation. While family farms have extensive farming experience and respective knowledge, passed on through generations (Cabrera-Suárez, De Saá-Pérez & García-Almeida 2001; Inwood, S, Clark & Bean 2013; Thomas, E, Riley & Spees 2020), they lack knowledge about and experience in the value-adding utilisation of digital technologies (Bramley 2009; Burton & Riley 2018; Franco, Singh & Praveen 2018). The acquisition of such information and knowledge on Australian farms may be problematic too because, despite research unanimously emphasising the centrality of knowledge in agriculture (Blandy & Brummitt 1990; Meijer et al. 2015; Miller et al. 2019), farmers favour and trust practical experience over theoretical knowledge (Lees & Reeve 1991; Salam 2020) and perceive local knowledge, the willingness to work hard and the ability to work reliably and independently as the most important characteristics of a farm manager (Moore 1990).

The last strategic attribute suggested by the literature-based framework is designing products and services smart. As agriculture is concerned with the practice of cultivating the soil, producing crops, and raising livestock and in varying degrees the preparation and marketing of the resulting products (Merriam Webster Dictionary 2020), the agricultural outcomes cannot be designed smart.

Management: In the management category, the framework, based on generic readiness theory, emphasises various aspects of project management necessary for digital innovation in an organisation (Khalfan, Anumba & Carrillo 2001). As family farms have only a limited number of individuals working in the organisation (Australian Government 2018; Watts & Harrison 2015), project management is unlikely to be carried out. Furthermore, the management category of the framework suggests that leadership should focus on, inter alia, constant improvement and inspiring the IT vision. As leadership on family farms balances business and the often contradictory family goals (Berrone, Cruz & Gomez-Mejia 2012; Saleem, Siddique & Ahmed 2019), focusing on improving and inspiring the IT vision may be difficult to realise as it can potentially disrupt the balance between emotional and rational farm goals.

Moreover, farms highly value peer approval (Burton 2004, 2012; Greiner, Patterson & Miller 2009), which is generally generated via traditional practices, including physical work and practical skills more than innovation and novel technologies (Lees & Reeve 1991; Warren et al. 2016). Hence making a transition towards digital innovation is a socially difficult endeavour.

Resources: The framework suggests that financial resources need to be available and flexible. However, family-farms have generally little monetary resources at their disposal, as the farm capital is provided by the farming family (Block 2012), sharing equity with non-family members is generally avoided to maintain the financial and managerial independence (Sirmon & Hitt 2003; Suess-Reyes & Fuetsch 2016), and government support is limited, as Australian farmers receive the second lowest levels of support in the developed world (OECD 2019). Hence, this prerequisite may be a hurdle for Australian farms.

Staff: The Australian agricultural sector has several characteristics that are opposite to the attributes required according to the research framework. The framework suggests that farms need to have a positive attitude and perception towards technology adoption, perception of change valence and change efficacy, and have employees who are committed to digitalisation. However, farming, which is described as a way of living (Vayro et al. 2020), is characterised by individuals who are attached to conventional farming practice and reluctant to change (Warren et al. 2016).

The agricultural sector is Australia's least digitalised sector, and globally as well as in Australia (Blackburn, Freeland & Grätner 2017; Gandhi 2016), it appears reluctant to apply digital technologies. Therefore, perceiving digital innovation as necessary and beneficial may be contradictory to the current mindset.

The framework highlights the need for employees to possess innovation-specific knowledge and skills as well as experience in IT and innovation. Technology-related knowledge and skills are not a commonly present resource on Australian family farms (Blackburn, Freeland & Grätner 2017; The Regional Australia Institute 2018). Factors such as an undiversified workforce, difficulties in recruiting skilled workers, the appreciation for traditional practices and the rural location restricting exposure to current developments (Coleman, James S 1988; Covin 1994; Suess-Reyes & Fuetsch 2016; Warren et al. 2016) lead to limited quality and quantity of technology knowledge and skills on farms (Blackburn, Freeland & Grätner 2017; Franco, Singh & Praveen 2018; Sony & Naik 2019; The Regional Australia Institute 2018).

External capacity: Finally, the framework outlines the necessity of collaborating with external parties and making use of their support. While farms have been shown to interact with their external network, they lack the capabilities and multidisciplinary competencies to utilise the external input (Huber, Wainwright & Rentocchini 2020; Laursen & Salter 2014).

The last factor of external capacity readiness refers to the extent of digitalisation of the supply chain, which influences the organisational readiness for digitalisation. The agriculture supply chain can be divided into the three stages: (1) production planning, (2) cultivation, and (3) post-harvest management and marketing (Ali & Kumar 2011), none of which none rely on external organisations. While they may be consulted and integrated, their contribution in terms of digital innovation is limited to knowledge exchange, questioning the necessity of digitalisation of the supply chain.

In summary, literature characterising family farms partly contradicts the extant readiness research, questioning its generalisability and consequently calling for in-depth research into organisational readiness for digital innovation in the context of family farming.

3.5 Research Objective and Questions

As outlined earlier, the sector is in urgent need of innovation if it is to address the global food supply crisis and the extensive environmental impact of agriculture (FAO 2017a; FAO et al. 2019). Digitalisation fostering and facilitating innovation, is regarded as the breakthrough required to meet these challenges (Blackburn, Freeland & Grätner 2017; Burdon et al. 2017; EY 2019; FAO 2018; Trendov, Varas & Zeng 2019; United Nations 2012). However, agriculture is the least digitalised sector (Gandhi 2016; Manyika et al. 2015).

Australia, being a major exporter of agricultural goods, plays a central role in meeting the stated challenges (Howden, Nelson & Zammit 2018; Jackson, Hatfield-Dodds & Zammit 2020; Wyers 2019), and is therefore the context of this thesis. Reflecting the global status quo, agriculture is the least digitalised sector in Australia (Blackburn, Freeland & Grätner 2017; Gandhi 2016; Zhang et al. 2017). The aim of this thesis is to uncover how Australian farms, of which the majority are family farms (ABARES 2019; Jackson, Hatfield-Dodds & Zammit 2020; National Farmers' Federation 2017), can be ready to transition towards a digital agriculture practice and apply digital technologies to generate innovation on the farm, by answering the overarching question underpinning it:

How do Australian farms become ready for digital innovation?

This umbrella question guiding this thesis is expanded into two sub-research questions (RQs).

First, research and practice both highlight the necessity for readiness when applying digital technologies to innovate (Lokuge et al. 2019; Snyder-Halpern 2001; Williams, I 2011). The concept of readiness has received the attention of innovation scholars (Holt & Daspit 2015; Setiawan et al. 2018; Williams, I 2011). However, in the context of digitalisation the explanatory power of existing innovation literature is questioned (Barrett, M et al. 2015; Benner & Tushman 2015; Yoo et al. 2012), as digitalisation fundamentally changes the nature and characteristics of innovation (Nambisan et al. 2017; Sedera & Lokuge 2017). Therefore, organisational readiness for digital innovation requires separate, in-depth investigation (Agostini 2017; Appio et al. 2018; Nambisan et al. 2017), which so far is limited.

Moreover, as outlined in 3.4, the extant readiness literature, generic or specific to other industries, appears to be not generalisable to the context of family farms in Australia. To shed light on how Australian farmers can become digital innovators, specifically focusing on their readiness to apply digital technologies to generate an innovative outcome, which is the first objective of this thesis, the prerequisites of organisational readiness for digital innovation in the Australian agricultural sector are investigated. This investigation is guided by the first sub-research question:

RQ1: What are key factors that influence the readiness for digital innovation of family farms in Australia?

Second, readiness is not a dichotomous variable but a continuum (Holt, Armenakis, Feild, et al. 2007). Consequently, becoming ready to innovate with digital technologies is a process that involves a gradual transition towards a digital innovation practice within the organisation. Australian farms are currently at various development stages in this regard (Leonard, E et al. 2017; Trindall, Bainbow & Leonard 2018). The spectrum ranges from novice with no prior knowledge of digital technologies and their application, to early stage technology adopters and successful digital innovators seeking more opportunities to exploit the innovative potential of digital technologies.

To analyse the process of becoming ready for digital innovation and provide actionable knowledge for all Australian farms, regardless of their experience with digital innovation, which is the second objective of this thesis, the second sub-research question investigated is:

RQ2 2: How do family farms in Australia transition from their current practice to digital innovation?

3.6 Summary

This chapter introduced and analysed the research context and the readiness literature utilised in this thesis and derived the research questions. This chapter identified the urgent need for digital innovation in the Australian agricultural sector to meet the global challenges of ensuring the food supply and limiting the sector's negative environmental impact, while highlighting the lack of readiness for digital innovation in the sector. An interplay between the challenges that farming practices face with regard to readiness for digital innovation and the scholarly literature of the topic, in particular the lack of it, the research objective was defined and the research questions guiding the thesis were developed.

The next chapter presents the methodology employed in this thesis.

Chapter 4: Research Methodology

4.1 Objective

This chapter details and motivates the research methodology implemented in this thesis. First, it presents the philosophical background of this thesis and introduces the research approach, design and method, deemed best suited to answer the research questions. Then, the data collection and analysis are detailed. Finally, this chapter highlights the potential methodological issues of this thesis and explains how these are overcome.

4.2 Research Paradigm

A research paradigm is a plan or framework guiding a researcher's work (Bogdan & Biklen 1997). As it contains ontological, epistemological and methodological premises in research philosophy, it reflects the researcher's worldview and understanding of the nature of existence, specific to the logic of inquiry (Creswell, JW 2017; Lincoln & Guba 1985). It is critical to be aware of the philosophical assumptions underpinning a research endeavour, as ambiguous worldviews impede the development of an appropriate research design and endanger the research integrity (Easterby-Smith, Thorpe & Lowe 2002).

There are three main research paradigms: pragmatism, post-positivism and constructivism (Creswell, JW & Clark 2017). The research paradigm consists of three main philosophical dimensions: ontology, epistemology and methodology.

Ontology refers to the nature of reality, representing the researcher's assumptions about the reality of the phenomenon under investigation. It is essential to a paradigm as it provides an understanding of the things that constitute the world as it is known (Scott & Usher 2010).

Epistemology refers to the theory of knowledge, describing its origin and structure (Cooksey & McDonald 2011). It is concerned with the researcher's beliefs about the type of knowledge acquired and the question as to whether or not there are necessary and sufficient conditions for justifying a belief (Rawnsley 1998). Therefore, it determines the relationship between the inquirer, the researcher and the known, which is the issue investigated (Denzin, Norman K. & Lincoln 2018).

The methodology dimension represents the practice of science and is therefore concerned with how the researcher gains knowledge (Easterby-Smith, Thorpe & Lowe 2002). Consequently, methodology refers to the techniques used to enquire into the situation of interest (Creswell, JW 2017). An overview of the main research paradigms is provided in Table 9.

Table 9: Overview of main research paradigms, adapted from Creswell, JW (2017)

Paradigm	Post- Positivism	Constructivism	Pragmatism
Common Research Approach	Quantitative	Qualitative	Mixed methods
Key Characteristics	• Deterministic philosophy: causes determine effects • Reductionistic: reduction of ideas into discrete tests • Empirical observation and measurement: studying the world by application of numeric measures • Theory verification: beginning with theory which is tested based on collected data	• Understanding: individuals seek understanding of their world • Multiple participant meanings: individuals develop subjective meanings of their experience, which are varied and multiple • Social and historical construction: subjective meanings are shaped by historical and cultural norms • Theory generation: inductive development of theory	• Consequences of actions: worldview arises from actions, situations and their consequences • Problem-centred: focus on research problem • Pluralistic: pluralistic approaches used to study research problem • Real-world practice oriented
Influential Work	(Smith, JK 1983) (Phillips & Burbules 2000)	(Berger, P & Luckmann 1967) (Lincoln & Guba 1985) (Crotty 1998)	(Cherryholmes 1992) (Murphy, JP 1990) (Patton, Michael Quinn 1990)

This thesis employs the philosophical stance of constructivism. The core principle of the constructivist paradigm is the socially constructed nature of reality (Bogdan & Biklen 1997). Consequently, constructivism is concerned with understanding subjective human experiences and views of their own world and emphasises the necessity of gaining deep insight into the individual's thinking, sensemaking and eventually their interpretation of the world (Guba & Lincoln 1989) .

This thesis aims to uncover key factors of readiness for digital innovation in the Australian agricultural sector and shed light on the transition process towards digital innovation in this context. As the academic literature on the topic is limited, this thesis requires an in-depth investigation, relying on the views and experiences of farmers and their subjective interpretation of the situation, reflecting the constructivist paradigm.

The constructivist paradigm assumes a subjectivist epistemology. According to Lincoln, Lynham and Guba (2011) individuals 'are shaped by their lived experiences' (p.104), as well as their social environment (Crotty 1998). This will always be apparent in the data generated by the subjects under study and the knowledge generated by researchers (Lincoln, Lynham & Guba 2011). Therefore, a subjectivist epistemology requires a bottom-up approach of theory generation, grounded in data and generated through the research activity (Marshall, C &

Rossman 2014), consistent with the grounded theory approach proposed by Strauss and Corbin (1994).

This thesis develops and applies a research framework based on the topic literature. However, the model is not imposed on the data. First, it serves as the foundation for developing an interview guide, which helps to maintain a topical conversation with interviewees while providing the opportunity to glean in-depth information about their opinions and experiences. Second, it allows the researcher to capture the participants' voices and perspectives by gathering and analysing data in a manner consistent with grounded theory. However, the theory-based research framework is used for complementary data coding using a priori codes, enabling the researcher to reflect upon and evaluate the applicability of the existing literature. Thereby, instead of applying grounded theory to generate new theory, with the progressing analysis the theory-based model is restructured, revised and refined according to the participants' views. An advantage of this approach is its flexibility and manageability regarding data interpretation and eventually model development (Charmaz 2006).

Constructivism assumes varied and multiple meanings developed by individuals (Creswell, JW 2017). Hence, researchers following the constructivist paradigm are interested in understanding the underlying complexity in participants' meanings. To make sense of this complexity, qualitative research methodology is applied, as gathering data through interviews, observations, reflective sessions, etc., allows an in-depth exploration (Creswell, JW 2017).

This thesis employs semi-structured interviews. Semi-structured interviews with rather broad questions enable individuals to share their views, including all details they perceive as important (Crotty 1998). They allow the researcher to access detailed information on the topic and explore the research questions thoroughly, as the researcher can ask follow-up questions, when more depth is required for a full understanding of the answer, or in case of interpretative uncertainties (Minichiello, Aroni & Minichiello 1990; Turner III 2010). The ongoing conversation during an interview produces rich, in-depth and meaningful data.

While the focus of interviews is on generating data, the interaction between the interviewer and interviewee and the quality of this exchange is what facilitates a deep understanding, allowing the researcher to create a reality inside out and to make sense of the social interaction (McMurray, Pace & Scott 2004).

Moreover, as the constructivist paradigm assumes subjective meanings being shaped by historical and cultural norms, the format of semi-structured interviews allows the inclusion of the individuals' environment (social and historical) to understand how opinion has been shaped (Creswell, JW 2017).

4.3 Research Approach

The importance of choosing an appropriate research approach has deep roots in organisational research (Bouchard 1976). Scholars have highlighted the interplay of multiple factors influencing the decision on research design (Edmondson & McManus 2007). In this regard the consideration of existing research questions has been identified as inevitable (Marshall, M 1996b). In fact, 'the key to good research lies not in choosing the right method, but rather in asking the right question and picking the most powerful method for answering that question' (Bouchard (1976, p. 402).To meet the objectives of this thesis and answer the stated research questions, this thesis follows a qualitative approach.

Qualitative research allows the researcher to acquire deep knowledge about a particular phenomenon and its socioeconomic context (Myers, MD 2013), by delving below the surface and providing sophisticated insights (McMurray, Pace & Scott 2004). Through personal interaction with the study subjects, it enables an understanding of the participants' perceptions of the phenomenon (Creswell, JW 2017). Both of these characteristics have been identified as particularly helpful when attempting to comprehend complex matters (Myers, MD & Newman 2007). An additional advantage of qualitative research is its nature, looking for the 'complexity within the topic rather than narrowing its meaning down to a limited set of categories or ideas' (Creswell, JW 2017, p.8). Therefore, a qualitative research is most suitable to shed light on 'how' and 'why' questions (Creswell, JW 2017).

Qualitative research has evolved to be a commonly used research strategy for theory building (Eisenhardt, Kathleen M & Graebner 2007). It has gained popularity among researchers, especially in the field of social science (Denzin, Norman K & Lincoln 2008; Silverman 2016), and gained increasing relevance over the past 40 years (Symon, Cassell & Johnson 2018; Üsdiken 2014). Considering the research context of this thesis, agriculture, scholars have successfully applied the qualitative approach to gain meaningful insights into management topics in agriculture (Fischer et al. 2019; Karanasios & Slavova 2019).

However, the field of management and IS research, where this thesis is situated, is dominated by the quantitative research approach (Calabrò et al. 2019; Conboy, Fitzgerald & Mathiassen 2012). Qualitative researchers face difficulties justifying the representativeness and transferability of their research findings (Bluhm et al. 2011; Llewellyn & Northcott 2007). Scholars have expressed their concerns with regard to the validity of qualitative research, as it is difficult to determine the 'truthfulness' of qualitative research findings (Jones, I 1997). Furthermore, qualitative research is often criticised for its lack of scientific rigor, and for being more prone to bias and hence less credible (Sandelowski 1986). Qualitative research has even been called ‘the unwanted, red-headed stepchild of the field of management’ (Eby, Hurst & Butts 2009).

Despite these issues, recent developments in the field indicate more openness towards qualitative management and IS research (Sarker, Xiao & Beaulieu 2013; Symon, Cassell & Johnson 2018). *MIS Quarterly*, a highly respected IS journal, published a special issue in Intensive Methods, institutionalising the acceptability and respectability of qualitative research (Markus & Lee 2000). Established management journals, such as the *Academy of Management* state their appreciation of qualitative research, highlighting its ability to advance ‘new ways of seeing’ and offering ‘insights that challenge taken-for-granted theories and expose new theoretical directions’ (Bansal, Smith & Vaara 2018, p.1189).

In regard to digital innovation, while innovation is a primarily quantitatively explored research area, the novelty of digitalisation in this context (Nambisan et al. 2017), as well as the complexity of the topic (Holmström 2018), has led to a multitude of qualitative studies (Nylén & Holmström 2019; Tumbas, Berente & Brocke 2018). In fact, IS research stresses the importance of qualitative research on digital innovation (Vega & Chiasson 2019), justifying the research approach and design chosen in this thesis.

While qualitative research is, as outlined, subject to several downsides, in light of the objective of this thesis, its research questions and its thematic scope, the qualitative research approach seems most suited due to the following five reasons.

Firstly, this thesis intends to build practice-enhanced theory, in line with the recommended approach by Van de Ven, AH (2007). While traditionally, theory development has been based on a combination of observations from previous literature, common sense, and experience (Perrow, Reiss & Wilensky 1986; Pfeffer 1982), a tie to actual data has often been tenuous (Eisenhardt, Kathleen M 1989). As a close link to practice has been recognised as central to the development of a testable, relevant, and valid theory (Eisenhardt, Kathleen M & Graebner 2007; Glaser & Strauss 1967; Woodside & Wilson 2003) a qualitative research approach is most suitable for ensuring a strong link between theory and information grounded in practice.

Secondly, digitalisation questions the explanatory power of the present innovation literature fundamentally, leading to research calling for more theory-enhancing, in-depth studies on digital innovation (Agostini 2017; Appio et al. 2018; Nambisan et al. 2017). The lack of theory applicable to explain digital innovation motivates an inductive approach, facilitated by a qualitative research approach. The analysis of the acquired qualitative data is conducted in an interplay with the literature-based knowledge derived in chapter two, ensuring a connection to existing theory and hence a strong foundation for the theoretical contribution (Eisenhardt, Kathleen M & Graebner 2007).

Digital innovation is a complex topic (Holmström 2018), as it involves both technology and humans. Any investigation regarding digital innovation must consider both of these components, which has been identified as a substantial obstacle for research on digital innovation in the past (Holmström 2018; Tilson, Lyytinen & Sørensen 2010). Consequently, the investigation of readiness for digital innovation in this thesis requires a high degree of depth to understand the phenomenon. Qualitative research, answering 'why' and 'how' questions (Creswell, JW 2017), allows the researcher to drill down to the necessary depth to uncover the complex processes, interdependencies and factors of readiness for digital innovation (Myers, MD 2013), while providing a holistic picture due to the wide range of data sources (Gummesson 2000).

Despite the wide range of opportunities for and benefits of digital innovation in agriculture (The Regional Australia Institute 2018; Zhang et al. 2017), the lack of its realisation indicates a high level of complexity regarding the readiness for its implementation and utilisation. A qualitative research approach facilitates access to the participants' perceptions, enabling an understanding of the complex phenomena (Creswell, JW 2017)

Finally, the viability of the planned research encourages a qualitative research approach. To show significant results, quantitative research requires a sample size far bigger than that required for qualitative studies (Kotrlik & Higgins 2001; Marshall, M 1996b). The context of this thesis is the Australian agricultural sector, which is characterised by a tremendous workload (Groborz & Juliszewski 2013) and nation-wide the second-longest average working hours (Bagshaw & Hanna 2017). Therefore, it is questionable whether a large enough sample size of respondents could be acquired for a quantitative or mixed methods study. A qualitative study, on the other hand, can help overcome poor survey study response rates (Austin 1981).

While the presented reasons motivate a qualitative research approach, the matters introduced to question the approach are taken into consideration when designing the research. Therefore, being aware of potential concerns in this regard, this thesis pays particular attention to precautions and explains in detail the measures taken to minimise the drawbacks common to qualitative research in section 4.7.

4.4 Research Design

The research design refers to a detailed plan setting out the structure, procedures and methods of data collection, analysis, interpretation and reporting (Creswell, JW 2017), with the objective of omitting a mismatch between collected evidence and the research questions guiding the investigation (Richards & Morse 2012).

The research design of this thesis, developed applying academic rigor, consisted of five sequential stages, detailed in the following section and depicted in Figure 8.

The first stage was an extensive literature review on the readiness theory and specific readiness concepts relevant to organisational readiness for digital innovation as well as the research context, presented in chapters 2 and 3. The literature review positioned this thesis thematically in the theoretical research space (Randolph 2009). Furthermore, in line with established research practice, the literature review 1) generated the research framework, 2) identified research gaps, and 3) informed the development of the research objective and specific research questions (Prajogo & Sohal 2001; Vrontis & Christofi 2019), which originate from literature and the practical context (Van de Ven, AH 2007).

Informed by the first stage, in the second stage, the research paradigm and the research method were selected. As a qualitative technique was deemed appropriate to answer the research questions guiding this thesis, semi-structured interviews were chosen. Specifically, the data collection consisted of two sequential phases; first, exploring the field of inquiry interviewing the subjects affected, and second, confirming the findings, gaining additional depth on the topic and acquiring complementary explanations in regard to the findings by interviewing experts in the field. In preparation for the data collection, for both studies the interview guides were developed, 'ethics' approvals were obtained in line with the guidelines of the Australian Research Council (2007) and the interview guides were tested, ensuring a consistent and unified thematic approach during all interviews.

In stage three, the first wave of data collection was carried out via face-to-face interviews. The interviews were transcribed and analysed using Microsoft Excel and NVivo 12, to inform the second phase of data collection.

This was followed by the fourth stage, which was the second phase of interview-based data collection with experts, verifying and offering additional knowledge on the findings of stage three. Again, the interviews were transcribed and analysed using Microsoft Excel and NVivo 12.

The last stage involved the reporting and discussion of the findings.

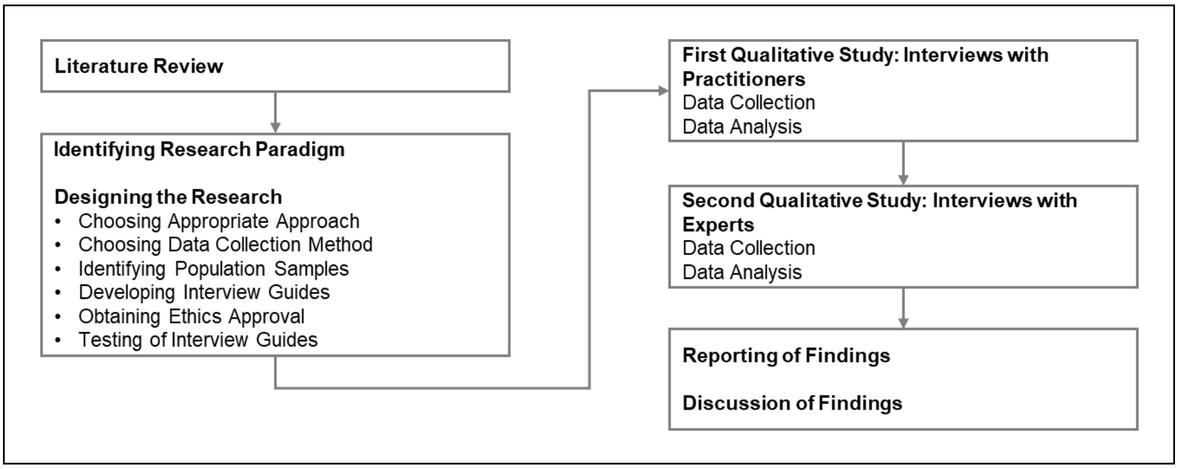

Figure 8: Research Design

4.5 Data Collection

The qualitative data collection, while excellent for gaining rich insights into a complex topic, is fraught with difficulties, potentially negatively impacting the outcome (Myers, MD & Newman 2007). Therefore, careful consideration in regard to the data collection technique and the selection of participants is required.

4.5.1 Technique

The data collection technique employed in this thesis was the interview. The qualitative interview is the most commonly used tool in qualitative research (Myers, MD & Newman 2007). It allows the researcher to understand the perceptions of individuals (Fontana & Frey 2005), as well as the reality of the phenomenon under investigation (King, Horrocks & Brooks 2019). Furthermore, due to their conversational nature, interviews enable the acquisition of deep and rich information, as well as their interpretation (King, Horrocks & Brooks 2019; Ticehurst & Veal 2000).

Interviews can be classified on a spectrum, from structured to unstructured (Qu, SQ, Dumay & management 2011). Structured interviews follow a strict research protocol throughout the interview, utilising a set of pre-defined questions, with the intent of minimising researcher influence and other sources of bias. Unstructured interviews forego a guide with predetermined questions with the intent of creating a free-flowing conversation.

Between these two extremes lies the semi-structured interview, which represents a form of guided conversations with respondents (Yin 2003). Semi-structured interviews have been shown to be particularly suitable to acquire rich, detailed and in-depth information about participants' experiences and views on the topic of interest (Tanggaard 2009; Turner III 2010). Their format ensures that the conversation adheres to a theme, but at the same time leaves room for the respondent's own narrative and spontaneous contribution (Brinkmann 2014), necessary to explore an under-researched field of interest, such as the readiness for digital innovation.

The semi-structured interview was chosen as the data collection technique for the following three reasons.

Firstly, the format of semi-structured interviews enables the researcher to guide the conversation around the topic of interest while allowing the freedom to explore, probe, and follow up and seek additional information on themes that emerge during the interview (Minichiello, Aroni & Minichiello 1990). The aim of this thesis is to obtain knowledge on organisational readiness for innovation, which so far has received little academic attention (Lokuge et al. 2019), and which in the context of Australian agriculture is rare in practice (Gandhi 2016; The Regional Australia Institute 2018). Therefore, the success of this thesis depends on in-depth knowledge provided by the interviewees. The semi-structured interview format allows the researcher to explore and acquire a wide and deep spectrum of information provided by the interviewees directly (King, Horrocks & Brooks 2019; Ticehurst & Veal 2000).

Secondly, the flexibility of a semi-structured interview, not following a predefined structure and set of questions, facilitates the opportunity for the interviewee to lead the conversation towards topics the individual perceives as important (Brinkmann 2014; Horton, Macve & Struyven 2004), and thereby helps the researcher to gain a realistic understanding of the inquiry.

Thirdly, participants answering questions according to their individual perceptions can help to determine their subjective and otherwise not accessible experiences, attitudes and beliefs (Peräkylä & Ruusuvuori 2011; Smith, H 1975), to establish links between different readiness factors and to identify their influence on the state of readiness for digital innovation.

4.5.2 Study Sample

The sampling process in qualitative studies is critical to the outcome as it determines the scope and depth of knowledge that can be gained. Furthermore, a clear sampling logic ensures that the sample studied is of substantive significance or theoretical relevance (Dubé & Paré 2003). At the same time, sampling is one of the principal areas of confusion (Marshall, M 1996b). Therefore, a careful selection of the study sample is required, which serves a unique purpose within the enquiry (Johnston, Leach & Liu 1999), as well as key respondents who can provide critical information about the subject (Marshall, M 1996a).

As detailed earlier, the qualitative study consisted of two sequential phases. The first phase was of an exploratory nature. The second phase was intended to verify, specify and contextualise the findings of the first phase, serving a confirmatory purpose. Due to the different goals of these phases, two samples with different characteristics were investigated.

4.5.2.1 Study Sample: First Phase

The first phase of the qualitative study, capturing the behaviour of people in their everyday work life, requires naturalistic sampling. This study utilised judgement sampling, known as purposeful sampling, of which several forms were utilised in this thesis. It is the most commonly applied naturalistic sampling approach, as it seeks the most productive sample to answer the research question(s) (Marshall, M 1996b). To determine the sample of organisations for this thesis, typical case sampling technique was applied (Eisenhardt, Kathleen M & Graebner 2007). This technique includes a sample that is representative of the typical population under investigation, which is highlighted as one of the most critical quality factors in qualitative research (Merriam 1988). In the following section, attributes of the sample included in this thesis are elaborated.

First, as the context of this thesis is the Australian agriculture sector, for which livestock, cropping and aquaculture farms account over 75% (National Farmers' Federation 2017), these three specifications of agriculture are the subject of investigation in this thesis. Second, the majority of Australian farms are owned and operated by a farming family (ABARES 2018; ANZ 2016; Local Farm Produce 2019). Therefore, the first phase of the investigation looked at Australian family-owned and -operated farms.

Third, according to the Australian Department of Innovation, over 80% of Australian farms are classified as SMEs (ANZ 2016; Clark et al. 2011), so farms with less than 19 employees (98% of Australian farms) were considered.

With regard to organisational readiness for digital innovation, this first qualitative study focused on farms that have successfully employed digital technologies to generate an innovative outcome. This includes both the possession of digital technologies and their purposeful utilisation for the creation of an innovative outcome. In order to identify, compare and contrast the differences between farms that are ready for digital innovation and those that are not, a number of farms with low readiness for digital innovation were included. A sample of farms which have not applied digital technologies to generate an innovative outcome were included as well. This latter group allowed the researcher to understand why digital innovation was not being pursued and, in turn, better understand the factors necessary for its implementation, allowing for a more nuanced and in-depth knowledge on the topic.

The qualitative study included multiple representative organisations as it increases the representativeness and the transferability of the results, while at the same time allowing comparisons to be made, and hence a vigorous explanation of the phenomenon (Chiesa et al. 2007). Following Marshall, M (1996b), the exact sample size of the study was not determined a priori. Instead, going between sampling and analysis, the study started with an initial set of 10 interviews with 10 different farms and was enriched by interviews with additional farms until no new content emerged with additional interviews and hence, the saturation point was reached. While typical case sampling was applied to narrow down the sample of potential organisations, snowball sampling was applied to access these organisations.

Snowball or chain referral sampling determines a study sample through referrals from people who possess or know of potential entities who possess the attributes of interest (Biernacki & Waldorf 1981). Introduced by Coleman, James S (1958) and Goodman (1961), it is a sampling method best suited for hard-to-reach populations, and has therefore been commonly used in agricultural research (Aidoo & Freeman 2016; Depczynski et al. 2005; Stuart & Houser 2018).

Digital innovation in Australian agriculture is still in its infancy and therefore the number of farms eligible to be the object of this study, representing farms ready for digital innovation, was limited (Grundke, Marcolin & Squicciarini 2018). Conversely, the number of farms that are not ready for digital innovation and fit all other criteria, was quite large. Either way, it was difficult to identify, contact and recruit farms that fit the typical farm profile with respect to the context of this study. Only 14% of Australian agricultural firms have a homepage (Australian Bureau of Statistics 2018), reducing their visibility for individuals outside of their network. Furthermore, farmers have very limited time resources due to their above average workload (Blackburn, Freeland & Grätner 2017; The Regional Australia Institute 2018), which they are unlikely to designate to research purposes. Therefore, snowball sampling offered a unique possibility to tap into the existing network of farms with similar profiles, all involved in digital innovation.

Snowball sampling is often criticised for providing a limited and uniform view of the phenomenon under investigation and therefore limiting the generalisability of the research, as the chain of referrals often includes individuals with similar characteristics and views (Biernacki & Waldorf 1981; Handcock & Gile 2011). Aware of the potential downsides of this sampling technique, this thesis followed the recommendation of Coleman, James S (1958) and Goodman (1961), controlling for the number of chains and referrals within each chain, to ensure a diverse set of participants and reflect the general sample under investigation. The 19 participants interviewed were identified based on seven referral chains, with a maximum number of three participants per referral chain. Moreover, before setting up the interview, the participants were asked specific questions regarding the outlined criteria to evaluate their eligibility for the research.

Key informants were chosen within the identified potential organisations based on the potential richness of information they could provide (Marshall, M 1996a). According to Neuman (1997) selecting the right informant is key for gaining meaningful results employing qualitative research techniques. These informants were identified based on strict selection criteria (Burgess 2003).

For the purpose of the first phase of the study, which is intended to capture the farms' experiences with and perceptions of digital technology, key informants had to be in a managerial role, able to comment on the necessities required for digital innovation and possess a deep understanding of complex interrelations between factors. In the context of family farms with up to 19 employees, these key informants were farm owners, acting as CEOs (FAO & IFAD 2019; Suess-Reyes & Fuetsch 2016). The CEOs seemed the most promising source of knowledge, as they have an overview and the decision-making power over the farm's strategy and operations (FAO & IFAD 2019; Suess-Reyes & Fuetsch 2016), and hence possess a deep understanding of why digital innovation is or is not being applied. Furthermore, to ensure a representative sample and findings transferable throughout the industry, the sampling accounted for differences in respondent's ages. Several studies have pointed out differences in perception and application of technologies dependent on the user's age (Chung et al. 2010; Lim 2010). Therefore, as recommended by Byrne (2001), participants of a diverse age range were included in the sample.

To ensure a study sample that represented the context of this study and provided adequate and meaningful data with which to respond to the research questions, the inclusion criteria for the sample studied were refined by a set of exclusion criteria.

Excluded from the study were farms that are family owned, but where the family is not in an active operational role, as this research seeks to investigate family-owned and -managed farms in Australia. Furthermore, farms often employ seasonal workers, who are not counted as staff on the farm due to their limited length of occupation. This research aims to capture the readiness for digital innovation on Australian farms, of which the majority (71.2%) employ less than 19 individuals. Therefore, any farm exceeding this number at any point in time was excluded. Additionally, excluded were farms that, in their current state were eligible according to the stated criteria, but which in the past would not have been considered due to their size or family involvement in the business. Organisations with prior advantage in terms of human, financial, technology or knowledge resources, and applying digital innovation could not provide information on readiness for digital innovation in the given context, as they had achieved their readiness under different circumstances, not investigated in this thesis.

The final sample consisted of 19 farms, of which 11 are active in cropping, 2 with livestock, 5 active in both cropping and livestock, and 1 with a fish farm. The farms investigated in this thesis are Australian family-owned and -managed, with less than 19 employees. 16 of these farms apply digital technologies to generate an innovative outcome, 3 do not possess any digital agricultural equipment. The informants interviewed were the managing farm owners. For two farms that are owned and operated by a couple, both were interviewed together as requested by the participants. On the remaining farms the interviews were conducted with only one managing farm owner. The age of the respondents was distributed as follows: 4 of the participants were in the age range 20 to 39, 8 of the participants were in the age range 40 to 59, and 7 of the participants were older than 60 years old. A detailed overview of the digital technologies applied by each farm is provided in section 5.2. The final sample of respondents is presented in section 5.2- Table 10.

4.5.2.2 Study Sample: Second Phase

The second phase of the qualitative study, intending to verify, specify and contextualise the findings of the first study, employed criterion sampling, which involves a criteria-based selection of interview subjects (Patton, Michael Quinn 1990). Criterion sampling allows the researcher to identify the most informative participants, able to provide additional depth to the findings of the first qualitative study (Draucker et al. 2007; Suri 2011). This study sought respondents who met the following criteria:

- at least 3 years of experience in the agriculture sector
- deep understanding of the sector and its individuals
- an overview of the development in the sector
- a consulting and advisory role.

These criteria were chosen to ensure a deep understanding of the sector and its development as well as the individuals involved. In doing so, this thesis has captured perspectives with an experience-based knowledge of the established sector and a deep understanding of digital technologies currently being used in the Australian agricultural sector.

However, due to the context and subject matter of this thesis, the number of experts in the field is limited and proved difficult to access. Furthermore, because the sample size in qualitative studies is usually small, chosen participants must add depth and value to the study (Hamilton & Bowers 2006). Therefore, the respondents were recruited using the snowballing technique (Biernacki & Waldorf 1981).

The final sample of respondents consisted of 6 experts in the field of digital innovation in the Australian agricultural sector. Two of the experts both lead Australian companies developing digital technologies for farming – one a CEO and the other a Director. One of the experts is the COO of Australia's leading agriculture technology accelerator. Two experts are involved in research units and organisations that focus on digital innovation in the agricultural sector – one as a team leader and the other a former CEO. Finally, the last expert is an agriculture-technology coordinator for the Australian government. A detailed overview of the sample of the second phase is presented in section 5.2 - Table 11.

4.5.3 Process

4.5.3.1 Preparation

Scholars repeatedly point out the necessity of preparation for conducting interviews, as the interviewer's skill and competence will determine success with regard to width and depth of knowledge acquired (Barriball & While 1994; Evers & De Boer 2012). The interviewer must not only facilitate a topical conversation, but at the same time guide the interviewee to reveal in-depth information and, over the course of the interview, make a number of decisions to ensure both are addressed (Moser & Kalton 2017). Therefore, as recommended by Barriball and While (1994), two measures were applied to prepare for the data collection.

First, an extensive literature review on the topics of innovation, digitalisation, their intersection (digital innovation), readiness, and family farms in Australia was conducted, to ensure that the researcher was familiar with and had a deep understanding of the topics relevant to the study. By developing topical and contextual awareness, the researcher was better able to understand and identify errors or bias which may have occurred during the interview. This knowledge background prevented the researcher from missing important data with a potentially significant bearing as well.

Second, the interviewer conducted multiple pre-test interviews (3 rounds each with 2 scholars or practitioners). During the pre-test interviews, respondents were interviewed using the developed interview guide, simulating the future interviews with key respondents. Pre-test studies allow the researcher to develop necessary interviewing skills and confidence, and enable self-reflection in this setting (Marshall, C & Rossman 2014). Besides interviewing skills, the interviewer requires a set of characteristics, to facilitate and ensure the success of the interview. The acquisition of deep knowledge requires that the interviewer is fully present, listens actively to the interviewee's answers and reflects upon the speaker's emotions, so that greater understanding of the interviewee's message can be gained and appropriate follow-up questions can be asked (Guion, Diehl & McDonald 2001).

Further, the interview outcome may be influenced by differences in ethnicity, gender, socio-economic status, education or age between the interviewer and the interviewee (Bailey 1987). However, the self-presentation of the interviewer with regard to dress, etiquette and manner can put the respondent at ease and hence largely overcome the potential bias (Denzin, N 1989).

4.5.3.2 Recruitment

The initial set of organisations and their key informants, fitting the previously detailed criteria, were identified in two ways – through active searches and referrals. Five participants were found through a search on the platform LinkedIn, at the AgTech Summit '19, a conference on agricultural technology, and through reports on agricultural technology. The majority of the respondents (16) were identified through referrals.

The researcher contacted potential respondents via LinkedIn, email or phone, following the ethical conduct guidelines of the Australian Research Council (2007). Each potential participant was provided with a recruitment letter (see Appendix H) which summarised the research of this thesis and its boundary conditions, and encouraged them to respond and participate.

Additionally, to facilitate communication, enhance the results of the qualitative interviews (Myers, MD & Newman 2007) and follow ethical research practice, the recruitment letter reassured the participants that their anonymity would be ensured and results published without any identifying information. Willing participants were invited to an interview – in person when possible or via skype or phone, if more convenient. Each lasted between 30 and 60 minutes. Before the interview, all participants were required to sign a participation consent form (see Appendix I).

Key informants referred by previous interviewees or network participants, were contacted in the same manner, following the recruitment procedure described above. Where the individual referring another potential participant did not wish to disclose his/her identity or share contact information, the referring individual was provided with the recruitment letter, which she/he was at liberty to distribute to potential organisations.

4.5.3.3 Execution

The foundation of an interview and one of the primary determinants of its success is a set of good questions (Green & Brown 2005). The choice of topics to be discussed and respective research questions to be asked are central to the credibility and significance of the research (Rubin & Rubin 2011). Therefore, the semi-structured interviews followed a question guide, which ensured that a consistent and unified thematic approach was adhered to during all interviews.

This thesis consists of two consecutive phases. The first phase is of an exploratory nature. The questions for the exploratory interviews were derived iteratively and in close proximity to the relevant literature identified and analysed in chapters 2 and 3 (Rubin & Rubin 2011). The questions for the second phase, which is of a confirmatory nature, were based on the results of the first phase. While these two qualitative studies employed different interview guides, the structure of the interview, which is detailed in the following section, remained the same.

As recommended by Kvale (1994), the researcher kickstarted the interview with three introductory questions regarding the interviewee’s background, their experience with digital technologies and how they applied the technology for an innovative purpose. These questions do not reveal any sensitive information or ask personal opinions and were intended to start a conversation and set the scene for the interview.

Specific, topic-related questions ensured that the interview then covered a series of themes. Semi-structured interviews are applied to allow respondents the freedom of responding according to their own opinion with regard to what they consider important and meaningful (Qu, S & Dumay 2011). Hence, after establishing the thematic scope with a specific and direct question, the interviewer relied on follow-up, probing and indirect questions (Kvale 1994). Integrating the information provided by the interviewee, the interviewer then asked questions such as, ‘Would you elaborate more on this?’ and other open-ended questions to elicit more in-depth knowledge. Probing questions increase the interactive opportunities between interviewer and interviewee, reducing the risk of receiving a socially desirable answer (Denzin, N 1989).

The format of a semi-structured interview allows the researcher to alter the order of questions and change the words used without affecting the meaning (Barriball & While 1994). Therefore, when the interviewer recognised that the interviewee was having problems with the line of questioning or needed clarification or rephrasing (Guion, Diehl & McDonald 2001), the order and phrasing of the questions was customised and adapted to be suitable and appropriate for the respondent. In line with established research practice (Holstein & Gubrium 1995; McCracken 1988), the interview questions were kept simple, could not be answered with one word and sought the interviewee’s opinion. The researcher was careful to allow the participant to fully respond to one question before asking another.

The final interview guides for both phases of the qualitative study are presented in Appendix J and K. They are the result of 3 rounds of pre-test interviews each with 2 scholars or practitioners, chosen conveniently. Pre-test studies, commonly utilised when designing interview guides (Rowley 2012), are conducted in order to evaluate the comprehensibility of the questions as well as the information they access (Yin 2015). The participants of these pre-tests were asked to report on their experience during the interview and give feedback on how it could be improved. The feedback and knowhow acquired in each pre-test round was incorporated in the following version of the interview guide, enhancing its quality and capacity to serve the intended purpose.

In total, 19 interviews were conducted during the exploratory study. The first interviews were conducted in April 2019. The following 9 interviews were conducted in September 2019. 18 interviews were carried out in person, and one interview was conducted over the phone. Each interview lasted between 40 and 90 minutes.

The six confirmatory interviews were conducted in January and February 2020. Four of the interviews were conducted over the phone and two in person. These interviews lasted between 40 and 70 minutes.

4.5.3.4 Recording

All interviews were audio recorded. Interviews are dynamic and, particularly when applying the semi-structured format, differ in the order of questions asked, their wording as well as the general direction of the interview, which is strongly influenced by the interviewee and the follow-up and probing questions asked in response to the answers received. Therefore, to capture all details of each interview the logging of data is necessary (Barriball & While 1994).

A practical issue to be considered is the time lapse between the interview and its analysis. The use of audio recording and transcription ensures that all details of the interview are considered in the data analysis, and not just what the researcher can recall, increasing the credibility and auditability of the research (Sarker, Xiao & Beaulieu 2013). However, despite the importance of data recording, the interviews were only captured electronically when given permission to do so by the interviewee.

4.6 Data Analysis and Interpretation

Data analysis refers to the processing of the empirical material collected with the aim of describing and explaining a social phenomenon (Dey 2003). In order to ensure rigor in the analysis of the qualitative data, scholars highlight the necessity of deploying analytic strategies paying systematic attention to the content (Denzin, Norman K & Lincoln 2011).

This research, as recommended (Miles, Huberman & Saldaña 2014; Pope, Ziebland & Mays 2000), followed an established analysis approach described by Creswell, JW (2017) and depicted in Figure 9. The analysis consisted of 6 consecutive stages. In stage one the researcher organised and prepared the data for analysis. Data were prepared for the analysis (transcribed, printed for manual coding and inserted in NVivo 12), the focus of analysis was determined and the analysis technique (thematic and content analysis) was chosen. In qualitative studies, especially where the data analysis is based on verbal contributions by participants, it is recommended to focus on the content of what participants say (Dey 2003). As this thesis aims to understand the participants' experience and perspective on readiness for digital innovation, a non-mathematical analytical approach was chosen, allowing an investigation of the meaning of participants' words (Morehouse & Maykut 2002).

The second phase consisted of the researcher thoroughly familiarising herself with the data set by reading it several times. Thus, the research was reviewed as a whole and could be interpreted for meaning, before going into detailed analysis (Saldaña 2015; Sayer 1992).

The third step of the data analysis was coding. Two separate coding processes were carried out, thematic and content analysis (described in detail later), in order to enhance the data integrity, and ensure that it remains reliable and accurate throughout its lifecycle, which can be endangered in qualitative studies, in particular those inductive in nature (Jones, R & Noble 2007).

Based on the codes generated in step three, content which appeared to reflect and capture the same content was grouped into thematic categories and the respective categories were described during step four.

In the fifth step, a narrative presentation of the themes and categories identified was developed, followed by the interpretation of the data, which was the last step of the data analysis (step six).

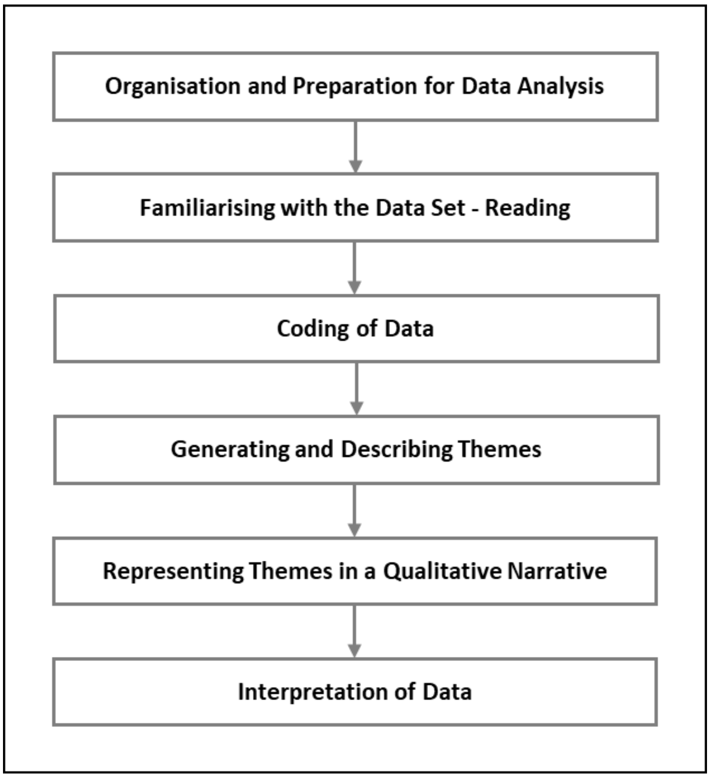

Figure 9: Data Analysis Approach adapted from Creswell, JW (2017)

4.6.1 Transcription of Data

As part of the preparation for the data analysis, all interviews were transcribed. This process involves listening to the audio format of the interview and converting it into written text, generating an artificial construction of the oral data (Ryan 2010).

The importance of transcription goes beyond being a technical detail. Transcription is a crucial activity in qualitative research (Heritage & Atkinson 1984). Transcriptions help researchers to systematically organise data acquired during interviews, and in the next step, ease their analysis (McLellan, MacQueen & Neidig 2003). While transcripts facilitate a more efficient data analysis, the transcription process enables the researcher to not only recall the content of the conversation in detail, but the tone, expressions and important behaviours of the interviewees as well, which may be otherwise overlooked (Morehouse & Maykut 2002).

Transcription is a task which requires careful consideration, as inappropriate or inadequate data preparation decisions can delay or negatively affect the analysis process (MacQueen & Milstein 1999). Moreover, it represents a preliminary data analysis, triggering several consequent decisions. When transcribing, the researcher must undertake a first data reduction, deciding what will be transcribed and what will be left out (Miles et al. 1994). Furthermore, it must be determined if non-linguistic observations, such as body language and setting descriptions, are transcribed verbatim (McLellan, MacQueen & Neidig 2003).

In this thesis all audio recordings were transcribed within 4 weeks of the initial interview. The transcription was first executed by the online provider rev, which was chosen due to its high accuracy of 99% (rev 2019). While the transcription of audio data is characterised as time consuming and tedious (Bell, E, Bryman & Harley 2018), it helps the researcher to understand the data better and therefore enable their meaningful processing (Saldaña 2015; Sayer 1992). Therefore, after the transcripts had been generated by the chosen provider, the audio files were re-listened to, in parallel with reading the respective transcripts several times, to become familiar with the content.

At the same time, the transcripts were double-checked for their accuracy, mistakes were corrected, and missing words were added, as recommended by (Fasick 1977). Strauss and Corbin (1990) indicate that text selected for transcription should take into account the analytical contribution it will provide. Therefore, social conversations with the intent of building a relationship between interviewer and interviewee, but not associated with the objective of this thesis, were deleted. The final transcripts varied in length, from 9 to 17 pages.

While there is no universal transcription format, scholars have identified several guidelines, which enable a thorough data analysis. Poland and Pederson (1998) recommend that transcripts be read more like written text than conversations, as they serve as the foundation for further analysis of the qualitative data and must hence be re-read and analysed in-depth. When the analysis focuses on providing an in-depth description of the knowledge, attitudes, values, beliefs, or experiences of an individual, as is the case in this thesis, Drisko (1997) recommends including a greater number and possibly lengthier units of text for better contextual understanding and hence capturing the intended meaning.

Furthermore, to minimise the chances of an incompatible transcript, which the researcher must work with (McLellan, MacQueen & Neidig 2003), MacQueen and Milstein (1999) suggest a standardised format for all transcriptions. Following all advice, the transcripts in this thesis were read like written texts, structured into paragraphs according to their meaning, and presented in a standardised format.

As qualitative research has, over time, gained acceptance and therefore popularity, scholars have summarised their experiences with transcription, pointing out several difficulties that may occur, including speech elisions, incomplete sentences, overlapping speech, a lack of clear-cut endings in speech, poor audiotape quality, and background noises (McLellan, MacQueen and Neidig (2003). Being aware of potential problems, preventive measures were taken by ensuring a high-quality resolution of the audio recording and by conducting interviews in a quiet surrounding. However, difficulties regarding the interviewees' speech and verbal expressions could not be prevented. To overcome these issues, the specific conversation was re-listened to until the context of the conversation could be understood.

4.6.2 Coding Research Data

Once transcribed, the first analytic step is to code; that is, explore the data set, make sense of the raw data and generate initial relevant themes by moving from concrete statements to analytic interpretations (Charmaz 2006). The process of coding consists of reading the transcripts and identifying segments of text relevant to the research topic, which are tagged with codes representing their thematic content (Ryan 2010). Consequently, each code is a theme emerged from the data (Thomas, DR 2006). As coding enables the identification of the commonality between data and key categories (McMurray, Pace & Scott 2004; Strauss & Corbin 1990), in this thesis it facilitated uncovering aspects of readiness for digital innovation in the context of the Australian agricultural sector. Coding the interview transcripts and thereby exploring the core ideas around readiness for digital innovation in the given context, allowed the researcher to establish and refine the previously introduced, theory-based research framework (Flick 2018).

When coding, there are two competing approaches from which the researcher can chose. The first approach is a deductive approach, where the so-called a priori codes are developed before the empirical work, derived from research aims, questions and the topical reviewed literature (Crabtree & Miller 1992; Miles et al. 1994). The second approach is inductive, where the code development is data driven. These ‘empirical codes’ are derived by the researcher from the examination of the data set (Boyatzis 1998; Glaser & Strauss 1967).

This thesis employed a combination of both a priori-derived codes based on the literature reviewed, as well as empirical codes inductively derived from the data. The application of a priori codes, besides providing a training opportunity for the researcher to develop coding skills (Boyatzis 1998), allows the researcher to reflect upon the existent literature on the topic and evaluate its applicability. Empirical codes, on the other hand, enable the researcher to uncover unforeseen aspects, which help to refine the initial, theory-based framework and contribute to new theory building (Boyatzis 1998).

In preparation for the coding process, the transcribed data were printed and inserted into NVivo 12, as the coding process in this thesis employed manual, as well as computer-aided coding. For the initial data analysis, as recommended by various scholars (Bogdan & Biklen 1997; Lofland & Lofland 1971), a manual approach was applied, as it helps the researcher to engage with the data and gain a deep understanding of its meaning (Saldaña 2015).

Moreover, manual coding allows flexibility and creativity with regard to generating initial themes emerging from the data (Flick 2018).

Once the data preparation was complete, the transcripts were read carefully several times, allowing the researcher to familiarise herself with the content, gain a sense of the data set as a whole, identify which data were relevant to the stated research questions and interpret what the data may mean, before going into detailed analysis (Saldaña 2015; Sayer 1992). In the next step, the researcher analysed the data by reading each cohesive paragraph, identifying data excerpts supporting the a priori codes derived from literature as well as new themes, which were coded accordingly.

These manually identified themes were then transferred to NVivo 12 for an additional, complementary coding. Text excerpts fitting the previously identified themes can be assigned to nodes, which allows for a more fine-grained analysis, as multiple codes can be assigned to a theme. Furthermore, additional themes can be uncovered when analysing the data for the second time, especially when created nodes do not fit the existing themes.

Applying both manual coding and coding with NVivo 12 ensured rigor in the analysis process (Bazeley & Jackson 2013). Utilising both approaches contributed to the data integrity, meaning that the data will remain reliable and accurate throughout its lifecycle (Jones, R & Noble 2007). The data reduction in the initial step of the data analysis was carried out with great precaution, taking care to avoid premature deletion of potentially valuable data, with all data being analysed twice. Finally, applying two complementary methods that compensate for each other's shortcomings, allowed the researcher to gain a holistic, richer and deep understanding of the topic.

4.6.3 Data Analysis Method

As Thomas, DR (2006) summarises, data analysis is conducted in order to (1) condense extensive and varied raw text data, (2) establish clear links between the research objectives and the findings derived from the raw data, and (3) develop theory based on the knowledge evident in the raw data. To achieve these goals, this thesis applied two complementary techniques of data analysis, the thematic and the content analysis, as detailed and discussed in the following section.

4.6.3.1 Thematic Analysis

Thematic analysis is a method of systematically identifying, organising, and offering insight into meaning across a data set (Braun, Virginia & Clarke 2006). By focusing on the meaning within the data set, this technique allows the researcher to identify and make sense of the data set as a whole. Thematic analysis is concerned with identifying, analysing, and reporting patterns emerging within the data, which are catalogued and organised into themes (Aronson 1995), central to describing the phenomenon under investigation (Fereday & Muir-Cochrane 2006). The emerging themes combine fragmented components of the qualitative data set, which when viewed alone may often be meaningless (Leininger, MM 1985). As thematic analysis is an appropriate technique for both inductive and deductive coding and allows the researcher to develop fundamental skills needed for conducting qualitative data analysis regardless of the technique applied (Braun, Virginia & Clarke 2006), it has become a widely recognised method of data analysis (Braun, Virginia & Clarke 2006). Consequently, a wide range of publications providing guidance on the approach and its utilisation can be found (Fereday & Muir-Cochrane 2006; Guest, MacQueen & Namey 2011; ManMohan & Tang 2018).

As thematic analysis is often criticised for being used as a generic approach without a clear structure (Antaki et al. 2003), questioning the explanatory power of the derived findings, this research applies the established 6-phase approach as outlined by Braun, Virginia and Clarke (2006), ensuring the required rigor for qualitative data analysis. The phases are (1) becoming familiar with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing potential themes, (5) defining and naming themes, and (6) producing the report. Stage 6 will be detailed in the next chapter of this thesis.

As recommended by McMurray, Pace and Scott (2004) all interview data were analysed during the thematic analysis. The coding process proposed by Corbin and Strauss (2008) was followed, consisting of open, axial and selective coding. Applying these different approaches of coding helped the researcher to make sense of the wealth of information and arrive at systematically derived core categories. In order to become familiar with the data, first, the researcher read all interview transcripts multiple times and listened to the respective audio recordings, making notes regarding potentially interesting information. As notes serve the purpose of helping the researcher to go beyond the surface meaning of the data and start analysing the depth of their meaning, they are a 'stream of consciousness, a messy rush of ideas, rather than polished prose' (Braun, V. et al. 2012, p.61).

Once familiar with the data, the researcher read each transcript and carried out an initial coding of selected text, meaningful for answering the research questions guiding this thesis. During open coding, which is recommended as the initial coding approach (Saldaña 2015), the large mass of data was reduced into preliminary codes and eventually 'nodes', which is a term used in NVivo to describe the concepts, thoughts and ideas derived from the data (Edhlund 2011). A line-by-line approach of data analysis was followed as it is recommended to reduce bias in analysis due to fracturing of the data (Bowen 2009) and at the same time, it ensures the analysis of the entire data set. Following the open coding, the next cycle of coding was carried out applying axial coding (Saldaña 2015), which represents the third and fourth stage of the data analysis process proposed by Braun, Virginia and Clarke (2006) and the process followed in this thesis.

During axial coding, codes with similar content or a connection to each other are grouped into thematic nodes (Boeije 2010). The aggregated codes, providing strong supporting evidence, allowed dominant themes to emerge. The initial codes identified were then refined and filtered, supporting an accurate representation of the interviewees' experiences (Braun, Virginia & Clarke 2006). As axial coding involves the transition from a descriptive to an interpretative analysis (Bowen 2009), the researcher sought the opinion of colleagues and experienced researchers in regard to the created themes and their relevance, to minimise researcher bias (Fereday & Muir-Cochrane 2006). The emerging themes were then compared to the themes identified in the literature-based framework of readiness for digital innovation, ensuring a close link to both practice and theory and thereby strengthening their representativeness (Eisenhardt, Kathleen M & Graebner 2007).

When analysing data applying NVivo, the number of respondents and references represented in each node are presented by the software, allowing the researcher to identify dominant themes, and strengthen the confidence in the identified themes and the internal validity (Boeije 2010). Nodes with a low number of references within the data set indicated the low importance of the specific theme or their wrong classification, which necessitated revisiting the specific references and either deleting or re-assigning these to other nodes.

The last coding approach to be carried out, as proposed by Corbin and Strauss (2008), is selective coding. During selective coding, the core themes, central to organisational readiness for digital innovation, were identified, labelled and defined, creating a theoretical umbrella for all previously identified codes (Fereday & Muir-Cochrane 2006). This last coding approach represents the fifth stage of the analysis process followed in this thesis. Here, again, the additional application of NVivo provides an advantage, as the software provided an overview of which nodes have been linked with higher order themes. The depiction of parent and child nodes allowed a deeper understanding of the interconnection and relationships between the nodes, adding valuable information and meaning to the analysis and its findings (Strauss & Corbin 1990).

As introduced earlier, this thesis applied both a priori and empirical codes. Therefore, it is important to note that while, as widely acknowledged by scholars, the application of a priori codes, in this case derived from the literature, influences the coding process in a guiding manner (Boyatzis 1998; Fereday & Muir-Cochrane 2006), following Creswell, JWa and Poth (2018), the researcher kept an open mind and allowed additional codes and themes to emerge during the data analysis process.

4.6.3.2 Content Analysis

As stated earlier, two data analysis techniques were carried out to manifest and refine the findings of the thematic analysis and to prevent the researcher from missing valuable insights the data set can provide during the selection process of the thematic analysis (McMurray, Pace & Scott 2004). As pointed out by several authors, such as Patton, M.Q. (2002) and Silverman (2006), the depth and level of abstraction and consequently the interpretation of qualitative data depend on the researcher conducting the analysis.

Content analysis is a complementary approach which can compensate for the shortcomings of a thematic analysis. This analysis refers to a systematic process of quantifying qualitative data by noting frequencies of variables related to the research, in this case words, events and actions related to organisational readiness for digital innovation (Lancaster & Crowther 2012). In other words, content analysis, commonly referred to as the constant comparative method (Boeije 2002; Fram 2013), converts qualitative data into a numerical form, allowing the discovery of evidence for a given proposition. The basic principle of content analysis is, according to Morse, J.M. and Field (1996), to compare each piece of data with every other piece of relevant data, identifying which factors are most commonly cited and thereby revealing patterns and themes in the data.

The software NVivo12 was used to carry out the content analysis. NVivo coding queries, analysing each theme's sources and the respective references in the data set, allowed the researcher to identify the most cited factors, providing insight into the importance of each factor. Furthermore, NVivo matrix queries, identifying patterns in the data, enabled an understanding of connections and contradictions between the themes.

4.7 Research Trustworthiness

The findings of qualitative research and hence the truth uncovered in the qualitative inquiry are based on the researcher's subjectivity (Kuhn 1962), not surprisingly raising questions and suspicions about its objectivity (Patton, M.Q. 2002). One of the major issues is the absence of specific evaluation criteria setting standards and providing rules to assess qualitative research (Morse, Janice M 1994).

The application of common quantitative criteria, such as validity and reliability, essentially embedded in a positivist epistemology (Golafshani 2003), has been discouraged, as they do not represent the purpose, goals, and philosophical assumptions used in qualitative research

(Lincoln & Guba 1985; Morse, Janice M 1994). Scholars have highlighted the necessity and importance of using criteria that fit qualitative research, in order to enhance rigor and thereby ensure the quality of the research (Lincoln & Guba 1985; Morse, Janice M 1994).

The academic debate on appropriate criteria has led to a multitude of publications (e.g. Altheide & Johnson 1994; LeCompte & Goetz 1982), reflecting the difficulty and complexity of creating an overarching system for specifying quality in qualitative research.

Authors such as Rolfe (2006) argue that quality and rigor in qualitative research cannot be assessed based on standardised criteria due to the employment of a multitude of paradigms, which establish the philosophical positioning of the researcher and guide its execution. However, bearing in mind the consequences of different research paradigms, over time an established set of criteria specifically to evaluate qualitative research has emerged, based on the work of authors such as Lincoln and Guba (1985), Leininger, M and Morse (1994), and Trochim and Donnelly (2001). Qualitative research is evaluated based on four criteria: credibility, transferability, dependability and confirmability. These four criteria serve as alternative criteria for the quantitative criteria of (internal and external) validity, reliability and objectivity (Creswell, JW 2017).

Credibility and transferability in qualitative research refer to ensuring accuracy; in other words, the truth of the findings established by the researcher, and their transferability, representing a qualitative measure for the validity applied in quantitative research. Dependability refers to a consistent and reliable research approach, enabling replication. It represents the qualitative counterpart to the traditional reliability criterion. Confirmability refers to the extent to which the results of the qualitative research can be confirmed by others, representing the quantitative criterion of objectivity. Figure 10 depicts the traditional criteria for research assessment and the proposed alternative criteria for qualitative research adapted from Creswell, JW (2017) and Trochim and Donnelly (2001)

Being aware of potential trustworthiness issues and the challenges of articulating the trustworthiness of the findings while at the same time observing that reality may only be imperfectly understandable (Healy & Perry 2000), this research treats the key quality criteria (credibility, transferability, dependability and confirmability) as imperatives and hence with particular consideration in the research design, as detailed in the following section.

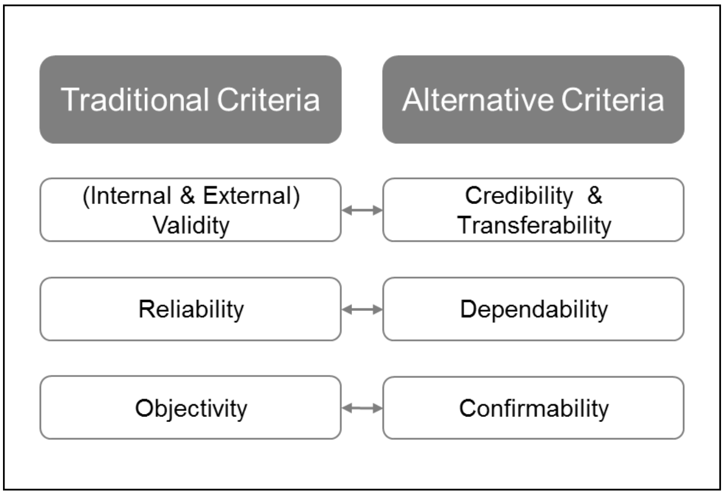

Figure 10: Corresponding traditional and qualitative criteria of research assessment, adopted from Creswell, JW (2017) and Trochim and Donnelly (2001)

4.7.1 Credibility and Transferability

In this thesis, the traditional criterion of validity is addressed by the qualitative counterpart of credibility and transferability. Research credibility was ensured by matching the theoretical framework derived from existing literature on the topic with the data collected. Moreover, the researcher ensured credibility by reconstructing the research findings on par with the views communicated by the study subjects. Several strategies were implemented in this regard.

First, the data were coded systematically, following the process recommended by Yin (2003), allowing the matching of patterns. As both coding approaches, bottom-up and top-down, were applied during this process, the emerging themes were consistently compared with those represented in the relevant literature. This comparison allowed the researcher to identify themes supporting and contradicting the existing theoretical view of the topic.

Second, this thesis implemented two analysis techniques. These techniques, as detailed earlier, complement each other, ensuring that the full extent, as well as a deep and detailed view, of the participants' experiences were captured. Additionally, the data analysis was accompanied by a parallel analysis of the interview transcripts and listening to the audio recordings, which helped prevent omitting important information and allowed the researcher to interpret the verbal statement correctly by taking into consideration non-verbal information transferred through the voice.

The third strategy is the validation of the results. During the analysis the researcher sought the expertise of colleagues and experienced scholars to confirm the results of the analysis and ensure their correct interpretation. Furthermore, the second qualitative study in this thesis was dedicated to discussing the results of the first qualitative research with experts in the field.

The second alternative criterion for qualitative research, research transferability, refers to the extent to which the research findings can be generalised to other settings and a wider population. The qualitative research, compared to the quantitative approach, is often criticised for lacking the statistical generalisation that survey research offers (Crookes 1998; Yin 2003). However, while quantitative research is concerned with providing significant evidence of a phenomena for the whole population (Greenhalgh & Taylor 1997), qualitative research usually, and in the case of this thesis, intentionally applies to a specific population under investigation (Higginbottom 2004). Therefore, qualitative research must ensure the generalisability of findings within a specific context.

To realise transferability of the findings, this researcher paid particular attention to sampling, reporting and linking closely with literature. The population sample was identified based on typical case sampling, with well elaborated inclusion and exclusion criteria defining characteristics of the population under investigation, ensuring the generalisability to the specific population under investigation (Murphy, E et al. 1998). While snowball sampling was applied to gain access to the population sample, six referral chains, with a maximum number of five participants per referral chain were followed to ensure high diversity. Additionally, to allow the results of this thesis to be transferred to a different context or population, the research methodology as well as the evidence of findings are reported in great detail (Miles et al. 1994). The theoretical foundations, methodology and research findings are consistently derived and adapted from and compared with theory, enabling a thorough understanding of the research conducted in this thesis necessary for their transfer.

4.7.2 Dependability

Reliability refers to the generation of stable and consistent results (Golafshani 2003). This thesis, in line with Creswell, JW (2017) and Trochim and Donnelly (2001), applies its qualitative counterpart, dependability, which describes the ability of replicating the given study with the same results. Dependability was implemented in several ways. First, the research design, including research method, data collection and data analysis were elaborated in detail. Second, all methods of data collection and analysis followed standardised and well-established guidelines, which researchers intending to conduct a replication study can understand and follow. Third, the non-standardised interview guide was explained and attached, so it can be applied in following studies.

4.7.3 Confirmability

The concept of confirmability is associated with the objectivity criterion in quantitative research (Patton, Michael Quinn 1990). It ensures that findings are not subject to the individual researcher's opinion, but the experiences and ideas of the informants (Miles et al. 1994) and could hence be confirmed by other researchers (Baxter & Eyles 1997). To implement confirmability, this thesis, following the suggestions of Miles et al. (1994), has detailed the beliefs underpinning this research, as well as all methodologies applied in regard to data collection and analysis. Moreover, all decisions made and reasons for favouring specific approaches have been elaborated, enabling external individuals to determine whether the researcher has arrived at reasonable results.

An additional confirmatory measure was taken via the twofold analysis of the research data. Specifically, the content analysis, which was driven by a quantitative approach to qualitative data, enabled an independent review of the initial results of the thematic analysis, which was highly dependent on the reviewer. Furthermore, throughout the analysis process, the researcher sought the opinion and expertise of colleagues and supervisors, which helped to confirm the data interpretation during the analysis process.

4.8 Summary

This chapter identified and detailed the research methodology appropriate to meet the objective of this thesis and answer the research questions guiding it.

This thesis employed the philosophical stance of constructivism, which encompassed a qualitative approach. The data were collected via semi-structured interviews in two consecutive qualitative studies: an exploratory followed by a confirmatory study. The data analysis was carried out using the 6-phase approach outlined by Braun, Virginia and Clarke (2006). The data were coded applying open, axial and selective coding, employing a priori and empirical codes. The main techniques of data analysis used were thematic and content analysis. Both coding and analysis processes were conducted using a manual coding technique and NVivo. Throughout the data collection and analysis process particular attention was paid to ensuring research trustworthiness.

The following chapter reports on the analysis and findings of this thesis.

Chapter 5: Analysis - RQ1

5.1 Objective

The goal of this chapter is to shed light on the first research question (RQ1) by presenting the analysis of the qualitative data. This chapter starts with an overview of the organisations investigated in section 5.2. In section 5.3 the experts interviewed during the second phase of the data collection are introduced. It is followed by section 5.4, which answers the first sub-research question of what key factors influence the readiness for digital innovation of family farms in Australia.

5.2 Overview of Sample Backgrounds – Exploratory Interviews

To gain an in-depth understanding on the subject of this thesis, 19 family-owned and -managed farms located in Australia were investigated. The firms investigated were divided into three groups. Sixteen of the 19 farms generate an innovative outcome applying digital technologies. However, the data analysis unveiled substantial differences between the digital innovators regarding the 1) knowledge of digital technologies, 2) number of digital technologies applied, and 3) synergies derived from the parallel application and interaction between specific digital technologies.

Therefore, the pool of respondents ready to innovate with digital technologies was divided in digital innovators (DI) and advanced digital innovators (ADI). Respondents labelled as ADI had to possess three qualities: they had to have extensive knowledge about digital technologies and their application, use a wide range of different digital technologies on their farm to innovate, and utilise synergies of different digital technologies.

Three of the farms were not ready to innovate with digital technologies and these respondents were labelled non-digital innovators (NDI). Participant NDI3, an olive grower, has not adopted any digital technologies beyond the foundational technologies, such as a computer and laptop, and is hence not generating any innovative outcomes applying digital technologies. Participants NDI1 and NDI2, both livestock farmers, use only one digital technology, electronic ear-tags, besides a computer and smartphones, as they are government-prescribed. Despite having this digital technology, these two farms are not using the technology for any innovative purpose but only so that later in the value chain of the product, the livestock and its origin can be identified by a third party. Due to the lack of organisational readiness for digital innovation, these 3 farms are labelled as NDI.

The digital technologies used on the farms investigated in this thesis are detailed in Appendix L, sorted according to the three main agricultural specifications in Australia: cropping, livestock and fishery. An overview of which digital technologies are used on each farm can be found in Table 10.

While digital technologies, as detailed in 3.2.3 can generate all four forms of innovation (product, process, organisational and marketing), the 16 farms investigated in this thesis that are ready for digital innovation all apply digital technologies to innovate their farming practice.

Table 10: Overview of farms investigated

Participants	Level of Organisational Readiness	Agricultural Specification	Owning and managing family members	Examples of Applied Digital Technologies	Age of Participants
ADI1	Advanced	Cropping	Multiple	Digital weather stations Irrigation monitoring Variable rate technology Yield mapping	> 60
ADI2	Advanced	Livestock and Cropping	Multiple	Electronic ear tags GPS guidance system Multiple farm management software Yield mapping	20 - 39
ADI3	Advanced	Cropping	Multiple	Multiple farm management software Digital weather stations GPS guidance system Variable rate technology Yield mapping	40 - 59
ADI4	Advanced	Cropping	Multiple	Digital moisture probes Digital weather stations GPS guidance system Ground pressure mapping Yield mapping	20 - 39
DI1	Basic	Cropping	Multiple	GPS steering Yield mapping	> 60
DI2	Basic	Livestock and Cropping	Multiple	Digital sowing technology Digital weather stations Electronic ear tags GPS guidance system GPS livestock tracking Variable rate technology Yield mapping	> 60
DI3	Basic	Cropping	Multiple	Digital sowing technology GPS guidance system Guidance systems (spraying) Yield mapping	20 - 39
DI4	Basic	Livestock and Cropping	Multiple	Farm management software GPS guidance system	40 - 59
DI5	Basic	Cropping	Multiple	Farm management software GPS guidance system Variable rate technology Yield mapping	> 60
DI6	Basic	Livestock and Cropping	Multiple	Digital moisture probes Digital weather stations Electronic scales Farm management software	20 - 39

DI7	Basic	Cropping	Multiple	GPS guidance system Variable rate technology Yield mapping	40 - 59
DI8	Basic	Livestock	Multiple	Drone Electronic ear tags Electronic scales Intelligent spraying	> 60
DI9	Basic	Cropping	One	Controlled atmosphere technology for storage Irrigation monitoring Picking platform	> 60
DI10	Basic	Fishery	One	Farm management software Automated water quality monitoring and management technology	40 - 59
DI11	Basic	Cropping	Multiple	Digital soil testing Farm Management Software GPS guidance system Variable rate technology Yield mapping	40 - 59
DI12	Basic	Cropping	Multiple	Digital moisture probes Digital water supply monitoring GPS guidance system	40 - 59
NDI1	None	Livestock and Cropping	Multiple	Electronic ear tags (no digital functions used)	> 60
NDI2	None	Livestock	One	Electronic ear tags (no digital functions used)	40 - 59
NDI3	None	Cropping	One	none	40 - 59

5.3 Overview of Experts – Confirmatory Interviews

While the investigation into the specific farms provides in-depth knowledge on the research inquiry of this thesis, the semi-structured interviews with the farms' managing owners are limited to their own context. To gain a broader and equally informed perspective on the research inquiry, in the second phase of the data collection 6 experts in the field of digital innovation in the Australian agriculture were interviewed.

Expert 1 (E1) works for a national independent research organisation in Australia as a team leader of the digital agriculture innovation research unit.

Expert 2 (E2) is an agriculture technology coordinator for the Australian government currently supervising on-farm trials of a diverse range of digital technologies.

Expert 3 (E3) has been the CEO of a farmer-led agriculture research organisation in Australia for over 5 years, initiating, coordinating and supervising research initiatives, many into digital agricultural technologies, in collaboration with regional farms.

Expert 4 (E4) is the current COO of Australia's leading agriculture technology accelerator, responsible for operations around recruiting, and investing in and coaching agricultural technology start-ups.

Expert 5 (E5) is the director of an Australian organisation developing data mining and machine learning based applications for the agriculture sector.

Expert 6 (E6) grew up on a farm and is now the founder of an Australian start-up developing big data and machine learning-based farm management software.

Due to the inevitable continuous interaction with Australian farmers required by their organisational roles, these experts have a profound understanding of the Australian agricultural sector and in particular its organisations and individuals. Furthermore, being active in the digital agriculture space, all six experts possess a comprehensive overview of digital agricultural technologies and sound knowledge on their application in practice. Having worked or currently working with farms adopting and innovating with digital technologies, each expert can provide in-depth insights on the enablers and inhibitors of digital innovation in the Australian agricultural sector as well as the process of transitioning towards a digital agricultural practice, hence being particularly fitting informants for this thesis. An overview of the experts interviewed is provided in Table 11.

Table 11: Overview of experts interviewed

Participants	Organisation	Position within the Organisation	Experience with Digital Innovation
E1	National independent research organisation	Team Leader - Digital Agriculture Innovation	Team leader of research group on digital innovation in the Australian agriculture
E2	Australian Government	Agriculture-technology coordinator	Currently supervising on-farm trials of various digital technologies in Australia
E3	Farmer-led agriculture research organisation	Former CEO	Leader of research initiatives on digital innovation in the Australian cropping sector
E4	Australia's leading agriculture technology accelerator	Current COO	Responsible for recruiting, evaluation and mentoring of digital technology for agriculture start-ups in Australia
E5	Digital technology provider	Director	Director of a data mining and machine learning application developed in Australia
E6	Digital technology provider	CEO	Founder of a big data and machine learning based farm management application developed in Australia.

The insights derived from the semi-structured interviews with managing farm owners introduced in the previous section as well as the experts introduced in this section will be presented in the following section. Specifically, the insights are structured around the two sub-research questions, starting with factors influencing the readiness for digital innovation of small family farms in Australia (section 5.4), followed by the process of gaining organisational readiness for digital innovation (section 6.2).

5.4 Key factors Influencing Organisational Readiness for Digital Innovation

This sub-section presents a short summary of the findings followed by a detailed elaboration upon the key factors of organisational readiness for digital innovation, employing both thematic and content analysis. Thereby, it answers the first sub-research question: *What are the key factors that influence the readiness for digital innovation of family farms in Australia?*

The analysis of the exploratory interviews with farm owners/managers led to the identification of six key factors influencing organisational readiness for digital innovation: Strategic readiness, Managing Farm Owner(s) readiness, Management readiness, Resources readiness, Digital Technology readiness and External Capacity readiness, as depicted in Figure 11. This figure and all the following figures in this chapter visualising the coding structure are screen shots of the data analysis in Nvivo 12, presented in order for the sake of transparency in data analysis.

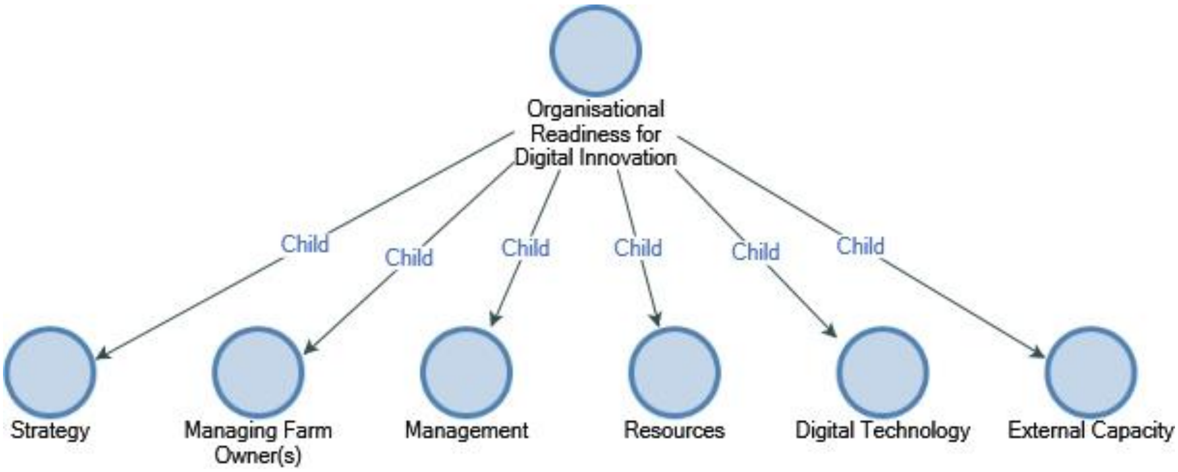

Figure 11: Key factors of organisational readiness for digital innovation

These key factors, which are the 1st level themes, were identified during the manual data analysis of the exploratory interviews. These findings were supported by the consecutive analysis applying NVivo 12, which captured the amount of codes created for and the number of respondents representing each key factor. Furthermore, this classification of key factors was confirmed by the subsequent thematic and content analysis of the confirmatory expert interviews, strengthening their validity.

The number of interviews coded and individual codes within each category, for the interviews with both the digital innovators and experts, confirming and manifesting the suitability of the categories, is depicted in Table 12. Column one shows the key factors that influence a farm's readiness for digital innovation. The second column outlines the attributes which constitute the readiness of each of the influencing key factors. Columns three and four show the number of interviewees that substantiate the importance of each of the identified key factors, column three referring to the 16 DIs and the ADIs, and column four to the 6 experts. The last column contains the number of codes generated for each of the key factors.

Table 12: Detailed overview of unveiled key factors of organisational readiness or digital innovation

Key factors of Organisational Readiness for Digital Innovation	Attributes of Key Factors	Number of Respondents (DI & ADI)	Number of Respondents (Experts)	Number of Codes
Strategy	• Strategic Orientation • Knowledge Acquisition • Culture	16	6	520
Managing Farm Owner(s)	• Change Valence • Positive Attitude towards Digital Technologies • Mindset	16	6	413
Management	• Leadership • Operations Management	13	5	91
Resources	• Financial • Time • IT infrastructure	16	6	93
Digital Technology	• Strategic Fit • Characteristics	14	6	153
External Capacity	• Innovation Network • Inter-organisational exchange and support	16	6	408

Each category has been highlighted by at least 13 out of the 16 DIs and ADIs, and 5 out of the 6 experts interviewed. The minimum number of codes within each of the identified themes is 91. While the high numbers of interviewees and codes related to each key factor underpin their significance, the differences in participants and codes related to each category cannot be interpreted as differing in importance. This notion originates from the identified process involved in transitioning towards organisational readiness for digital innovation as well as the interdependencies between the key factors, which will be elaborated in detail in Chapter 6.

To identify key factors influencing the organisational readiness for digital innovation both a priori and empirical codes were applied. However, the 1st level themes identified during the analysis were all pre-defined categories previously derived from literature. While no new 1st level themes emerged during the data analysis, this specific set of themes does not appear in this composition in the literature but has been derived from a synthesis of various publications. Furthermore, the pre-defined themes were specified and extended.

Each of these key factors has been identified to consist of a set of attributes which define and specify what the key factors entail:

- Strategic readiness in the given context consists of Strategic Orientation, Knowledge Acquisition and Culture.

- Managing Farm Owner(s) readiness entails the attributes Change Valence, Positive Attitude towards Digital Technologies and Mindset.
- The key factor Management includes Leadership and Operations Management as attributes.
- Resource readiness is achieved ensuring the related attributes Financial, Time and IT infrastructure.
- Digital Technology is constituted of the attributes Characteristics and Strategic Fit.
- Finally, the key factor External Capacity refers to the attributes Innovation Network and Inter-organisational exchange and support.

An overview is provided in Figure 12.

The attributes, which are the 2nd level themes of each factor, were derived analysing both exploratory interviews with managing farm owners and confirmatory interviews with experts. They were identified partly during the manual data analysis and confirmed and supplemented by the complementary analysis carried out using Nvivo 12. The attributes were uncovered applying a priori and empirical codes generated during the data analysis.

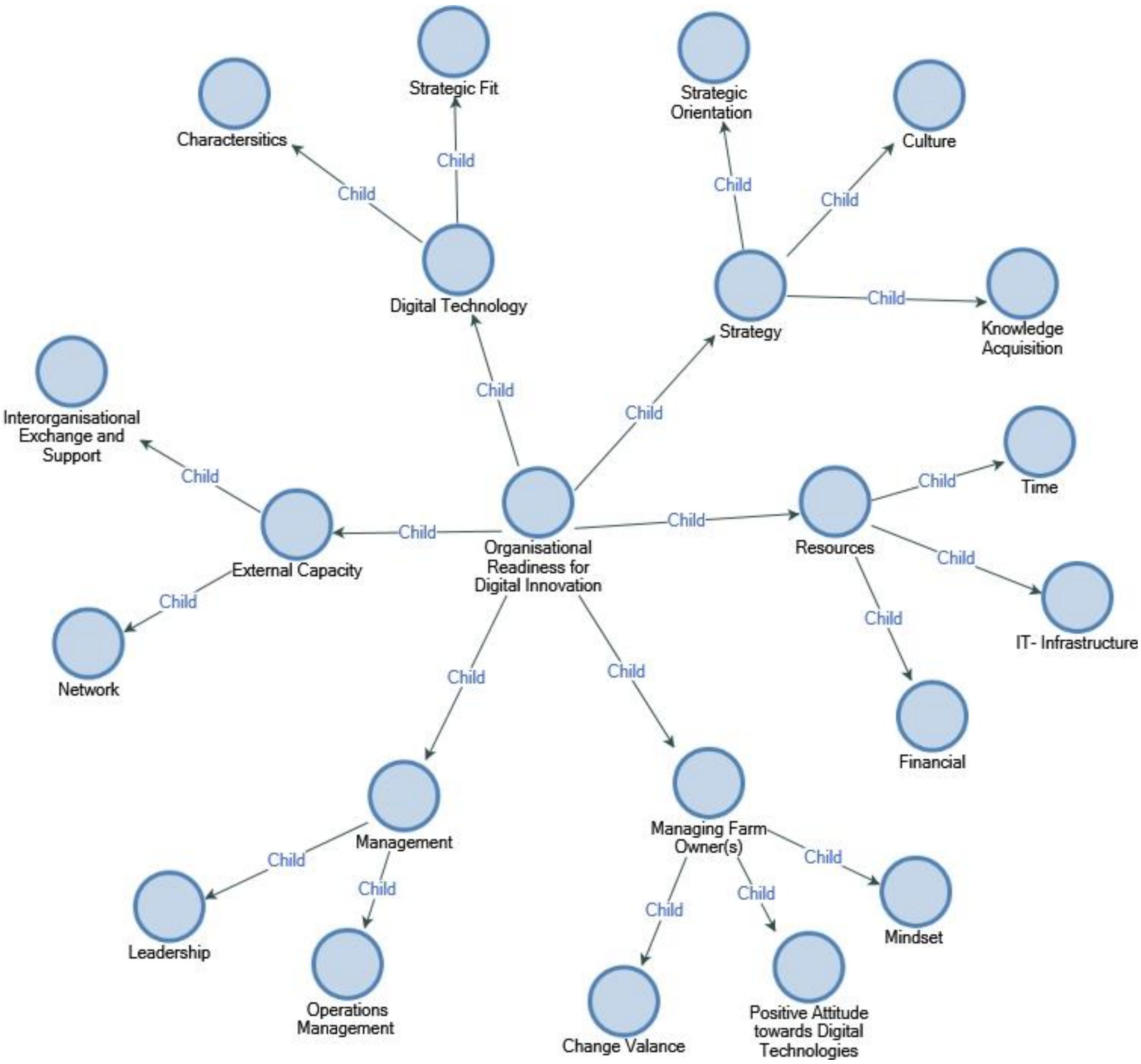

Figure 12: Overview of all key factors and respective attributes influencing organisational readiness for digital innovation

In the following section, each of the six identified key factors and their constituent attributes will be analysed and elaborated in detail. Particular attention is paid to providing insights into 'why' these factors are central to the organisational readiness for digital innovation as well as 'how' they contribute to Australian family farms being ready to innovate with digital technologies.

5.4.1 Strategy

The first key factor of organisational readiness for digital innovation on Australian farms which emerged is Strategy. As depicted in Figure 13, during the thematic analysis, three attributes were uncovered that constitute Strategy readiness for digital innovation: Strategic Orientation, Knowledge Acquisition and Culture.

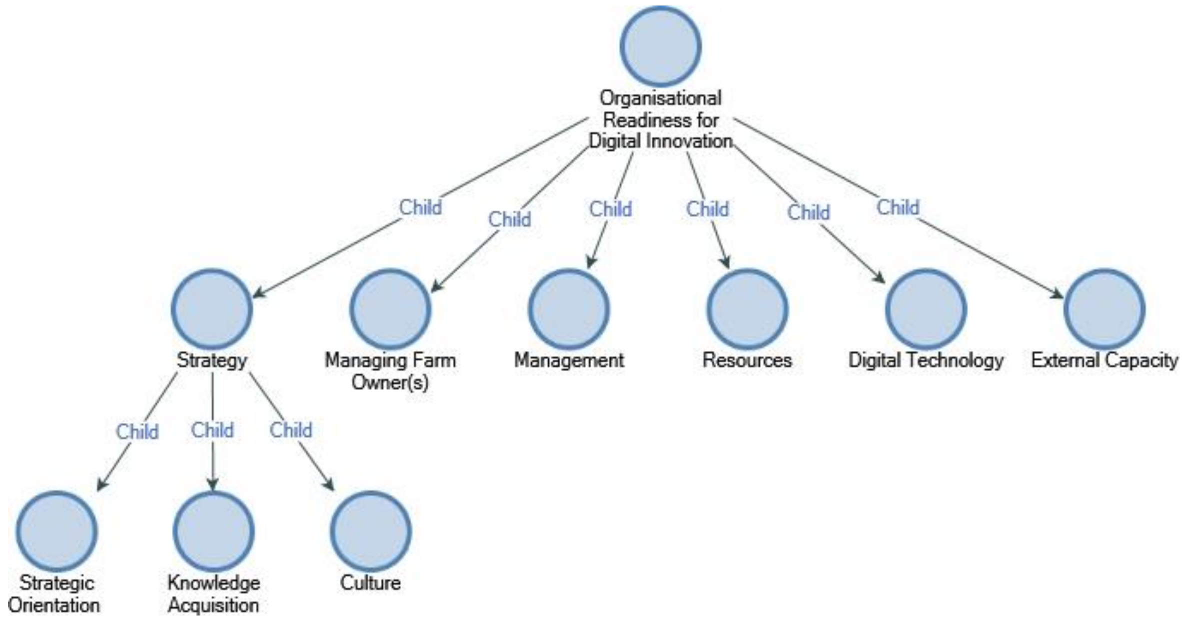

Figure 13: Attributes of strategic readiness for digital innovation

5.4.1.1 Strategic Orientation

The first attribute contributing to the strategic readiness for digital innovation is the strategic orientation. While none of the digital innovators interviewed stated that they possess a clear strategic plan, the 11 participants that elaborated on their strategy described having a strategic orientation characterised by a long-term focus and continuous improvement as priority.

The common dominator of long-term focus involved considerations regarding, for example, compatibility of digital technologies when extending the digital set-up on the farm (e.g., ADI4, DI1), potential synergies between digital technologies (e.g., DI7, DI3), and data collection for future evaluation (e.g., DI2, DI11). The experts referred to the long-term orientation as a strategic imperative, as the statement by E1 shows:

> *It's not just about a short-term finance focus, it should be about a long-lasting value change.*

The second strategic orientation characteristic shared by the participants is prioritising continuous improvement, as participant DI3 explained:

> *I'm starting out with one technology and then just being curious and looking for more.*

In fact, all 16 DIs described their approach towards digital technologies to be a process of observing technology development, evaluating its suitability, and adoption if there was potential benefit. Appendix M lists representative examples from the managing farm of strategic orientation.

Consequently, the findings indicate that strategy readiness involves a strategic orientation which is 1) long-term and 2) focused on continuous improvement.

5.4.1.2 Knowledge Acquisition

The second attribute contributing to the strategic readiness for digital innovation is Knowledge Acquisition. All DIs and experts spoke about the necessity of acquiring knowledge when transitioning to and being active in the digital innovation space. Specifically, three different kinds of knowledge were uncovered in the thematic analysis – product knowledge, process knowledge and data knowledge.

Product knowledge refers to the knowledge about what digital technologies exist, their benefits, what infrastructure they require and what technologies they are compatible with. Participant DI9, for example, explained that they stayed informed about new digital technology releases by visiting industry specific events:

> *… you can walk around and see all the new technologies and what's going on.*

However, digital technologies must create additional value on the farm:

> *I think farmers really need to see results, right? They need to see results and justification for money spent. And that's the big thing, really. (E2)*

Another central component of product knowledge was understanding the potential benefit of technology:

> *I've seen enough benefits through attending field days and conferences to see that it could have a place and a financial return for our business. (D2)*

Additionally, knowledge of the required infrastructure for each digital technology is required, but, as participants such as DI3 pointed out, not all farms have that knowledge:

> *With luck you're walking into a farm, they might have a 10-year-old computer that doesn't run.*

Finally, product knowledge was identified to include knowledge on the compatibility of digital technologies, as some digital technologies can only, or more easily, be added to specific farm equipment, as participant DI11 stated:

> *So, we use a lot of John Deere equipment. … It's easier to link, it all just works better together.*

Process knowledge refers to understanding how a digital technology works, how to operate it, how to use it to create the biggest value and how to resolve problems that occur when using the digital technology. Participant DI3 explained:

> *So, you have to get everyone up to speed about how it can work and everyone learns which buttons to press and what to do. Once everyone starts to understand that and utilise the technologies, then you start to actually go, okay, that's all right, we've got that down pat. What's the best way of sewing this? What's the best way of spraying this paddock? Maybe if we turn in this way, that will save us another 5%.*

As the operation of different digital technologies varies between products, process knowledge is acquired once a product is chosen based on the product knowledge.

Data knowledge refers to the knowledge of what data to collect, how it can be collected and when to collect it, as well as what data can be analysed, how and when it can be analysed and interpreted. In contrast to product and process knowledge, data knowledge is not substantial to achieving strategic readiness. 15 out of 16 DIs acknowledge the value of and the advantage that can be gained through data collection and analysis, as the following representative statement by participant DI8 shows:

> *It's a great thing to record data.*

Consequently, 15 interviewees collect data. However, only six of these farms analyse their data, while the remaining farmers are planning to incorporate analysis in the future. Participant DI11 analyses the data collected, however, described the analysis as very basic. Participant DI5 outsources the task to an agronomist who has the knowledge to interpret the data. Only four interviewees, AD1, AD2, AD3 and AD4, analyse the data collected and derive actionable knowledge themselves.

In summary, farms with strategic readiness must possess product and process knowledge about digital technologies. Data knowledge, while beneficial, is not a prerequisite for strategic readiness. However, no farm investigated indicated holding this knowledge internally. Instead, every digital innovator interviewed actively seeks knowledge from outside of the mostly rural farms. As participant ADI2 stated:

> *… no more just sitting isolated in your cabinet.*

The channels of knowledge acquisition cover a wide spectrum, depending on the existence of a local network around digital technologies and the extent of knowledge required. The most common methods of gaining knowledge related to digital technologies require overcoming the farms' rural limitations. Channels include in-person interactions with industry networks which have a strong focus on digital technologies (mentioned by 15 interviewees), attending informative events on digital agriculture, such as workshops, conferences and field days (mentioned by 10 interviewees), and online research and communication (mentioned by 10 interviewees).

The content analysis revealed that digital innovators rely on several different methods of overcoming rural limitations to acquire knowledge related to digital technologies. Appendix N provides an overview of the methods of knowledge acquisition applied.

The experts' opinions on knowledge acquisition support the analysis of the farm interviews. In the experts' opinions, farms still rely heavily on the transmission of information by 'word of mouth'. As E2 explained:

> *People talk to each other, they find out what works or what doesn't, and the reputation tends to grow based on that word of mouth affirmation that goes around.*

Additionally, experts such as E5 recognised the role of the internet in knowledge dissemination within the sector:

> *So, the information that they may be seeking in order to make a decision on farm, they know that if they have high speed internet, they've got a world of potential answers at their fingertips with a smartphone.*

In summary, acquiring knowledge on digital technologies, which involves overcoming rural limitations by seeking knowledge related to digital technologies outside of the farm, is a central attribute of strategic readiness.

5.4.1.3 Culture

The analysis revealed the topic of company culture was not raised by any of the farming participants. None of the 19 farm owners mentioned the term 'culture' during the interview.

In contrast, five out of the six experts (E1, E3-E6) agreed that culture does have an influence on farms' readiness to innovate with digital technologies. However, none of the experts was able to characterise a culture which supports organisational readiness for digital innovation due to farms being very different, as the following statement explains:

> *I think it's very variable for everybody. (E3)*

Looking for shared patterns between the digital and the non-digital innovators, the analysis supports the necessity of a specific farm culture and provides insights into its specifications. The analysis unveiled that the majority of farms that apply digital technologies for an innovative purpose (14 out of 16) are operated by multiple family members that are all involved in digital technologies (see section 5.2, Table 10). The interviewees stated that often one family member takes the initiative in regard to digital technologies, and explains how to operate the digital technology to other family member(s):

> *My oldest brother, he does a lot of the marketing and logistics and he doesn't operate the equipment very often, so he doesn't know how to use it. So, he has to be shown each time basically how to operate some of the equipment. (ADI11)*

This seems to create a sense of responsibility and motivation, or encourages the older generation farmers in their application, as the following participants stated:

> *… smart young sons who can see things, … who might be able to interpret the reasons, knowing what we did the previous year and whether it was a super run out or whatever. (DI1)*

> *Dad's since passed away but two nephews that come on board, so they're probably pushing the adoption of new technology in that more than us and get their heads around it a lot better as well. (DI5)*

In other cases, such as described by ADI1, ADI4, DI2, DI4 and DI6, farms have equally engaged family members who share ideas and support each other in exploring new digital technologies.

The two farms (DI9, DI10) which are run by only one family member, are missing this element and are therefore not as motivated and encouraged to adopt digital technologies. However, they share the commonality of hoping to pass on the farm to their children, ensuring the continued existence of the farm in family ownership.

In summary, while not explicitly stated, farms that innovate with digital technologies have a culture of embracing digital technologies, mostly motivated by the exchange and interaction with other family members engaged in this field or the prospect of passing on the family farm to the next generation, which is seen as encouragement to invest in the sustainability and long-term future of the farm.

The necessity of the described culture for strategic readiness is supported by the responses of the participants who do not innovate using digital technologies. Participants NDI2 and NDI3 do not have any family members involved in operating the farm and will not pass it on to other family members, as they stated:

> *Well, I'm not going to pass anything on to anyone, someone's got to buy me out. (NDI2)*

> *Everybody loves the land, but no one loves the olives. … They like to come here to have a meal and enjoy the weekend, but not do work. (NDI3)*

Participant NDI1 explained that while the farm is currently owned and operated by the married couple, neither are interested in digital technologies. However, as they are hoping to pass on the farm to their children, they state that the younger generation will probably apply digital technologies.

5.4.2 Managing Farm Owner(s)

The second key factor that has emerged as influencing organisational readiness for digital innovation is the Managing Farm Owner(s). It refers to the readiness of the individual(s) managing a farm to innovate with digital technologies, including their Change Valence, Positive Attitude towards Digital Technologies and Mindset, as visualised in Figure 14.

The role of the managing farm owner(s) is pivotal for the following two reasons. First, farm managers are in a unique position. As manager and owner, they are responsible for both the decision-making around digital technologies, as well as their realisation, which, as uncovered through the data analysis, requires individual-specific readiness.

Second, this is supported by the lack of involvement of farm workers in digital innovation. Farm workers are often employed only casually, they have no executive power and if working with digital technologies, they are only executing given tasks. Consequently, the managing farm owner(s) are the key people realising digital innovation on farms and, as the analysis uncovered, they must possess specific attributes, detailed in the following section, in order to support digital innovation.

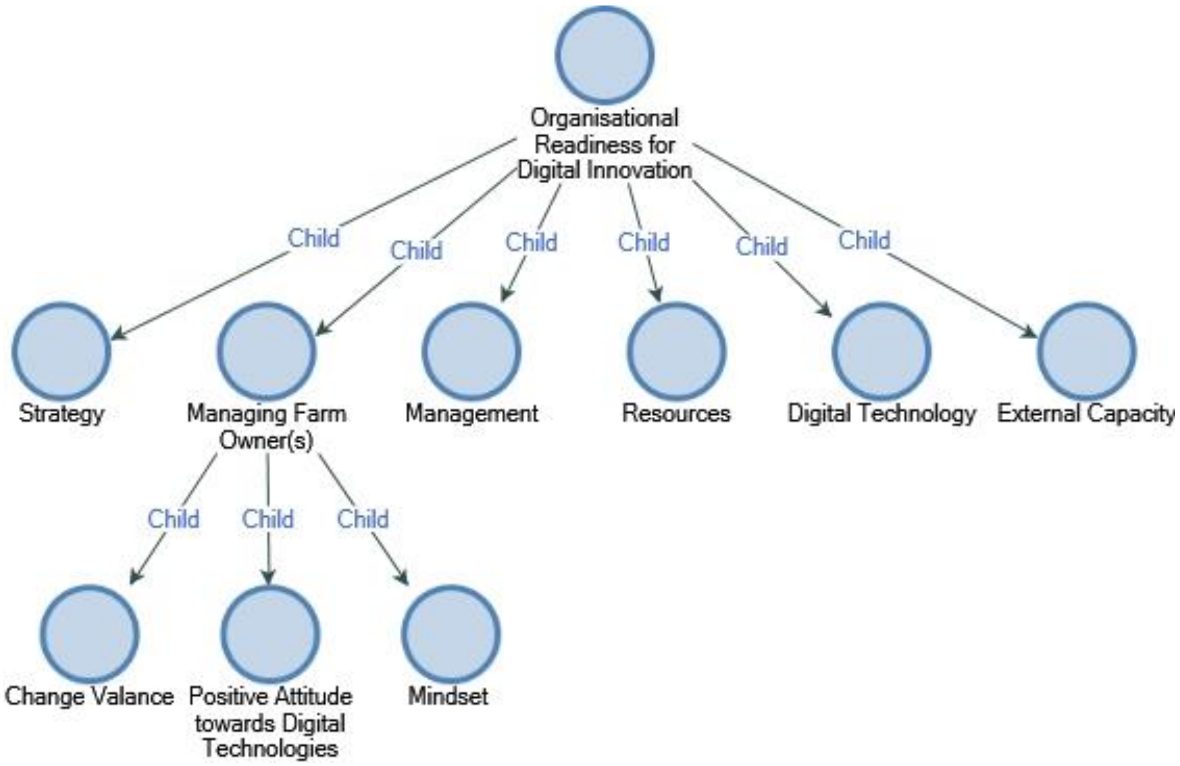

Figure 14: Attributes of managing farm owner(s) readiness for digital innovation

5.4.2.1 Change Valence

In order to adopt a digital technology, all participants have highlighted the role of change valence, which expresses the perception of whether change is needed, as central. For example, after a long and dry summer, for respondent ADI1 the moisture availability in the soil became a concern. As it can have a strong negative effect on the volume and quality of the season's harvest, a change was of high importance. To solve this problem, sensors for moisture probes and automated irrigation systems were adopted, as the participant explained:

> *And then in the middle of the summer here, it's very hot, and they have hardly any moisture reserve. So, I looked at that and read about it and decided we should buy it.*

Participant DI1 has returned to farming after retiring. Due to the participant's advanced age the participant recognised the limited capacity for physical activity which led to the purchase of an autonomous tractor. The participant stated:

> *… it means that as old as I am now I can continue to do a hell of a lot.*

Experts such as E6 and E5 supported this claim:

> *It usually comes down to a problem or a pain. (E6)*

I think what, first and foremost, the farmer needs to work out is what's the problem they're trying to solve. (E5)

Once the need for change and its importance is identified, potential benefits of applying a digital technology to meet the challenges and needs must be perceived, as various experts, such as E4 and E1 stressed:

… if you're coming up with a solution, it's got to be, it can't be a luxury. It's got to be something that's changing significantly your potential to improve yield or generate profit. (E4)

It has to be something that they can see the benefit of … (E1)

The spectrum of needs for and benefits of applying digital technologies is wide. Examples stated by the participants were the decrease in manual labour (DI1, DI9), cost saving (ADI1, DI11), improvement of mental health (DI3), viewer operator errors (DI4, DI9), more environmentally friendly farming (ADI1, DI9) and informed decision-making, as indicated in the informants' statements presented in Appendix O. Besides meeting the corresponding need, each specific adoption of the digital technology was described as enabling additional benefits.

Despite the need recognition and perception of benefit of digital technologies, the participants, such as DI7, stated the necessity of weighing the benefits against the costs:

I think it's a combination of the right sort of equipment becoming available at the right price.

Finally, in line with the insights derived from the analysis of farm interviews, two experts, E1 and E2, emphasised the need for digital technologies to have a positive bottom line:

I think farmers really need to see results, right? They need to see results and justification for money spent. And that's the big thing, really. (E2)

Is it worth the benefit that I'm seeing from having this technology? (E1)

5.4.2.2 Positive Attitude towards Digital Technologies

Another attribute that emerged as determining the readiness of managing farm owner(s) for digital innovation is the attitude towards digital technologies. Experts such as E2 and E4 stated:

So, I think from an internal farm perspective, especially what is an enabler for adoption is mainly I think an attitude … (E2)

So, I think it's more an attitude thing than anything you could detect with your eyes looking at the property … (E4)

The analysis of interviews with farmers ready for digital innovation uncovered the attitude towards digital technologies being determined by the previously introduced attribute, change valence. Participants with change valence have a positive attitude towards digital technologies. While recognising that innovating with digital technologies has downsides, such as causing frustration at times:

> *I never regret this decision to move from this manual system that was just pathetic to a cloud based. It's a massive jump. I don't regret it because we've learned a lot in this process and it's the reason why I am here at this conference today, because of this frustration that comes from this process. (ADI2)*

or the breakdown or malfunction of digital technologies:

> *… this stuff either will break down or something will go wrong. … There will be problems. (DI1),*

the participants have embraced the advantages of digital technologies, leading to a positive attitude towards them. As participant DI10 concluded:

> *Happy to use it, if it can be helpful.*

In contrast, two interviewees who are not ready for digital innovation have a negative attitude towards digital technologies originating from their lack of change valence. When asked how they feel about digital technologies, both participants NDI1 and NDI2 stated that they were satisfied with the current practices and would therefore continue as is, without any application of digital technologies. Interviewee NDI1 explained:

> *What I do now, and have been doing for 45 years works all right, so I stick to it.*

Interviewee NDI2 responded:

> *I'm not too sure, because I never went through with it. … I don't see much of the benefit, so I don't know.*

Participant NDI3 has a generally positive attitude towards digital technologies, evaluating them as 'good'. However, the participant's lack of change valence, identified in the statement, '*But it's got a lot of things in it that I would never use*,' highlights the interdependence of change valence and attitude. This leads to the conclusion that both factors, change valence and positive attitude towards digital technologies, are attributes influencing the readiness of farm owners to innovate with digital technologies.

5.4.2.3 Mindset

The attribute mindset was coded 241 on average over 10 times per interviewee (farm owners and experts), indicating the importance of this attribute and the traits characterising it. The thematic analysis supported this claim, revealing the two characteristics, change orientation and commitment, as predominant traits of digital innovators.

Change orientation refers to the willingness to explore and realise different avenues for the future of farming. This is not always the case, as participant DI1 stated, '*people are uneasy with change'.* E3 highlighted:

> *… most technologies require farmers to change their workflows, change their practices, or generally have to do something differently.*

To explore and evaluate potential options, the managing farm owner(s) must demonstrate *a* willingness to a) search for and review existing digital technologies, described by participant ADI1 as '*willingness to read and review and look at stuff'*, and moreover, they must be willing to b) research and explore the most value-creating digital solutions. Participant DI6 explained, '*I love to see, how does it work best.'*

In line with the farmers' view, E4 highlighted the need for the willingness to explore and evaluate different options of potential digital innovations, describing managing farm owner(s) ready to innovate with digital technologies as:

> *… curious people willing to kind of spend the time when they're not out working in the field, sitting on the computer and having a real serious look into complex kind of weighing up of costs, looking at their balance sheet, what they can afford to integrate, what they can't, is that expense worth the improvement and having a real hard look at that.*

Once potential for digital innovation is identified, managing farm owner(s) must become proactive to generate the change necessary for its successful realisation. Participants have reported proactively preparing for the application of digital technologies. Participant DI9, for example, aware of needing to operate computers and apps when using digital technologies, signed up for a computer course. By attending evening classes the participant acquired a skillset and the confidence that motivated the purchase of a foreign technology with limited support in Australia, which has led to significant improvements on the farm. Furthermore, not all, but many digital technologies require working with a computer, entailing a transfer from hands-on farming to more cognitive work, which only managing farm owner(s) with a change orientation are willing to do. This change in nature of work has been stated as a major barrier to applying digital technologies by many interviewees, as it contradicts the traditional views and practice of farming. Participant DI7 mentioned:

I think in general, most farmers want to spend as little time as we can in the office. We don't want to spend more time in there.

Once a digital technology is adopted on a farm, change orientation of managing farm owner(s) is required for further optimising and ensuring the continuous operation of digital technologies. The following participants exemplified:

So, we founded a cooperative so better communicate with digital solution providers as a team to actually develop solution to develop something meaningful for us. (ADI2)

It's when you're starting to ask for aftermarket stuff, which isn't a tick box, that's when you have to start being creative and finding other solutions. (ADI4)

The second characteristic defining managing farm owner(s) mindset readiness for digital innovation is commitment. Commitment to innovate with digital technologies is necessary as it is not straightforward and self-explanatory. Participant DI9, in line with participants DI2, DI4, DI6, DI7 and DI11, reported finding it ‘scary’ when starting to use digital technologies:

It was scary when you first get it, trying to work out how it works.

Experts acknowledged the difficulties of engaging in digital innovation too:

… it can be quite overwhelming … (E1)

… a lot of the time those things don't quite work as seamlessly and so that causes major frustration. (E5)

E6 supports the need for commitment, recapturing the comments heard from farmers not ready to innovate with digital technologies:

This is too hard. I'll go back to what I was doing before that was, that was much easier. I don't have to worry about this.

Even participants who have worked with various digital technologies in the past, such as, for example, ADI2, described it as a frustrating and work intense process:

I never regret this decision to move from this manual system that was just pathetic to a cloud based. It’s a massive jump. I don’t regret it because we’ve learned a lot in this process and it’s the reason why I am here at this conference today, because of this frustration that comes from this process.

Experts E2 and E4 added that many farmers had had negative experiences with digital technologies:

… a lot of people have been burned before by technology … (E2)

> *… they've been burned by the myriad of silly apps that do one thing instead of doing the whole sort of end-to-end decision making or apps that don't talk to one another. (E4)*

Overcoming these negative experiences requires commitment to digital innovation. Moreover, digital innovation requires commitment from the managing farm owner(s) to continuously acquire more knowledge and experience in operating digital technologies. E2 explained:

> *… a lot of it is not simple in the way of, you plug and play, so push, plug it in and then it will give you the result you need to just make a decision based on that. It is not easy. So, it's a tool that you have to learn how to use to get the best result.*

Even just technology updates can require familiarisation and learning to operate the new set-up, as participant DI1 elaborated:

> *… with these new models of tractors and combined harvesters, they've changed the system a bit and the GPS is not the same as it used to be in terms of setting up. So it takes a bit of effort from my point of view to become familiar with the new set-ups.*

DI5 summarised:

> *You never stop learning. I just wonder how much further they can go!*

Furthermore, managing farm owner(s) need to be committed to self-teaching. Despite the existence of advisors, all respondents reported the need to teach themselves some aspects related to applying digital technologies, as the following selected statements demonstrate:

> *… we're sort of teaching ourselves. (DI11)*

> *But a lot is to self-learning pretty much … (DI4)*

> *So, you're bit on your own, I guess. So maybe it's up to you to go and do. (DI6)*

5.4.3 Management

The third key factor of organisational readiness for digital innovation in the Australian agricultural sector that emerged during the data analysis is Management, referring to the readiness of a farm's management practice to innovate with digital technologies.

The key factor Management is, as the name indicates, related to the key factor Managing Farm Owner(s). However, while Managing Farm Owner(s) describes the specific characteristics of the managing individuals defining their readiness, Management is concerned with the execution of the firm's managerial activities, divided into two individual key factors. The attributes defining Management readiness are Leadership and Operations Management, as shown in Figure 15 and detailed in the following section.

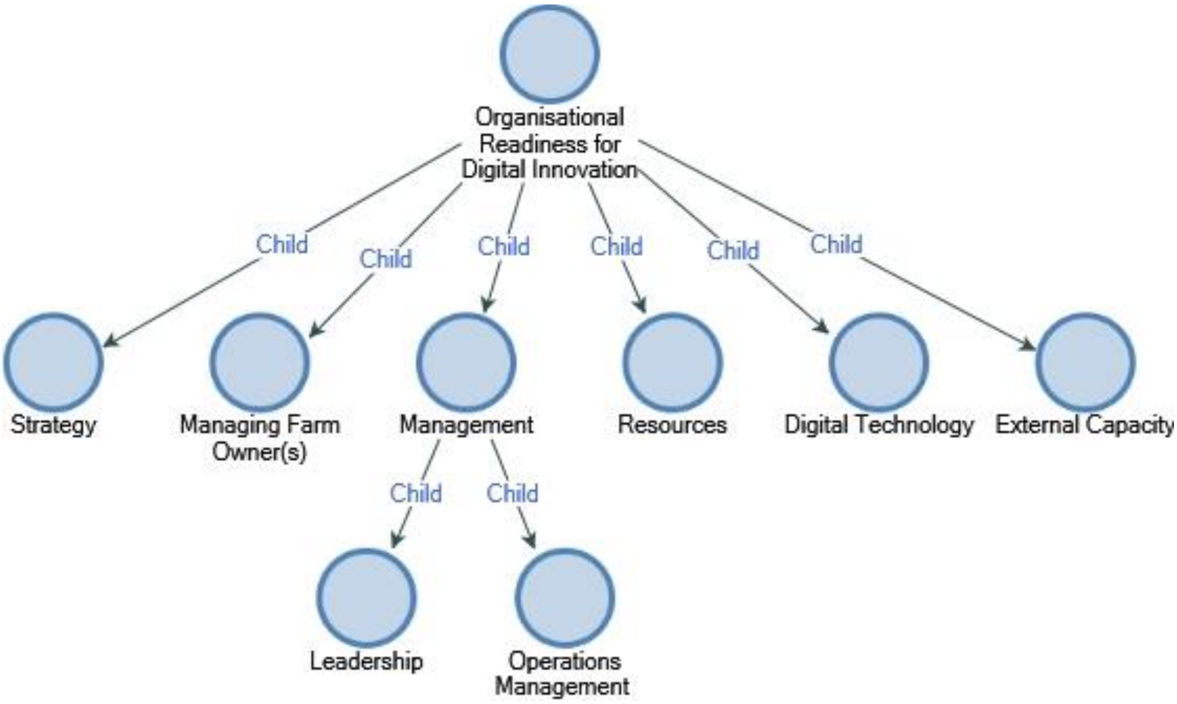

Figure 15: Attributes of management readiness for digital innovation

5.4.3.1 Leadership

To realise digital innovation on a farm, leadership as part of management has been identified as a necessary attribute. Leadership is generally seen as the action of leading a group. However, in the family farm context the majority of workers are employed only casually and not usually engaged in digital innovation. Hence, leadership in this context does not refer to the interaction of the managers with employees but as the necessity of the managing farm owners to take on a leadership position in driving digital innovation. Experts E3 and E5 described the need for leadership:

> *… there's someone taking a leadership position within that particular space. … there's generally someone driving it. (E3)*

> *I think there probably needs to be champions… (E5)*

The need to take on the leadership position in driving digital innovation on the farm is reflected in the interviews with the managing farm owners of farms ready for digital innovation. Each of these individuals, when describing the process of starting to engage in digital innovation and expanding it within the organisation, spoke about the actions they took, as the example quotes in Appendix P demonstrate.

5.4.3.2 Operations Management

The second attribute of Management readiness is operations management around digital technologies. Once a farm has adopted digital technologies to generate an innovative outcome, operations management has been identified to focus on improvement. The focal point of improvement is twofold. First, it refers to improving the operation of digital technologies. Digital innovators reported having experienced difficulty with operating new technologies, and understood that continuous improvement was an ongoing process. The experts interviewed had the same experiences:

> *Using all the information on your farm to make that decision and really due to the lack of time because farmers are time poor, that learning curve process can be quite frustrating. (E2)*

> *They still get frustrated very easily with it, like everyone, because of they're poor on time and capital and all those resources, you need to run the business. So, they want it to work straight away, and if it doesn't, that can be frustrating and put people off. (E5)*

Therefore, managing digital innovation on a farm has been uncovered to require an improvement focus, which is realised by continuous experimentation with and learning about digital technologies, as the following statements of managing farm owners engaged in digital innovation demonstrate:

> *From the farmers side it requires a lot of experimentation I suppose. And self learning and try and error. (DI11)*

> *So, I just kept on trying. I was getting close to calling SMS and AG leader to say, can you help me here? But then I managed to work it out at the end. (ADI3)*

> *So, you're bit on your own, I guess. So maybe it's up to you to go and do. (DI6)*

Experts E5 and E6 advise farm management to focus on exploring how to use and improve the application of digital technologies:

> *… you've got to be out into all the trial and error of it from a management point of view. (E5)*

> *Don't wait. Give it a go. (E6)*

With a management focus on continuous improvement, respondents such as ADI1, ADI2 and DI6 reported a gradual improvement of performance achieved over time when experimenting and trying to optimise their applications of digital technologies.

The second focal point of improvement has been identified as value creation. Improvement of value creation with digital technologies has been uncovered to be driven by the experience and confidence gained through the application of digital technologies, as participant DI1 expressed:

> *… it's just got better and better and easier and easier to use.*

With increased experience in operating digital technologies comes an understanding of how they can be applied for more value creating activities. DI3 explained:

> *So, you have to get everyone up to speed about how it can work and everyone learns which buttons to press and what to do. Once everyone starts to understand that and utilise the technologies, then you start to actually go, okay, that's all right, we've got that down pat. What's the best way of sewing this? What's the best way of spraying this paddock? Maybe if we turn in this way, that will save us another 5%.*

The awareness of the potential for additional value creation has led the digital innovators to continuously look out for new areas of potential improvement that can be achieved with digital technologies, as ADI3 reported:

> *I guess you're always looking for ways to do things better.*

This focus on improvement of value creation with digital technologies has been identified to encourage broadening the scope of digital technologies applied on the farm (e.g. ADI4, DI3, DI10) to generate additional value with digital technologies as well. Experts described observing this development:

> *But then there are other things where you do invest that time and then you go, yes, this is working, and I'm going to continue to use it and then it might lead you down the path of okay, well, then that means maybe I can try this related thing or this extension of that, or do this additional component. (E1)*

In conclusion, the analysis revealed that management of operations focused on improvement in regard to the operation but with the value creation with digital technologies as well, to achieve readiness for digital innovation.

5.4.4 Resources

The fourth key factor of organisational readiness for digital innovation identified is Resources. Participants emphasised the necessity of the three resources Financial, Time and IT infrastructure, as visualised in Figure 16.

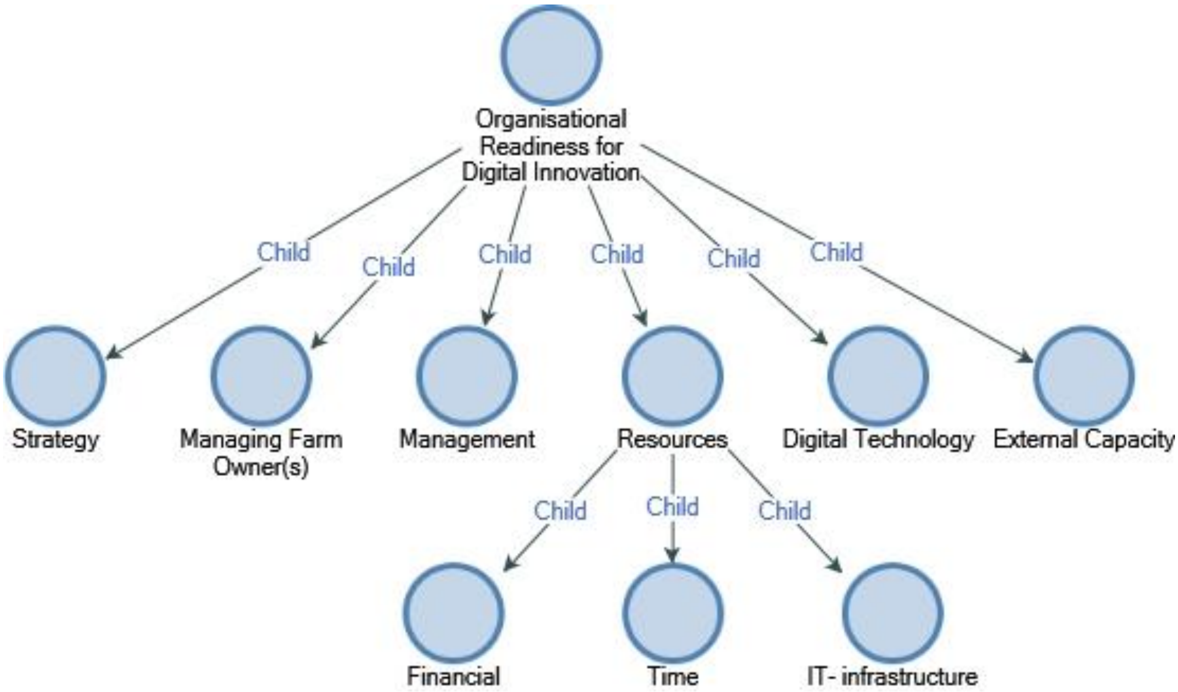

Figure 16: Attributes of resources readiness for digital innovation

5.4.4.1 Financial

The need for financial resources was pointed out by 15 of the 16 digital innovators and 5 of the 6 experts interviewed. The adoption of digital technologies has been described as very costly:

> *… often they might come with a big capital expense. (E4)*

> *… [they] get quite expensive quite quickly. (E1)*

Managing farm owners repeatedly highlighted affordability as a major component holding back or delaying the purchase of digital technologies. Participant ADI1, for example, detailed the costs of a new harvester being between $500,000 and $600,000.

Furthermore, ADI3 stressed the risk of not receiving a return on investment:

> *If you do go down the path, sometimes it can be expensive, and you don't actually get any return.*

In line with this statement, E3 explained that the process of learning how to innovate with digital technologies on a farm involves making mistakes, and described it as crucial to have the financial resources to compensate for potential losses:

> *You learn by doing and staff ups are often how you learn because you're trying to understand how the equipment works, the technology works, and generally it involves*

making mistakes and it's having the ability to make sure those mistakes are non-fatal businesswise.

Moreover, 10 interviewees stated that they employed agronomists, consultants or technology specialists for mentoring, advice or repair work related to digital technologies, as shown in Appendix Q. These are additional costs that require financial resources. DI6 explained:

> *… what happens if something goes wrong? So, we don't have the skills. … Suddenly it costs a lot of money because you need their computer expert and then they call and say, oh no, you actually need the diesel mechanic to fix it.*

Hence, financial resources are a prerequisite for resource readiness.

5.4.4.2 Time

The second attribute of resource readiness is time, as the following statements of experts and digital innovators show:

> *… I think the thing to realise with all the technologies is you've got to have enough financial means and time to allow the adoption process to occur. (E3)*
>
> *It takes time. (E5)*
>
> *It takes a little time. (ADI3)*

Time has been highlighted as a resource needed to evaluate different options of potential digital technologies and, once acquired, to set them up, learn how they operate and improve their value creation.

As detailed in section 5.4.1.2 the digital innovators interviewed go to conferences and field days, speak to their peers and even travel overseas (ADI1), in order to evaluate and compare different digital technologies. Hence, coming to a final decision, as DI5 described, takes time:

> *So, we're going through a lot of field days and we just don't like the decision process, it can take a number of years before we adopt it.*

In addition, digital innovators reported needing time to set up the digital technologies acquired, as participant DI2 stated:

> *It's not a pick up and run with it. It might be a good idea to implement it but it's actually a lot harder cause you spend time implementing it and attaching things to the machine and then it doesn't work.*

Once a digital technology was set up, more time was needed to learn how to operate it and become familiar with the differences in operation between products of different brands:

> *It's also the time it takes to learn new things. (DI2)*

> *One company will say, oh, you click the x to close it. The other one is you have to drop them in here and hit that to exit. And all these things are just time consuming… (ADI4)*

Finally, when focusing on improving the value creation of a digital technology, again, time investment can be required, as the example of digital innovator ADI2 shows. ADI2 had to learn how to program software by watching online tutorials to unlock its full potential:

> *Going from this to coding. I watched a lot of videos.*

Consequently, time is another attribute necessary for resource readiness.

5.4.4.3 IT infrastructure

Digital technologies, regardless of sector, rely on connectivity. Whether AI-powered farming software, self-steering tractors or wireless sensors, all digital technologies require connectivity for their operation. Hence, connectivity is a fundamental IT infrastructure prerequisite for resource readiness, which is not always guaranteed, as E1, in line with E4, E5 and E6, explained:

> *… the infrastructure is also a big problem for farms especially in Australia. So being able to actually access the technology service, in itself is not guaranteed for everyone around Australia.*

Participant DI6, for example, is situated in an area with no mobile internet service. The participant explained how internet access was gained through bouncing signals off self-positioned containers in order to be able to apply digital technologies on the farm.

Besides connectivity, hardware is required for digital technologies. This can be, for example, computers powerful enough to run the specific programs, which participant DI3 explained are often not available on farms:

> *With luck you're walking into to a farm, they might have a 10 year old computer that doesn't run.*

Hardware could include smartphones, which are needed to operate some digital technologies via a mobile app, as participants such as ADI1 and DI2 stated.

In summary, ensuring adequate IT infrastructure is a prerequisite of resource readiness. However, besides internet access, which is a must-have when operating digital technologies, other necessary IT infrastructure needs to be in place. This can vary depending on the digital technologies.

5.4.5 Digital Technology

The fifth key factor of organisational readiness for digital innovation which emerged during the data analysis is Technology. This key factor refers to adopting a digital technology which strategically fits with the farm and has specific characteristics, as depicted in Figure 17 and as detailed in the following section.

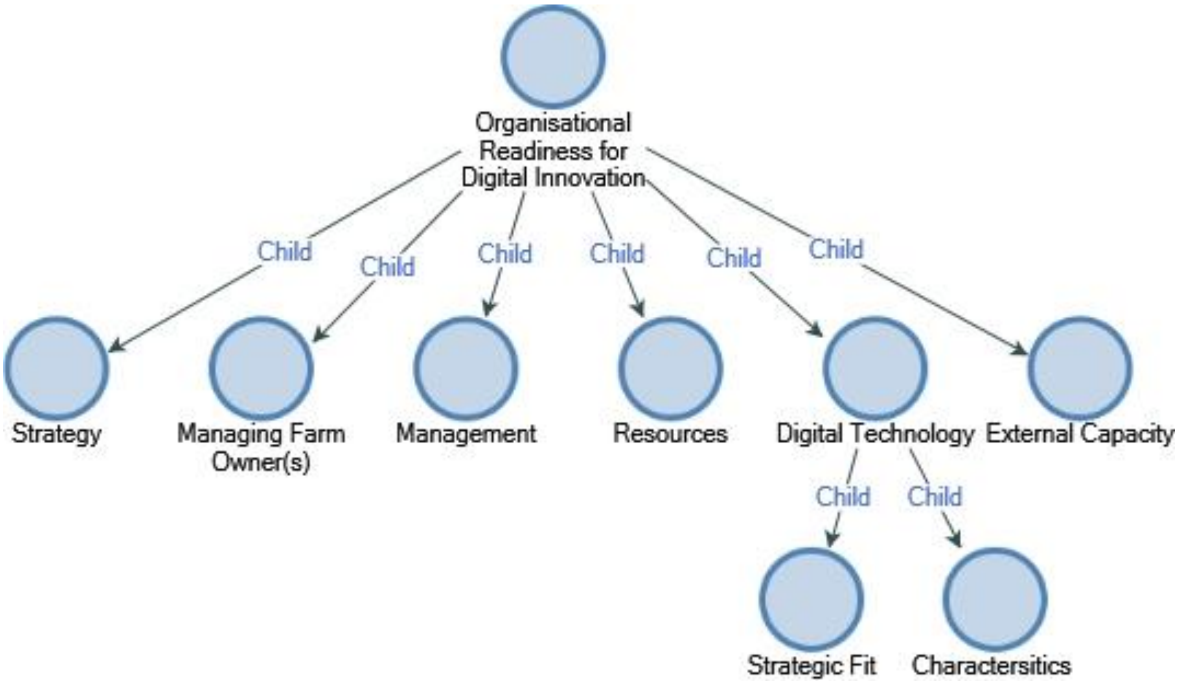

Figure 17: Attributes of digital technology readiness for digital innovation

5.4.5.1 Strategic Fit

The analysis uncovered that achieving readiness in Digital Technology requires ensuring a strategic fit. The experts interviewed described the strategic fit as identifying a specific problem and matching it with a digital technology to solve it:

> *You got to have a problem to solve and then you're in the market for that particular technology. (E3)*

> *I think what, first and foremost, what the farmer needs to work out is what's the problem they're trying to solve. (E6)*

Participant DI8 highlighted:

> *It's got to suit your operation. Not technology for technology sakes. You've got to pick out what you can utilise, what you can use.*

Consequently, with each machine acquired, the digital innovators pursued different goals (often multiple), such as reducing costs, increasing efficiency or quality, reducing environmental impact and gaining more control. A detailed overview and exemplar quotes can be found in Appendix O.

E5 provided an example of a digital technology that was adopted but that did not have a good strategic fit with the farm:

> *I think drones is a really good example. A lot of farmers rushed out and bought a drone. Only cheap ones, maybe 1200 bucks or two grand or whatever it might be for this small sort of, your base level drone and they're all trying to work out how they potentially use it commercially and I still argue that many of them are actually using it very commercially if they're using it at all. Because it just wasn't fit for purpose here in Australia.*

In summary, the analysis revealed the need to choose a digital technology that fits the farm's needs and goals.

5.4.5.2 Characteristics

Beyond a strategic fit, the analysis unveiled the necessity to choose digital technology based on its characteristic in order to achieve readiness in regard to the key factor Digital Technology. Digital Technology characteristics, which digital innovators and experts commonly highlight as a prerequisite, for adopting digital technology can be classified into two groups: general characteristics and farm-specific characteristics.

Confirmed by most farm managers and experts, general characteristics critical for adopting digital technology include fit for purpose, high usability, and compatibility with existing IT infrastructure. Fit for purpose refers to the reliability as well as the functionality of the digital technology. Participant DI10, owner of a fish farm, explains the importance of reliability:

> *I'm always wary of adopting... because it's a high risk thing here. If a pipe blocks on me in the middle of the night, with leaves coming down the river, the oxygen levels drop, and I'll kill $20,000 worth of fish.*

E3 stressed the need to ensure reliability of technology as:

> *… the reliability was oversold…*

explaining the cause for this as:

> *Generally, because the communication is happening from the marketing side of what the technology could potentially do, but it was all unproven…*

The necessity of technology being fit for purpose has been highlighted by participants such as DI2, DI4, DI7 who stated that seeing the results of applying a digital technology, which is proof of its functionality, is a major influence on their uptake decision.

High usability is the second common characteristic of digital technology identified. Participant DI10 explained:

> *Obviously, you want it to be simple and easy to use … . So, it's got to be something generic or something that is fairly intuitive.*

Participants DI6 and ADI2, unsatisfied with the usability of their yield mapping software, explained the consequences:

> *And it's so many buttons. It's so not user friendly. It just, I can't use it, I don't know what to do with it. (DI6)*

> *I'm getting bombarded with too many information and too many platforms that don't talk to each other. (ADI2)*

Another general characteristic which must be ensured is the compatibility with the existing IT infrastructure on the farm, as E4 recommended:

> *Probably ensure … that it connects in with maybe your existing data or it has interoperability with how you record your fertiliser application or this satellite imagery …*

This refers to the farm equipment (such as headers) as well as already applied digital technologies. The majority of the cropping farmers interviewed (ADI2, ADI3, DI2, DI4, DI5, DI6, DI7, DI11, DI12) criticised the lack of compatibility between different cropping software, as the following examples show:

> *I can make some decisions based on Flurosat but then I have to go back from this platform to another platform to work out what would be the impact, if I can afford that changes that Flurosat recommended. (DI2)*

> *And I have learned since then that paddock records and farm financials you just can't get them to match up perfectly and they are better off being separated rather than brought together I believe anyway. (DI12)*

Digital innovators such as DI1, DI2, DI5, DI7 and DI11, highlighted that some digital technologies are compatible with only one brand of header and farm equipment, limiting their ability to adopt digital technologies as they must fit the existing infrastructure.

Besides the presented characteristics, the analysis unveiled specific characteristics depending on the individuals' preferences that influence the degree of technology readiness. For example, participant DI8, managing a livestock farm, only applies digital technologies with high durability, as they are being used outdoors, regardless of weather conditions:

> *It's got to be robust.*

Participant ADI3 expects good online tutorials for the accompanying software as the participant relies on self-teaching:

> *I decided on SMS, … it had good online tutorials that enabled me to teach myself rather than relying on a specific advisor. (ADI3)*

In summary, to ensure Digital Technology readiness, digital innovators need to choose technologies that meet their generic as well as their individual criteria.

5.4.6 External Capacity

The sixth key factor of organisational readiness for digital innovation uncovered is External Capacity, which includes the attributes Innovation Network as well as Inter-organisational Exchange and Support, as depicted in Figure 18.

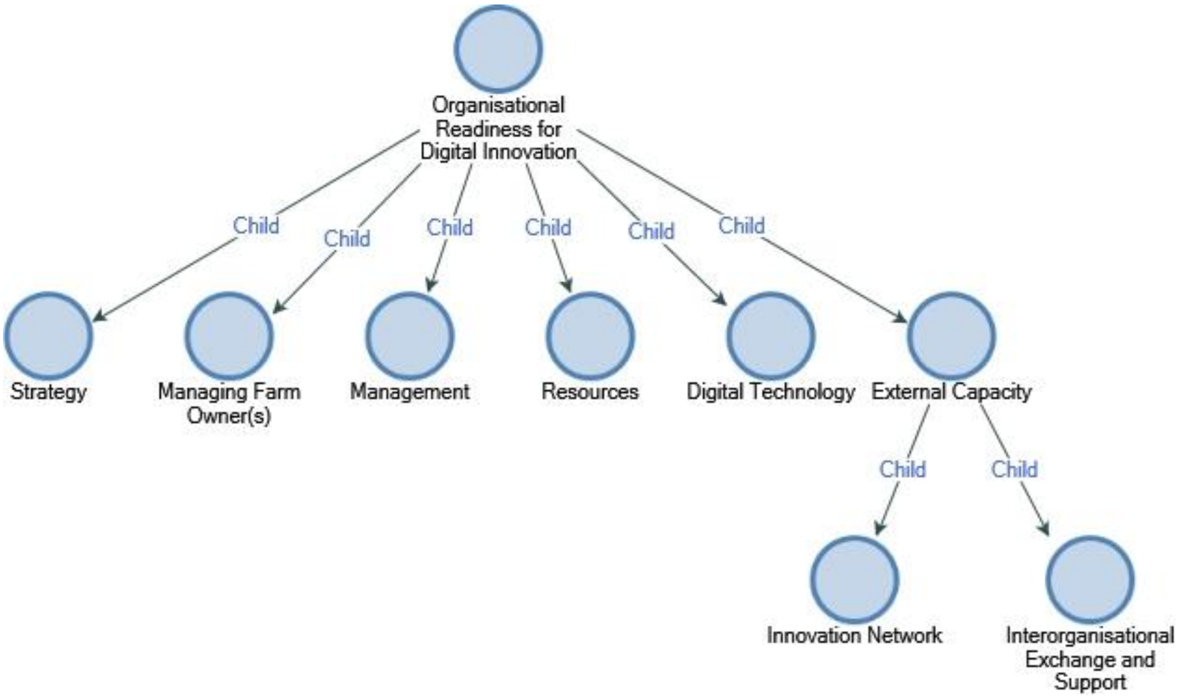

Figure 18: Attributes of external capacity readiness for digital innovation

5.4.6.1 Innovation Network

The first attribute, Innovation Network, refers to the necessity of establishing a network, in particular an innovation network, when innovating with digital technologies, which 15 out of the 16 digital innovators and 5 out of the 6 experts interviewed highlighted. The need for a specific innovation network is supported by the analysis results of interviews with farms who are not ready for digital innovation. All three managing farm owners of these farms stated that they did actively interact with a network, formal or informal:

> *Oh, we are members of the VFF. (ND1)*

I look at the farmers who are successful, and I make a few inquiries on how they're doing, and that's all I do. (NDI2)

I've been on to a group called the Australian Olive Association, and when we started 20 years ago there was quite a few groups. … We met, and we discuss and exchange the problems and the joy. (NDI3)

However, a comparison of the networks described by the digital innovators and non-digital innovators revealed the pivotal role of the network's knowledge on and experience with applying digital technologies to generate an innovative output, characterising an innovation network around digital technologies. Participants ready for digital innovation expressed trust in the expertise of their innovation networks, when, for example, asking for advice in serious matters regarding digital technologies and using them as the main source for the acquisition of product knowledge, as participant DI4 and DI5 described:

We are strongly connected to the BCG. I attend a lot of their field days and seminars, and I suppose you hear it from there. …The BCG are as well providing expert staff expertise. (DI4)

Chris from BCG put me in contact with someone who knows the legal implications of all this and it's a huge issue. (DI5)

Interviewees not ready for digital innovation, on the other hand, stated a lack of knowledge on and application of digital technologies within their network. NDI1, for example, described the farming activities of the network as:

Nothing more than basic things.

The experts, as the following statements show, identified the role of an innovation network as a community with which to share information and experience as well as get advice and support:

… being able to talk through the actual basic steps of how technology is used and why that's useful and relevant, is a real key component to social learning and the adoption of technology. (E1)

I think everyone's a bit different but it'll be in the conversation, social media, peers … those conversations encourage the farmers to try something, truthfully either because they're friends or had respectful relationships over a period of time so that they'll give it a go. (E3)

Hence, the readiness of external capacity requires the involvement in an innovation network around digital technologies.

The participants reported their networks consisting of farming groups, experts, agronomists, dealers, consultants, scholars who publish relevant information and peers (see Appendix Q).

The analysis revealed the key role that peers play in innovation networks. Peers have been identified as a major factor influencing the decision process to transition toward a digital agriculture practice. Fourteen out of 16 farmers reported relying on their peers to acquire knowledge on digital technologies as well as proof of concept assuring their functionality, as the following exemplar statements show:

> *Uptalking these technologies in the farm community requires a lot of word of mouth and other peoples' experiences. (ADI2)*

> *In the AG industry, we talk a lot and when we're a very small industry, particularly in Australia, so you see what other people are doing. (ADI3)*

Experts such as E1, E5 and E6, in line with the digital innovators interviewed, stressed the important role of peers:

> *… I would say never discount the neighbour to neighbour, that sort of stuff, over the fence 'What are they doing? What are they trying? Is that working? Oh that's interesting, I've never heard of that, I might give it a go, I should look into it. (E1)*

5.4.6.2 Inter-organisational Exchange and Support

The second attribute of external capacity readiness has been uncovered as inter-organisational exchange and support.

The exchange between organisations ready to innovate with digital technologies and the external innovation network as well as the support received was highlighted by all 16 innovators and all experts interviewed. The exchange and support serves multiple purposes: 1) acquisition of product knowledge (e.g., D7,E3), 2) help with technology set-up (e.g., DI1,DI3), 3) support with repair work (e.g., DI5, DI11), 4) help with data management (e.g., DI12,DI5), and 5) topical discussion (e.g., E1,ADI2). Supporting evidence can be found in Appendix R.

Even advanced digital innovators stated that they rely on their external innovation network to acquire specific knowledge. However, digital innovators reach out to others outside of their established network as well, for instance via twitter or online:

> *And look, there is help out there if you do need it, it's like Google, I like Google, it's a fantastic resource. Twitter's a fantastic resource that you can put up a*

question somewhere and someone will have the answer for you because they probably have done it before you have. (ADI3)

There is this group of early adopters in this community. We found each other on twitter. There are many other producers, using these platforms. And from there on, we had a chat group, it continued. (ADI2)

In summary, inter-organisational exchange and support are antecedents of organisational readiness for innovation, as they allow access to knowledge and skills that do not exist within the organisation but which are recognised as necessary to innovate with digital technologies.

5.4.7 Differences between different levels of Organisational Readiness for Digital Innovation

The key factors and respective attributes are derived from commonalities between all digital innovators (both DI and ADI), experts and non-digital innovators, allowing generalisability of the results. However, the data analysis has unveiled some differences in the peculiarities of the key factors between the ADIs and DIs, visualised in Table 13 and detailed in the following section.

Table 13: Specific attribute characteristics of advanced digital innovators

Key factors of ORDI	Specific Attributes Characteristic for <u>Advanced</u> Digital Innovators
Strategy	• Data knowledge (when, what & how to collect, analyse and interpret data)
Managing Farm Owner(s)	• Enjoy and hence enforce predominantly working on the computer • Questioning of how and why digital technologies work a certain way
Management	• No specific characteristics
Resources	• Intense time investment (e.g. oversea trips, writing own code)
Digital Technology	• Less focus on usability, more interested in output and innovative potential
External Capacity	• Wider and deeper knowledge networks (bigger thematic scope and more in-depth knowledge)

The possession of product and process knowledge has been identified as a prerequisite for Strategy readiness. Additionally, however, the ADIs have extensive data knowledge, including an understanding of when, what and how data can be collected, analysed and interpreted. Participant ADI2, strongly engaged in data collection and analysis, reported a lack of commercially available software suiting the participant’s needs, or more specifically the lack of functionality in the available farming software:

I can make some decisions based on Flurosat but then I have to go back from this platform to another platform to work out what would be the impact, if I can afford that changes that Flurosat recommended.

Hence, the participant has taken charge and created their own reporting structures by coding and creating their own data visualisation and integration methods. Participant ADI3 expressed dissatisfaction with the calculations of the cropping management software applied, as only standardised formula and average values are being used. Therefore, the participant is manipulating the software, changing calculations, to be more accurate and specific to their farm. Participant ADI4, besides using collected data for informed management decisions, uses it for troubleshooting on the farm.

In respect to the key category Managing Farm Owner(s), ADIs differ in two ways from the identified general characteristics of digital innovators. First of all, while DIs understand the value of digital technologies and are therefore willing to adapt to a new work nature, which consists of more computer-related work, all ADIs stated that they enjoy working on the computer. This seems to be due to the ADIs' backgrounds, which include medicine (ADI1), research (ADI2), consulting (ADI3) and engineering (ADI4), all of which include more cognitive work on a computer.

Second, the ADIs' backgrounds all contribute to the second difference in the category, people, which refers to mindset. While all digital innovators share a common mindset, only ADIs are characterised by their approach of questioning how and why digital technologies work a certain way. Participants ADI2 and ADI3, for example, explained that they don't simply use a digital technology and its functionalities, but instead question what the technology does, how it works, and the foundation of its results. Participant ADI4 followed a very precise approach when dealing with data, entering data correction factors, weighting samples, etc. The participant, a scientist, justified the procedure by explaining that this would be the right scientific procedure.

The key factor Management includes the attributes leadership, as well as operations management focusing on improvement of operating digital technologies and the value created applying these. It is the only category which did not show any differences, regardless of level of knowledge of digital technologies, the number of digital technologies applied and the synergies among the digital technologies utilised. Both DIs and ADIs follow the same approach in ensuring management readiness, which influences their readiness to innovate with digital technologies.

In regard to Resources, the only differentiating factor is the time investment. Time as a resource is necessary when innovating with digital technologies, as identified by all digital innovators. However, the amount of time invested differs between DIs and ADIs. For example, participant ADI1 has travelled overseas multiple times (Europe and Asia) to learn about the newest digital technologies in the sector and see their application; ADI2 has taken up coding in order to be able to personalise and enhance existing digital technologies applied, and has started up a multidisciplinary cooperation to develop more user-friendly and user-centred farm management software; ADI3 has modified the data collection on the farm over multiple years, optimising the information gathered through an iterative approach of data collection and meticulous analysis to then identify potential improvement in data collection.

Based on the identified specification of ADIs, such as the willingness for intense time investment to become familiar with a digital technology and optimise its applications, a mindset questioning why and how a digital technology operates a certain way, as well as the ability to find an innovation network that provides knowledge and support, it can be stated that ADIs are open to trying technologies which are complex and require comparatively high human input. While these technologies are perceived as being difficult to use by other digital innovators, ADIs are more focused on the innovative outcome they can generate, accepting the additional effort required to operate them.

In terms of External Capacity, ADIs differ in two aspects from the DIs. ADIs have wider and deeper innovation networks, in terms of knowledge available. Participant ADI4 stated that, to apply digital technologies that are new to the market or rarely used, it was necessary to involve a wider network: '*It's when you're starting to ask for aftermarket stuff, which isn't a tick box, that's when you have to start being creative and finding other solutions or talk to different people outside of your normal machinery channels*'. Participant ADI3 highlighted the value of being connected and receiving mentorship from experts within the CSIRO, which is a leading independent research institution of the Australian federal government. The innovation networks of participants ADI2 and ADI1, for example, consist of professional connections inside as well as outside of the agriculture industry to access specific knowledge necessary for digital innovation.

Furthermore, all interviewees engaged in digital innovation stated that they rely on their external innovation networks to acquire knowledge on and receive support with digital technologies. However, ADIs, due to their knowledge and experience with digital technologies are at the same time knowledge and support providers. Participants ADI1 and ADI3 founded organisations which provide information on and service around specific digital technologies applied in their respective sectors. ADI2 and ADI4 reported being approached by farmers in the area asking for their advice and opinion on digital technologies.

In summary, the analysis revealed changes in regard to the attributes characterising readiness for digital innovation depending on the level of the farm's readiness. The particularities of ADIs are worth noting, especially as they highlight additional unique attributes needed by digital innovators planning to advance their digital innovation practice to a more advanced level. However, as this thesis aims to uncover general factors influencing organisational readiness for digital innovation, independent of the organisation's proficiency in this regard, the findings of this sub-section are not considered in the framework of organisational readiness for digital innovation.

5.5 Summary

Guided by the first research question of this thesis, this chapter presented the analysis results uncovering key factors influencing the readiness of family farms for digital innovation. Furthermore, it detailed the attributes constituting each of the identified key factors, providing in-depth insights into what readiness for digital innovation entails. Finally, comparing the readiness of digital innovators and advanced digital innovators, differences in regard to the key factors when advancing along the spectrum of readiness for digital were outlined.

The following chapter reports on the analysis results addressing the second research question of this thesis.

Chapter 6: Analysis - RQ2

6.1 Objective

The goal of this chapter is to shed light on the second research question (RQ2) by presenting the analysis of the qualitative data gathered. Section 6.2 provides insights into the process of how family farms in Australia become ready for digital innovation. It outlines and explains the relationships between the identified key factors, as well as identifies an order in which readiness in regard to the key factors becomes relevant. It is followed by section 6.3, in which the findings are brought together in an empirical framework.

6.2 Transition Process towards Organisational Readiness for Digital Innovation

This sub-chapter elaborates upon the uncovered process of achieving organisational readiness for digital innovation in the Australian agricultural sector. It answers the second sub-research question of this thesis: *How do family farms in Australia become ready for digital innovation?*

As detailed in section 5.4 the analysis revealed organisational readiness for digital innovation to be influenced by the six key factors Strategy, Managing Farm Owner(s), Management, Resources, Digital Technology and External Capacity. To achieve organisational readiness in regard to digital innovation, the manual analysis identified that the key factors had to be achieved in a specific order: first, Managing Farm Owner(s), followed by the key factors External Capacity, Strategy, Resources, Digital Technology and finally Management (see Figure 19).

Figure 19: The sequence of key factors enabling organisational readiness for digital innovation

This specific order is based on the enabling influence between the factors, detailed in section 6.2.1, uncovered during the NVivo-based content analysis. The high number of codes coded at multiple nodes (1st and 2nd level categories) indicated connections and relationships between the different key factors, which motivated an additional investigation carried out through a thematic analysis focusing on unveiling the identified relationships between each key factor. The additional thematic analysis uncovered the key factors to have enabling as well as reciprocal influences on each other as visualised in Figure 20.

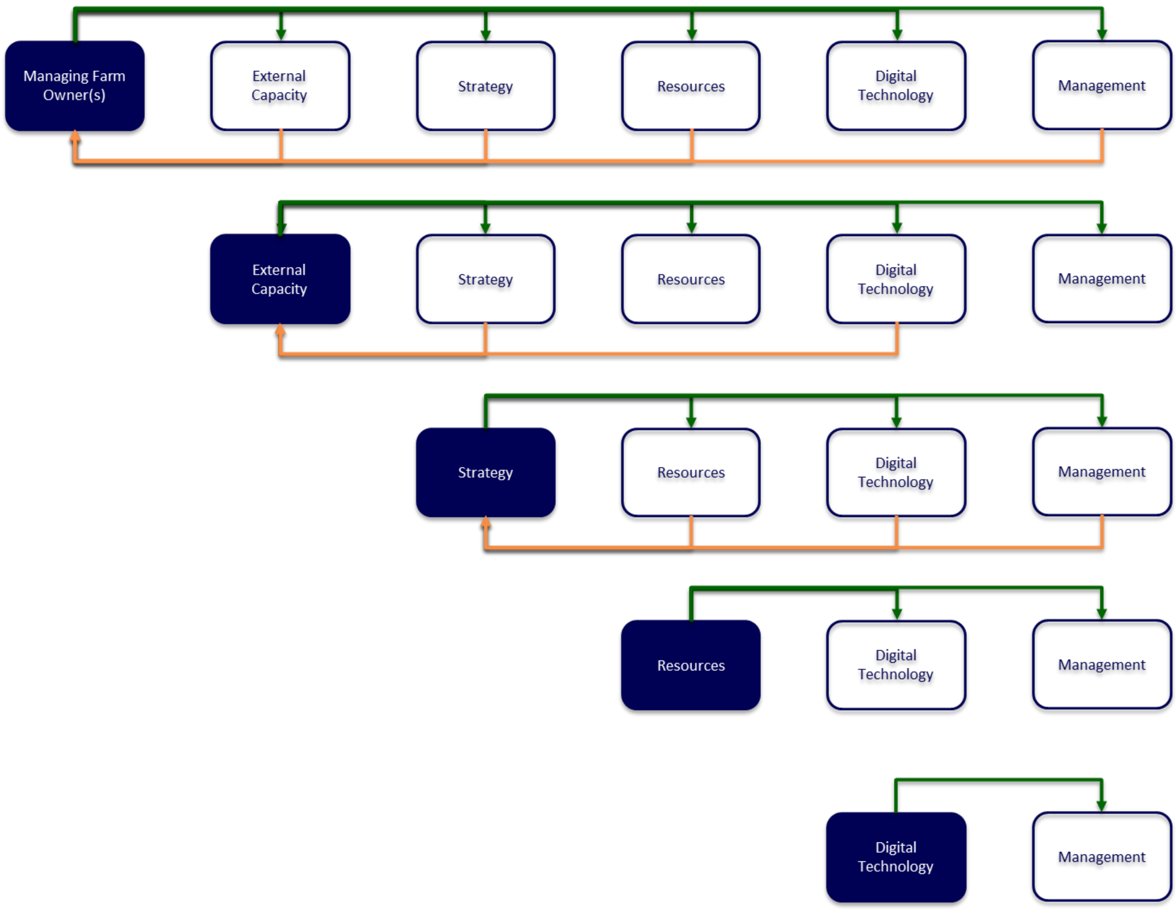

Figure 20: Enabling (green arrows) and reciprocal (orange arrows) relationships between key factors

While the identified sequential order of key factors indicates a linear process of farms gaining readiness for digital innovation, the reciprocal relationships highlight its complexity. Furthermore, when conceptualising the process of gaining readiness for digital innovation in the given context, the comparison between DIs and ADIs, detailed in section 5.4.7, was taken into consideration. While some differences dependent on the level of readiness were identified, all digital innovators met readiness requirements in regard to the identified key factors and associated attributes. Consequently, when progressing along the readiness spectrum, previously gained readiness was identified to be maintained.

Bringing these findings together, the process of family farms gaining readiness for digital innovation emerged. The process consists of six stages. At each stage, readiness in regard to a key factor is gained, readiness in regard to the previous key factor is maintained, and reciprocal influence is activated.

Stage one refers to Managing Farm Owner(s) readiness, which consists of the attributes change valence, positive attitude towards digital technologies and mindset.

Stage two consists of maintaining the previously acquired Managing Farm Owner(s) readiness, as well as gaining readiness in regard to External Capacity, which includes the attributes innovation network and inter-organisational exchange and support, reflecting the previous key factor.

Stage three refers to remaining ready in regard to the previous key factors, gaining Strategy readiness, defined by the attributes strategic orientation, knowledge acquisition and culture, which in turn reflects both of the previous key factors.

Stage four includes sustaining Managing Farm Owner(s), External Capacity and Strategy readiness as well as achieving Resource readiness, which refers to financial, time and IT infrastructure resources. In turn, gaining resource readiness has a reciprocal influence on the key factors Managing Farm Owner(s) and External Capacity.

Stage five consists of preserving the readiness of the previous key factors and achieving Digital Technology readiness, which involves ensuring specific technology characteristics and a strategic fit. Furthermore, gaining Digital Technology reflects back to Strategy and Resource readiness.

The final stage, stage six, is dedicated to gaining Management readiness, defined by the attributes leadership and operations management, sustaining the previously gained readiness of all the other key factors, and the reciprocal influence on the key factors Managing Farm Owner(s) and Strategy.

The process is visualised in Figure 21 (green arrows referring to the enabling relationships, orange arrows referring to reciprocal influences).

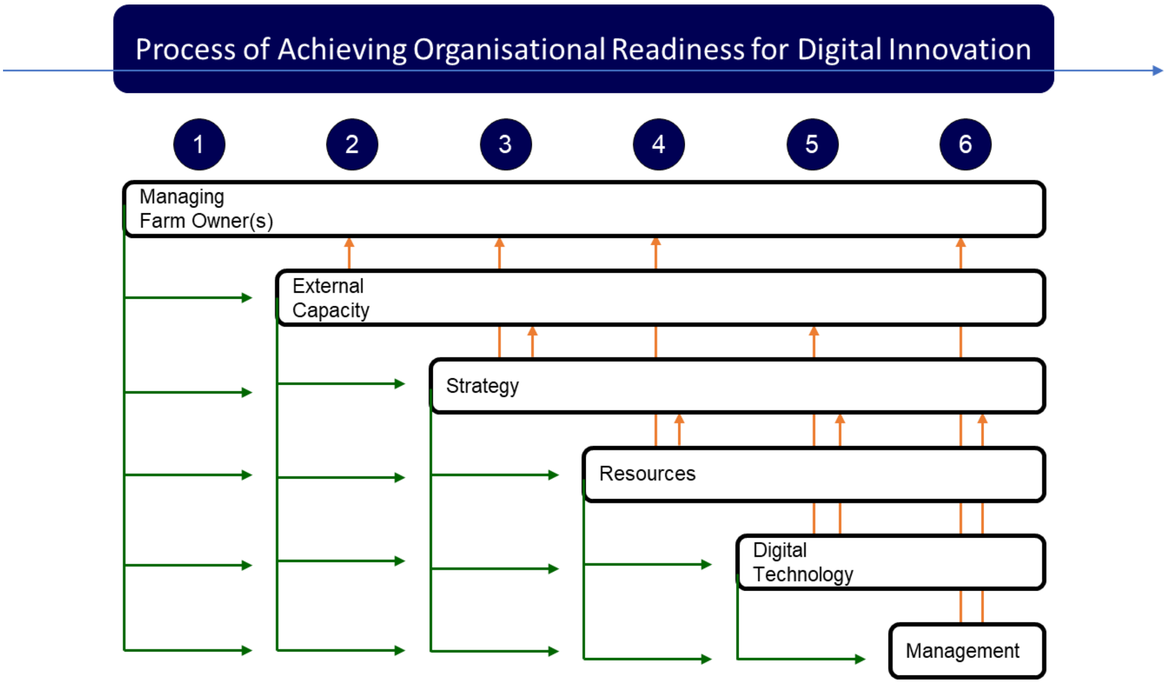

Figure 21: The process of family farms gaining readiness for digital innovation (green arrows represent enabling relationships while orange arrows represent reciprocal relationships)

In the following section, first the enabling, followed by the reciprocal relationships are elaborated in detail. Particular attention is paid to providing insights into 'how' and 'why' these relationships are central to the process of family farms gaining readiness for digital innovation.

6.2.1 Enabling Interdependencies between Key factors

6.2.1.1 Key Factor Managing Farm Owner(s)

The key factor identified as the first antecedent of organisational readiness for digital innovation is Managing Farm Owner(s), as explained in section 5.4.2. Readiness in regard to this key factor requires the managing farm owner(s) to perceive change valence, have a positive attitude towards digital technologies and a specific mindset, which is characterised by change orientation and commitment. Achieving Managing Farm Owner(s) readiness is the first stage of the transition process towards organisational readiness for digital innovation, as this factor has been identified as the foundation for the existence of all other identified key factors, which is elaborated in the following section.

<u>Influence of Managing Farm Owner(s) Readiness on External Capacity Readiness</u>

As detailed in section 5.4.6.1, being part of a knowledgeable innovation network around digital technologies, which is an attribute of the key factor External Capacity, is essential for successful digital innovation on farms. However, building up such a network and engaging in exchange and support activities requires additional energy and time investment, especially as the information and skills required for digital innovation are often not available rurally, as E2 stated:

> *So, a lot of farmers find it quite hard to get responsive customer service/support from the companies they work with because they might not have a regional presence.*

The measures taken by the digital innovators to establish innovation networks around digital innovation are detailed in Appendix N. While each of these measures is already linked to additional efforts, such as identifying scientific articles on digital agriculture technologies, travelling to events and building communication channels with experts and peers, every digital innovator interviewed stated that they apply several of these outlined measures in parallel.

Such investment into establishing and interacting with the external network requires the managing farm owner(s) to perceive the need for digital innovation, have a positive attitude towards it and be committed to realising digital innovation on the farm, supporting the need for readiness in the key factor Managing Farm Owner(s) before readiness in the key factor External Capacity can be established.

Furthermore, as E1 outlined, the interaction and exchange with the external innovation network is not only limited to acquiring initial product and process knowledge needed to decide whether and which digital technology could be potentially valuable for a farm, but includes topics such as data privacy, involvement in technology development and many other considerations:

> *It's really important to have that and technically to discuss through that and decide, on a personal or social level, what are we willing to accept in terms of giving up data about ourselves in our businesses? And what is a reasonable threshold and all those kinds of things? How can I stay fully engaged with Facebook to get what I want but make sure I'm protected? Or how can I safely engage with my local scientists to make sure I get what I want and them protected? And how can I be involved in developing technology that's more relevant to me? (E1)*

Discussions of such depth, however, presuppose commitment to digital innovation by the Managing Farm Owner(s), which characterises their mindset as being ready for digital innovation.

The necessity of Managing Farm Owner(s) readiness to establish External Capacity readiness is supported by the interviews with the NDIs. All NDI farmers interviewed stated that they do not access any innovation networks engaged with digital technologies because they failed to see the benefit of doing so, especially with relation to costs:

> *What I do now, and have been doing for 45 years works all right, so I stick to it. (NDI2)*

> *… it's really not much benefit to me. Yes, it would help our knowledge to have it. But, I don't see the value to spend $20/30,000 for it. (NDI3)*

> *But you've got to be in a reasonably big way, to be able to justify the costs of those things … . So, you do what you know. You make do, you know? (NDI1)*

Consequently, the analysis reveals Managing Farm Owner(s) readiness to be a requirement for establishing External Capacity readiness.

Influence of Managing Farm Owner(s) Readiness on Strategy Readiness

The readiness of the managing farm owners is necessary to establish a strategy to innovate with digital technologies as well. Only individuals who perceive a need for innovation with digital technologies or can see its benefits are willing to make it part of their strategy, as participant DI2 explained:

> *I've seen enough benefits through attending field days and conferences to see that it could have a place and a financial return for our business. … It's obviously a lot of work. The next generation is more tech savvy to go along with it, but I am trying.*

The statement by participant DI2 indicates that, at the same time, mindset traits such as change orientation and commitment are necessary to overcome the rural limitations and acquire the product and process knowledge necessary for digital innovation. In fact, all digital innovators interviewed are actively seeking knowledge on digital technologies outside of their rural farms, convinced that changing their current farming practices to more digital systems will benefit their farm, as outlined in Appendix O.

Furthermore, a positive attitude towards digital technologies is necessary to embrace digital innovation and create a shared culture among the family members engaged in the management of the farm. As participant ADI2 described, it was her positive perception of digital technologies and their benefit that led to her teaching her husband how to use it:

> *I am a bit more tech savvy then my husband. What has amazed me is that he was able to sit in front of these programs with some very basic instructions from me and he just picked it up. So, he would be able to use them with just a little bit of assistance of someone more experienced. Actually, that's quite critical. Having that one on one with someone and slowly build up your confidence...*

E6 referred to the difference in attitude towards digital technologies when describing the participant's experience with farms that do not have a culture supporting digital innovation, supporting the theory that a positive technology perception is needed before a culture supporting digital innovation can be established on a farm. E6 stated:

> *So that conservative culture is quite a big part of the slow uptake of digital technology in agriculture. I think for a while, I think it's changing now, a lot of farms were digital adverse. They wouldn't even go near it. I've seen older farmers walk pass our stand, laugh at our title, 'Livestock Farm Manager Software'. Software to manage your farm? I manage my farm! - Sort of thing.*

Influence of Managing Farm Owner(s) Readiness on Resource Readiness

Managing Farm Owner(s) readiness is an antecedent for Resource readiness. As detailed in 5.4.4 innovating with digital technologies requires the availability of financial, time and IT infrastructure resources. However, time and money are two resources that farmers lack. Participants such as ADI2 and DI2 explicitly state that they are time poor:

> *But I barely have the time. If I had more time, you know. (ADI2)*

> *It's also the time it takes to learn new things. Farmers as I suppose other business owners are rather time poor. (DI2)*

Participants such as DI1 and DI3 reported the necessity of saving up financial resources to fund new digital technologies:

> *Because I said before, this is a relatively good area and most farmers after a year or two or three can afford to build up to get a proper system. (DI1)*

> *So, probably as our farm has grown, so early on it had to make very, very sound financial sense because when you're a smaller business and growing, you need every dollar to be making at least $2, like another investment. (DI3)*

The experts stressed that the circumstances of Australian farms strongly influenced their monetary and time resources. For example, it was clear that climate change was the cause of some monetary losses and some farming processes urgently needing to be changed to manage these types of problems (E1, E2, E4). Hence, to allocate the necessary monetary and time resources for digital innovation, the managing farm owner(s) must have a positive attitude towards digital technologies and be convinced of the necessity of engaging in digital innovation.

Besides financial and time resources, appropriate IT infrastructure is needed to establish digital innovation on a farm (ADI3, DI3-DI8, DI10, E1, E4-E6). Ensuring the necessary IT infrastructure involves the managing farm owner(s) traits, such as change valence and a positive attitude towards digital technologies as well as change orientation and commitment, as per the example reported by participant DI6, who had to buy and position a shipping container to bounce an internet signal to the farm:

> *We have really poor mobile reception here at the house. So normally you wouldn't be able to talk on the phone or get Internet. So, we're bouncing Telstra signal to a shipping container on the edge of our neighbour's property, which is in the 14 kilometre radius. And from that shipping container, we put up a TV tower with a satellite receiver. And so we're bouncing WIFI signal from there to three houses.*

In summary, readiness in the key factor Resources can only be gained when readiness in the key factor Managing Farm Owner(s) is established.

<u>Influence of Managing Farm Owner(s) Readiness on Digital Technology Readiness</u>

In addition, Managing Farm Owner(s) readiness was identified as a prerequisite for Digital Technology readiness. Digital technology readiness involves acquiring a digital technology that is dedicated to meeting a specific need or pursuing a specific goal. However, in order to do so, first, the managing farm owner(s) must perceive the need for change as E3 and E1 explained:

> *You got to have a problem to solve and then you're in the market for that particular technology. (E3)*
>
> *I think like I said before, it has to start with the value proposition. So those spark of the, why should I even try and engage you to the question of what are they're trying to achieve. (E1)*

Second, the managing farm owner(s) must have a positive attitude towards digital technologies, so that digital innovation is seen as a desirable solution, as E4 summarised:

> *So, I think it's more an attitude thing than anything you could detect with your eyes looking at the property.*

This is supported by the practitioners as well as experts, as the following examples manifest. E6 gave an example from their own experience, growing up on a farm. E6 said that new digital technology was purchased only when the farmer realised that they needed an overview of the cattle. This new technology met a specific requirement.

ADI4 for example, perceived the need to transition towards a more sustainable agricultural practice and considered digital technologies as promising means to achieve this goal, which led the participant to evaluate and acquire the appropriate digital technology to do so:

> *We're not trying to be a digital farm, we're just trying to farm really well, really sustainably, and we're using digital tools to make that better or more efficient.*

Influence of Managing Farm Owner(s) Readiness on Management Readiness

Finally, Managing Farm Owner(s) readiness is necessary to enable readiness of Management. Once a farm has adopted digital technologies, it is the responsibility of management to take on the leadership position to drive digital innovation, to ensure the best use of the digital technology adopted and maximise the value created with the respective technology. As the managing farm owner(s) take on this role and execute these tasks, they must 1) perceive a need for change, 2) consider digital technologies as a reasonable solution in order to drive digital innovation and seize the opportunities it presents, and 3) be committed to digital innovation in order to be effective in its management.

E2 mentioned that all of the farmers he supervises for an on-farm IoT trial participate in the program because they are positive towards digital technologies based on previous experience:

> *I would say majority of the group that I work with, already had some sort of technology on their farm. … And that's why they're sort of exploring, trying to put more stuff on their farm.*

E2 continues, outlining the management of the new digital technology, which is focused on exploring its application and value creation to unlock the benefits of the digital technologies applied:

> *So each sort of tool and each sort of device will give them specific information and then it's about the farmer going on to do a journey exploring, okay, well if it gives me this information, how do I use that information in a valuable way and apply that … .*

E3 highlights the challenges for management that accompany the transfer to digital innovation:

> *I say, most technologies requiring farmers to change their workflows, change their practices, or generally have to do something differently and that it normally increases the level of complexity. So management is a huge challenge, because every time you heard something, increases complexity.*

When asked what is required from individuals in order to be successful in managing this change, the expert mentioned the need for intellectual curiosity, which in turn requires a change-oriented mindset, problem identification and commitment to make the transition successful:

> *The ones that deploy it successfully, I think they are generally intellectually curious. They also have an awareness of what problems they are trying to solve, and they are also intellectually sceptical.*

The managing farm owners made similar comments as the experts. ADI2 is representative of the experience of all other digital innovators interviewed. This following example illustrates clearly the relationship between readiness of managing farm owner(s) and management readiness.

Participant ADI2 explained that she was motivated to engage in digital innovation for more informed decision-making:

> *In farming making real time decision is key. So, for me it's making smarter decisions, knowing the implications of those decisions.*

While the participant reported that the process of applying and utilising digital technologies was not simple, the participant, nonetheless, remains positive towards digital technologies:

> *… I know the benefits will outweigh the pain.*

This statement outlines the commitment of participant ADI2 to realise digital innovation on their farm, despite the hurdles which must be overcome. Furthermore, when realising the potential for improvement through the application of digital technology in regard to the farm's accounting, the participant taught herself how to use the technology's application and then pass on the knowledge to her husband who is responsible for accounting matters:

> *So, my husband who is doing the accounting, he would fill all these forms out and then give it to the accountant. So, everything was very manual. Going from this to coding. I watched a lot of videos. I am a bit more tech savvy then my husband. What has amazed me is that he was able to sit in front of these programs with some very basic instructions from me and he just picked it up. So, he would be able to use them with just a little bit of assistance of someone more experienced.*

This statement manifests the need of participant ADI2 to take on a leadership position to drive digital innovation on the farm as well as commitment to realise and optimise the application and outcome of the digital technology used.

6.2.1.2 Key factor External Capacity

The key factor External Capacity has been identified as the second readiness factor in the process of achieving organisational readiness for digital innovation. The key factor External Readiness consists of the attributes Innovation Network and Inter-organisational exchange and support. An organisation which has achieved readiness in regard to its external capacity has established a knowledgeable innovation network around digital technologies and is engaged in continuous interaction with the network, exchanging knowledge on and acquiring support with digital technologies.

Achieving external readiness is the second stage, as it follows the Managing Farm Owner(s) readiness, which it is enabled by, and contributes to the existence of all the following key factors: Strategy, Resources, Digital Technology and Management.

Influence of External Capacity Readiness on Strategy Readiness

External Capacity is an antecedent for the key factor Strategy. First, the existence of an innovation network, which can offer support when needed, has been called by participants ADI3, ADI4, DI1, DI3, DI5, DI7 and DI12 a prerequisite for establishing a long-term vision involving digital innovation. The participants stated that due to the novelty of the technologies as well as potentially occurring issues, they rely on external support and hence only integrate digital technologies in their strategy when external support is guaranteed, as the following statement by participant DI1 shows:

> *I think the local John Deere agent is quite keen on high tech and it and so on. And he's appointed some younger guys to provide the service. Yeah. It's not cheap, but anyway, if you've got all this stuff, you have to have it and you have to have to have service no matter what it costs.*

Participant ADI2 called the exchange with their innovation network as a source of motivation and resilience, encouraging them to pursue digital innovation as a long-term strategy:

> *There is this group of early adopters in this community. We found each other on twitter. There are many other producers, using these platforms. And from there on, we had a chat group, it continued. … It certainly helped to get sucked into this and certainly knowing that I can chat to other people.*

Experts E2 and E4 support the need for an innovation network when making digital innovation part of the farm’s strategy. E2 stated:

> *I think a huge part of it, it's about getting the right support and the right input from the people who do know what that information could mean for them.*

E4 advised farmers who sought his counsel, to plan for transition to digital innovation:

> *I'd always say make sure that you're able to get customer support.*

Second, the external innovation network has been identified as the primary source of knowledge on digital innovation in agriculture, as no farm, regardless of the experience with digital technologies, possesses internally all the knowledge necessary to integrate and operate digital technologies in the most value creating manner. The interviewees reported using a variety of channels, as detailed in Appendix N, to acquire external knowledge.

The experts shared this opinion. E5, who is leading an on-farm IoT trial, when asked about what participants expect from their participation, answered:

> *… information and feedback and bouncing ideas off other farmers … (E5)*

E6 recommended acquiring products and processes from the external innovation network, due to the multitude of technology available and the uniqueness of each farm and its operations:

> *… looking for testimonials, reviews from other farmers, and how they've used it. … But probably the most effective way to go about it would be, find testimonials of that product. How people have used it. Because every farm operation is different. And not every product is going to fix that problem for every farmer that's trying to solve that problem.*

Hence, readiness in regard to the key factor External Capacity is necessary to establish Strategy readiness.

<u>Influence of External Capacity Readiness on Resource Readiness</u>

In regard to Resource readiness, External Capacity is critical to ensure the necessary IT infrastructure. In order to gain an understanding of the required infrastructure and how it can be established, again, the knowledge is acquired through the external innovation network. Hence, it is important to have an innovation network around digital technologies and establish a line of communication to access this knowledge. Participant DI9, for example, lacking mobile service on the farm necessary to operate digital technologies, reached out to a peer who had faced a similar issue in the past and could therefore share their own experience regarding a potential solution to the problem. The participant stated:

> *We have a friend farm, and he has a neighbour in Bendigo, he doesn't get signal. So he bounces the signal from someone's house to his house doing the same thing, but just house to house in Strathfield. So he said we should be able to as well. So it needed just a smart person who knows how telecommunications work.*

E3, in line with E4’s observations, outlined the importance of an innovation network in regard to financial resources as well. The expert explained that marketing campaigns have overstated the potential of digital technologies in the past:

> *Generally, because the communication is happening from the marketing side of what the technology could potentially do, … the reliability was oversold, the amount of savings was... Probably highlighted the very best possible case example, rather than a realistic example.*

Hence, adopting a digital technology that is not yet in common use involves considerable risks. The farm must therefore, as E3 stated, have the financial resources to ensure survival when the investment in a digital technology does not lead to the expected results:

> *… the farmers who are in the market to adopt this new technology, they know that it can fail but they've got to make sure that it's not fatal to their business.*

However, the expert stressed that only a small number of farms is in the position to take such financial risks:

> *There's that rare group that are very inventive and want to try something because they can.*

The remaining farming community with fewer financial resources relies on these early adopters sharing their experience, E3 explained, so they only invest into digital technologies which fit their financial situation without risking the business:

> *Then the next group is interacting with those farmers and those conversations encourage the farmers to try something, truthfully either because they're friends or had respectful relationships over a period of time, so that they'll give it a go.*

Influence of External Capacity Readiness on Digital Technology Readiness

External capacity plays an important role in regard to Digital Technology readiness as well. Characteristics commonly considered as critical when choosing a potential digital technology to adopt on a farm are fit for purpose, usability and compatibility. In order to acquire the knowledge on whether specific digital technologies meet expectations in terms of the stated characteristics, the participants stated that they rely on their external innovation network. Most participants trust in the experience and opinion of peers, as participant DI5 explained:

> *I guess the guys selling it, the dealers they show the technology off and there are always the early adopter and you see it and you're thinking, oh yeah, you know, that looks all right. And then you'll get that farmer off side, the dealer will always tell you it's good but it's the farmers who speak the truth.*

E1 stated the major role of an innovation network in the context of sharing information about digital innovation:

> *… how it's actually useful and used by farmers in a day to day basis and the benefit that they can see.*

When requiring visual proof, participants explained that they either observed peers operating a specific digital technology, or went to field days, where technology providers display and explain their technologies:

> *Well, just looking at the farm over the fence. In the AG industry, we talk a lot and we're a very small industry, particularly in Australia, so you see what other people are doing. (ADI3)*

> *So some farms open up for farmers to come and see different applications and different businesses trialling their tech in a particular property, so it's a bit of a show and tell before they buy. (E4)*

While the innovation network's knowledge and experience on digital technologies is used to evaluate the essential characteristics of a digital technology, at the same time it helps to ensure a strategic fit. A strategic fit, as part of Digital Technology readiness, refers to adopting a digital technology that suits the need(s) and goal(s) of the farm. The described interaction of farms with their innovation network helps farmers to understand the functionality and actual (not marketed) benefits of innovating with a digital technology, enabling an informed choice. As E2 observed:

> *People talk to each other, they find out what works or what doesn't and the reputation tends to grow based on that word of mouth affirmation that goes around.*

Summarising the presented need for readiness in regard to the External Capacity to achieve Digital Technology readiness, E5 encourages the involvement of the innovation network to evaluate technologies. When sharing his advice to farmers on digital innovation in agriculture, E5 stated:

> *… just leverage your networks because there's lots of people out there that are using this technology … they'll be able to give you first hand knowledge.*

<u>Influence of External Capacity Readiness on Management Readiness</u>

Management, while an internal process, is strongly dependent on external capacity. Part of management readiness has been identified as managing operations, which entails the improvement of operating digital technologies and the value creation they allow.

The experts agree that the external innovation network is essential to managing operations. When asked about the role of networks to establish digital innovation on a farm, the experts answered:

> *I think it's significant, the support networks. (E2)*

> *Absolutely. I think they play a massive role … (E5)*

The interviews with digital innovators provide more insights into how external innovation networks contribute to managing digital innovation on a farm. Twelve participants have stated that they reach out to their external innovation network for support regarding operation and enhancement of digital technologies. Participants DI1 and DI5, for example, explained that they need an innovation network and to know what specific knowledge each individual possesses, so that they can request help when running into issues with operating digital technologies:

> *There will be problems. And even now, you know, farmer X thinks he knows all about it. And he's very good at it, but he still has to ask the guy how to work the wheel, the specialist IT John Deere person, listen, how do we do this or this has happened, you know, something hasn't gone wrong. And farmer X will either ring up or come out or say look, you know, try this, try that. (DI1)*

> *Error codes can be sent to the machinery dealer if something goes wrong and potentially, they can be on your doorstep with a part next day. If something breaks down or, you can ring up and say, look, I've got this problem, and they say this is what fixes it and that sort of stuff. (DI5)*

Participants DI3 for example, inexperienced with data analysis, emphasised the necessity of employing external help in this regard in order to utilise the knowledge captured in the data collected and thereby enable more informed decision-making:

> *We also pay for a consultant on our farm. So, they will be gathering knowledge and advising us on what to do as well. So you can focus on doing the job on the farm, but you have an expert advisor coming in and helping you with your decision making and strategic planning.*

Consequently, External Capacity readiness is essential to establishing Management readiness.

6.2.1.3 Key Factor Strategy

The key factor Strategy has been identified as the third readiness factor in the process of achieving organisational readiness for digital innovation. Strategic readiness is achieved when the strategic orientation has a long-term and continuous improvement focus, product and process knowledge is acquired, and a culture that embraces digital innovation is established.

Achieving Strategy readiness is the third stage, as it follows the Managing Farm Owner(s)- and External Capacity readiness, which it is enabled by, and contributes to the existence of all the following key factors: Resources, Digital Technology and Management.

<u>Influence of Strategic Readiness on Resource Readiness</u>

Strategic readiness is an antecedent for resource readiness in multiple ways, as elaborated in the following section. First, as detailed in section 5.4.4 and summarised by E3, digital innovation requires financial as well as time resources:

> *And I think the thing to realise with all the technologies is, you've got to have enough financial means and time to allow the adoption process to occur.*

However, on farms, time and money are scarce resources. Participants such as ADI2, DI2, and DI9 explicitly stated that they are time poor. Participants such as DI1 and DI3 reported the necessity of saving up or finding additional sources of funding for digital technologies. Experts such as E3 and E5 highlighted the lack of time and financial means on farms:

> *… farmers are time poor … (E3)*

> *… they are poor on time and capital and all those resources you need to run the business. (E5)*

Hence, financial and time resources are only freed up and dedicated to digital innovation if part of the strategy, meaning digital innovation, is seen as an investment, aiming for improvement and a long-term advantage, as the following statements of digital innovators show:

> *So there's investment in doing those sorts of things, upgrading the computer, you know, having all that set up … (DI3)*

> *So I think we'll still have fences on the highway, but later on we might just have internal digital fences. I think that would one thing that we could do and in the long term. It may save many, many thousands of dollars in fencing costs, but also in insurance costs. (DI8)*

To assign resources specifically to innovating with digital technologies, a farm, as part of its culture, must already be embracing digital technologies. The managing farm owners expressed this propensity in various ways, such as calling themselves technology adopters or highlighting and communicating the advantages of digital technologies:

> *I'm a technology adopter, if it's available, and I can see that it's successful and effective. And that's improved the overall quality of fruit production. (ADI1)*

> *I've seen enough benefits through attending field days and conferences to see that it could have a place and a financial return for our business. (DI2)*

In summary, Strategy readiness is necessary to make the necessary resources available and dedicate them to digital innovation.

<u>Influence of Strategic Readiness on Digital Technology Readiness</u>

Strategic readiness is necessary to establish Digital Technology readiness. Digital Technology readiness refers to farms adopting a digital technology that fits with a farms' needs and furthermore meets characteristics such as fit for purpose, usability and compatibility.

Matching a digital technology with a farm's needs necessitates the farm's strategy focusing on improvement. Interviewee ADI4 illustrated the relationship when explaining that their choice of digital technology needed to improve the farm's performance:

> *… you're trying to see where it fits with your vision of where you need to be and what benefit you're going to get and whether what they're proposing actually extends your vision further.*

In order to ensure that the adopted digital technology meets the characteristics of fit for purpose, usability, and compatibility, the participants must acquire product knowledge, which is part of Strategic readiness.

E4 asked farmers who were engaged in digital innovation about their sources of product and process knowledge:

> *…where do you get this information from? Is it coming from your industry body? Are they doing a, 'here's the latest for dairy, here's the startup to watch, here's the new technology consumer review of technology.*

The expert then learned that farmers themselves are responsible for acquiring information and knowledge necessary, as a farmer she works with reported:

> *… no, absolutely nothing. We don't get any of that from any sort of event industry bodies. All of that research, I've just had to go out and do myself.*

In line with the experts' experience, the digital innovators all reported that knowledge acquisition on digital technologies originated from their individual proactiveness, engaging different sources.

Several participants suggested that peer feedback, for example, was a trustworthy source for affirmation in this regard, as participant DI5 explained:

> *I guess the guys selling it, the dealers they show the technology off and there are always the early adopter and you see it and you're thinking, oh yeah, you know, that looks all right. And then you'll get that farmer off side, the dealer will always tell you it's good but it's the farmers who speak the truth.*

Participant ADI1, for example, reported on evaluating digital viticultural technologies on an overseas trip. ADI1 visited world-leading vineyards that showcased their agricultural practices:

And I saw this new technology that actually mechanically harvests. And once it's harvested, processes it on board. … And I saw this in France, and I said, 'I think this is going to change how processing is done …

In conclusion, having a long-term orientation and applying the described methods to acquire product knowledge about digital technologies is part of Strategy readiness, and necessary to establish Digital Technology readiness.

Influence of Strategic Readiness on Management Readiness

Management readiness consists of operationalising the organisation's strategy and leading accordingly. Consequently, strategic readiness in regard to digital innovation is a prerequisite for management readiness. Examples, such as given by participant ADI3, underline the necessity of Strategy readiness for Management readiness. This digital innovator has established an improvement-oriented strategy:

I guess you're always looking for ways to do things better.

While ADI3 is still undecided about what digital technologies they will deploy on the farm, considerations of autonomous machines and robotics highlight the long-term orientation to deploy digital technologies as part of their strategy:

First step is to get variable rate working on our farm. And after that, I don't quite know where I'm going to go with digital technologies. Maybe like sort of self-driving, those kinds of things, robotics, that sort of stuff.

As digital innovation is a central part of a farm's strategy it must be implemented and utilised within the organisation, which is part of management readiness. ADI3 explained that they were responsible for leadership in this regard, which involves setting up the digital technologies as well as generating innovative output:

Our workers are 55, plus. So in terms of managing the technology, we can get them to drive with GPS, but to actually get them to fill out paddock software or variable rate maps, that's outside of their capabilities. So as a result I have to do majority of that stuff and set it up for them.

So I spend less time sitting on a tractor and more time sitting in front of a computer, creating the maps, et cetera.

Furthermore, to understand how operations and value creation can be improved, process and in some cases data knowledge, as described in section 5.4.1.2 are necessary, which is acquired as part of Strategy readiness. Participant ADI4 summarised it when explaining the digital technology applied on a harvester to enable autonomous driving:

Part of it is understanding how the programs work …

Participant DI11 explained what happens if specific knowledge, in this case on the operation of a digital technology, is not acquired prior to its management. The participant stated that they had not put the correct information into the system when setting it up for operation years ago. The consequences were still making themselves felt, as DI11 has missed out on years of valuable insights due to the digital technology not recording the required data:

> *We didn't enter the right information properly, so it's got lost or it hasn't been entered correctly … . We would get back and the whole harvest operations are missing because one header on harvest hasn't been recording. So all that data is not recorded because we didn't understand how. We didn't realise we weren't doing it properly.*

Hence, Strategy readiness is needed to achieve Management readiness as it dictates 'what' management should be executing and provides insights into how the actions should be carried out.

6.2.1.4 Key Factor Resources

The key factor Resources is the fourth readiness factor in the process of achieving organisational readiness for digital innovation. The key factor Resources consists of three attributes: financial, time and IT infrastructure. An organisation which has achieved readiness in regard to its resources has established all the outlined resources available for innovating with digital technologies on the farm.

Achieving Resource readiness is the fourth stage, as it follows the Managing Farm Owner(s), External Capacity and Strategy readiness, which it is enabled by, and contributes to, the existence of the two following key factors: Digital Technology and Management.

<u>Influence of Resource Readiness on Digital Technology Readiness</u>

Resources such as time, money and IT infrastructure are necessary to achieve Digital Technology readiness. Digital technology readiness consists of choosing and adopting digital technologies that fit with the farm's goals and meet certain characteristics, such as fit for purpose, usability and compatibility with other digital technologies.

In order to gather knowledge on different digital technologies and their operation, which allows a farmer to evaluate the fit with the farm's goals and expectations, considerable time investment is required.

To gather information on potential options of suitable digital technology, DIs reported pursuing various activities and accessing multiple channels in parallel as outlined in Appendix O.

Furthermore, time is required to process this information. E4 shared the experience of a farmer who, despite high interest in a specific digital technology, did not respond to any attempts by the respective technology company to establish communication. This farmer reported being overwhelmed with the number of organisations trying to get in touch and the information received:

> *… look, I get about 50 emails a day from agronomists from product salesman, from chemical salespeople who know my growth cycles, right.*

Hence, to process this information and identify the digital technologies fitting the farm's expectations and goals requires time.

Once the strategic fit and characteristics of a digital technology are evaluated, it is necessary to determine what IT infrastructure is necessary for its operation, as not every farm has access to the needed IT infrastructure. E6 shared one example which outlines this scenario:

> *And one farmer explained to me that he was really into it. He just couldn't because he didn't have mobile service.*

E4 acknowledged the relationship between IT infrastructure and digital technology adoption too, stating:

> *So there's sort of a base connectivity landscape that will determine what things a farmer can or can't choose.*

If the specific IT infrastructure can be ensured, time is required to establish it on a farm. Digital innovator DI6, for example, outlined considerable effort and time investment to establish mobile service on their farm:

> *We have really poor mobile reception here at the house. So normally you wouldn't be able to talk on the phone or get Internet. So we're bouncing Telstra signal to a shipping container on the edge of our neighbour's property.*

Finally, to acquire a digital technology, monetary resources are required, as digital technologies are costly. DI5, for example, speaking about the costs of adopting the digital technology necessary for GPS guidance systems, stated:

> *We were amongst the first to use that technology 15 years ago and it was a considerable cost. It was about $60,000 or there abouts, for two steering boxes and the corrections, back then that was a sizable amount of money, still is. (DI5)*

Hence, a farm needs to have the necessary financial resources available to be able to make such an investment.

In summary, resource readiness is a prerequisite of digital technology readiness.

Influence of Resource Readiness on Management Readiness

Part of Management readiness is improving the operation of digital technologies and the maximisation of value generated by their application, which, as the following examples illustrate, requires Resource readiness, in particular the availability of time and in some cases money.

Participant DI3 is representative of most of the DIs' views. Digital innovation requires experimentation to operate and uncover the most valuable application of digital technologies to be successful, which in turn requires time:

> *So you have to get everyone up to speed about how it can work and everyone learns which buttons to press and what to do. Once everyone starts to understand that and utilise the technologies, then you start to actually go, okay, that's all right, we've got that down pat. What's the best way of sewing this? What's the best way of spraying this paddock? Maybe if we turn in this way, that will save us another 5%.*

Additionally, it is the technology adopter's responsibility to operate the digital technology in a way that captures the full performance of the digital technology, which requires time, as stated by ADI3, for example:

> *It takes a little time. It's patience, I guess. It's harder than you think, sort of. (ADI3)*

The experts agreed – time is needed to improve the operation of and value creation with digital technologies. E1 explained that managing a new digital technology was challenging as it generally involves the realisation that more effort and time investment is required than originally anticipated:

> *That's when they sort of have that the step of oh, okay, I have to do a whole lot in order to be able to get to my original goal, which they might not have realised right at the beginning.*

E3, emphasised the role of experimenting and making mistakes in order to improve:

> *You learn by doing and staff-ups are often how you learn because you're trying to understand how the equipment works, the technology works, and generally it involves making mistakes and it's having the ability to make sure those mistakes are non-fatal businesswise.*

indirectly confirming the need for Resource readiness, as both activities require time investment.

Besides time, financial means can become necessary when managing digital innovation. While, as stated earlier, innovating with digital technologies requires management to experiment, explore and learn, in some cases expert support is needed. Participant ADI2, for example, stated the need for initial support:

> *Having that one-on-one with someone and slowly build you confidence …*

Therefore, to achieve Management readiness, Resources readiness must be established.

6.2.1.5 Key Factor Digital Technology

The key factor Technology has been identified as the fifth readiness factor in the process of achieving organisational readiness for digital innovation. The key factor Technology consists of two attributes: technology characteristics and strategic fit. An organisation ready in regard to the key factor Digital Technology has digital technologies which are characterised as fit for purpose, usable and compatible. Achieving Technology readiness is the fifth stage, as it follows the Managing Farm Owner(s), External Capacity, Strategy and Resource readiness, which it is enabled by, and contributes to the existence of the key factor Management.

Influence of Resource Technology on Management Readiness

Management readiness involves the improvement of operations and value creation with digital technologies. However, for satisfactory application of and value creation with digital technologies, the digital technologies must possess the characteristics specified by Digital Technologies readiness. For instance, DI6 stated that they acquired a yield mapping program which is difficult to operate. Unable to fully use the functionalities of this software, the participant acquired multiple additional mapping programs hoping to identify one with the expected usability and desired performance. Once this solution is found, the participant will be forced to manually transfer across all data recorded in the previous yield mapping programme. Summarising the experience of not achieving Digital Technology readiness prior to Management readiness, the participant stated:

> *Well, I actually don't think it saved anytime. If anything, it's wasted more time. At least with the programming takes a lot of time to re-enter data in and work out how the program works, and it doesn't do everything that you want it to. So then suddenly you need a second program. So, you're doubling off in time for what you're recording. So, we've got, like I said, three programs with our data. So, we're going to have to put it in one, so that's going to be another full-time person to put that in.*

Consequently, achieving readiness in regard to the key factor Digital Technology is a prerequisite to Management.

6.2.1.6 Key Factor Management

The key factor Management has been identified as the sixth readiness factor in the process of achieving organisational readiness for digital innovation. The key factor Management consists of the two attributes, Leadership and Operations Management. An organisation which has achieved readiness in regard to its Management has 1) at least one individual taking on the leadership role in driving digital innovation, and 2) a management style focused on improving the operation of and value creation with digital technologies. Achieving Management readiness is the last stage, as it follows the Managing Farm Owner(s), External Capacity, Strategy, Resource and Digital Technology readiness. Consequently, it does not enable the existence of any of the key factors.

6.2.2 Reciprocal Interdependencies between Key factors

The interdependencies presented in the previous section substantiate the sequential order of key factors being relevant to achieving readiness for digital innovation on a farm, due to their enabling nature. However, the thematic analysis carried out to shed light on the relationships first identified during the content analysis has, besides the enabling relationships between the key factors, unveiled reciprocal relationships.

For example, readiness of Managing Farm Owner(s) enables External Capacity readiness. However, External Capacity readiness has an influence on the Managing Farm Owner(s) too. While these reciprocal relationships do not have an influence on the order of key factors in the process of achieving readiness for digital innovation, they nevertheless are important to note as they provide insights into the dynamics between the influencing key factors of readiness for digital innovation and the complexity of the process of its achievement.

The reciprocal relationships identified are visualised in Figure 22 and detailed in the following section.

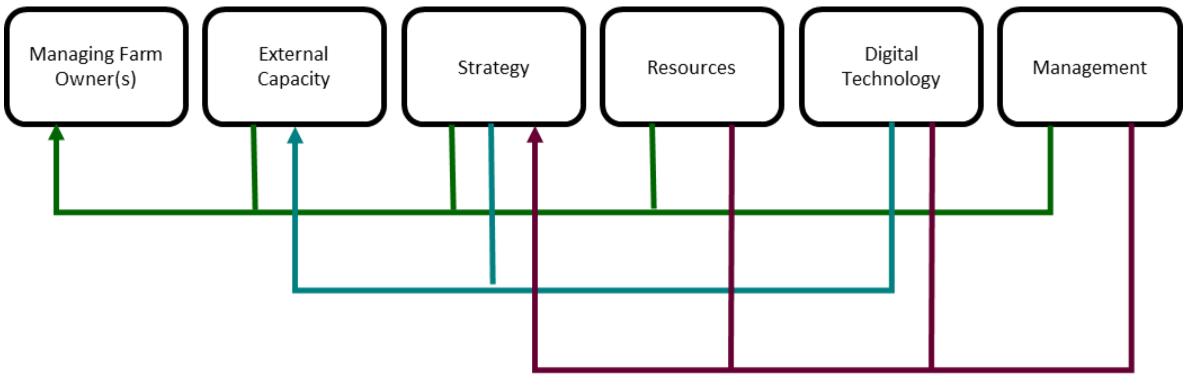

Figure 22: Reciprocal influences between the identified key factors of organisational readiness for digital innovation (visualised by the depicted arrows)

6.2.2.1 Influence of Key Factors on Managing Farm Owner(s) Readiness

As detailed in section 6.2.1.1 the readiness in regard to the key factor Managing Farm Owner(s) is necessary to establish readiness of all remaining key factors. However, the analysis revealed that other key factors influence the readiness of the key factor Managing Farm Owner(s), as described next.

The existence of a knowledgeable innovation network around digital technologies and the interaction with it, both attributes of External Capacity readiness, have been reported to the following.

1) These attributes encourage and support staying committed to digital innovation, particularly as participants described this commitment as often being frustrating and not straightforward, as ADI2, for example, reported:

> *There is this group of early adopters in this community. We found each other on twitter. There are many other producers, using these platforms. And from there on, we had a chat group, it continued. … It certainly helped to get sucked into this and certainly knowing that I can chat to other people.*

2) These attributes help establish a positive attitude towards digital technologies, as knowledge on and experience with their functionality and suitability is shared and confirmed by peers. ADI2 explained the role that innovation network communication played in changing their perception towards digital technologies:

> *It's that realisation that technology has evolved compared to what we had the last 10-15 years. It's awareness, talking to other farmers, hearing what they are doing. And then they ring me a month later and tell me they are about to implement it in their farm business.*

While the external innovation network is the primary source of knowledge on digital innovation, the acquisition of this knowledge in order to decide whether and which digital technologies will be added to the farm is part of Strategy readiness. The knowledge gained fundamentally shapes the behaviour towards digital innovation, meaning whether they are perceived as a potential solution, leading to a farm being willing to try them. E5 elaborated on the acquisition of knowledge and its influence on the farmers' openness to change and to try to innovate with digital technologies on their farm:

> *So they're information hungry, they know how to find that information, source it, filter it, do some of that research on their own and, I guess, that becoming confident, at a base level, with that sort of stuff may makes them a little bit more open to try new technologies at the farm.*

Furthermore, the availability of Resources, such as financial means, time and IT infrastructure, fundamentally influences the openness to digital innovation and the willingness to commit to its realisation, as the following experts highlighted:

> *At a really base level, I think the willingness to explore digital options is very much impacted by what sort of connectivity is available in that particular area. (E4)*

> *I think the thing to realise with all the technologies is you've got to have enough financial means and time to allow the adoption process to occur. (E3)*

Finally, the digital innovators spoke about the relationship of Management readiness, in particular improving the application of and value creation with digital technologies and their openness and commitment to adopting more digital technologies. According to participant DI3:

> *… as your knowledge builds over time, you start to seek more knowledge.*

Hence, the more experience farmers have in innovating with digital technologies, the more open they are to exploring new potential digital technologies.

In summary, while the readiness of Managing Farm Owner(s) is a prerequisite for readiness of all other key factors, in turn, it is influenced by the majority of them as described in this section.

6.2.2.2 Influence of Key Factors on External Capacity Readiness

As detailed in section 6.2.1.2 the readiness in regard to the key factor External Capacity is necessary to establish readiness of the key factors Strategy, Resources, Digital technology and Management. Additionally, however, the analysis uncovered a reciprocal influence of the key factors Strategy and Digital Technology on the key factor External Capacity.

Strategy readiness, in particular the acquisition of product and process knowledge on digital technologies and the long-term and continuous improvement orientation, reflect back on the External Capacity readiness.

As explained earlier, the external innovation network provides the farmers with knowledge on what digital technologies exist as well as their functionality. However, the participants stated that as their understanding of the potential of digital technologies for their farms grows, they must extend their innovation networks and seek out new sources of knowledge to evaluate if and how these technologies could be applied on their farms, as the examples of participant ADI3 illustrates.

ADI3 has a wide and highly knowledgeable innovation network on digital technologies due to their previous occupation in the sector. However, when interested in additional aftermarket digital technologies, the participant started to extend their external innovation network:

> *It's when you're starting to ask for aftermarket stuff, which isn't a tick box, when you're putting in an order form that you have to start being creative and finding other solutions or talk to different people outside of your normal machinery channels.*

Furthermore, with long-term and improvement orientation the farms establish deeper and stronger connections with their innovation network, as participant DI3 explained:

> *… realistically the person that's going to fix it is the person that sold it to you in the end. So yeah, they're the key people that you really need to build a relationship with to be able to say, yeah, what's your service capability and come out and fix it when I'm having trouble. (DI3)*

Digital Technology readiness, which involves choosing digital technologies that fit the farm's goals, in turn has an influence on the External Capacity readiness, as it leads to additional involvement with the external innovation network in order to implement the digital technology on the farm, which is seen as challenging:

> *In terms of setting up, in terms of someone new coming in and trying and doing it, yeah. There's plenty of hill. (DI1)*

Hence, participant DI5 explained that once a digital technology was purchased the participant was invited to a workshop where the process of setting up the digital technology was explained:

> *They have workshops when you buy the new equipment, the dealer, they'll have a day on how you can set it up. (DI5)*

Moreover, the choice of digital technology dictates which new innovation network relationships must be established, as these individuals must possess knowledge and experience with the particular technology, as ADI1 stated:

> *… people who are trained in the technology … because they're all computerised. It's like flying an airplane, seriously.*

6.2.2.3 Influence of Key Factors on Strategy Readiness

Section 6.2.1.3 presents the enabling influence of Strategy readiness on the key factors Resources, Digital Technology and Management. The analysis, however, unveiled the influence of these factors on Strategy readiness.

First, committing to a long-term orientation requires the availability of Resources, in particular money and time. E2 explained that a lack of financial resources discourages long-term orientation, as any investment that is not guaranteed to lead to the expected results poses a risk that farms are not willing to take:

> *So, less money, less willingness to accept risk. So people don't want to invest in channels you really not sure would necessarily work.*

Besides money, a farm must have the ability to invest time to realise and improve digital innovation, as E3 stated:

> *And I think the thing to realise with all the technologies is you've got to have enough financial means and time to allow the adoption process to occur.*

Further examples of the time investment needed to engage in digital innovation are provided in section 5.4.4.2.

Hence, when looking at establishing a long-term and improvement orientation, the farm must already possess the described resources or be sure about their ability to acquire these, so it can pursue the strategy enabling digital innovation on the farm and make the needed resources available when necessary.

Another key factor which is enabled by, but so too has an influence on, Strategy readiness, is Digital Technology. In order to evaluate the strategic fit and characteristics of a digital technology and thereby choose the most suitable option, product knowledge must be acquired. However, once the digital technology is purchased, the new knowledge, in particular process and data knowledge, must be acquired to implement and use the digital technology on the farm, as participant DI3 highlighted:

> *And the key bit is how to actually apply that in the field. Yeah. So, having an understanding of the background of how it works, but then having the experience of applying it on a farm, in the field is really critical.*

The same applies to the key factor Management. Working on improving the application of and value creation with digital technologies involves learning, generating new knowledge and thereby extending the current knowledge spectrum, as the following exemplar statement of participant DI7 illustrates:

> *But if you go to the next level where you're setting up stuff in terms of what you want to do with it, so you're not actually just operating it quickly but when you're actually putting in the maps and telling the machine what you want it to do with it, where you want it to do. Then I think you've got to be reasonably switched on and … I'm just guessing, but I'm just really keen on learning.*

> *Because you just don't know from the very first place on how to use it, but you actually need to sit down and give it in. So you understand it.*

Hence, once a digital technology is chosen and the adoption, implementation and value creation start, the acquisition of new knowledge on digital technologies is inevitable.

6.2.2.4 Influence of Key Factors on Resources, Digital Technology and Management Readiness

While the analysis did not uncover any reciprocal relationships between the key factors Resources, Digital Technology and Management, their reciprocal influence on the preceding key factors – Managing Farm Owner(s), External Capacity and Strategy – has been detailed in sections 6.2.2.1 to 6.2.2.3. A summary of all reciprocal relationships identified is provided in Table 14.

Table 14: Summary of reciprocal interdependencies between the key factors influencing organisational readiness for digital innovation

	Managing Farm Owner(s)	**External Capacity**	**Strategy**	**Resources**	**Digital Technology**	**Management**
Managing Farm Owner(s)						
External Capacity	Supports commitment to DI. Helps establish positive attitude towards DTs.					
Strategy	Knowledge on DTs influences change valence.	Growing understanding of DT potential requires extension of innovation network. Long-term orientation requires building strong external relationships.		**Enabling Interdependencies**		
Resources	Their availability influences openness to change.		Resources (time and financial) are needed to commit to long-term and improvement orientation.			
Digital Technology	-	Choosing a fitting DT requires additional interaction with and extension of innovation network.	Knowledge (process and data) on the specific DT adopted must be acquired.	-		
Management	With experience managing DT increases openness to change and change valence.	-	Gaining experience in operation and value creation with DT leads to new knowledge generation.	-	-	

6.2.3 Comparison with Organisations not Ready for Digital Innovation

To gain more insight into the process of achieving organisational readiness for digital innovation and the barriers involved, an additional thematic analysis was carried out investigating what is holding back the three farmers NDI1, ND2 and NDI3 from innovating with digital technologies. Particular attention was paid to uncovering where and why these farms are in the process of transitioning towards readiness to innovate the digital technologies.

The analysis was first carried out manually, to understand which key factors are the main obstacles to gaining organisational readiness for digital innovation. It was supported by a subsequent NVivo-based analysis, which provided more analytical depth by allowing the researcher to review and compare all codes generated in this particular inquiry.

As detailed in the following, the analysis revealed that none of three participants were ready in regard to the key factor people. This finding supports the notion that the role of the Managing Farm Owner is pivotal to readiness, as reported in section 5.4.2, and is the first stage of achieving organisational readiness for digital innovation. Furthermore, it supports the findings reported in section 6.2.1 regarding the interdependency between the identified key factors. Due to the lack of Managing Farm Owner(s) readiness, none of these three organisations has achieved readiness in regard to the following readiness stages: External Capacity, Strategy, Resources, Digital Technology and Management.

Participant NDI3 does not apply any digital technologies beyond the basic tools such as a computer and smartphone. When asked why, the participant named the costs involved as a barrier:

> *No, because I think that the money to invest when you plant it, the sensor for the water, to me it was a bit too much money.*

While acknowledging the positive attributes of digital technologies, the participant pointed out they would not be beneficial for their farm due to the cost-benefit ratio, indicating a lack of change valence:

> *The modern technologies, they're helpful, but the cost is prohibitive …*

> *No, the value for money is not there.*

When asked about the perception of digital technologies, the participant displayed a negative attitude towards digital technologies, possibly due to lack of experience and knowledge:

> *I'm not too sure, because I never went through with it.*

So, don't know. I don't know very much about that. I know they exist. I know they cost a lot of money.

Furthermore, the participant suggested that working with computers is an obstacle:

I'm not very smart with a computer. Because I didn't grow up with the modern technology, with the computers. When the computer came, say 20 years ago, 30 years ago. I was already too old for that. So, the younger generation grew up with, to me, something too difficult to understand.

As the participant does not indicate at any point a willingness to learn about, or acquire the knowledge and skills necessary to use digital technologies, this statement reflects a mindset that is not in line with that required of digital innovators, as described in section 5.4.2.3. The participant stated that they were part of an innovation network which does not have any competencies in regard to digital technologies, but has not taken any measures to reach out to other individuals or network with the respective capabilities, indicating a lack of change orientation as part of their mindset.

Participant NDI2 only applies electronic ear tags because they are government prescribed, however, they do not use any of the associated digital functions. When asked about why no other digital technologies are applied, the participant stated they did not have the time or need for it:

I haven't got the time to do it, to be quite honest. What I do now, and have been doing for 45 years works all right, so I stick to it.

The lack of change valence was substantiated by the statement:

I don't need it that bad, for decision-making, no. That's not quite right, no.

When elaborating further, the participant admitted they lacked any interest in change:

I've gotten by without it before, so it's just another job for me, and I'm probably past learning it, I suppose, is one of the best ways of describing it.

Another barrier cited by the participant is the operation of computers:

I actually find it hard, you're able to, I assume you're a lot younger than me, to pick it up quicker and easier, because you're born and bred into it. I can't. I never had anything to do with computers until I was 45-50 probably. So, I find it difficult.

The analysis further uncovered that the attitude towards digital technologies was responsible for not adopting digital technologies as well. The participant stated that they had to apply ear-tags or else the business could not continue:

If I didn't learn about it and didn't start using them, well I wouldn't own my own livestock, or, particularly cattle.

When asked under which circumstances the participant would consider applying any other digital technologies, they replied:

If I was forced to. Had to.

Participant NDI1, running a cropping and livestock farm only uses the compulsory ear-tags besides basic digital technologies such as phones, due to the costs and learning involved with digital technologies:

But you've got to be in a reasonably big way, to be able to justify the costs of those things and, you've got to go and learn about them.

… so you do what you know. You make do, you know?

Furthermore, the participant stated that they have little interest in digital technologies, indicating a lack of change orientation and change valence:

That's what it'll be, the next generation that are a bit more into their electronics than we are.

The necessity of working with computers and learning their application was a barrier too:

The biggest problem is, modern technology is moving too fast for the older generation of the farmers …

I find I don't learn the computer as well and I forget …

Accordingly, the digital technologies were described by the participant as too difficult to use:

… it's good, but it's got to be easy to use. You know, following the prompts is quite good, but sometimes it can be, you've got to go here or there. Oh, but how did I do that? Or how did I get there? There's too many steps. That's just the way I feel.

In summary, the participants who do not apply digital technologies on their farm all stated a lack of readiness in regard to the key factor Managing Farm Owner(s) as the reason. Table 15 provides a summary of the People-readiness for all three NDIs.

Table 15: Barriers stated by non-digital innovators as holding back digital innovation on their farm

Attributes of key factor People	NDI1	NDI2	NDI3
Change Valence	Too high costs	No need	No cost-benefit balance
Positive Attitude towards Digital Technologies	No – too difficult to use	No – would only apply digital technologies if forced by regulations	Not positive due to lack of knowledge and experience with digital technologies

Mindset	Lack of curiosity and interest in learning Prefers not to work with computers ➔ No change orientation and commitment	Lack of interest in continuous learning Finds it difficult to work with computers ➔ No change orientation and commitment	Lack of interest in continuous learning, pro-active behaviour, curiosity and improvement orientation No change orientation and commitment ➔ Lack of experience with computers

6.3 The Empirical Framework of Organisational Readiness for Digital Innovation

The empirical framework of organisational readiness for digital innovation brings together the analysis results of the previous sections outlining the key factors influencing the organisational readiness for digital innovation as well as the transition process involved in its establishment. Thereby, it answers the overarching research question guiding this thesis: *How do Australian farms become ready for digital innovation?*

Section 5.4 demonstrated that organisational readiness for digital innovation is influenced by the six key factors of Strategy, Managing Farm Owner(s), Management, Resources, Digital Technology and External Capacity. Each of these factors is defined by a number of factor-specific attributes. An overview of the key factors and their constituting attributes is presented in Table 16.

Table 16: Summary of key factors and their constituting attributes influencing organisational readiness for digital innovation

Key factors	Constituting Attributes
Strategy	• Strategic Orientation • Knowledge Acquisition • Culture
Managing Farm Owner(s)	• Change Valence • Positive Attitude towards Digital Technologies • Mindset
Management	• Leadership • Operations Management
Resources	• Financial • Time • IT infrastructure
Digital Technology	• Strategic Fit • Characteristics
External Capacity	• Network • Inter-organisational Exchange and Support

Section 6.2 uncovered the process of family farms gaining readiness for digital innovation. First, the researcher identified a sequential order for when each of the key factors becomes relevant in the process of gaining organisational readiness for digital innovation: first, Managing Farm Owner(s), followed by External Capacity, Strategy, Resources, Digital

Technology and finally Management. The sequential order is based on the identified enabling interrelations between the key factors. In addition, reciprocal relationships were uncovered, providing insights into the complexity of family farms gaining readiness for digital innovation. Additionally, findings from the comparison of digital innovators and advanced digital innovators were taken into consideration, indicating that regardless of the level of readiness, previously gained readiness must be sustained.

Joining together these results, the empirical framework of organisational readiness for digital innovation, depicted in Figure 23, has been developed.

The influence of the six key factors Strategy, Managing Farm Owner(s), Management, Resources, Digital Technology and External Capacity on family farms' readiness for digital innovation is illustrated by the black arrows.

The empirical framework is divided into six consecutive stages (numbered 1 to 6). Each stage describes readiness in regard to a specific key factor which must be achieved in order to progress in the process of gaining organisational readiness for digital innovation. Furthermore, highlighting the complexity of the process, at each stage the enabling relationships (green arrows) and reciprocal relationships (orange arrows) come into play.

The framework is built as a waterfall model, as readiness gained for a key factor remains relevant for the following stages. Hence additionally, each stage is dedicated to preserving the readiness of the previous key factors.

Stage one refers to Managing Farm Owner(s) readiness, which consists of the attributes change valence, positive attitude towards digital technologies and mindset.

Stage two consists of maintaining the previously acquired Managing Farm Owner(s) readiness, as well as gaining readiness in regard to External Capacity, which includes the attributes network and inter-organisational exchange and support.

Stage three refers to remaining ready in regard to Managing Farm Owner(s) and External Capacity readiness and gaining Strategy readiness, which is defined by the attributes strategic orientation, knowledge acquisition and culture.

Stage four includes sustaining Managing Farm Owner(s), External Capacity and Strategy readiness as well as achieving Resource readiness, which refers to financial, time and IT infrastructure resources.

Stage five consists of preserving readiness of the key factors Managing Farm Owner(s), External Capacity, Strategy and Resources and achieving Digital Technology readiness, which involves ensuring specific technology characteristics and digitalisation of the organisation.

The final stage, stage six, is dedicated to gaining Management readiness defined by the attributes leadership and operations management, and perpetuating the previously gained readiness of the other five key factors: Managing Farm Owner(s), External Capacity, Strategy and Resources and Digital Technology.

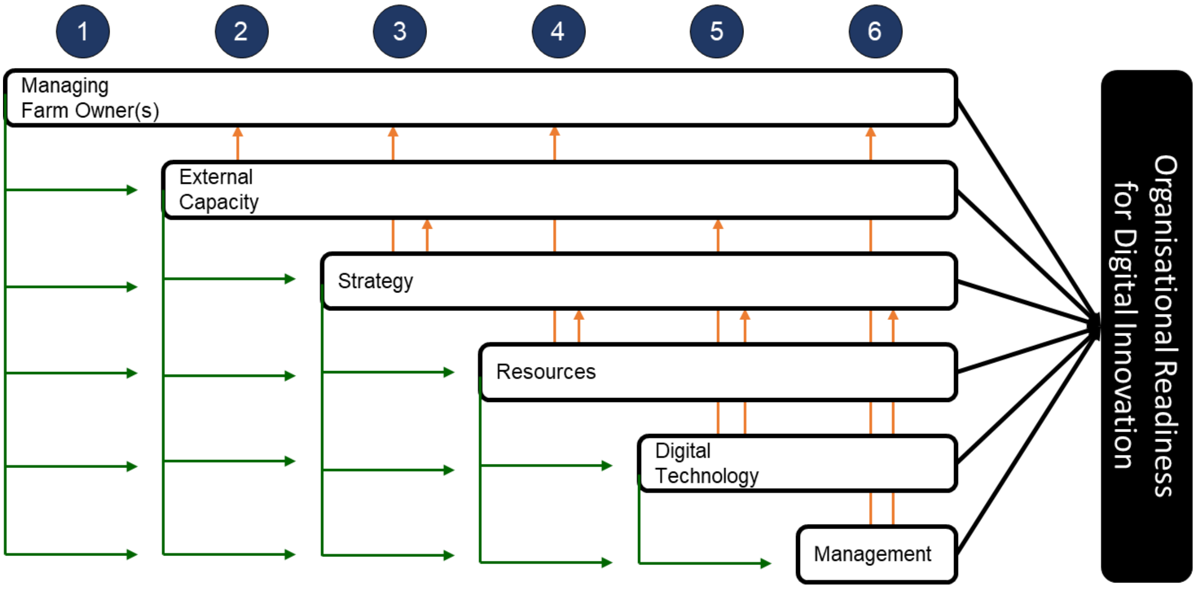

Figure 23: Empirical framework of organisational readiness for digital innovation (green arrows represent enabling relationships while orange arrows represent reciprocal relationships)

6.4 Summary

This chapter presented the qualitative analysis results addressing the second sub-research question of this thesis. To provide insights into the process of family farms towards gaining readiness for digital innovation, it uncovered and explained the interdependencies between the identified key factors. Finally, bringing together all analysis results, an empirical framework of organisational readiness for digital innovation for family farms was developed, to answer the overarching research question guiding this thesis: *How do Australian farms become ready for digital innovation?*

In the following chapter the analysis results are discussed in light of relevant literature.

Chapter 7: Discussion

7.1 Objective

This chapter examines the results of the data analysis presented in chapters 5 and 6 in relation to the thematic literature introduced in chapters 2 and 3.

It is structured to address the two thesis research questions. Therefore, section 7.2 discusses the factors influencing organisational readiness for digital innovation in the Australian agriculture sector, while the discussion in section 7.3 centres around the process of Australian farms gaining organisational readiness for digital innovation.

7.2 Factors Influencing Organisational Readiness for Digital Innovation in the Australian agriculture

While different terms may be used, the readiness literature and organisational readiness for digital innovation literature highlight that Strategy, Management, Technology, Resources, Staff and External Capacity are factors that influence organisational readiness to innovate with digital technologies. The findings of this research support the validity of all but one of these factors – the relevance of the factor Staff.

The readiness literature considers the influence of readiness of staff to be of great importance for an organisation's readiness for digital innovation. To be specific, it outlines the following attributes of employees as prerequisites: perception of change valence (Lokuge et al. 2019; Ruikar, Anumba & Carrillo 2006; Weiner 2009), change efficacy (Weiner 2009), their positive attitude and perception towards technology adoption (Ruikar, Anumba & Carrillo 2006), their positive past experience with change, their adaptability and commitment to digitalisation as well as their possession of innovation-specific knowledge, skills, and IT and innovation experience (Lokuge et al. 2019; Nguyen et al. 2019; Sony & Naik 2019; Yen et al. 2012; Yusof et al. 2010).

Recent research in the agricultural context investigating factors influencing farms' adoption of technology and their innovative behaviour identified worker involvement to be a key component too (Cofre-Bravo et al. 2019). The research, however, has identified that the employees of Australian farms do not have an influence on the farm's readiness to generate an innovative outcome. The respondents consistently described activities around the search for, evaluation and adoption of, and innovation with digital technologies to be driven and executed by the managing farm owner(s). The context of the Australian agricultural sector provides insights into and justification for this finding, as over 70% of Australian farms are non-employing (Australian Bureau of Statistics 2016). If staff are being engaged, they are labourers and trade workers (ABARES 2018), executing manual tasks not related to the complex activities associated with digital innovation.

At the same time, reviewing the responsibilities and activities related to realising digital innovation on farms, the analysis has identified the significance of the role that managing farm owner(s) play in regard to the farm's ability to adopt, implement and innovate with digital technologies. Their readiness, which is detailed later in this chapter, has been identified as influencing the organisation's readiness for digital innovation. This finding is in line with family farm literature, which states that executive power on a farm is in the hands of the managing farm owner(s) in order to 1) protect the invested capital, as it is provided by the farming family (Block 2012), 2) maintain the welfare of the farming family (Olson et al., 2003, Heck and Trent, 1999, Chrisman and Patel, 2012, Binz et al., 2017), and 3) ensure succession of the family business (Chrisman & Patel 2012).

Understanding that family farm's employees are less relevant in the context of digital innovation and identifying the central role of managing farm owner(s) are significant findings, as they challenge the extant readiness literature and are specific to the family farm context.

In regard to the attributes defining readiness specific to each of the key influencing factors, there are substantial discrepancies between the relevant, industry independent readiness literature and the analysis results of this thesis specifying the key factors in the context of the Australian agricultural sector. In the following section, the differences for each of the six key factors are discussed.

7.2.1 Strategy

7.2.1.1 Strategic Orientation

The findings of this thesis reveal that digital innovators in agriculture have a strategic orientation which is characterised by long-term outlook and continuous improvement as a priority. In contrast, the readiness literature argues the need for a clear strategic plan, referring to a well-defined strategy with clear explanation of the stakes, objectives and benefits related to the application of digital technologies for the company itself as well as its stakeholders (Pessot et al. 2020; Sony & Naik 2019). The findings of this thesis do not support the need for a clear strategic plan on Australian farms, as the digital innovators interviewed described the farming environment as dynamic and the application of digital technologies as an endeavour that is not straightforward. Consequently, the participants did not describe their strategy as a clear plan, but instead one that is continuously adapting, following a long-term orientation and focusing on constant improvement.

The family business literature supports the finding of this thesis in terms of strategic plans (Sreih, Lussier & Sonfield 2019). A potential explanation the research offers is the duality of the family business system. Family businesses, being economically as well as emotionally driven, pursue both business and family goals in parallel and they often compete with and influence each other (Binz et al. 2017; Fitz-Koch, Cooper & Cruz 2019; Saleem, Siddique & Ahmed 2019), which can potentially lead to a lack of clarity in regard to the strategy. Agricultural management research supports the findings of family farms pursuing a long-term orientation in regard to their economic activities as well (Gasson & Errington 1993). The long-term orientation on family farms originates from 1) the tradition of intra-family succession (Bell, C 2019; Bohak, Borec & Turk 2010; Leonard, B et al. 2017), 2) the necessity to protect the farm's capital solely provided by the farm family, and 3) the absence of short-term reporting of results due to no external equity holders being involved (Dreux IV 1990).

The need for continuous improvement orientation identified in this thesis has not been identified as a prerequisite by the readiness literature and is opposing to the characterisation of family farms. Farm families have been shown to possess a high degree of adaptability in order to respond appropriately and sustainably to the highly volatile environment in Australia (Brookfield & Parsons 2007; Darnhofer & Strauss 2014; Nicholas-Davies et al. 2020), involving, for example, unpredictable climate events (Jackson, Hatfield-Dodds & Zammit 2020). However, the literature commonly describes farms as reluctant to change, highlighting the farming culture as one of the primary reasons (Warren et al. 2016), as pursuing established farming practices generates socio-cultural rewards, such as peer approval, acknowledgment and admiration (Burton 2004, 2012; Burton, Kuczera & Schwarz 2008). In summary, the literature suggests that change is pursued only as an immediate response to significant events threatening the business.

While it may appear that farms engaged in digital innovation may not be representative of the common farming culture, the farms investigated in this thesis did articulate a desire for socio-economic rewards, highlighting the role of their peers and networks. However, these were characterised as being innovative and strongly engaged in digital innovation. Consequently, the fundamental principles which characterise the farming culture seem to apply in the context of digital innovation on farms; however, digital innovators in the agriculture sector aligned themselves with social networks that have the same attitude towards digital innovation and therefore embrace change and encourage progressive farming practice

Identifying the inconsistency in regard to the need for a clear strategic plan dependent on the industry context and specifying the strategic orientation of family farms engaged in digital innovation, this finding is significant.

7.2.1.2 Knowledge Acquisition

The findings of this thesis identify knowledge acquisition as a prerequisite of readiness for digital innovation on Australian farms. This finding is in line with the readiness literature suggesting the need for information and knowledge on technology as well as innovation being present within the organisation (Evans, JD & Johnson 2013; Lokuge et al. 2019; Scaccia et al. 2015; Yusof et al. 2010).

The agriculture literature recognises that farms need to gain information and knowledge related to digital innovation. Farms have been shown to possess collective practical knowledge of all individuals engaged (Thomas, E, Riley & Spees 2020), accumulated and diffused throughout the farming family over multiple generations (Cabrera-Suárez, De Saá-Pérez & García-Almeida 2001; Inwood, S, Clark & Bean 2013). However, family farms lack the knowledge and experience to harness the value-adding of emerging technologies (Annosi et al. 2019; Bramley 2009; Franco, Singh & Praveen 2018). While the presented literature acknowledges the need for knowledge, it categorises it broadly into knowledge needed for digitalisation, innovation and digital innovation.

Expanding on existing literature, the findings of this thesis provide additional insights into the knowledge acquired, specifying it as 1) product, 2) process and 3) data knowledge. In other words, 1) what digital technologies exists, what are their benefits, what infrastructure do they require and what IT infrastructure are they compatible with; 2) how does the digital technology work, how is it operated and used, and how are problems resolved; and 3) what, how and when can data be collected and analysed.

Furthermore, the findings of the thesis identified the need to overcome rural limitations in order to acquire the outlined knowledge. Those farms which did engage in digital innovation mentioned a number of knowledge sources, all of which involved reaching out to geographically distant, nationally and internationally located knowledge holders. Examples provided were going to conferences and field days, interacting with industry networks, interacting online with globally dispersed peers, and following international research on the topic of digital innovation. The digital innovators explained that taking these measures is central for acquiring the knowledge necessary for digital innovation as this is a new and quickly emerging field and the local community lacks the appropriate knowledge and experience.

Although there is no corresponding research in the readiness literature within the context-specific environment of Australian farms, it is widely acknowledged that the rural location of farms is significant (ABARES 2020; EY 2019), and there has been some recent research supporting this notion. Fielke, Taylor and Jakku (2020), in a recent literature review, highlight the importance of knowledge providers beyond the local network for the digitalisation of agriculture innovation systems. Emerick and Dar (2020) stress the importance of field days where farmers can get together and exchange knowledge. Silvestri et al. (2020) identified a significant increase in adoption of innovative farming practices on rural farms due to the acquisition of relevant knowledge via ICTs.

This finding is significant as it builds upon extant readiness literature specifying that knowledge is necessary for digital innovation on farms, and provides a bridge with agricultural research identifying the necessity to overcome rural limitations for knowledge acquisition.

7.2.1.3 Culture

The findings of this thesis identify culture as another influencing attribute, revealing that farms that engage in digital innovation have a culture of embracing digital technologies and consequently the innovation they bring onto the farm, motivated by exchange with members of the farming family interested and engaged in digital innovation, or the farm succession.

This finding is consistent with the readiness literature. While some readiness literature speaks about such an organisational culture in a general manner (Lou, Lee & Goulding 2020; Scaccia et al. 2015), others specify traits, for example, idea sharing and decentralised decision-making (Lokuge et al. 2019), shared values, behaviour patterns and sets of norms determining the business practice (Yusof et al. 2010), embracing innovation, risk-taking and learning (Weiner et al. 2020). Despite the differing specifications, the readiness literature suggests the need for an organisational culture supporting and encouraging innovation.

The components of culture influencing the organisational readiness for digital innovation identified in this thesis and in the readiness literature seems to contradict the common characterisation of the farming culture. The farming culture, which authors such as Vayro et al. (2020) call ‘a way of living’, is conceptualised as a reflection of the farming family’s identity. Farmers take great pride in their enterprise, seek peer approval (Greiner, Patterson & Miller 2009) and pursue established farming practices to gain socio-cultural rewards (Burton 2004, 2012; Burton, Kuczera & Schwarz 2008). Consequently, they are deeply attached to conventional farming practice and reluctant to change (Warren et al. 2016). However, as discussed in section 7.2.1.1, the fundamental principles of farming are still valid in the context of Australian farms engaging in digital innovation. The farms engaged in digital innovation investigated in this thesis expressed great pride in their work and described farming as the decisive component dominating and determining their lives. Their peers play a fundamental role, detailed in section 7.2.6.1, and support the farmers’ aspirations for socio-cultural rewards from the farming community. The only differing factor is their social network. Digital innovators described their social network within the farming community as engaged in and encouraging digital innovation. Therefore, socio-cultural rewards such as peer-approval do not originate from pursuing conventional farming practice and avoiding change, but on the contrary, from experimenting with and engaging in digital innovation.

The characteristics of organisational culture present on farms engaged in digital innovation identified in this thesis and the readiness literature do not intend to describe the farming culture in general. Neither do they challenge the recent scholarly efforts investigating organisational culture in the digital domain (Duerr et al. 2018; Martínez-Caro, Cegarra-Navarro & Alfonso-Ruiz 2020). Instead, they present an additional component of the organisational level of culture in the context of digital innovation in the Australian agricultural sector, expanding upon the current culture research on family farms.

7.2.1.4 Strategy Attributes Suggested by Readiness Literature and Not Supported by the Findings of this Thesis

In regard to the category strategy readiness, the literature suggests that a number of attributes influence the overall organisational readiness for digital innovation. However, this thesis has identified that these attributes are not relevant in the context of digital innovation in the Australian agricultural sector, or are already a characteristic of Australian farms, independent of their engagement in digital innovation.

First, the readiness literature suggests the need for firm structure, financial management and processes that support innovation (Evans, JD & Johnson 2013; Yen et al. 2012; Yusof et al. 2010). Yusof et al. (2010) argue that a firm structure that supports innovation must be informal, decentralised, and permit flexibility and speedy decision-making. This thesis identifies this attribute not to be a prerequisite specific to readiness for digital innovation of family farms, as all farms investigated in this thesis, regardless of their engagement in digital innovation, were characterised as being informal, flexible and able to make decisions quickly. Australian farms are governed and managed by the farming family (Australian Government 2018; Watts & Harrison 2015), and therefore per se informal. If there are employees on the farm, turnover is low and strong social bonds lead to established social relationships and therefore informal behaviour (ABARES 2018; Block 2012; Kotey 2005).

Furthermore, the decision and executive power being in the hands of the managing farm owner(s) automatically leads to their ability to be flexible and make quick decisions, and eliminates the need for a decentralised firm structure, contradicting Yusof et al. (2010).

The same applies to the need for financial management to support innovation. This thesis has identified that financial resources play a crucial role, detailed in section 7.2.4.1, as digital technologies require considerable monetary investment to acquire, maintain, service and support equipment. However, as the decision to purchase, implement and apply digital technologies is the responsibility of the managing farm owner(s), specific strategic financial management supporting innovation, as suggested by Yen et al. (2012), is irrelevant.

Moreover, this thesis identifies that the need for processes supporting innovation, as proposed by Evans, JD and Johnson (2013), is not relevant in the context of family farms. The managing farm owner(s) interviewed stated that they are the only individuals engaged in innovating with digital technologies, and do not require a specific procedure for its realisation. In fact, none of the digital innovators interviewed mentioned the need for specific processes supporting innovation. On the contrary, digital innovators stated that they were continuously experimenting on their farms to incorporate new technology and harness their innovative potential, which contradicts the need for an established and set process to support innovation with digital technologies. Current literature on the digitalisation and the exploitation of its potential in organisations support the findings of this thesis, as the engagement in and exploitation of digitalisation is described as a chaotic, ill-defined process (Berghaus & Back 2017; Fielke, Taylor & Jakku 2020).

Second, the readiness literature suggests that an organisation must already be highly digitalised as a prerequisite of readiness for digital innovation (Sony & Naik 2019). The farms investigated, however, have shown that they can be ready for digital innovation, regardless of their pre-existing engagement in digitalisation. In fact, this thesis distinguishes between digital innovators and advanced digital innovators, the latter possessing extensive knowledge on digital technologies, applying a multitude of digital technologies and deriving synergies from their parallel application. However, regardless of their current engagement with digital innovation, all digital innovators reported having started innovating with digital technologies with no prior experience. The digital innovators explained that they only applied a limited number of digital technologies at the beginning and once more comfortable, they expanded their digital portfolio.

Third, the readiness literature identifies the need for processes to be agile (Khalfan, Anumba & Carrillo 2001) and standardised (Lou, Lee & Goulding 2020; Ruikar, Anumba & Carrillo 2006), to enhance the incorporation of change. In the context of Australian agriculture, this thesis identifies that agility is not a prerequisite of readiness for digital innovation, but a general characteristic originating from the managing farm owner(s) executive power and the lack of other stakeholders involved. Furthermore, it uncovers that standardisation of processes is not consistent with the context of family farms, due to the previously discussed limited number of individuals involved in digital innovation. On the contrary, the digital innovators interviewed reported digital innovation involving constant experimenting and improving, further detailed in section 7.2.3.2, which contradicts the need for standardised procedures.

Fourth, the readiness literature proposes the need for designated roles in regard to digitalisation, to distribute responsibility and structure the complex processes of incorporating and applying new technology (Lokuge et al. 2019; Pessot et al. 2020; Yusof et al. 2010). The findings of this study identify that the designation of roles related to digital innovation is not relevant in the context of Australian farms, as the managing farm owner(s) are solely responsible for digital innovation on farms, which is discussed in more detail in section 7.2.2.

Fifth, the readiness literature suggests designing products/services smart to influence readiness for digital innovation (Sony & Naik 2019). This thesis identifies this attribute as not applicable in the context of agriculture as agricultural products, such as crop and livestock, cannot be designed smart.

Identifying attributes of Strategy readiness suggested by extant readiness literature that are not applicable or less relevant in the context of family farming is a significant finding, as it provides insights into the context boundaries and peculiarities of family farming.

7.2.2 Managing Farm Owner(s)

As mentioned before, this thesis identified the significance of the role that managing farm owner(s) play in regard to the farm's ability to adopt, implement and innovate with digital technologies, and revealed that their readiness fundamentally influences their farm's readiness for digital innovation. At the same time, it has uncovered that a farm's staff are not engaged in digital innovation due to the manual nature of their work as labourers and trade workers, which is contrary to the cognitive work required when innovating with digital technologies. Consequently, the category staff and its attributes suggested by the readiness literature are identified in this thesis as not relevant in the context of family farms.

However, many of the attributes within the category staff suggested by the readiness literature are in line with the attributes uncovered in this thesis that influence the readiness of the managing farm owners. This thesis identified that three attributes – change valence, positive attitude towards digital technologies, and mindset – determine the readiness of the managing farm owner(s).

7.2.2.1 Change Valence

Change valence refers to the managing farm owner(s) identifying a need for change, perceiving the application of digital technologies as beneficial to meet the need, and considering the outcome of digital innovation to have a positive bottom line. Change valence has been outlined as an influencing attribute by the readiness literature (Lokuge et al. 2019; Ruikar, Anumba & Carrillo 2006; Weiner 2009), however, the literature refers to the employees' change valence.

Reflecting upon changes pursued by farms in the past, the agriculture literature too supports the need for change valence in order for a farm to enforce change (Moerkerken et al. 2020). While farms are commonly described as reluctant to change (König, Kammerlander & Enders 2013; Warren et al. 2016), the agriculture literature provides examples of farms undergoing change in situations where change in necessary to ensure the continued existence of the farm, such as responding to an extreme weather event (Brookfield & Parsons 2007; Nicholas-Davies et al. 2020; Sutherland et al. 2012), which corresponds with the perception of change valence.

As neither the agriculture literature nor the readiness literature provide clarity on which individual's perception of change valence is necessary to implement change, the findings of this thesis, specifying the managing farm owner(s) need for perception of change, expands on the current literature and is significant.

7.2.2.2 Positive Attitude towards Digital Technologies

Positive attitude towards digital technologies refers to the managing farm owner(s) having a positive perception of digital technologies and, while aware of potential challenges that may occur in relation to the application of digital technologies, a willingness to use them, as they believe in their positive contribution to the farm as well as their own ability to make them work. This attribute is in line with the readiness literature, which highlights the need for a positive attitude and perception towards technology adoption and perception of change efficacy. However, again, contrary to the findings of this thesis, the literature refers to employees (Ruikar, Anumba & Carrillo 2006), or stakeholders (Lokuge et al. 2019), not specifically the managing farm owner(s).

The need for a positive attitude towards digital technologies has been identified by research investigating the barriers and enablers for the adoption of digital technologies in the agriculture sector as well. Annosi et al. (2019), for example, uncovered the managerial perception of technological usefulness as central for the uptake of smart agriculture and 4.0 technologies. Pathak, Brown and Best (2019) identified the need for a relative advantage provided by the digital technology for the adoption of precision agriculture.

While the readiness and agriculture literatures both support the need for a positive attitude towards digital innovation, they are inconsistent about which individual(s) must display it. Therefore, by identifying that only the managing farm owner's attitude towards digital innovation is relevant to the readiness for digital innovation of Australian farms, this thesis provides additional clarity on the topic.

7.2.2.3 Mindset

The attribute mindset refers to managing farm owner(s) change orientation and commitment.

A managing farm owner's change orientation is characterised by their willingness to explore and realise future avenues of farming and their proactive behaviour to carry them out. This finding is in line with the readiness literature, as Nguyen et al. (2019) identify the need for organisations to be proactive in searching for and being responsive to exploiting the opportunities of digital technologies.

This thesis identified commitment as the managing farm owner(s) capacity to overcome negative experiences, continuously acquire knowledge, learn constantly, and be willing to self-educate and adapt to a new work nature. This description of commitment displayed by managing farm owners has been consistent among the digital innovators and subject experts interviewed. Moreover, the readiness literature acknowledges the role that commitment plays; however, contrary to the findings of this study which identified the commitment of the managing farm owner(s), Sony and Naik (2019) identify the need for top management commitment to implement digital technologies, while Nguyen et al. (2019) refer to employee and management commitment. As previously detailed, this thesis has identified that the farm's staff are not engaged in digital innovation. Therefore, their specific mindset is not relevant in the context of readiness for digital innovation of family farms.

Furthermore, the readiness literature suggests that employees need to be adaptable (Sony & Naik 2019), possess innovation-specific knowledge and skills, possess experience in IT and innovation (Lokuge et al. 2019; Nguyen et al. 2019; Yen et al. 2012; Yusof et al. 2010), and have a positive past experience with change (Weiner 2009). As previously detailed though, this thesis has identified that the farm's staff are not engaged in digital innovation. Therefore, these employee attributes are irrelevant in the context of digital innovation on family farms.

However, adaptability of the managing farm owner(s), not employees, has been identified in this thesis to be of importance, which is in line with the agriculture literature outlining the changes in work routine when engaging in digital agriculture (Carolan 2020). Furthermore, this thesis has identified that employees or managing farm owner(s) do not need to possess innovation- and IT-specific knowledge, skills and experience or positive past experience with change in the context of digital innovation in the Australian agriculture, as proposed by the readiness literature. Instead, it found that the managing farm owner(s) willingness to acquire knowledge, learn and self-educate are prerequisites, which compensate for the lack of knowledge and experience in regard to digital innovation, as they enable the managing farm owner(s) to access the knowledge and learn the skills needed when necessary. The digital innovators stated too, that these characteristics were needed by the managing farm owner(s) in order to successfully innovate with digital technologies, as they are new to the farm and furthermore, are being continuously improved and developed, changing the way they are being used.

Recent agricultural management research identified a lack of knowledge on digital technologies as a reason for limited adoption of digital technologies (Annosi et al. 2019; Miller et al. 2019; Pathak, Brown & Best 2019). However, considering 1) the broad spectrum of existing and the growing number of emerging digital technologies (Salam 2020), which all require specific knowledge and skills to be used, as well as 2) the historically limited knowledge, capabilities and skills on farms due to an undiversified workforce and difficulty attracting highly skilled workers (Coleman, James S 1988; Dunn 1995), the findings of this thesis suggest that managing farm owner(s) need to be willing to acquire knowledge on and learn to operate and innovate with digital technologies. Furthermore, many Australian farms are located rurally (EY 2019), providing a reasonable explanation for the need to self-educate.

Specifying and defining managing farm owner(s) readiness is a significant finding, as due to the context-specific role, managing farm owner(s) and their readiness attributes have so far not been addressed by extant readiness research.

7.2.3 Management

7.2.3.1 Leadership

This thesis has uncovered leadership as a prerequisite of readiness for digital innovation of Australian farms. The analysis of interviews with digital innovators revealed that leadership in this context refers to managing farm owner(s) taking leadership in driving digital innovation on their farms. Experts interviewed highlighted the need for individuals on farms to take the initiative to pursue digital innovation. This is a significant finding, as the readiness literature refers to leadership as the action of a leading a group.

While Scaccia et al. (2015) do not specify the characteristics of leadership, scholars such as Lou, Lee and Goulding (2020), Pessot et al. (2020) and Lokuge et al. (2019), in line with the current academic debate on the adoption of digital technologies (Biegler et al. 2018; Zangiacomi et al. 2020), stress the importance of communication within organisations, which in turn leads to collaboration and thereby facilitates the adoption of and innovation with digital technologies. In the context of the Australian agricultural sector, a high level of communication and collaboration within the organisation has been shown to be a general characteristic of farms due to their close, long-term relationships and networks built over time (Classen et al. 2012), and hence not specific to digital innovation.

Moreover, this thesis has identified that communication and collaboration within the organisation do not have an effect on the readiness of family farms to innovate with digital technologies. This is due to the previously discussed role of managing farm owner(s) as the sole person responsible for digital innovation. As only the managing farm owner(s) are engaged in digital innovation of the farm, communication and collaboration with the remaining individuals on the farm do not have any effect on the farm's readiness for digital innovation.

The readiness literature too, as suggested by Khalfan, Anumba and Carrillo (2001), outlines management's responsibility to establish project management with a focus on clients, quality assurance and facility design, but it is inconsistent with the findings of this thesis. Project management aims at establishing functional teams that contribute to the organisation's overarching goals. In the context of the Australian agricultural sector, where farm staff consists of the farming family and in some cases a limited number of casual labourers, of which only the managing farm owner(s) work on digital innovation, no team formation and management is required in order to be ready for digital innovation.

Finally, research has identified that family firms, such as those investigated in this thesis, have a fundamentally different leadership style to non-family firms (Williams Jr et al. 2018). Farms are at least partially governed emotionally (Daspit et al. 2017; Wanzenried 2018) due to the farms' capital being provided by the farming family (Block 2012), the personal principle describing the owning manager(s) view of the task as a lifelong duty (Loecher 2000) and the tradition of intra-family farm succession (Bell, C 2019; Bohak, Borec & Turk 2010). While this thesis acknowledges the existence of the specific leadership style found on the farms investigated, leadership style has not been identified as an influence on the farm's readiness for digital innovation, as only the farm manager(s) are involved in digital innovation.

7.2.3.2 Operations Management

The second attribute of Management identified in this thesis to influence farms' readiness for digital innovation is operations management. This attribute refers to improving operations and the value creation with digital technologies. The digital innovators interviewed reported that the process of implementing digital innovation was challenging and not straightforward. Therefore, the participants stated that they needed to experiment with digital technologies, gather experience on their application, and then continue to exploit their potential, which the subject experts interviewed supported.

This finding is significant as the readiness literature does not consider continuous improvement of the operation and value creation with digital technologies as prerequisites of readiness for digital innovation, while recent research highlights innovation and value creation with digital technologies as a main challenge for farms (Ayre et al. 2019). Scholars such as Weltzien (2016) and Weersink et al. (2018), for example, shed light on the difficulty of creating value with digital technologies such as big data in the agriculture context, as the corresponding applications on the market require considerable expertise in the analysis and interpretation of data sets.

Furthermore, the Management responsibility readiness literature specifically (Khalfan, Anumba & Carrillo 2001) suggests the need to ensure availability of support systems within the organisation, such as, for example, IT support. This thesis too, has identified the importance of support in regard to the implementation, application and maintenance of digital technologies. However, again the role of the managing farm owner(s) as the sole individual engaged in digital innovation on farms explains the lack of need to establish such support within the organisation. Uniformly, the digital innovators and experts interviewed explained that IT support was received from external innovation networks (discussed in detail in section 7.2.6.

7.2.4 Resources

7.2.4.1 Financial

This thesis has identified financial resources as a prerequisite of readiness for digital innovation. The farm owners and experts both outlined various financial investments related to digital innovation. The most obvious is the acquisition of digital technologies, such as purchasing a new machine with integrated digital technology, digital technologies as add-ons for existing machines or subscriptions for specific software. Moreover, digital innovators stressed the complexity of applying digital technologies, explaining that they had to engage consultants and agronomists to extract the potential from the digital technologies, which all require financial investment. Furthermore, in light of the digital technologies being applied outdoors on the farm, the digital innovators repeatedly stated the need for repairs, which involve costs for parts as well as service. Finally, as detailed in the following section, digital innovation requires time. Therefore, financial resources are necessary to ensure that the farm can continue until the benefits of the applied digital technology are generated.

While no digital innovator reported failing to generate value with a digital technology, one expert who has worked closely with farms to implement digital technologies explained the importance of possessing enough financial resources to compensate for a potential lack of benefits. This finding is in line with the readiness literature, which identifies the availability and utilisation of financial resources as a prerequisite (Evans, JD & Johnson 2013; Lokuge et al. 2019; Scaccia et al. 2015; Yusof et al. 2010).

However, in the context of the Australian agricultural sector, ensuring the availability of financial resources is a considerable barrier identified by Salam (2020), preventing farms from engaging in digital innovation. The lack of external capital (Block 2012) and not involving external parties as equity holders helps maintain the financial and managerial independence of farms (Sirmon & Hitt 2003; Suess-Reyes & Fuetsch 2016) but hampers them in other ways.

7.2.4.2 Time

Time has been another resource identified in this thesis as crucial for a farm's readiness to innovate with digital technologies. The digital innovators interviewed described various activities related to digital innovation which require time. First, the participants said that they go to conferences, field days, and even travel overseas to familiarise themselves with what digital technologies exist and evaluate their potential for application on their farms. Once the digital innovators decide on a digital technology and acquire it, they report needing more time to set it up, which involves, for example, integrating it into the existing infrastructure or entering data. Furthermore, the participants said that the process of learning how to operate a digital technology requires time. They highlighted the importance of accounting for any issues that may occur, which may take time to resolve. Finally, even when the digital technology is in use on the farm, the digital innovators said they must continue to experiment with its utilisation to maximise the value created. This finding is consistent with current studies on technology adoption on farms, such as that conducted by Kaler and Ruston (2019), in which participants repeatedly mentioned time as a crucial component for technology adoption.

The readiness literature does not identify time as a prominent resource influencing organisational readiness. This inconsistency originates from the specific context of family farms, which research has identified as being time poor (Boza et al. 2019). Time being a rare resource and freeing time for digital innovation directly affecting the other farm business, farms must consciously account for it, making it a resource which influences whether they are ready to engage in digital innovation.

This finding, identifying time as a resource central to farm's readiness for digital innovation, is significant, as it brings together the technology adoption and readiness literatures in the context of family farms.

7.2.4.3 IT infrastructure

IT infrastructure, specifically the availability of connectivity and hardware appropriate for the application of digital technologies, has been identified in this thesis as another resource influencing farms' readiness for digital innovation. The digital innovators and subject experts both highlighted the importance of connectivity for the application of digital technologies. While in the 21st century connectivity may appear to be omnipresent and hence not worth mentioning, recent research has identified gaps in connectivity specifically in the Australian context (Fleming et al. 2018; Keogh & Henry 2016; Marshall, A et al. 2019).

Due to the rural location of many Australian farms, connectivity cannot be assumed to be present. For example, one of the digital innovators explained that they had purchased and positioned a shipping container to bounce an internet signal to the farm. This finding is consistent with the literature on digital technologies in agriculture, which outlines the importance of connectivity and the impact of unreliable connection (Bacco et al. 2019; Virk et al. 2020), particularly in small villages where farms are mostly situated. Furthermore, the digital innovators stated the need for specific hardware, such as smartphones and powerful computers, that can run the software operating digital technologies.

As all digital technologies, regardless of industry, require connectivity and well performing hardware. This finding is in line with the readiness literature, which indicates that the availability and performance of all hard and software (Ruikar, Anumba & Carrillo 2006), access to stable, up-to-date, and reliable IT infrastructure and enterprise systems (Lokuge et al. 2019), and the ability to maintain appropriate IT infrastructure (Nguyen et al. 2019; Pessot et al. 2020) are prerequisites of readiness for digital innovation.

7.2.5 Digital Technology

7.2.5.1 Strategic Fit

The findings of this thesis identify that ensuring a strategic fit, which refers to matching a digital technology with a specific need or problem, is an attribute that influences farms' readiness for digital innovation. The digital innovators outlined the various needs they wanted met with the digital technologies they adopted, such as reducing costs, increasing efficiency or quality, reducing environmental impact and gaining more control. The reasons for the centrality of ensuring a strategic fit, highlighted by both the digital innovators and the subject experts, is in line with the literature, which has identified that farms possess only limited monetary resources (Block 2012; Sirmon & Hitt 2003; Suess-Reyes & Fuetsch 2016), requiring careful and effective utilisation.

Furthermore, recent research on the adoption of digital technologies in agriculture has identified a considerable lack of agreement between farms and technology providers. When investigating the digitalisation of agricultural knowledge, Fielke, Taylor and Jakku (2020) uncovered different priorities and interests between the different stakeholders, such as technology providers and governments, as well as the farms. Research on big data application in the agriculture sector uncovered a lack of agreement in regard to socio-ethical dimensions, such as for example, data ownership, privacy, and sharing the benefits of data collected (Fielke, Taylor & Jakku 2020; Kosior 2018; Wiseman et al. 2019)

For decades scholars have stressed the importance of farmers engaging in innovation and technology development, calling for farmers to be co-developers who can provide focus on functionality rather than pure technology advancement (Eastwood, Chapman & Paine 2009; Kaler & Ruston 2019; Paine & Kenny 2002). The participants stressed the need to choose a digital technology with strategic fit carefully, as they had been disappointed with functionality, applicability and the actual performance of digital technologies in the past, which is consistent with the research outlining the disconnect between technology providers and farmers.

This finding is significant as the readiness literature does not identify the need to ensure the digital technology can meet a specific need or support the pursuit of specific goals. This is likely due to the specific context of agriculture, where very limited financial resources leave little room for poor investment. Digital innovators and subject experts both repeatedly highlighted the importance of adopting a digital technology that created value for the farm, explaining the high risk of poor investment endangering the existence of the farm. Furthermore, digital technologies in agriculture are a newly emerging field compared with other highly digitalised industries, such as the automotive industry (Gandhi 2016), and therefore likely not yet in a mature state.

Finally, the rural location of farms can potentially be another barrier for technology developers to gain an in-depth understanding of their market and its needs, leading to digital technologies providing little value to farms and their needs. Several digital innovators criticised the lack of technology providers' understanding about farming practices, and developing technologies which fail to generate value for the farm.

7.2.5.2 Characteristics

The digital technology must have both a good strategic fit and certain characteristics. The general characteristics described by the digital innovators are fit for purpose, high usability and compatibility with existing IT infrastructure, while the specific characteristics refer to the farm setting, and the preferences of the individual(s) applying it, such as, for example, the availability of online tutorials, or durability of the digital technology for application in the paddock.

While the need for user-specific characteristics identified in this thesis has so far not been a topic of academic discussion, the general characteristics outlined in this thesis build upon existing agricultural research.

Prerequisites of digital innovation, in terms of characteristics, include the usefulness of the technology (Annosi et al. 2019), how compatible it is with existing IT, and how quickly and easily it can be applied (Pathak, Brown & Best 2019).

Furthermore, this finding extends the readiness literature, which only outlines the need for IT to be available and well performing (Lou, Lee & Goulding 2020; Ruikar, Anumba & Carrillo 2006). While the readiness literature characterises such technology to be applicable throughout the organisation (Lou, Lee & Goulding 2020), this thesis has not identified that this characteristic of digital technology is a prerequisite in the context of family farms, as the digital technology is not applied throughout multiple departments or by various individuals but only the farm manger, as detailed in section 7.2.2.

Furthermore, the readiness literature suggests the necessity of IT enabling information sharing and automated information processing (Khalfan, Anumba & Carrillo 2001). As this is part of the generic description used for digital technologies in this thesis, only digital technologies which meet this criterion were investigated, therefore not requiring explicit classification as an influencing attribute.

7.2.6 External Capacity

7.2.6.1 Innovation Network

This thesis has identified that being part of an innovation network knowledgeable and experienced with digital innovation is an attribute influencing farms' readiness for digital innovation. The digital innovators stated that they were part of such networks, for example, through their engagement in their farming cooperative and online discussion forums, and by being active in a community of practice, etc. This finding is consistent with existent literature that asserts that networks are central to the farming culture (Burton 2004, 2012; Burton, Kuczera & Schwarz 2008). Those farms that were not engaged in digital innovation considered themselves to have networks too. However, the differentiating factor is the knowledge on and experience with digital innovation which innovation networks of farms engaged in digital innovation possess.

A recent study by Pathak, Brown and Best (2019), in line with Kernecker et al. (2020), supports the findings of this thesis identifying that peers in the context of family farming are an important source for exchanging experience and knowledge, facilitating the adoption of digital technologies in the agriculture sector. The findings of Annosi et al. (2019) who identify a supporting business environment in terms of availability of professional services or institutional support as additional prerequisites for technology adoption in the agriculture sector, further strengthen the need for an innovation network of farms engaging in digital innovation.

The readiness literature acknowledges the centrality of a network in the context of digital innovation (Lokuge et al. 2019; Nguyen et al. 2019; Pessot et al. 2020; Scaccia et al. 2015; Yen et al. 2012; Yusof et al. 2010), however, does not specify its peculiarities. Hence, this finding, identifying the differentiating factors of innovation of farms engaged in digital innovation extends the existent readiness literature.

Although the readiness literature has identified the importance of the digitalisation of the supply chain (Sony & Naik 2019), the findings from this research reveal that it is less relevant in the context of Australian family farms. The agriculture supply chain can be divided into three stages: (1) production planning, (2) cultivation, and (3) post-harvest management and marketing (Ali & Kumar 2011). While each of these stages represents an interaction with external organisations, none of these have been described by the participants as being involved in the farm's digital technologies. Consequently, the supply chain and the respective organisations have not been prominent in the interviews conducted with farms engaging in digital innovation or the subject experts.

7.2.6.2 Inter-organisational exchange and support

The second attribute identified in this thesis that influences farms' readiness for digital innovation is their engagement in inter-organisational knowledge and support exchange. The digital innovators explained that they engage with external individuals and entities 1) to acquire information about what digital technologies are available, their functionality and their potential benefit for the farm, 2) to receive help with setting up the digital technology, 3) for support with repair work when needed, 4) to access help with data entry, analysis and interpretation, and 5) to discuss topics around the engagement in digital innovation.

This finding is consistent with the readiness literature calling the engagement with external entities a readiness prerequisite (Lokuge et al. 2019; Nguyen et al. 2019; Pessot et al. 2020; Scaccia et al. 2015; Yen et al. 2012; Yusof et al. 2010), as well as research on digital innovation in farming outlined in the following section.

Pathak, Brown and Best (2019) identify the need for farms to find, interpret, re-codify and integrate new knowledge in order to foster their technology adoption. However, SMEs, such as Australian family farms, lack the sufficient knowledge acquisition and exploitation (Huber, Wainwright & Rentocchini 2020; Lee, Sungjoo et al. 2010; Spithoven, Vanhaverbeke & Roijakkers 2013). In the farming context, scholars have investigated various scenarios in which farms fail to access and use information (Evans, KJ, Terhorst & Kang 2017; Gent, De Wolf & Pethybridge 2011; Rose et al. 2016). Consequently, as uncovered by Wójcik, Jeziorska-Biel and Czapiewski (2019) and supported by various recent studies, farms rely on inter-organisational knowledge exchange and support, sourced from (1) the local community (Kernecker et al. 2020), (2) managing institutions and those associated with agricultural policy (Fielke, Taylor & Jakku 2020), and (3) the media (Silvestri et al. 2020). The digital skill gap between urban and rural areas, as identified by Trendov, Varas and Zeng (2019), forces farms to not only rely on their local community but to tap into external sources to capture knowledge and receive the support necessary for digital innovation.

Summarising the discussion of section 7.2, first, the findings reveal that the readiness factor Staff is irrelevant in the context of family farming, and instead the Managing Farm Owner(s) is central. Second, the findings redefine the influencing key factors in the given context. Specifically, the findings uncover which attributes suggested by the readiness literature as constituting specific key factors are, in fact, not relevant or applicable in the context of family farming. Moreover, the findings specify various attributes, adapting them to the context investigated. Finally, the findings uncover new, context-specific attributes of key factors influencing farms' readiness for digital innovation. Hence, these findings make a significant contribution to the readiness theory, especially to the concept of organisational readiness for digital innovation.

7.3 The Process of Gaining Organisational Readiness for Digital Innovation in the Australian Agricultural Sector

This research has identified that key factors must follow a specific sequence to influence the readiness for digital innovation, as will be discussed further in section 7.3.2. The sequential nature, which describes the process of gaining readiness for digital innovation in the context of the Australian agricultural sector, relies on interdependencies between the identified key factors.

7.3.1 Interdependencies

Data analysis revealed interdependencies between the identified key factors influencing the readiness for digital innovation of Australian farms. Specifically, the nature of the interdependencies was identified to be either enabling or reciprocal. The enabling nature refers to the readiness in regard to some factors being a prerequisite for the readiness of other factors. The reciprocal relationship refers to the influence some factors have on their enabling factors. The enabling as well as reciprocal relationships are summarised in Figure 24 where green arrows represent enabling relationships and orange arrows indicate a reciprocal influence.

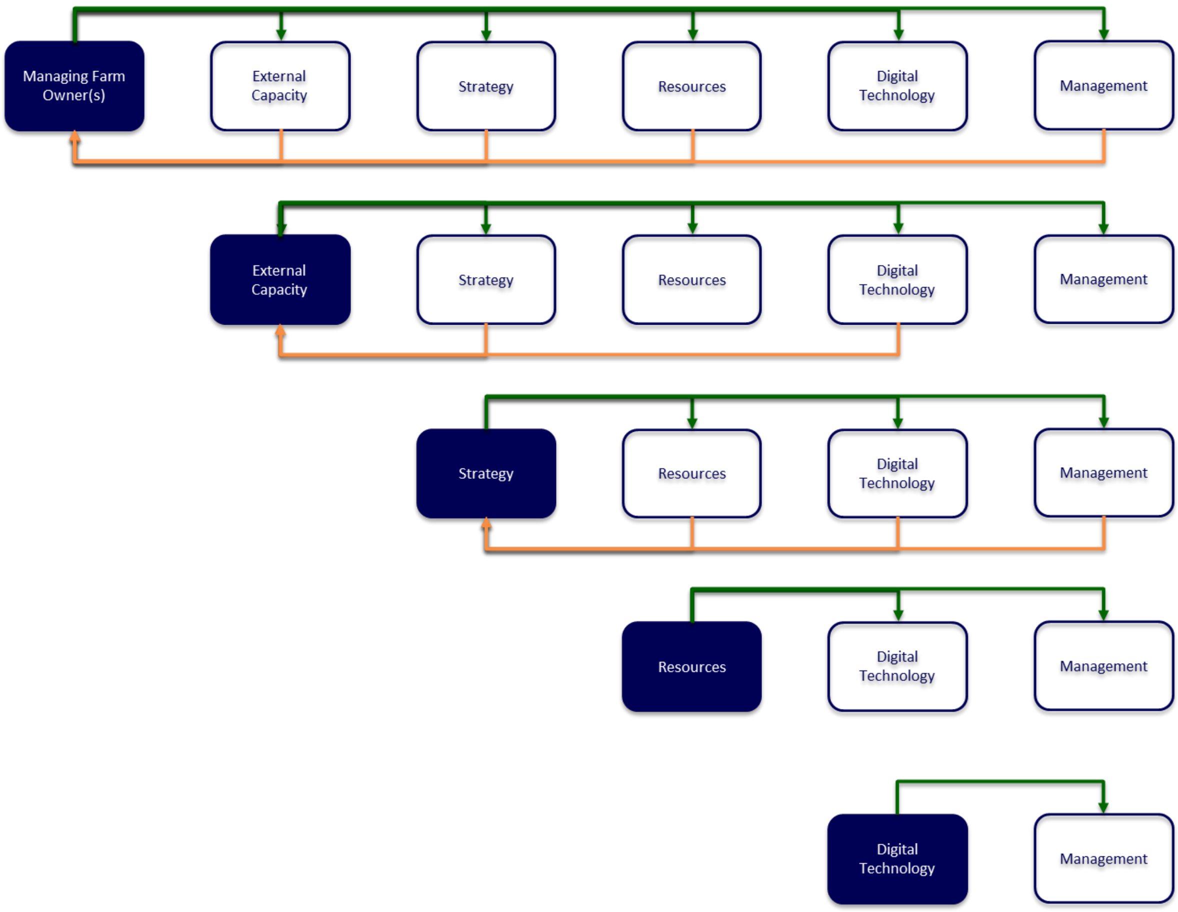

Figure 24: Interdependencies between the key factors identified to influence farms' readiness for digital innovation (green arrows represent enabling relationships while orange arrows represent reciprocal relationships)

The readiness literature reviewed in this thesis suggests interdependencies between factors influencing readiness as well. Scaccia et al. (2015), referring to innovation readiness, suggest a mutual relationship between the key factors 1) Resources (financial, human and IT-resources), 2) External Capacity (inter-organisational collaboration and external support), 3) Staff (perceived change valence and change efficacy), and 4) Management (leadership). Ruikar, Anumba and Carrillo (2006), referring to e-readiness, suggest a mutual relationship between the key factors 1) Staff (attitude towards technology adoption, change valence and change efficacy), 2) Management (leadership instrumentalising digital strategy), 3) Technology (IT availability and performance) and 4) Strategy (processes enhancing change). Sony and Naik (2019), referring to Industry 4.0 readiness, propose a mutual relationship between the key factors 1) Staff (adaptability), 2) Management (involved, committed and communicative leadership), 3) External Capacity (extent of digitalisation of supply chain), and

4) Strategy (clear organisational strategy, a high level of digitisation and smart products/services).

Some of these factors and their constituent attributes have been identified in this thesis as irrelevant in the context of digital innovation on family farms. As discussed in section 7.2.2, the key factor Staff does not have an influence on family farms' readiness for digital innovation, as only managing farm owner(s) are involved in digital innovation. Due to the limited number of individuals engaged in digital innovation on a farm, as well as the exploratory nature of innovating with digital technologies, discussed in section 7.2.1.4, no processes enhancing the incorporation of change, as suggested by Ruikar, Anumba and Carrillo (2006) are required. Furthermore, the External Capacity attribute of digitalisation of the supply chain, as suggested by Sony and Naik (2019), was not prominent in the interview data, as discussed in section 7.2.6.1. Finally, the Strategy attributes of clear organisational strategy, a high level of digitisation and smart products/services proposed by Sony and Naik (2019), were identified in this thesis to be irrelevant in the context of small Australian farms, as discussed in section 7.2.1.4. At the same time, this thesis identified additional factors and constituent attributes which influence the readiness of family farms to innovate with digital technologies, as discussed in section 7.2.

The relationships between factors and their attributes identified in this thesis as influencing organisational readiness for digital innovation in the context of the family farming are discussed in more depth in the following section.

7.3.1.1 Managing Farm Owner(s) and External Capacity

This thesis identified that the readiness of the Managing Farm Owner(s) influences the readiness in regard to the key factor External Capacity and is, in turn, influenced by the key factor External Capacity.

As discussed in section 7.2.6 farms rely on their innovation networks to acquire knowledge on digital innovation. Lowitt et al. (2020) found that a lack of networks or limited collaboration with networks limited the knowledge available on farms and therefore acted as a barrier to innovation. Due to the heterogeneity of knowledge required for digital innovation, in line with Hund and Wagner (2019), the digital innovators considered themselves to be part of multiple innovation networks. However, establishing and continuously interacting with innovation networks took them considerable time and money. These resources were outlined as necessary in order to participate in conferences, engage in (mostly online) discussions with peers, and identify and engage with subject experts as consultants, etc.

As all the farms investigated were financially limited and generally time poor, this research, comparing digital and non-digital innovators, identified that only managing farm owners who perceive the need for change, have a positive attitude towards digital technologies and are committed to realising digital innovation on their farm are willing to make the needed resources available and dedicate them to digital innovation. As these characteristics describe attributes of the key factor Managing Farm Owner(s), readiness in regard to this key factor is a prerequisite for Resource readiness.

The management literature supports the necessity of managerial change valence and positive attitude towards digital innovation to establish and maintain innovation networks, highlighting the related challenges, which include, for example, managing the partly competing organisations, bringing together various roles within an innovation network, satisfying varying interests and managing all parties' responsibilities (Ekboir & Initiative 2012; Keast & Hampson 2007). The literature too, recognises that managers need to have a specific mindset, as innovation networks have been shown to only enhance innovation if the focal firms' managers have capacity to scan and acquire external knowledge (change orientation and commitment) (Najafi-Tavani et al. 2018). This is consistent with the findings of thesis which uncovered the need for change orientation displayed in willingness to explore and realise future avenues of farming in order to benefit from engagement with external innovation networks.

While readiness of Managing Farm Owner(s) was found to be a prerequisite for achieving readiness in regard to External Capacity, once readiness of the key factor External Capacity is established, it influences readiness of Managing Farm Owner(s).

All of the participants stated that the innovation networks' opinions about the potential benefits of digital technologies contributed to establishing a positive attitude towards digital technologies. This finding supports the literature on digital innovation in the agriculture sector. As Pathak, Brown and Best (2019) identified, external feedback strongly influences the family farms' perception and eventually adoption of digital technologies. Farms have been shown to rely on their peers' opinion and experience acquired from the local as well as global network, accessed via social media (Pathak, Brown & Best 2019; Suchiradipta & Raj 2018).

Furthermore, the interaction with the innovation network was described as central to staying committed to digital innovation. Digital innovators explained that especially when encountering problems with technology adoption or application, sharing the experience with peers and being able to rely on their support or the service of other network partners is crucial to maintain the positive attitude towards digital technologies and continue their application. The agriculture literature describes digital innovation on farms as not straightforward, leading to challenges and problems (Cook et al. 2018; Zambon et al. 2019). Hence, learning from peers in the digital innovation context, as De Haes et al. (2020) suggest, is likely to enhance the success of digital innovation and therefore contribute to remaining committed to its realisation, as identified in this thesis.

The identified mutual influence of the key factor Managing Farm Owner(s) and External Capacity, consistent with the agriculture literature, is a significant finding, as it is new to the readiness literature. Readiness literature identifies the necessity of the key factor External capacity (detailed in section 7.2.6), however, due to the central role of Managing Farm Owner(s) being dependent on the family farming context, the relationship between these two factors has so far not been addressed by the readiness literature.

Hence, by establishing a connection between Managing Farm Owner(s) readiness and readiness in regard to External Capacity, this finding builds upon and extends the readiness literature in the context of family farms.

7.3.1.2 Managing Farm Owner(s) and Strategy

This thesis identified that the readiness of the Managing Farm Owner(s) influences the readiness of the key factor Strategy and is influenced by the key factor Strategy.

The findings revealed the necessity of managing farm owners perceiving a need for innovation with digital technologies and their benefits in order to make it part of their farm's strategy. This finding is in line with recent research that suggests that innovations are adopted based on their perceived benefits (Chavas & Nauges 2020). A potential explanation for this, is that digital technologies are continuously emerging and not yet well-established in the agriculture sector (Gandhi 2016), which leads to their usefulness being questioned (Annosi et al. 2019). Furthermore, due to the limited financial resources available (ANZ 2016; Block 2012), farms have only limited room for unprofitable investment, which can explain why farms only engage in digital innovation if they perceive the need for change and are convinced of the benefits that can be gained.

The thesis has identified change orientation and commitment of managing farm owner(s) as necessary to overcome the rural limitations and acquire the product and process knowledge necessary for digital innovation, by for example, going to conferences and field days, engaging in online discussion and following recent research developments on the topic. In line with this thesis, recent publications by Fielke, Taylor and Jakku (2020) and Silvestri et al. (2020) highlight the importance of knowledge sources outside of the local network when engaging in the digitalisation of agricultural innovation systems. Furthermore, the agricultural sector has been and remains subject to constant changes and requires continuous acquisition of new knowledge and skills to adapt its farming practice (Federation 1993; Kuehne et al. 2017). However, research has identified that farmers favour practical experience over theoretical knowledge (Lees & Reeve 1991; Salam 2020). Consequently, managerial change valence and commitment, as identified in this thesis, is required to access and gain knowledge on digital innovation and especially in order to overcome the hurdle of acquiring it outside of the familiar rural network.

Finally, the digital innovators interviewed displayed a positive attitude towards digital technologies, necessary to embrace digital innovation and create a shared culture among the family members engaged in the management of the farm. This finding is consistent with the management literature, which suggests that leaders influence the employees' innovative behaviour through their deliberate actions well as by their daily behaviour (De Jong & Den Hartog 2007). In the context of family farms in Australia, the farms' human resources consist mostly of family members and occasionally labourers or trade workers (ABARES 2018). Consequently, the farms' individuals have close relationships (Classen et al. 2012), and pursue the same economic and emotional goals, such as maintain the farm to ensure succession, provide all family members with work opportunities, and protect the farm's reputation (Alsos et al. 2003; Barbieri 2010; Binz et al. 2017; Chrisman & Patel 2012; Heck & Trent 1999; Olson et al. 2003).

As the managing farm owner(s) have been identified in this thesis to be the sole individuals on a farm engaged in digital innovation and therefore the only individuals on the farm knowledgeable in this regard, their attitude towards digital technologies evidently influences and likely determines the perception of digital technologies of the remaining members of the farm family. Hence, to create a shared culture that embraces digital innovation, the managing farm owner(s) must have a positive attitude towards digital technologies.

While readiness of Managing Farm Owner(s) must be established first in order to enable readiness in regard to Strategy, once readiness of the key factor Strategy is established, it has been revealed to influence readiness of Managing Farm Owner(s).

Digital innovators reported that the knowledge gained on digital technologies fundamentally shaped their attitude towards digital innovation, which the subject experts interviewed confirmed. Specifically, understanding the potential of digital technologies as well as how they can be integrated on the farm were identified as providing managing farm owners with more openness to try innovating with digital technologies.

This finding is in line with literature investigating technology adoption in the agricultural sector. High levels of adoption of precision farming, for example, require high intensity of information (Vecchio et al. 2020). Annosi et al. (2019) found that farms search for evidence-based knowledge prior to investment in digital technologies. Gathering information has been shown to help farmers learn about the existence of technology and its effective use (Phiri, Chipeta & Chawinga 2019) as well as the advantages and opportunities associated with their use (Vecchio et al. 2020). Furthermore, it can reduce the perceived complexity of the adoption process (Vecchio et al. 2020). Thereby, knowledge enables farmers to transition from a subjective opinion to an objective, fact-based perception of digital technologies (Mwangi & Kariuki 2015).

As discussed in section 7.2.1 and 7.2.2 the readiness literature only partly identifies attributes of Strategy readiness and focuses on the readiness of staff rather than managing farm owner(s), which are identified in this thesis as central to digital innovation of farms.

Hence, by establishing a connection between Managing Farm Owner(s) readiness and readiness in regard to the key factor Strategy, this finding builds upon readiness and agriculture research and extends the readiness literature in the context of family farms.

7.3.1.3 Managing Farm Owner(s) and Resources

This thesis identified that whilst managing farm owner(s) readiness is important for ensuring that the resources are in place to enact digital innovation, at the same time the availability of resources increased the managing farm owner(s) readiness.

The digital innovators stated that innovation with digital technologies was costly, time consuming and required an appropriate IT infrastructure, as discussed in section 7.2.4. At the same time, the digital innovators and subject experts, in line with agricultural research (Fleming et al. 2018; Kaler & Ruston 2019; Keogh & Henry 2016; Salam 2020), said that these resources were lacking. Therefore, to allocate the necessary monetary and time resources for digital innovation, as well as ensure the availability of the required IT infrastructure, this research identified the necessity of managing farm owner(s) being convinced of and committed to digital innovation. A recent review conducted by Pathak, Brown and Best (2019) supports this finding, identifying the ability and willingness for technology adoption as characteristics determining whether digital technologies are adopted on a farm.

While managing farm owners must be ready to make available and dedicate resources to digital innovation, the accessibility of these resources reflects on their openness to engage in digital innovation. Specifically, the analysis unveiled digital innovators' openness to digital innovation and the willingness to commit to its realisation on farms to be dependent on the availability of money and time, as well as the suitability and reliability of the IT infrastructure. This relationship is based on the risk perceived when engaging in digital innovation. As digital innovation is both costly and time intensive and dependent on the IT infrastructure, its lack poses a risk to a farm's existence. Fleming et al. (2018), for example, identified that the status of connectivity in Australia, especially in rural and remote regions, is perceived as a risk by farms. Family farms are risk averse because they are afraid of endangering the farming family's invested capital, its existence and ultimately the family legacy (Aimin 2010; Carney 2005; Suess-Reyes & Fuetsch 2016).

However, while scholars such as Pathak, Brown and Best (2019) suggest the need for a risk-taking climate on a farm to provide an environment fostering technology adoption, the findings of this thesis align more closely with the risk aversion perspective, in that Australian farmers tend to be risk-minimising. By minimising risk, managing farms owner(s) were more open to digital innovation and more confident about their ability to realise it once certain to possess the necessary resources.

The readiness literature, as discussed in section 7.2.4 acknowledges the need for specific resources in order to gain readiness for digital innovation. Scaccia et al. (2015), in line with the findings of this thesis, suggest a mutual relationship between an organisation's management, referring to its leading individuals, which in the context of family farming have been identified as the managing farm owner(s), and the availability of fiscal, human and IT-resources. However, the authors do not provide any specific information on the relationship, highlighting its dependence on the particular innovation.

Hence, this finding bridges the gap between the readiness and agricultural literatures and provides additional insights into the topic, confirming and specifying the mutual influence of the key factors Managing Farm Owner(s) and Resources in the context of family farming.

7.3.1.4 Managing Farm Owner(s) and Digital Technology

The findings of this thesis have unveiled that readiness of managing farm owner(s) influences the farm's ability to match its needs with potential digital technologies.

Gaining readiness in the factor Digital Technology requires farms to match a digital technology solution with a specific problem or need. However, before a technology fitting the farm's need(s) can be determined, first the managing farm owner(s) must perceive the need for change and have a positive attitude towards digital technologies, so that digital innovation is seen as a beneficial solution. Therefore, this thesis identifies the readiness of Managing Farm Owner(s) as an enabler for readiness in the key factor Digital Technology. This finding is in line with recent agricultural research which highlights digital technologies on farms being adopted based on their perceived benefits (Chavas & Nauges 2020). Annosi et al. (2019), for example, uncovered the managerial perception of technological usefulness as central for the uptake of smart agriculture and 4.0 technologies. Pathak, Brown and Best (2019) identified the need for a relative advantage provided by the digital technologies for the adoption of precision agriculture. The agricultural literature supports the need for change valence in order for farms to pursue change (Moerkerken et al. 2020).

Needing to perceive digital technologies as useful, beneficial and providing a relative advantage before going ahead with their acquisition originates from the farms' risk aversion. As previously explained in section 7.3.1.3, family farms being, and traditionally remaining through succession, solely in the hands of the farming family means that decisions are both economically and emotionally driven (Aimin 2010; Carney 2005; Suess-Reyes & Fuetsch 2016). Hence, the priority is the protection of the family's legacy, which in turn discourages risk-taking.

The readiness literature, as detailed in sections 7.2.2.1 and 7.2.2.2, while focusing on the employees and not the managing farm owner(s), highlights the need for the perception of change valence as well as a positive attitude towards change in general and digital technologies specifically to gain organisational readiness for digital innovation.

The readiness literature, in line with this thesis, identifies a relationship between the acquisition of technology and the perceived need for change as well as attitude toward technology adoption. Ruikar, Anumba and Carrillo (2006), referring to an organisation's staff members, suggest a mutual influence of the employees' attitude towards change, their perceived change efficacy and change valence on the availability and performance of technology. An explanation of the relationship, however, is not provided.

These findings bring together agricultural and readiness research and provide valuable new insights. They are significant as they specify the need for the managing farm owner to possess change valence and a positive attitude towards digital technologies, not employees, and they shed light on how these two factors are related and identify the relationship as unilateral in the context of family farming.

7.3.1.5 Managing Farm Owner(s) and Management

Finally, the readiness of a farm's managing farm owner(s) enables a management style which supports digital innovation. Furthermore, readiness in management activities has a reciprocal influence on the managing farm owner(s).

The digital innovators and subject experts both reported that the adoption of digital technologies does not automatically lead to its innovative application. The digital innovators reported taking on a leadership position in order to drive innovation with digital technologies. However, in order to execute such leadership, this research identified that the managing farm owner(s) required a perception of change valence, consideration of digital technologies as worthwhile, and commitment to digital innovation in order to be effective in its management.

The agricultural literature identifies that Managing Farm Owner(s) readiness is needed for the uptake of digital technologies on farms. Authors such as Annosi et al. (2019), Pathak, Brown and Best (2019) and Chavas and Nauges (2020) suggest that the managerial perception of technological usefulness, benefit and relative advantage is a prerequisite for farms adopting digital technologies. However, it does not provide insights into how and which managing farm owner(s) characteristics influence their ability to lead innovation with digital technologies on a farm.

The readiness literature, on the other hand, identified the need for top management commitment, which in the context of this thesis refers to the managing farm owner(s), as a prerequisite for institutionalising digital technologies in an organisation (Nguyen et al. 2019; Sony & Naik 2019). However, as the readiness research does not identify the managing farm owner(s) willingness and ability to drive innovation with digital technologies as dependent on the managing farm owner(s) readiness, this finding is significant.

While this thesis identified the necessity of managing farm owner(s) being ready in order to manage digital innovation on the farm, the readiness in regard to management has been revealed to reflect back on the managing farm owner(s) mindset towards digital innovation. The digital innovators stated that innovating with digital technologies and gaining positive experience in this regard has enhanced their openness to more change and has encouraged them to seek out other potential uses for the technology.

This finding is supported by the readiness literature. While focusing on employees, Weiner (2009) identified that having a positive past experience with digitalisation and an organisation's change efforts are prerequisites of readiness for future change events. In the farming context digital innovators reported that they rely on past experience to evaluate future risk. This relationship between past experiences and future decisions in the farming context originates from the farms' aversion to risk (Aimin 2010; Suess-Reyes & Fuetsch 2016).

Furthermore, research identified with a growing size of a farm an increase in risk taking (Inwood, SM & Sharp 2012; Sottomayor, Tranter & Costa 2011). Consequently, Australian farms, being small family farms, pay close attention to risk minimisation, re-evaluating their perception of change valence and re-adjusting their attitude towards digital technologies based on previous experiences. In line with this finding, Kernecker et al. (2020) identified that negative experiences with digital innovation leads to disillusion, and can hence cause a more hesitant approach towards digital innovation.

This finding expands on the existent readiness literature, enhances it with agricultural research and provides new insights into the mutual influence of managing farm owner(s) individual characteristics and their management style in the context of family farms.

7.3.1.6 External Capacity and Strategy

This thesis identified that the readiness of the key factor External Capacity influences the readiness of the key factor Strategy, and is influenced by it.

The digital innovators and subject experts both reported that the external innovation network was the primary source for product, process and data knowledge related to digital innovation in agriculture. They rely on external networks to understand which digital technologies can be adopted on a farm, and how and to what extent they can contribute to an innovative outcome. This finding is consistent with recent research on technology adoption in farming. Pathak, Brown and Best (2019) and Kernecker et al. (2020), for example, identify peers in the context of family farming as an important source of knowledge when adopting digital technologies in the agriculture sector. Authors such as Emerick and Dar (2020) and Belyaev et al. (2020) highlight the role of field days, where farmers can not only learn about digital technologies emerging in the agriculture sector and experience how they work first hand, but have discussions with engineers and dealers about how to use the technology too.

The importance of innovation networks as facilitators of knowledge on digital technologies becomes even more evident in light of the continuously increasing number and novelty of digital technologies available for farms (Salam 2020; Sundmaeker et al. 2016). Regardless of their prior experience with digital technologies, the digital innovators stated that they rely on the experience and support of their innovation networks. They explained that each digital technology operated differently and that even simple software updates could be problematic and require external help. They must regularly repair digital technologies too, which they are unable to do without the help of specialised mechanics. Consequently, farms require an innovation network in order to access relevant knowledge on and support with digital technologies when needed. As knowledge acquisition is an attribute of Strategy readiness discussed in section 7.2.1.2, External Capacity readiness is a prerequisite for a farm's Strategy readiness.

Once readiness of the key factor Strategy is established, it has a reciprocal influence on the readiness of the farms' External Capacity.

With a growing understanding of the spectrum and potential of digital technologies, the digital innovators stated that they increasingly rely on their innovation networks. The more aware of the opportunities for digital innovation they became, the more knowledge they acquire from their innovation network. This knowledge refers in particular to process and data knowledge detailed in section 7.2.1.2, which is irrelevant when gaining an overview of potential digital technology options, but which is, however, central when evaluating their applicability and the potential value that can be created.

The readiness literature, as discussed in sections 7.2.1.2 and 7.2.6.1, highlights the need for knowledge on digital technologies and the existence of an external network. A potential relationship between the external network and knowledge is identified by Scaccia et al. (2015), who, without providing detail, state that the existence and support of the external network has a mutual influence on human resources, which are the source of knowledge and skills within the organisation.

Hence, this finding, consistent with the readiness literature, confirms the mutual influence of External Capacity and Strategy in the context of family farming and extends it by explaining the relationship between the two.

7.3.1.7 External Capacity and Resources

This thesis identified that the readiness of the key factor External Capacity influences the readiness of the key factor Resources.

In order to make an informed decision about whether and which digital technologies are adopted on a farm, the digital innovators stated that they acquire knowledge on the costs of digital technologies, the infrastructure needed for their operation and the time necessary to use them for on-farm innovation. The digital innovators, in line with the subject experts, explained that they rely on their peers' experiences in this regard, as technology providers commonly overstate the potential of digital technologies and understate the resources needed for their application, providing unrealistic estimates to increase their sales. This finding is consistent with research which identified that farmers rely on knowledge from sources they trust, such as their peers (Schewe & Stuart 2017). The literature, in line with the findings of this thesis, provides multiple explanations for why farmers rely on peer experience.

First, the impact and potential profitability of digital technologies is often difficult to demonstrate (Mintert et al. 2016), hence peers are consulted to gain insights into the value created by digital technologies. Second, digital technologies are often developed in isolation, leading to a lack of interoperability between systems and not being user-friendly (Wolfert, Sørensen & Goense 2014), which the digital innovators interviewed in this thesis mentioned on several occasions. Third, the reliability of digital technologies is not always guaranteed (Uddin et al. 2016), as highlighted by the participants interviewed. Fourth, there is a lack of accountability for mismanagement of digital technologies (El Bilali et al. 2019), leaving farmers with immense investment into technologies they cannot operate, or which do not possess their advertised functionalities. Finally, as outlined before, farms have only limited financial resources and are risk averse as they fear endangering the family business (Aimin 2010; Carney 2005; Suess-Reyes & Fuetsch 2016). Consequently, the majority of farms rely on the experience of innovators and early adopters before investing in new digital technologies, as has been shown by Rogers (2010) to be the case for the diffusion of any innovation.

The readiness literature outlines the need for both External Capacity and Resources, as detailed in sections 7.2.6 and 7.2.4. Furthermore, Scaccia et al. (2015) identify a mutual relationship between these factors. However, they claim that the relationship is specific to innovation and do not provide any further details. While this thesis supports the existence of an influence of the key factor External Capacity on Resource readiness, it challenges the existence of a reciprocal relationship in the context of family farming. However, due to the lack of explanation of the relationships by the readiness literature, it remains unclear why the influence of the factor Resources on External Capacity readiness does not occur in the specific context investigated.

Building upon readiness research, clarifying and explaining the relationship between the factor External Capacity and Resource readiness, this is a significant finding.

7.3.1.8 External Capacity and Digital Technology

This thesis identified that the readiness of the key factor External Capacity influences the readiness of the key factor Digital Technology and is influenced by it.

This thesis identified that digital innovators ensure a common set of characteristics when acquiring a digital technology. More specifically, the digital technologies adopted are fit for purpose, have high usability and are compatible with the existent IT infrastructure. To evaluate whether specific digital technologies meet expectations in terms of the stated characteristics, digital innovators reported reaching out to and relying on their innovation networks, which is in line with Schewe and Stuart (2017) who identified peers as farmers' trusted source of opinion and experience. This behaviour can be explained, with research identifying that digital technologies are not always user-friendly or fit for purpose (Uddin et al. 2016; Wolfert, Sørensen & Goense 2014), and calling for more co-creation between stakeholders in the agriculture industry (Eastwood, Chapman & Paine 2009; Kaler & Ruston 2019; Paine & Kenny 2002).

Once farms identify and acquire digital technology that is a strategic fit and meets the expected characteristics, which corresponds with Digital Technology readiness, this thesis identified changes in the innovation networks to follow. To be able to operate and utilise newly acquired digital technologies, digital innovators reported having to acquire more knowledge by, for example, attending specific introduction days or joining new online communities, which led to the extension of their innovation networks. This reciprocal relationship, the digital innovators explained, is based on their need for more, and especially specific, knowledge from experienced experts and peers.

This finding is supported by Van Es and Woodard (2017), who describe digital agriculture as complex and multifaceted, requiring knowledge ranging from broad to specific. According to Van Es and Woodard (2017), applying digital technologies on farms is often more complex and less scalable than optimisation processes in other industries, such as manufacturing or communications, and it explains the necessity of extending the farms' innovation network to gain access to the required expertise and experience on the topic. This finding is supported by IS researchers Hund and Wagner (2019), who highlight the importance of heterogeneity of knowledge for digital innovation.

As discussed in sections 7.2.5 and 7.2.6, the readiness literature identifies the need for availability of IT as well as external networks. However, it does not acknowledge the necessity of interaction with the external network to choose a fitting technology, nor the influence the choice of digital technology has on the external network formation. This relationship is likely to be specific to the agricultural sector, due to the complexity and lack of scalability of digital technologies on farms which call for a higher level of expertise and experience. Hence, shedding light on the mutual influence of the factors External Capacity and Digital Technology in the farming sector, this finding builds upon the readiness literature and positions it in the context of family farms.

7.3.1.9 External Capacity and Management

Managing digital innovation on family farms was identified in this thesis to depend on the input of its innovation network.

As detailed in section 7.2.3, to unlock the innovative potential of digital technologies, management needs to drive innovation and focus on improving and enhancing operations and use. Digital agriculture, however, is complex and multifaceted (Van Es and Woodard (2017). Consequently, to ensure appropriate management of digital innovation, both the readiness literature and the findings of this thesis, discussed in section 7.2.1.2, highlight the importance of knowledge.

The farms investigated in this thesis reported that they lacked such knowledge. An example commonly used by the digital innovators was data analysis. Digital technologies create data, which can be analysed to provide more insights and in-depth information, enabling more informed decision-making. Research continuously highlights the immense benefits of data collection on farms (Saggi & Jain 2018; Shakoor et al. 2019). Yet, the majority of the digital innovators stated that they are not able to analyse the data and transform them into actionable knowledge. The experience of the digital innovators is reflected in other studies on family farms which find that family farms lack knowledge about and experience in value-adding with emerging technologies (Annosi et al. 2019; Bramley 2009; Franco, Singh & Praveen 2018).

Despite their inability to work with data, the digital innovators reported that they nevertheless harvested the potential of big data by consulting their innovation networks. By engaging peers, online forums, agronomists, consultants, etc., they managed to source the necessary knowledge and skills. Family farms insourcing knowledge and skills for digital innovation to compensate for their farm-internal knowledge limitations explains their strong engagement in inter-organisational knowledge exchange (Belyaev et al. 2020; Emerick & Dar 2020; Fielke, Taylor & Jakku 2020; Kernecker et al. 2020; Silvestri et al. 2020; Wójcik, Jeziorska-Biel & Czapiewski 2019).

This finding is in line with the readiness literature, specifically Scaccia et al. (2015), who identify a relationship between the existence and support of external networks and management, referring to leading innovation within the organisation. Scaccia et al. (2015) however, state that the specific relationship depends on the innovation.

Hence, this finding extends the existent readiness literature, explaining the necessity of an external network to gain knowledge on digital technologies to drive and improve the utilisation of digital innovation on a farm. Furthermore, contrary to Scaccia et al. (2015), who suggest a mutual influence of these factors, it specifies that the relationship is unilateral in the context of family farming.

7.3.1.10 Strategy and Resources

While Strategy and Resources are two factors contributing to a farm's readiness for digital innovation, this thesis identified that they influence each other.

Digital innovation, as discussed in section 7.2.4, has been identified by the readiness literature and the findings of this thesis to require resources, specifically financial, time and IT infrastructure. Research, in line with the participants interviewed in this thesis, however, point out that both financial means and time are scarce (Boza et al. 2019; Salam 2020). The IT infrastructure component, connectivity, especially in rural Australia, where the majority of farms are situated, has been identified by research and confirmed by digital innovators to not always be available and reliable (Fleming et al. 2018; Keogh & Henry 2016; Marshall, A et al. 2019).

Consequently, in order to make time and monetary resources available and dedicate them to digital innovation, it must be part of the farm's strategy. Furthermore, digital innovators, such as participant DI6 in this thesis, have shown that they can overcome connectivity issues. DI6 purchased and positioned shipping containers to re-direct mobile internet to the farm. Such extraordinary measures, however, were only taken because digital innovation is a priority in the farm's strategy. Hence, strategic readiness has been identified in this thesis as a prerequisite for achieving resource readiness.

In turn, scarcity of monetary resources has been identified in this thesis to discourage strategic long-term orientation in regard to digital innovation.

Due to the intra-family succession, and the need to protect the farming family's invested capital, farms pursue a long-term orientation (Bell, C 2019; Bohak, Borec & Turk 2010; Gasson & Errington 1993; Leonard, B et al. 2017). However, digital innovation, as discussed in section 7.2.1.1, is a long-term investment where returns are not guaranteed. Hence, having sufficient monetary resources to compensate for the lack of or delays in unlocking benefits of digital innovation on the farm has been highlighted by experts and the digital innovators to be a safety net, which eases the digital innovators' worries about potential mis-investment and encourages a long-term orientation. The same applies to the existence and reliability of connectivity, which the digital innovators say provides confidence in including digital innovation in the farms' strategies.

Furthermore, an improvement orientation, which this thesis identified as part of Strategy readiness, calls for financial means as any additional future acquisitions to expand the digital portfolio of the farm are associated with considerable costs. Advanced digital innovators, who apply a wide spectrum of digital technologies, reported continuously adding new digital technologies to their existing digital infrastructure in order to increase the farms' innovative outcome and unlock synergies from their parallel application. To focus on the improvement of farming practice by adding complementary digital technologies, again, as previously detailed, the farm requires sufficient monetary and time resources.

The influence of the availability of these resources on the farm's strategic orientation towards digital technologies originates from the farmers' priority to minimise risk. As previously detailed in sections 7.3.1.3, 7.3.1.4, and 7.3.1.7, farms are driven by their desire to limit the potential of failure. In line with agricultural research, the digital innovators stated that taking unnecessary risks endangers the farming family's invested capital, its existence and ultimately the family legacy (Aimin 2010; Carney 2005; Suess-Reyes & Fuetsch 2016).

The readiness literature does acknowledge the need for strategic readiness, discussed in section 7.2.1, and resource readiness, discussed in section 7.2.4, but does not identify their mutual influence. Hence, this finding is significant, as it unveils the relationship between these two readiness factors and provides insights into their mutual influence in the context of Australian family farms.

7.3.1.11 Strategy and Digital Technology

Strategy and Digital Technology readiness have been identified in this thesis as having an influence on each other.

Part of Digital Technology readiness is matching a digital technology with the farm's needs, as discussed in section 7.2.5.1. However, to match a digital technology with a farm's needs the farm's Strategy needs to focus on improvement. Furthermore, to ensure the adopted digital technology meets the characteristics of being fit for purpose, highly usable and compatible with the existent IT infrastructure, the respondents reported that they acquired product knowledge, which is part of Strategic readiness, discussed in section 7.2.1.2.

Due to the novelty of digital technologies in the agriculture sector (Gandhi 2016), and their wide and continuously growing spectrum (Salam 2020), family farms have been identified to not possess knowledge on digital technologies internally (Annosi et al. 2019; Bramley 2009; Franco, Singh & Praveen 2018), and therefore continuously acquire it externally (Emerick & Dar 2020; Fielke, Taylor & Jakku 2020). While knowledge acquisition is a prerequisite for acquiring appropriate digital technologies, section 7.3.1.8 discusses the implication of acquiring new digital technologies on the knowledge necessary for their operation and innovative application. As Van Es and Woodard (2017) highlight, digital agriculture is complex and multifaceted, requiring knowledge ranging from broad to specific. Hund and Wagner (2019) further stress the importance of heterogeneity of knowledge for digital innovation. Multiple digital innovators interviewed in this thesis described various challenges with using digital technologies and exploiting their innovative potential, explaining that they have consulted their innovation networks to extend their knowledge on the topic.

Consequently, the adoption of new digital technologies triggers the need for extension of the farms' knowledge about these technologies, meaning that Digital Technology readiness has an influence on Strategy readiness, which includes the attribute Knowledge Acquisition.

The readiness literature recognises to some extent the need for Strategy and Digital Technology readiness, discussed in more depth in sections 7.2.1 and 7.2.5; however, it does not recognise the reciprocal relationship between these factors. Hence, this finding outlining and providing insight into the mutual influence of these readiness factors in the context of digital innovation on family farms is significant, building upon and extending the existent readiness literature.

7.3.1.12 Strategy and Management

Finally, this thesis identified a mutual influence between the key factors Strategy and Management.

In the context of family farms this thesis has identified the key factor Management to be concerned with operationalising the farm's strategy. Specifically, it refers to taking leadership in driving digital innovation and improving the operation of and value creation with digital technologies, as discussed in detail in section 7.2.3. Evidently, the farm requires readiness in regard to the factor Strategy first, so that managerial activities can focus on its realisation. Moreover, digital innovators said that setting up, operating and exploiting the potential of a new digital technology, in line with the readiness literature discussed in section 7.2.1.2, required specific knowledge. Knowledge acquisition, being part of Strategy readiness, further supports the finding of Strategy readiness enabling readiness in regard to the factor Management.

While knowledge is required to start innovating with digital technologies on a farm, with management activities centring around operations' and value creation improvement, continuous learning and developing experience was identified in this thesis to generate and expand the farm's knowledge. Digital innovators, in line with research on digital agriculture (Annosi et al. 2019; Bramley 2009; Franco, Singh & Praveen 2018), reported that they often lack full understanding of how to operate digital technologies and use them to exploit maximum benefit. However, they explained that they gained confidence and know-how following the 'learning by doing' approach. Consequently, operationalising digital innovation as an attribute of the key factor Management contributes to knowledge acquisition, which is an attribute of

Strategy readiness. The practical approach of gaining knowledge on a new topic is supported by agricultural research identifying that farmers favour practical experience over theoretical knowledge (Lees & Reeve 1991; Salam 2020).

The readiness literature, as discussed in sections 7.2.1 and 7.2.3, acknowledges the need for Strategy and Management readiness. It recognises, as outlined by Scaccia et al. (2015), a mutual relationship between management and knowledge availability within the organisation; however, it does not provide in-depth insights into the relationship.

Hence, this finding, complementing and extending extant readiness literature, explains the reciprocal relationship between these factors and specifies it in the context of family farming, and is therefore significant.

7.3.1.13 Resources and Digital Technology

Investigating Resource readiness, this thesis uncovered that it is a prerequisite for Digital Technology readiness.

Digital Technology readiness is concerned with choosing digital technology that is a strategic fit with the farm’s needs and possesses specific characteristics, such as being fit for purpose, compatible with existing IT infrastructure and highly usable. Resources such as time, money and IT infrastructure have been identified in this thesis to be necessary for achieving Digital Technology readiness.

Financial resources are necessary to purchase digital technologies, which digital innovators, in line with the literature on digital agriculture (Shepherd et al. 2020; Vorotnikov et al. 2020) described as a considerable monetary investment. The resource time has been identified as a prerequisite for choosing new digital technologies. Digital innovators reported, for example, going to conferences and field days to gain understanding about a digital technology. However, research identified, in line with the digital innovators interviewed in this thesis, that digital technologies often lack interoperability and reliability (Uddin et al. 2016; Wolfert, Sørensen & Goense 2014). Consequently, digital innovators additionally had to acquire knowledge through their peers’ experience, which is perceived as a reliable reference (Schewe & Stuart 2017). All of these activities, necessary to ensure finding a digital technology which will satisfy the farm’s expectations, require time. Finally, IT infrastructure, particularly connectivity, is required to operate digital technologies (Bacco et al. 2019; Virk et al. 2020). As it is not always available and reliable in rural areas, where the majority of farms are situated (Fleming et al. 2018; Keogh & Henry 2016; Marshall, A et al. 2019), it must be established prior to using digital technologies.

The readiness literature acknowledges the necessity of resources, however, does not address its influence on Digital Technology readiness. Hence, identifying and explaining the influence of Resource readiness on Digital Technology readiness in the context of family farms, this finding is significant.

7.3.1.14 Resources and Management

Besides Digital Technology readiness, this thesis identified that Resource readiness enables Management readiness.

Improving the operation of digital technologies and maximising the value generated by their application has been identified in this thesis as part of management readiness. In order to successfully improve the operation of and value creation with digital innovation, process and data knowledge are required, as discussed in section 7.3.1.12

However, this thesis, in line with agricultural research (Annosi et al. 2019; Bramley 2009; Franco, Singh & Praveen 2018), identified that farms lack such knowledge. Further, this research has revealed that the digital innovators acquire this knowledge via their innovation network, as discussed in section 7.2.6, as well as on the job, referring to the experimentation with digital technologies. Both of these approaches require time. When engaging, for example, agronomists and consultants, time too must be invested in the process of identifying the right expert, and then cooperating with and applying the actionable knowledge they offer. When farms experiment autonomously with digital technologies, the digital innovators said that they needed time to explore, try, make errors and eventually learn and understand how they can be applied. Furthermore, when experts are consulted, monetary resources for their fees are a prerequisite for receiving the service. Consequently, resource readiness, referring to the availability of financial and time resources, is a prerequisite of Management readiness.

This is a significant finding, as the influence of availability of resources on the readiness of managing digital innovation has only been outlined but not explained in the readiness literature (Scaccia et al. 2015). Furthermore, in line with Scaccia et al. (2015), who stress that the relationship depends on the particular innovation, the explanation of the relationship discussed in this section is likely specific to the family farming context, due to its peculiarities.

Digital technologies are fairly new to the farming sector (Salam 2020), and not yet fully established (Gandhi 2016). Hence farms are not yet experienced in their application.

Furthermore, family farms, consisting of the farming family and occasionally labourers and trade workers, lack human resources experience in IT and innovation, which the readiness literature suggests is necessary for digital innovation, as discussed in section 7.2.2. In order to compensate for this knowledge gap, family farms reach outside of their organisational boundaries for support as well as experiment themselves, which requires considerable time investment.

As organisations outside of the rural and technologically inexperienced context are more likely to have already gained empirical knowledge with digital innovation (Gandhi 2016), and can employ internal specialists, the time invested to acquire knowledge on the operation and exploitation of digital technologies is negligible, compared to the family farming context. Consequently, this finding is significant as it specifies the relationship for the context investigated.

7.3.1.15 Digital Technology and Management

Finally, this thesis identified that Digital Technology readiness influences readiness in the key factor Management.

Being ready in the key factor Digital Technology has been identified in this thesis to include adopting a digital technology which fits the farm's needs, as well as meets characteristics such as being fit for purpose, compatible with the existing IT infrastructure and highly usable. Choosing digital technologies which fit these attributes has been identified as a prerequisite for being able to innovate and create value, as those digital innovators who failed to do so reported having considerable problems, involving additional investment, delays and losses. For example, a digital innovator who acquired a field mapping software which was not user-friendly reported not being able to use it, which led to the purchase of other software programs and created additional work manually transferring data between the programs.

This finding is in line with the readiness literature, which identifies a relationship between the factors Technology and Management. Specifically, Ruikar, Anumba and Carrillo (2006) suggest a mutual influence between management orchestrating an organisation's strategy to derive benefits from technology application and the availability and high performance of technology. Contrary to Ruikar, Anumba and Carrillo (2006), however, this thesis identifies that the relationship is unilateral in the context of family farming. Furthermore, as the authors do not address the nature of the relationship, this finding provides additional insights into the mechanisms and peculiarities of the relationship in the given context.

In summary, relationships between factors are rarely addressed and explained by the readiness literature. In regard to the specific concept of organisational readiness for digital innovation, no research on factor relationships exists.

Moreover, the discussion in section 7.3.1 uncovers the necessity of specifying relationships in the context of family farming, which has so far not received academic attention. Hence, this thesis, by uncovering and explaining the relationships between factors influencing family farms' readiness for digital innovation, makes a significant contribution to the body of knowledge on organisational readiness for digital innovation in the context of family farming.

Furthermore, uncovering a difference in relationships, specifically enabling and reciprocal relationships, provides further depth to insights into the prerequisite of readiness for digital innovation, as well as its dynamics.

7.3.2 Process

The previous section discussed the interdependencies between the factors identified in this thesis that influence family farms' readiness to innovate with digital technologies. These interdependencies have been identified as either enabling or reciprocal. For example, while readiness in regard to the factor External Capacity has been identified as a prerequisite for gaining Strategy readiness (enabling interdependency), Strategy readiness, once achieved, has been unveiled to reflect back on External Capacity readiness (reciprocal interdependency).

The analysis of the enabling relationships has uncovered a specific order in which the identified key factors become relevant, as illustrated in Figure 25.

The factor Managing Farm Owner(s) is the first factor, as it enables all other key factors. External Capacity is the second factor, as it has an enabling influence on all key factors but Managing Farm Owner(s). The third factor is Strategy, as it is enabled by the first and second factor and enables all remaining key factors. The fourth factor is Resources, as it is enabled by the factors 1) Managing Farm Owners, 2) External Capacity and 3) Strategy, and, in turn, enables the remaining key factors. Digital Technology is the fifth factor, enabled by all previous factors and enabling the key factor Management readiness. Finally, Management is the last factor, as it is enabled by all other factors and is not a prerequisite for any factors.

Figure 25: The sequence of key factors indicating the order in which they become relevant

This finding is significant as it contradicts both the readiness and management literatures, which identify Strategy as the central factor enabling readiness and digital innovation.

Sony and Naik (2019) highlight strategy as the most important ingredient for Industry 4.0 readiness. Management research on digital transformation continuously highlights the centrality of Strategy for enabling organisations to adopt and apply digital technologies. Kane et al. (2015), for example, identify strategy to be the main driver of digital transformation. Hess et al. (2016) and Matt, Hess and Benlian (2015) stress the necessity of formulating and executing a strategy to enable digital transformation. Digital innovation research, investigating how firms can improve their product and process innovation, puts the development of a strategy as the first milestone to success (Nylén & Holmström 2015). Pisano (2015) goes as far as calling a lack of strategy the reason why some innovation efforts continuously fail and some firms are unable to sustain innovation performance. In this research, the managing farm owner(s) readiness and not strategy has been identified as central, based on the specific context of family farms. In family farming, the managing farm owners are the only individuals determining and executing Strategy (Aguilera & Jackson 2003; Block 2012). Consequently, to make digital innovation a strategic priority, they must first perceive a need for change and have a positive attitude towards digital technologies, so that digital innovation is seen as a worthwhile solution, as discussed in detail in section 7.3.1.2.

The sequential order of key factor relevance in the process of family farms gaining readiness for digital innovation is significant as it contradicts existent readiness literature, especially Ruikar, Anumba and Carrillo (2006) theory. While the majority of the readiness literature reviewed in section 2.4 only presents hierarchical models outlining factors influencing organisational readiness, Ruikar, Anumba and Carrillo (2006) address the process of gaining readiness. The authors suggest that all factors go hand in hand, which indicates the assumption that readiness is gained by achieving readiness in all influencing factors in parallel.

Additionally, this research has discovered that, despite being sequential, the process of gaining readiness is not linear. The complexity of the process is grounded in the reciprocal relationships previously discussed in section 7.3.1. Specific factors have been identified as reflecting back on previous factors, as illustrated in Figure 26.

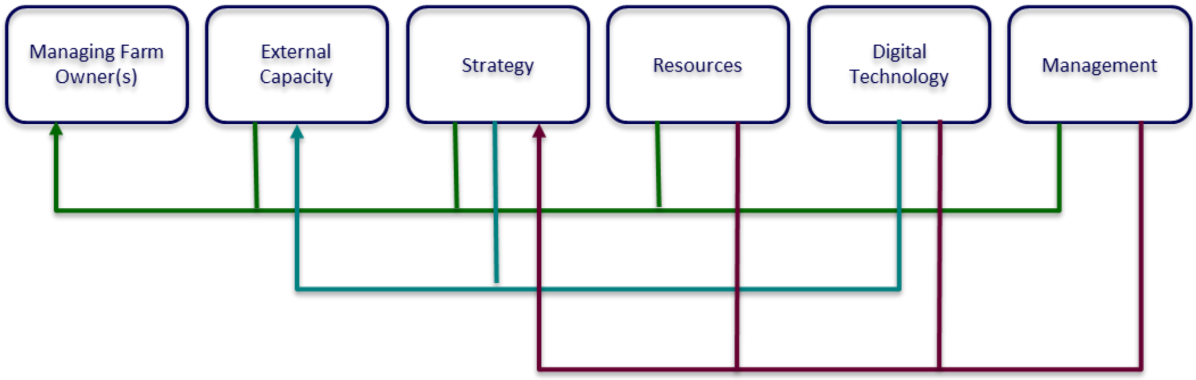

Figure 26: Reciprocal influence of key factors influencing readiness of family farms to innovative with digital technologies (indicated by the depicted arrows)

This study differentiated between less experienced digital innovators and advanced digital innovators (who possess extensive knowledge, use a wide range of different digital technologies to innovate and use synergies of different digital technologies), which allowed the researcher to gain further insights into the process of gaining organisational readiness for digital innovation in the given context. As readiness is not a dichotomous variable but a continuum (Holt, Armenakis, Feild, et al. 2007), a comparison in regard to the identified key factors between digital innovators and advanced digital innovators shed light on the process of moving along the readiness spectrum towards a higher degree of organisational readiness for digital innovation.

The analysis revealed a shift in focus and extent between some attributes of the key factors, illustrated in Table 17. Managing farm owner(s) who were advanced digital innovators predominantly work on the computer and question how and why digital technologies function in a certain way. Moreover, advanced innovators were discovered to have thematically wider and more knowledgeable innovation networks. In regard to the key factor Strategy, this thesis uncovered advanced digital innovators possess data knowledge in addition to product and process knowledge, referring to when, what and how to collect, analyse and interpret data. In regard to resources, advanced digital innovators were found to invest considerably more time than digital innovators on digital innovation. Finally, the comparison in light of the factor Digital technology revealed that digital innovators were less interested in usability and more interested in the innovative potential of digital technologies.

This finding is significant, as readiness is commonly conceptualised as a continuum (Holt, Armenakis, Feild, et al. 2007). However, the literature has only investigated factors necessary to gain readiness without considering how they might change as an organisation's level of readiness increases (Lokuge et al., 2019; Sony and Naik, 2019; Weiner, 2009). Therefore, uncovering changes in factors influencing organisational readiness for digital innovation with an organisation's evolving readiness is a significant finding.

Table 17: Specific attribute characteristics of advanced digital innovators

Key factors of organisational readiness for digital innovation	Specific attributes characteristic for advanced digital innovators
Managing Farm Owner(s)	• Enjoy and hence enforce predominantly working on the computer • Questioning of how and why digital technologies work a certain way
External Capacity	• Wider and deeper knowledge networks (bigger thematic scope and more in-depth knowledge)
Strategy	• Data knowledge (when, what & how to collect, analyse and interpret data)
Resources	• Intense time investment (e.g. oversea trips, writing own code)
Digital Technology	• Less focus on usability, more interested in output and innovative potential
Management	• No specific characteristics

However, besides these identified changes in focus and extent, the comparison of digital innovators and advanced digital innovators identified that the latter maintained readiness in regard to each of these identified key factors. Hence, regardless of where along the readiness spectrum a family farm is situated, once the readiness in regard to a key factor is achieved, it is sustained.

Bringing together these findings, this thesis identified the process of family farms gaining readiness for digital innovation, as illustrated in Figure 27 and summarised in the following section.

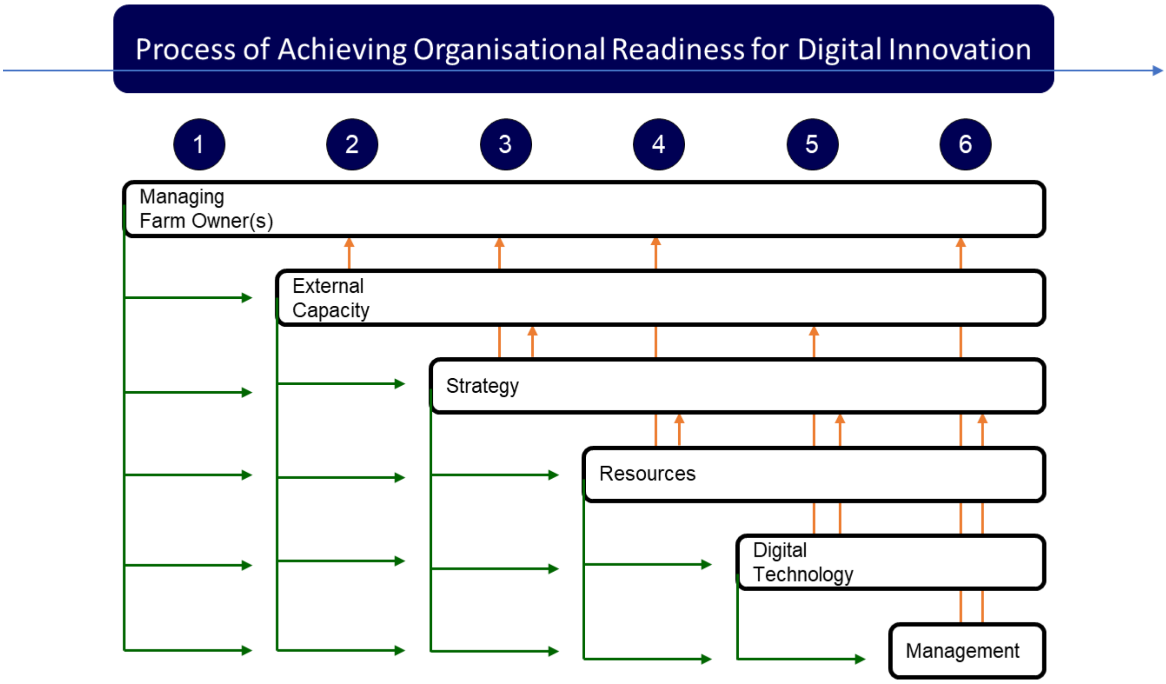

Figure 27: The process of gaining readiness for digital innovation on family farms ((green arrows represent enabling relationships while orange arrows represent reciprocal relationships))

The process consists of six stages. In each stage readiness in regard to a specific key factor is gained, enabling readiness in regard to the following key factors. Furthermore, readiness in regard to the previous key factors must be sustained. Finally, the reciprocal relationships identified in each stage influence the preceding key factors. The exact mechanisms are detailed in the following.

Stage 1: Readiness of key factor Managing Farm Owner(s) is gained, enabling the following key factors.

Stage 2: Readiness of key factor External Capacity is gained, enabling the following key factors and reflecting back on the key factor Managing Farm Owner(s). Readiness of the previous key factor is maintained.

Stage 3: Readiness of key factor Strategy is gained, enabling the following key factors and reflecting back on the key factors Managing Farm Owner(s) and External Capacity. Readiness of the previous key factors is maintained.

Stage 4: Readiness of key factor Resources is gained, enabling the following key factors and reflecting back on the key factors Managing Farm Owner(s) and Strategy. Readiness of the previous key factors is maintained.

Stage 5: Readiness of key factor Digital Technology is gained, enabling the following key factors and reflecting back on the key factors External Capacity and Strategy. Readiness of the previous key factors is maintained.

Stage 6: Readiness of key factor Management is gained, enabling the following key factors and reflecting back on the key factors Managing Farm Owner(s) and Strategy. Readiness of the previous key factors is maintained.

This finding is significant as it evaluates the relevance of process-related assumptions of the readiness literature in the context of family farming, and builds upon the readiness research, specifying the process of family farms gaining readiness for digital innovation.

Processes are what define and continuously re-define an organisation (Weick 1995). Hence, research calls for more organisational process studies (Langley et al. 2013; Reay et al. 2019). However, the readiness literature on the procedural nature of achieving readiness entities is limited and not specific to the family farming context, as discussed in this section. Hence, this thesis makes a significant contribution to the readiness literature and specifically the concept of organisational readiness for digital innovation in the family farming context by

1) providing insights into how and why factors influence each other, 2) articulating the underlying mechanisms of gaining readiness for digital innovation on small family farms, and 3) identifying and detailing the process of gaining such readiness.

7.4 Revised Conceptual Framework

This thesis aims to uncover factors influencing Australian farmers' readiness for digital innovation and further understand the specific process of gaining this readiness. The initial theoretical framework, as detailed in section 2.5 and visualised in Figure 28, was developed based on related readiness concepts: 1) readiness for innovation, 2) e-readiness, 3) readiness for Industry 4.0, 4), digital readiness, 5) readiness for change, and 6) readiness for digital innovation.

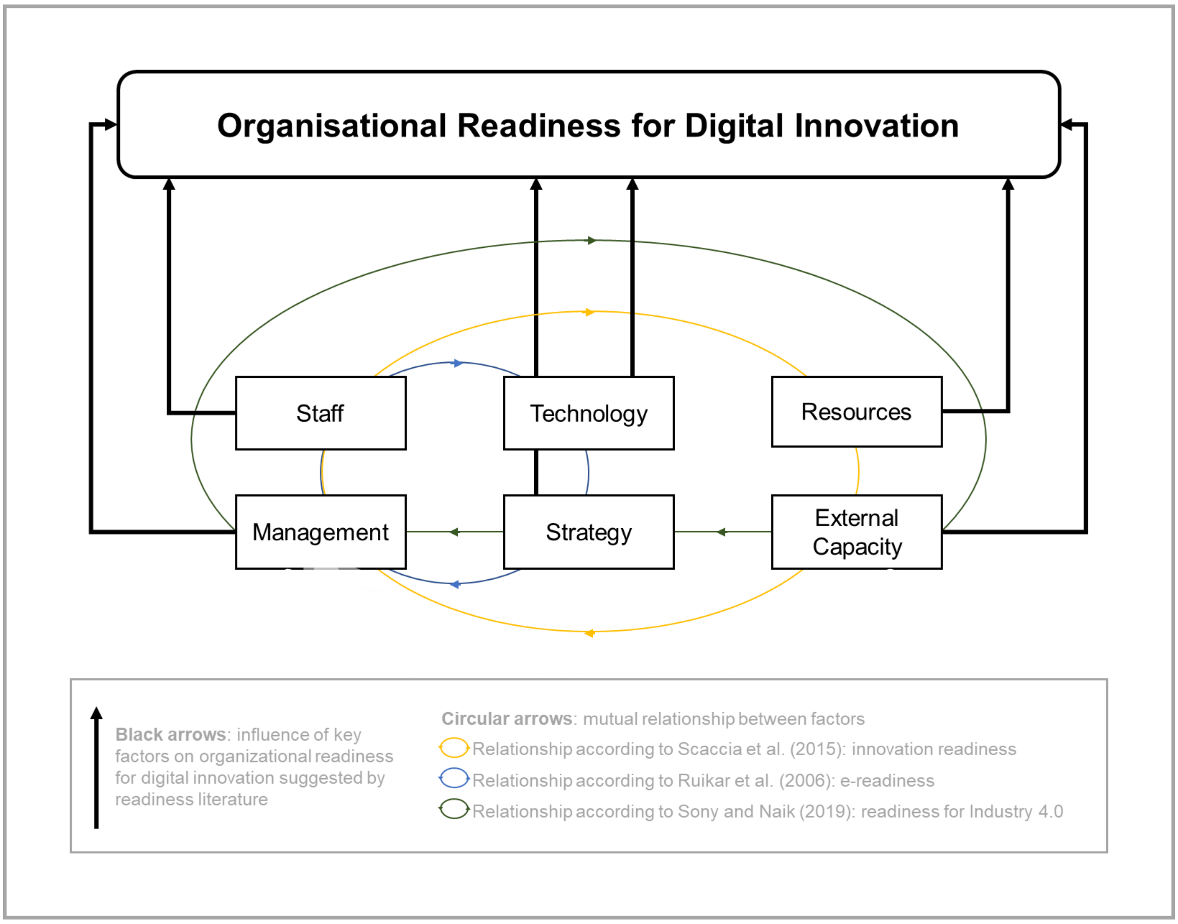

Figure 28: Initial theoretical framework

This initial theoretical framework, blending the ideas of these relevant readiness theories, highlights that the factors Staff, Technology, Resources, Management, Strategy and External Capacity influence organisational readiness for digital innovation and specifies the attributes detailed in Table 18 as constituting the respective factors (the colouring of the attributes will be discussed later).

Table 18: Attributes of readiness factors identified in the initial theoretical framework

Key Categories	Aspects of Respective Category
Strategy	• Clear organisational strategy (that implements change) • Firm structure, financial management and processes support innovation • The organisation possesses a high level of digitisation • Processes are agile and standardised enhancing incorporation of change • Organisation is proactive and responsive to digital opportunities • Roles in regard to digitalisation are designated • Necessary information and knowledge exist within the organisation • Organisational culture characterised by idea sharing, decentralised decision-making and shared values, behavioural patterns and set norms that creates a supportive and encouraging environment • Products/Services are, if possible, designed smart
Management	• Project Management is existent and focuses on clients, quality assurance and facility design • Leadership throughout hierarchies focuses on constant improvement by being involved, committed and collaborative to communicate and inspire the IT vision throughout all levels • IT-support for communication, coordination, integration and tasks is available
Technology	• IT is available and well performing • IT is applicable throughout the organisation. • IT enables information sharing and automated information processing
Resources	• Financial, human and IT infrastructure resources are available and flexible for utilisation
Staff	• Positive attitude and perception towards technology adoption • Employees perceive change valence • Employees perceive change efficacy • Employees have positive past experience with change • Employees are adaptable • Employees are committed to digitalisation • Employees possess innovation specific knowledge and skills as well as experience in IT and innovation
External capacity	• Inter-organisational collaboration and external support • Extent of digitisation of supply chain

Furthermore, the initial framework suggests mutual relationships between the influencing factors, indicated by circular arrows in Figure 28. Based on Scaccia et al. (2015) the factors Staff, Management, External Capacity and Resources are highlighted to mutually influence each other (yellow arrows). Borrowing from Ruikar, Anumba and Carrillo (2006) the factors Staff and Management are indicated to have a mutual relationship with the factors Technology and Strategy (blue arrows). Additionally, relying on Sony and Naik (2019), the factors Staff, Management, Strategy and External Capacity are suggested to have a mutual influence on each other as well (green arrows).

The readiness concepts used for the initial theoretical framework are generic. The revised conceptual framework brings together the ideas of extant literature and the findings of this thesis, specifying organisational readiness for digital innovation in the context of family farms. Figure 29 illustrates the revised conceptual framework. The black arrows indicate the influence of the identified key factors on family farms' readiness for digital innovation. Green arrows visualise the enabling relationships between the factors. Orange arrows depict the reciprocal influences identified between the key factors. The numbering indicates the order in which key factors become relevant in the process of gaining readiness for digital innovation. Finally, the key factors are presented in a waterfall model highlighting the necessity of maintaining readiness in regard to each key factor once it is gained. The revised conceptual framework, visualised in Figure 29, incorporates 1) the findings explaining the complex process of gaining readiness for digital innovation, and extends it by 2) the factors and their constituting attributes influencing readiness for digital innovation in the context of family farming.

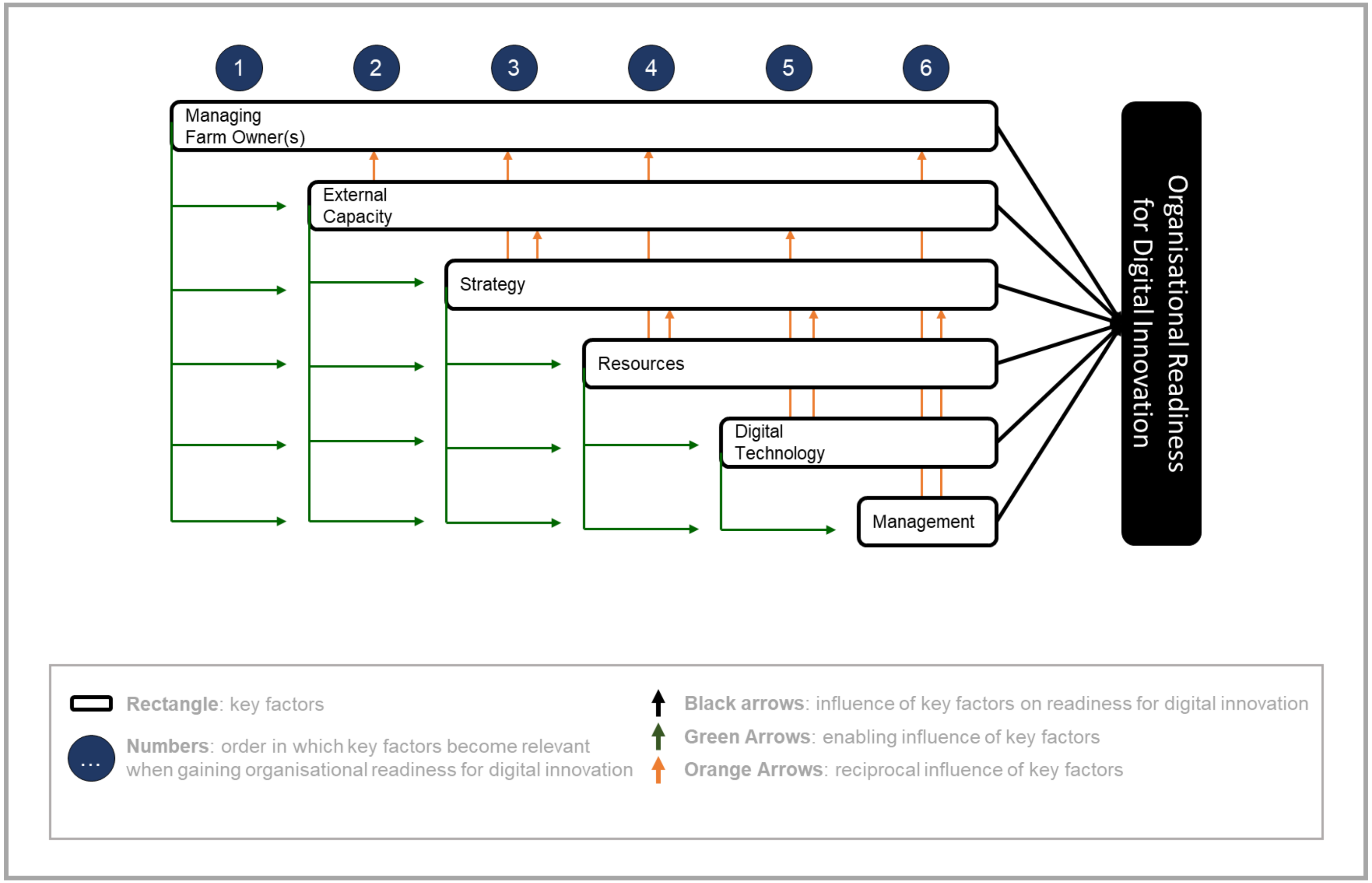

Figure 29: Revised conceptual framework

This framework supports the relevance of the key factors External Capacity, Strategy, Resources, Digital Technology and Management as influential for organisational readiness for digital innovation in the context of family farming. It clarifies attitudes and perceptions of employees toward digital innovation to be irrelevant in the given context, bringing forward the surprising finding of the centrality of managing farm owner(s) influence on a family farm's readiness for digital innovation. Moreover, this framework refines the attributes defining readiness in regard to each of the presented key factors in the context of family farming, as indicated in Table 18. Attributes derived in the initial theoretical framework, which are consistent with the findings of this thesis, are depicted in green, attributes specified in the context of family farms are depicted in orange, and attributes identified as less relevant in the given context are depicted in red. Furthermore, the framework provides insight into new, context-specific attributes, so far not considered by readiness literature. Specifically, it 1) highlights the necessity of managerial activities that focus on operations management, 2) stresses the centrality of time as a resource, and 3) outlines the importance of adopting a digital technology that is a strategic fit. An overview of all key factors and their constituting attributes is presented in Table 19.

Table 19: Attributes of readiness factors identified in the revised theoretical framework

Key factors	Constituting Attributes
Strategy	• Strategic Orientation • Knowledge Acquisition • Culture
Managing Farm Owner(s)	• Change Valence • Positive Attitude towards Digital Technologies • Mindset
Management	• Leadership • Operations Management
Resources	• Financial • Time • IT infrastructure
Digital Technology	• Strategic Fit • Characteristics
External Capacity	• Network • Inter-organisational Exchange and Support

Finally, the revised framework sheds light on the interdependencies between the key factors, differentiating between enabling and reciprocal relationships (indicated by green arrows for enabling and orange arrows for reciprocal influence in Figure 29). These relationships allow conceptualisation of the process of how family farms gain readiness for digital innovation. While the revised conceptual framework is similar to the initial framework with regard to the key factors influencing organisational readiness for digital innovation (with the only difference being managing farm owner(s) and not staff being influential), it differs substantially in all other aspects.

The revised framework retains only a small number of attributes suggested by extant readiness literature, because the remainder are not specific to the research context of this thesis. Other attributes derived from extant readiness literature have been adapted and specified for the family farming context in the revised framework. Moreover, new attributes are added, in particular 1) the need for managerial focus on operations management with digital technologies, 2) the need for the resource time when engaging in digital innovation, and 3) the importance of a strategic fit between a farm and the digital technology adopted. These attributes are context-specific, reflecting the lack of experience with digital innovation within family farms, the prevalent lack of time, digital innovation being the responsibility of only the managing farm owner(s), and the limited financial resources, coupled with risk aversion originating from the duty of protecting the family legacy.

The initial framework suggests circular relationships between specific key factors, indicating interdependencies that, however, are not further explained. The revised framework, on the other hand, is based on an in-depth investigation into digital innovation on family farms. It differentiates between enabling and reciprocal relationships uncovered in this thesis and identifies all existing relationships. Hence, in contrast to the initial generic theoretical framework, the revised framework is more elaborate and detailed, as it specifies the relationships between key factors in the context of family farming.

Finally, the majority of the readiness literature does not address the procedural nature of gaining organisational readiness for digital innovation. Only Ruikar, Anumba and Carrillo (2006) suggest that all factors go hand in hand, implying that readiness is gained by achieving readiness in all factors in parallel. Hence, the initial framework does not comprise any procedural aspects. This thesis, however, shed light on the complex process of family farms gaining readiness to innovate with digital technologies. Consequently, the revised conceptual framework reflects the findings, incorporating the procedural nature of family farms gaining readiness for digital. Specifically, it includes the identified 1) order in which the identified key factors become relevant in the process of gaining the specific readiness, 2) enabling and reciprocal relationships, and 3) the necessity of maintaining readiness in regard to each key factor.

The revised framework provides a holistic perspective on organisational readiness for digital innovation on family farms by identifying and defining influencing factors, uncovering their interdependencies, and conceptualising the process involved in gaining readiness. Furthermore, it makes a significant contribution to the readiness literature, specifically the concept of organisational readiness for digital innovation, by identifying context-specific boundaries of extant readiness literature and refining the concept in the context of small family farming. While grounded in theory and empirically enhanced, it is nevertheless practical, allowing others to derive actionable knowledge for practice.

7.5 Summary

Guided by the research questions, this chapter has discussed the findings of this thesis in light of extant readiness literature and agricultural research. The discussion addressed 1) the key factors influencing family farms' readiness for digital innovation, 2) the relationships between the key factors, and 3) the process of family farms gaining readiness for digital innovation. Finally, the chapter concluded with a revision of the theoretical framework, initially derived from thematic literature in chapter 2. Discussing the findings of this thesis in relation to extant readiness literature, it highlighted the significance of the findings of this thesis and outlined their contribution to the theoretical body of knowledge.

Chapter 8: Conclusion

8.1 Objective

This chapter provides an overview of the key findings, outlines the contributions to the body of knowledge, and implications for practice. Furthermore, limitations of this thesis are outlined and directions for future research are presented.

8.2 Significant Findings

Investigating factors that influence the readiness for digital innovation of family farms, the thesis identified that Managing Farm Owner(s), External Capacity, Strategy, Resources, Digital Technology and Management play a significant role.

Managing Farm Owner(s) are considered to be ready when they perceive change valence, have a positive attitude toward digital technologies and a mindset characterised by change orientation and commitment to digital innovation. Readiness in regard to the factor External Capacity consists of being part of and engaging with an innovation network. Strategy readiness involves farms having a long-term and continuous improvement orientation, acquiring knowledge on digital technologies, which involves overcoming rural limitations, and having an organisational culture that embraces digital innovation. Resources required for digital innovation readiness include financial means, time and IT infrastructure, referring to connectivity and respective hardware. Digital Technologies, which contribute to farms' readiness for digital innovation, have to be a good strategic fit with the farm and meet specific characteristics, in particular be fit for purpose, compatible with the existing IT infrastructure, and highly usable. Finally, readiness in regard to Management activities consists of leadership driving digital innovation on the farm and operations management which focuses on the improvement of operations and value creation with digital technologies.

Exploring the process, this thesis identified gaining readiness for digital innovation to mean gaining readiness in regard to the influencing key factors in a specific order, starting with Managing Farm Owner(s), followed by External Capacity, Strategy, Resources, Digital Technology and finally Management. Despite the linearity suggested by the specific order, this research uncovered interdependencies between the factors – enabling and reciprocal – which provide additional insights into the complexity of the process.

Additionally, conceptualising readiness as a continuum, this thesis presents the first effort to analyse the changes that occur in regard to the relationship between key factors when moving along the readiness spectrum. Comparing digital innovators and advanced digital innovators in the family farming context, this thesis identified that, for the latter group, as readiness increases, previously gained readiness is maintained. Furthermore, the focus of some attributes shifts. Specifically, 1) Managing Farm Owner(s) work predominantly on the computer and question how and why digital technologies work a certain way, 2) the innovation networks comprise a wider thematic scope and more in-depth knowledge, 3) knowledge on data collection, analysis and interpretation is acquired, 4) a considerably higher amount of time is invested into digital innovation on the farms, and 5) usability becomes less important, while farmers show more interest in the innovative potential of digital technologies.

Finally, this thesis identified farms' employees to be irrelevant for enhancing readiness for digital innovation on farms, as the managing farm owner(s) were discovered to be the only individuals involved in the adoption, application and innovation of and with digital technologies. This highlights the centrality of the managing farm owner(s) role in regard to a farm's readiness for digital innovation.

Bringing together all findings, this thesis developed a framework of organisational readiness for digital innovation for family farms, discussed in detail in section 7.4 and visualised in Figure 30. The purpose of this framework is to provide a comprehensive and structured approach explaining readiness for digital innovation on family farms. Therefore, the rectangles and black arrows illustrate the key factors identified as influencing family farms' readiness for digital innovation. The relationships between the key factors are indicated by the coloured arrows: green arrows represent enabling influences and orange arrows represent reciprocal influences. The numbering indicates the order in which key factors become relevant in the process of gaining readiness for digital innovation. Finally, the key factors are presented in a waterfall model, highlighting the identified necessity of maintaining readiness in regard to each key factor once it is gained.

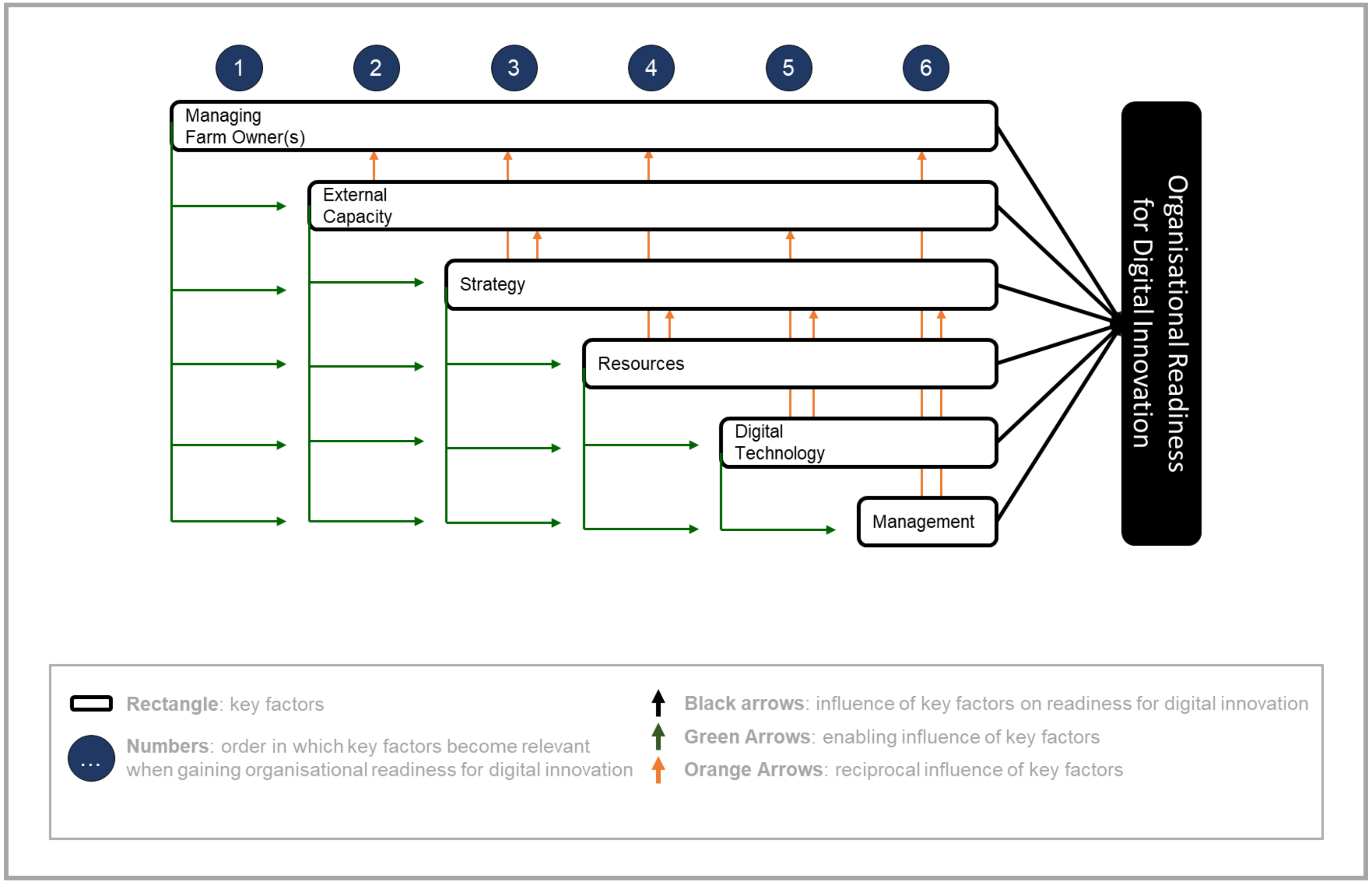

Figure 30: Framework of organisational readiness for digital innovation in the context of family farming

8.3 Contribution to the Body of Knowledge

While related readiness research does allow researchers to draw some assumptions about organisational readiness for digital innovation, its validity and the extent of transferability is questionable. So far, only one publication by Lokuge et al. (2019) specifically explores factors influencing organisational readiness for digital innovation in a generic industry context, but it does not investigate their relationships or the process of gaining readiness. As innovation follows industry-specific patterns (Hirsch-Kreinsen 2015; Malerba & Orsenigo 1995; Ryynänen & Hakatie 2014; Świadek et al. 2019; Tether 2002), this thesis presents the first academic investigation into organisational readiness for digital innovation in the context of family farming by bringing together management, information systems and agricultural research and enhancing it with an empirical investigation. Thereby, this thesis makes four contributions to the body of knowledge detailed in the following section.

8.3.1 Contribution 1 – Framework of Organisational Readiness for Digital Innovation for Family Farms

Building upon extant readiness research and incorporating the empirical findings of this thesis, a framework of organisational readiness for digital innovation in the context of family farming has been developed. This comprehensive framework is the main contribution of this thesis. It presents a structured approach to the complex process of family farms gaining readiness for digital innovation. Integrating extant research with the empirical findings of this thesis it offers a holistic perspective on the antecedents of readiness for digital innovation in the context of family farming.

Explaining organisational readiness for digital innovation on family farms, it extends research on organisational readiness for innovation in the specific context of family farming. Enhancing understanding of the topic is particularly relevant as the academic debate on digital innovation thus far focuses mainly on its implications for all stakeholders, such as organisations and policymakers (Nambisan, Wright & Feldman 2019). However, prior to experiencing the implications of digital innovation, organisations must first be ready for digital innovation. This framework provides insights into readiness as a prerequisite for digital innovation in the context of family farming, and thus makes a significant contribution to the body of knowledge.

8.3.2 Contribution 2 – Factors Influencing Family Farms' Readiness for Digital Innovation

This thesis, building on an extensive literature review and empirical findings, identifies the key factors and constituent attributes that influences family farms' readiness to innovate with digital technologies. Specifically, it 1) uncovers that the key factors and attributes suggested by current readiness research is less or not at all relevant in the context of family farming, 2) specifies and adapts key factors and attributes specific to the context investigated, 3) identifies new, context-specific attributes, and 4) unveils changes in regard to the key factors with a growing level of readiness. Furthermore, addressing the relationships between the key factors, this thesis 1) evaluates the relevance of the suggested relationships in the given context, 2) uncovers novel influences, 3) differentiates between enabling and reciprocal relationships, and 4) explains the relationships between key factors.

Therefore, this thesis extends and specifies extant research on factors influencing organisational readiness for digital innovation (Lokuge et al. 2019). Additionally, the findings make a contribution to the body of knowledge on antecedents of digital innovation. While in the past decade considerable academic effort has been dedicated to exploring the antecedents of innovation (Curado, Muñoz-Pascual & Galende 2018; Davis & Bendickson 2020; Lee, Saerom & Csaszar 2020; Popa, Soto-Acosta & Martinez-Conesa 2017; Wan, Williamson & Yin 2015), research calls for more in-depth studies specific to digital innovation (Nambisan, Lyytinen & Yoo 2020). Hence, the findings of this thesis contribute to understanding the organisational prerequisites of digital innovation on family farms and provide the possibility for further cross-sectoral comparisons. Moreover, the findings support existing theories about the central role of small business owners for technology adoption (Karanasios & Burgess 2008).

As relationships between the influencing key factors are scarcely addressed and not explained at all by the readiness literature (Ruikar, Anumba & Carrillo 2006; Scaccia et al. 2015; Sony & Naik 2019), especially in the context of family farming, this thesis enables a more elaborate, detailed and elucidatory understanding of the dynamics between the key factors. While readiness is commonly conceptualised as a continuum (Holt, Armenakis, Feild, et al. 2007), readiness research is yet to investigate changes when digital innovation readiness increases. Hence, this thesis offers novel insights into readiness and digital innovation research on the distinctions of more advanced digital innovators, providing a foundation for more differentiated research on the topic.

8.3.3 Contribution 3 – Process of family farms gaining readiness for digital innovation

This thesis makes a significant contribution to understanding the process of family farms gaining readiness for digital innovation. As processes are what define and continuously re-define an organisation (Weick 1995), research calls for more organisational process studies (Langley et al. 2013; Reay et al. 2019), with particular focus on theoretical development and integration (Stephenson et al. 2020). This thesis, anchored in readiness literature and enriched by a qualitative study, articulates the underlying mechanisms of gaining readiness for digital innovation on family farms, as well as identifies and details the process, which consists of gaining and maintaining readiness in regard to the specific key factors in a particular order. Thereby, this thesis explains the process of family farms' gaining readiness for digital innovation, marking the beginning of a debate on the procedural nature of organisational readiness for digital innovation.

8.3.4 Contribution 4 – Contextual Boundaries of Organisational Readiness for Digital Innovation

Extant readiness literature relevant to explaining organisational readiness for digital innovation is either generic (Evans, JD & Johnson 2013; Nguyen et al. 2019; Scaccia et al. 2015; Sony & Naik 2019; Yen et al. 2012), aiming to provide industry-independent insights on the topic, or specific to industries other than agriculture (Khalfan & Anumba 2006; Lou, Lee & Goulding 2020; Pessot et al. 2020; Ruikar, Anumba & Carrillo 2006; Weiner 2009; Yusof et al. 2010). This research identified context-specific boundaries of organisational readiness for digital innovation. The peculiarities of family farms resulted in differences in terms of 1) what their readiness for digital innovation is influenced by, 2) what readiness in regard to each influencing key factor entails, 3) the relationships between these key factors, and 4) the process of gaining readiness for digital innovation.

Discussing the context-specific findings of this thesis in relation to extant readiness literature, which is generic or specific to industries other than family farming, this thesis contrasted the industry-specific boundaries of organisational readiness. Thereby this thesis makes a theoretical contribution to the body of knowledge on the context-specific boundaries of organisational readiness for digital innovation.

8.4 Implications

The findings of this thesis offer an important contribution to practice. Based on the insights gained in this thesis, recommendations for family farms, policymakers and technology providers are derived and detailed in the following section.

8.4.1 Implications for Farms

This research uncovers the central role that managing farm owners play when engaging in digital innovation. Their readiness not only influences the farm's readiness for digital innovation but is the first step in the process of gaining readiness. Therefore, for a farm to be ready to engage in digital innovation, its managing farm owner(s) should perceive a need for change and have a positive attitude towards digital technologies, so they are seen as a worthwhile solution to the challenges a farm is facing. As digital innovation on a farm is not a straightforward endeavour, the managing farm owner(s) should be interested in change, willing to explore potential avenues of digital applications on the farm and committed to their realisation.

Agriculture is the least digitalised sector worldwide (Blackburn, Freeland & Grätner 2017; Gandhi 2016), and farms lack experience with digital innovation. Hence, not surprisingly, this research unveiled that being part of and actively engaging in an innovation network is a prerequisite for farms' readiness to innovate with digital technologies.

Furthermore, this thesis identified the need to adapt the farm's strategy for digital innovation. To realise digital innovation on the farm, the strategy must reflect a long-term orientation and focus on continuous improvement. This should be supported by an organisational culture which embraces digital technologies. Furthermore, digital innovation being complex and knowledge-intense, farms should acquire knowledge on digital technologies. The knowledge refers to 1) product knowledge, specifically what digital technologies exist, their benefits, what infrastructure they require and what technologies they are compatible with, and 2) process knowledge, which provides an understanding of how a digital technology works, how to operate it, how to use it to create the greatest value and how to resolve problems that occur when using the digital technology.

Digital innovation is resource-intense. Finance, IT infrastructure and time emerged as the key resources enabling digital innovation on a farm. While monetary investment is required to acquire a digital technology, farmers should account for the potential costs of maintenance, support, data analysis and delayed return on investment as well. Furthermore, farmers should ensure the availability of IT infrastructure necessary to operate digital technologies. Crucial IT infrastructure elements are hardware, such as smartphones and computers, and connectivity, not always guaranteed in the rural geographical locations of farms. Finally, digital innovation requires time, for example, to acquire necessary knowledge, evaluate different technology options, learn how to operate a newly adopted digital technology and exploit its innovative potential. Hence, farms should allow for time in order to avoid adopting a digital technology which does not meet the farm's expectations and is not used in a value adding manner.

When acquiring a digital technology, it must match with the farm's specific needs and goals, paying particular attention to its characteristics. To be able to harvest the innovative potential of a digital technology, farms should adopt technology which is fit for purpose, compatible with the existent IT infrastructure on the farm and meets the individual needs of the operators, such as, for example, high usability. Moreover, managing digital innovation is imperative as the acquisition of a digital technology does not automatically guarantee an innovative outcome. To exploit the potential of a digital technology, management must drive digital innovation and actively improve its operation and value creation.

Investigating the process of gaining readiness for digital innovation, this thesis identified that the different key factors influencing a farm's readiness become relevant at different stages. It is recommended that farms achieve readiness in a specific order, starting with Managing Farm Owner(s), followed by External Capacity, Strategy, Resources, Digital Technology and finally Management. This is due to the enabling relationships between the factors. For example, acquiring knowledge on digital technologies presupposes the existence of an innovation network, which acts as the main knowledge provider, compensating for the limited knowledge of and experience with digital technologies. A digital technology can be only acquired and managed if the required financial means for its purchase are made available. The IT infrastructure must enable application, and enough time must be dedicated to exploring and learning how it can be used in a value generating manner.

Finally, when advancing in readiness to innovate with digital technologies, this thesis suggests some changes in focus and practice. Managing farmer owners will have to work more on the computer to acquire knowledge on data analysis and unlock the value of data collected with digital technologies. Moreover, they will have to begin questioning why and how digital technologies work to identify additional innovative potential. Innovation networks should be widened to increase the thematic scope and depth of knowledge available. Furthermore, greater time investment should be factored in to allow the exploration of digital technologies and their potential. Finally, with increasing experience the focus should shift away from usability towards the innovative potential of digital technologies.

8.4.2 Implications for Policymakers

Currently the Australian government, in line with its global counterparts, is demonstrating considerable interest in enhancing digital innovation on farms, investing in initiatives that enable digital innovation in agriculture (Bacco et al. 2019; European Commission 2017; US Department of Agriculture 2014; Victoria State Government 2018). Incentivising and trying to facilitate digital innovation on farms is an approach taken to enhance innovation in the sector, which is urgently required to meet the increasing food demand. The findings of this thesis provide encouragement and guidance for policymakers on how to revise existing and formulate new policies that effectively support and enhance digital innovation on family farms not just in Australia, but globally.

First, family farms prioritise risk minimisation to protect the family's legacy. Consequently, they are reluctant to undertake digital innovation, because it often involves considerable initial monetary investment and there is no guarantee that it will provide a return on investment. Digital technologies are not always deemed appropriate for the farming sector and the benefits to the farm are not always clear. Furthermore, because farms have very limited experience with digital technologies, they often do not know which digital technologies should be adopted and how they can be applied. Moreover, farms were worried about being able to access technology support when needed.

Policymakers should therefore establish legal boundary conditions which ensure technology standards in line with the farms' expectations, as well as the availability and reliability of technology support. Supervised on-farm trials should be considered, as they reduce risk of failure. On-farm trials allow farmers to test different digital technologies to evaluate their applicability and benefits. Participating in such trials can provide farmers with a positive experience with digital technologies. Furthermore, industry cooperation between technology providers and farmers should be incentivised, as previous studies have noted too (Eastwood, Chapman & Paine 2009; Kaler & Ruston 2019; Paine & Kenny 2002), so that digital technologies can be developed specifically for the farming environment and its users, ensuring benefits and appropriability.

Second, a lack of experience with digital technologies leads to a lack of knowledge on digital technologies. However, in order to engage in digital innovation, farms must possess knowledge on what digital technologies exist, their fit for the farm, the infrastructure necessary, how they are operated, etc. Such knowledge is acquired through the farms' innovation networks but, due to the rural location of farms, accessing knowledge on digital technologies poses a barrier. Hence, policymakers should enhance knowledge transfer and facilitate more efficient and effective knowledge acquisition processes. This could be accomplished by 1) centralising the currently highly dispersed knowledge on digital technologies in a knowledge database on digital technologies in agriculture, and 2) establishing knowledgeable and easily accessible innovation networks within the sector. Policymakers should provide a realistic overview of the dynamic process of gaining readiness to innovate with digital technologies as well, so that farmers are aware of its complexity and do not perceive unexpected events as threatening.

Third, connectivity is a prerequisite for operating digital technologies. It is necessary for the communication between digital technologies, as well as their operation. However, connectivity in rural areas is not always secure. While participants provided examples of how they gained access to connectivity on their farms, the effort and knowledge required to do so were considerable. As it is unlikely that most farms possess such knowhow and can dedicate such effort to gain connectivity, policymakers interested in driving digital innovation on farms should ensure it is available, even in rural areas.

Fourth, adopting a digital technology does not automatically lead to its innovative application. On the contrary, this thesis identified the necessity of management driving digital innovation, focusing on improving its application and value creation to unlock its innovative potential. However, in light of the previously mentioned lack of experience with digital technologies on farms, this can be challenging and in the worst-case scenario farms are put off altogether. Hence, policymakers should provide training to ensure farms which have invested in digital technologies are able to exploit their benefits and maintain a positive attitude towards digital innovation.

To ensure a sustainable growth of digital innovation within the agriculture sector, younger generations of farmers should be educated on how to use digital technologies on the farm. Educational institutions could play a role in establishing a positive perception towards digital technologies by providing young farmers with the skills necessary to manage digital innovation successfully. Furthermore, prerequisites for digital innovation, such as resources, innovation networks, the right technology for the farm's needs, etc., should be taught early on. Developing awareness for the antecedents of successful digital innovation could prevent farms that are trying to establish a digital agricultural practice from failing, due to, for example, budget and time miscalculations (Trendov, Varas & Zeng 2019).

Finally, in line with previous research (Kosior 2018; Newton, Nettle & Pryce 2020; Wiseman et al. 2019), this thesis uncovered that farmers are reluctant to use digital technologies as they fear misuse of the data collected by technology providers. Farmers were not well-informed about what data collated on their farms is shared with the technology providers and for what purpose these data are being collected. Furthermore, they are critical about not receiving the benefits potentially gained by analysing these data. To enhance trust and confidence in data-driven applications on farms, policymakers should establish data protection and policy laws that enhance transparency, empower farm's rights to decide on their data usage and enable the distribution of potential benefits within the community. Such regulator frameworks should be developed in cooperation with farms as the primary asset holders.

8.4.3 Implications for Technology Providers

The findings of this thesis have implications for providers of digital technologies in the agriculture sector.

First, farms that successfully innovated with digital technologies were identified as having adopted digital technologies that fit their purpose and are compatible with the existing IT infrastructure on the farm. Furthermore, a clear benefit for the farm must be presented before farms decide to invest in new digital technologies. In order to meet their customers' expectations, technology providers must gain a deep understanding of what purpose a digital technology may serve on a farm and how it could generate a benefit. Hence, when developing new digital technologies, farmers, being the end-users, should be engaged as co-developers, as previous research has noted (Eastwood, Chapman & Paine 2009; Kaler & Ruston 2019; Paine & Kenny 2002). Providing first-hand experience and practical guidance, the cooperation with farmers can help generate a win-win situation as farmers are offered technology that meets their needs and are highly desirable, increasing sales and consequently profits for technology providers. To tackle the compatibility issues between digital technologies, providers should consider introducing industry standards and publishing relevant information as open source to encourage and enable standardisation. Additionally, digital technologies should avoid lock-in effects and instead be highly compatible, allowing interaction with digital technologies from other providers.

Second, family farms prioritise risk minimisation to protect the family legacy. Due to the novelty of digital technologies in the agriculture sector and the lack of experience with their application, they fear endangering the farm's existence when unable to operate digital technologies or repair them when needed. Consequently, to establish farms' trust and encourage the adoption of digital technologies, providers should ensure the availability and reliability of support.

Third, currently, engaging in digital innovation requires considerable monetary and time investment. However, on family farms money and time are scarce resources. Hence, technology providers should take these resource constraints into consideration when developing digital technologies. Potential solutions could forego luxurious add-ons and instead focus on the core functionalities to lower product prices, or develop more user-friendly applications that require less time to be set up and operated.

8.5 Limitations and Directions for Future Research

Despite paying particular attention to academic rigor, this thesis has limitations, which may serve as avenues for future research.

Due to the limited research on organisational readiness for digital innovation, particularly in the context of family farming, this thesis employed a qualitative research approach. This approach, which involved interviewing carefully chosen farmers as well as a diverse set of subject experts, allowed the researcher to access a greater depth of analysis (Creswell, JW

2017), especially when shedding light on the complexity of the topic (Myers, MD & Newman 2007). However, its findings may not be representative of all family farms. Another shortcoming of this thesis is the sample size, although it yields a comparable response rate as previous studies in the research field (Fleming et al. 2018; Gosnell, Gill & Voyer 2019). Furthermore, following Marshall, M (1996b) the exact sample size of the study was not determined a priori. Instead, the collected empirical data were analysed and enriched by interviews in additional organisations iteratively until saturation was reached and hence no new knowledge emerged. Future research should complement the findings of this thesis, by further specifying and quantifying the developed framework of organisational readiness for digital innovation in the context of family farming, by testing it quantitatively with a large sample size.

To take into consideration the different stages of readiness this thesis has investigated farms not engaged in digital innovation, digital innovators and advanced digital innovators. However, scholars emphasise the importance of longitudinal studies for understanding an organisation's management of innovation (Pettigrew 1990; Van de Ven, AH & Huber 1990). Hence, future research should conduct longitudinal studies on the subject, to fully capture the long-term transformation and impacts of digital innovation.

Finally, this thesis has investigated readiness for digital innovation of family farms in Australia. While the choice of the study sample paid particular attention to ensuring the transferability of the findings, research has shown management practice to differ between countries (Ajiferuke & Boddewyn 1970; Storey 2004; Teagarden, Von Glinow & Mellahi 2018). Hence, comparative studies in other geographical locations would provide further understanding on national level factors influencing family farms' readiness for digital innovation as well as the process of gaining it. Moreover, in line with previous research (Hirsch-Kreinsen 2015; Malerba & Orsenigo 1995; Ryynänen & Hakatie 2014; Świadek et al. 2019; Tether 2002), this thesis has confirmed that innovation follows industry-specific patterns. Consequently, future research may conduct comparative cross-industry studies to further widen the knowledge on industry peculiarities of readiness for digital innovation.

8.6 Summary

In summary, while readiness research is an established research stream, research on readiness for digital innovation is still in its infancy. Considering the idiosyncrasies of readiness for digital innovation in the family farming context identified in this thesis, there are significant opportunities for future research investigating and comparing readiness for digital innovation in other industry contexts. At the same time, this thesis provides insights which offer guidance for family farms, policymakers and technology providers to enhance digital innovation on family farms. These should be taken into consideration in order to meet the global food demand and limit the negative environmental impact of the agriculture sector.

References

ABARES 2018, *Snaopshot of Australia's Agricultural Workforce*, viewed 06.06.2019, <http://www.agriculture.gov.au/abares/Documents/snapshotaustraliasagriculturalworkforce20181213_v1.0.0.pdf>.

ABARES 2019, *The structure of farms and farming in Australia*, viewed 06.06.19, <http://www.agriculture.gov.au/abares/research-topics/surveys/structure-of-farms>.

ABARES 2020, *Insights: Snapshot of Australian Agriculture*, viewed 04.06.2020, <https://daff.ent.sirsidynix.net.au/client/en_AU/search/asset/1029981/0>.

Adamczewski, P 2016, 'ICT solutions in intelligent organizations as challenges in a knowledge economy', *Management decision*, vol. 20, no. 2, pp. 198-209.

Adams, R, Bessant, J & Phelps, R 2006, 'Innovation management measurement: A review', *International journal of management reviews*, vol. 8, no. 1, pp. 21-47.

Adelman, HS & Taylor, L 1997, 'Toward a scale-up model for replicating new approaches to schooling', *Journal of Educational and Psychological Consultation*, vol. 8, no. 2, pp. 197-230.

Agostini, LG, Luca; Savino, Tommaso; Appio, Francesco 2017, 'The digitalization of the innovation process: challenges and opportunities from a managerial perspective', vol.

Agriculture Victoria 2019, *Digital agriculture*, viewed 02.03.2020, <http://agriculture.vic.gov.au/agriculture/digital-agriculture>.

Aguilera, RV & Jackson, G 2003, 'The cross-national diversity of corporate governance: Dimensions and determinants', *Academy of management review*, vol. 28, no. 3, pp. 447-465.

Aidoo, DC & Freeman, CK 2016, 'Agricultural informational flow in informal communication networks of farmers in Ghana', *Journal of Development and Communication Studies*, vol. 4, no. 2, pp. 443-453.

Aimin, H 2010, 'Uncertainty, risk aversion and risk management in agriculture', *Agriculture and agricultural science procedia*, vol. 1, pp. 152-156.

Ajiferuke, M & Boddewyn, J 1970, '"Culture" and other explanatory variables in comparative management studies', *Academy of management journal*, vol. 13, no. 2, pp. 153-163.

Akdil, KY, Ustundag, A & Cevikcan, E 2018, 'Maturity and readiness model for industry 4.0 strategy', in *Industry 4.0: Managing The Digital Transformation*, Springer, Cham, pp. 61-94.

Ali, J & Kumar, S 2011, 'Information and communication technologies (ICTs) and farmers' decision-making across the agricultural supply chain', *International Journal of Information Management*, vol. 31, no. 2, pp. 149-159.

Alshawaaf, N & Lee, SH 2020, *Business model innovation through digitisation in social purpose organisations: A comparative analysis of Tate Modern and Pompidou Centre*, 0148-2963.

Alsos, A, Ljunggren, E, Pettersen, LT & Development, E 2003, 'Farm-based entrepreneurs: what triggers the start-up of new business activities?', *Journal of Small Business Management*, vol. 10, no. 4, pp. 435-443.

Altheide, DL & Johnson, JM 1994, 'Criteria for assessing interpretive validity in qualitative research', in T Oaks (ed.), *Handbook of qualitative research*, Sage Publishing, London, pp. 485-499.

Amankwah-Amoah, J, Egbetokun, A & Osabutey, EL 2018, 'Meeting the 21st century challenges of doing business in Africa', *Technological Forecasting and Social Change*, vol. 131, pp. 336-338.

Anderl, R, Picard, A, Wang, Y, Fleischer, J, Dosch, S, Klee, B & Bauer, J 'Leitfaden Industrie 4.0: Orientierungshilfe zur Einführung in den Mittelstand',

Anderson, RC, Mansi, SA & Reeb, DM 2003, 'Founding family ownership and the agency cost of debt', *Journal of financial economics*, vol. 68, no. 2, pp. 263-285.

Andreoni, M & Londoño, E 2019, *Amid Outrage Over Rainforest Fires, Many in the Amazon Remain Defiant*, New York Times, viewed 11.01.2020, <https://www.nytimes.com/2019/08/26/world/americas/brazil-amazon-rainforest-fire.html>.

Andriole, SJ, Cox, T & Khin, KM 2017, *The Innovator's Imperative: Rapid Technology Adoption for Digital Transformation*, CRC Press, Boca Raton, FL.

Annosi, MC, Brunetta, F, Monti, A & Nat, F 2019, 'Is the trend your friend? An analysis of technology 4.0 investment decisions in agricultural SMEs', *Computers in Industry*, vol. 109, pp. 59-71.

Antaki, C, Billig, M, Edwards, D & Potter, J 2003, 'Discourse analysis means doing analysis: A critique of six analytic shortcomings', vol. 1, no. 1.

ANZ 2016, *Australian Agriculture*, viewed 23.08.2019, < http://phx.corporate-ir.net/External.File?item=UGFyZW50SUQ9MzU5MDI5fENoaWxkSUQ9LTF8VHlwZT0z&t=1&cb=636149328686628849>.

Appio, FP, Frattini, F, Petruzzelli, AM & Neirotti, P 2018, *Digital Transformation and Innovation Management: Opening Up the Black Box*.

Aral, S, Dellarocas, C & Godes, D 2013, 'Introduction to the special issue—social media and business transformation: a framework for research', *Information systems research*, vol. 24, no. 1, pp. 3-13.

Armenakis, AA, Harris, SG & Mossholder, KW 1993, 'Creating readiness for organizational change', *Human relations*, vol. 46, no. 6, pp. 681-703.

Aronson, J 1995, 'A pragmatic view of thematic analysis', *The qualitative report*, vol. 2, no. 1, pp. 1-3.

Arthur, WB 2009, *The nature of technology: What it is and how it evolves*, Simon and Schuster.

Austin, EK 1981, *Guidelines for the development of continuing education offerings for nurses*, Appleton-Century-Crofts and Fleschner Publishing Company, New York.

Australian Bureau of Statistics 2016, *Counts of Australian Businesses, including Entries and Exits*,

Australian Bureau of Statistics 2018, *Summary of IT Use and Innovation in Australian Business, 2016-2017*, viewed 20.05.2019, <https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/8166.02016-17?OpenDocument>.

Australian Government 2017, *Australia-Korea Digital Agriculture Collaboration Strategy*, viewed 21.08.2019, <https://dfat.gov.au/people-to-people/foundations-councils-institutes/australia-korea-foundation/grantees2017/Pages/australia-korea-digital-agriculture-collaboration-strategy.aspx>.

Australian Government 2018, *Australian economy - farm sector*, viewed 20.08.2019, <https://data.gov.au/dataset/ds-dga-1f3da692-f0cf-4de4-a7d3-bae52d600bae/distribution/dist-dga-b50ec9c0-3585-44bf-8481-8cf8c75065cb/details?q=>.

Australian Government 2019, *Australia: Shaping the future of food and agriculture* viewed 21.08.2019, <file://rmit.internal/USRHome/el3/e38023/Downloads/Agriculture40-brochure%20(1).pdf>.

Australian Government 2020, *Coronavirus disease - Information for employers*, viewed 19.05.2020, <https://www.health.gov.au/sites/default/files/documents/2020/05/coronavirus-covid-19-information-for-employers_0.pdf>.

Australian Research Council 2007, *The National Statement on Ethical Conduct in Human Research*, Australian Government 1864962755.

Ayre, M, Mc Collum, V, Waters, W, Samson, P, Curro, A, Nettle, R, Paschen, J-A, King, B & Reichelt, N 2019, 'Supporting and practising digital innovation with advisers in smart farming', *NJAS-Wageningen Journal of Life Sciences*, vol. 90, p. 100302.

Bacco, M, Barsocchi, P, Ferro, E, Gotta, A & Ruggeri, M 2019, 'The Digitisation of Agriculture: a Survey of Research Activities on Smart Farming', *Array*, vol. 3.

Backer, TE 1995, 'Assessing and enhancing readiness for change: Implications for technology transfer', *NIDA research monograph*, vol. 155, pp. 21-41.

Backer, TE 1997, 'Managing the human side of change in VA's transformation', *Journal of Healthcare Management*, vol. 42, no. 3, p. 433.

Baena, F, Guarin, A, Mora, J, Sauza, J & Retat, S 2017, 'Learning factory: The path to industry 4.0', *Procedia Manufacturing*, vol. 9, pp. 73-80.

Bagshaw, E & Hanna, C 2017, *Census 2016: The workers with the longest hours in Australia*, The Sydney Morning Herald, viewed 21.08.2019, <https://www.smh.com.au/business/the-economy/census-2016-the-workers-with-the-longest-hours-in-australia-20171023-gz69w4.html>.

Bailey, K 1987, *Methods of Social Research* The Free Press, New York.

Baiyere, A, Salmela, H & Tapanainen, T 2020, 'Digital transformation and the new logics of business process management', *European Journal of Information Systems*, vol. 29, no. 3, pp. 1-22.

Banke, J 2010, *Technology readiness levels demystified*, NASA.

Bansal, P, Smith, WK & Vaara, E 2018, 'New ways of seeing through qualitative research', vol. 61, no. 4, pp. 1189-1195.

Barbieri, C 2010, 'An importance-performance analysis of the motivations behind agritourism and other farm enterprise developments in Canada', *Journal of Rural Community Development*, vol. 5, no. 1, pp. 1-20.

Barnes, AP, Soto, I, Eory, V., Beck, B, A., B, SánchezB. & Gómez-Barbero, M 2019, 'Exploring the adoption of precision agricultural technologies: A cross regional study of EU farmers', *Land Use Policy*, vol. 80, no. 163-174.

Barnett, HG 1953, *Innovation: The basis of cultural change*, McGraw-Hill Book Company, New York.

Barrett, JH, Haslam, RA, Lee, KG & Ellis, M 2005, 'Assessing attitudes and beliefs using the stage of change paradigm—case study of health and safety appraisal within a manufacturing company', *International Journal of Industrial Ergonomics*, vol. 35, no. 10, pp. 871-887.

Barrett, M, Davidson, E, Prabhu, J & Vargo, SL 2015, 'Service innovation in the digital age: key contributions and future directions', *MIS quarterly*, vol. 39, no. 1, pp. 135-154.

Barriball, KL & While, A 1994, 'Collecting data using a semi-structured interview: a discussion paper', *Journal of Advanced Nursing-Institutional Subscription*, vol. 19, no. 2, pp. 328-335.

Bassi, L 'Industry 4.0: Hope, hype or revolution?', IEEE, pp. 1-6.

Bauer, W, Hämmerle, M, Schlund, S & Vocke, C 2015, 'Transforming to a hyper-connected society and economy–towards an "Industry 4.0"', *Procedia Manufacturing*, vol. 3, pp. 417-424.

Baxter, J & Eyles, J 1997, 'Evaluating qualitative research in social geography: establishing 'rigour'in interview analysis', *Transactions of the Institute of British geographers*, vol. 22, no. 4, pp. 505-525.

Bazeley, P & Jackson, K 2013, *Qualitative data analysis with NVivo*, Sage Publishing, London.

Bechar, A & Vigneault, C 2017, 'Agricultural robots for field operations. Part 2: Operations and systems', *Biosystems engineering*, vol. 153, pp. 110-128.

Beer, M & Walton, AE 1987, 'Organization change and development', *Annual review of psychology*, vol. 38, no. 1, pp. 339-367.

Bell, C 2019, 'People of Future Agriculture; Trust and Succession in Family Businesses', *International Journal of Agricultural Management*, vol. 8, no. 3, pp. 107-111.

Bell, E, Bryman, A & Harley, B 2018, *Business research methods*, Oxford university press, Oxford

Belyaev, V, Silantyeva, M, Meinel, T, Grunwald, L-C, Belyaev, D, Kozhanov, N & Sokolova, L 2020, 'Field Days for Technology Transfer and Knowledge Exchange of Dealers and Farmers', in *KULUNDA: Climate Smart Agriculture*, Springer, Cham, pp. 493-500.

Benešová, A & Tupa, J 2017, 'Requirements for education and qualification of people in Industry 4.0', *Procedia Manufacturing*, vol. 11, pp. 2195-2202.

Benner, MJ & Tushman, ML 2015, 'Reflections on the 2013 Decade Award—"Exploitation, exploration, and process management: The productivity dilemma revisited" ten years later', *Academy of management review*, vol. 40, no. 4, pp. 497-514.

Berger, P & Luckmann, T 1967, *The reality of social construction: Treatise in sociology of knowledge*, Garden City, NY: Anchor.

Berger, S, Denner, M-S & Roeglinger, M 2018, 'The Nature of Digital Technologies-Development of a Multi-Layer Taxonomy', in *ECIS*, pp. 28-2018.

Berghaus, S & Back, A 2017, 'Disentangling the fuzzy front end of digital transformation: Activities and approaches', Association for Information Systems.

Berrone, P, Cruz, C & Gomez-Mejia, LR 2012, 'Socioemotional wealth in family firms: Theoretical dimensions, assessment approaches, and agenda for future research', *Family business review*, vol. 25, no. 3, pp. 258-279.

Bessant, J, Lamming, R, Noke, H & Phillips, W 2005, 'Managing innovation beyond the steady state', *Technovation*, vol. 25, no. 12, pp. 1366-1376.

Bharadwaj, A, El Sawy, OA, Pavlou, PA & Venkatraman, NJMq 2013, 'Digital business strategy: toward a next generation of insights', vol., pp. 471-482.

Bharatula, S & Murthy, B 2020, 'Digital Readiness Index—Empowering the Nation', in *ICT Analysis and Applications*, Springer, Singapore, pp. 209-216.

Biegler, C, Steinwender, A, Sala, A, Sihn, W & Rocchi, V 'Adoption of Factory of the Future technologies', IEEE, pp. 1-8.

Biernacki, P & Waldorf, D 1981, 'Snowball sampling: Problems and techniques of chain referral sampling', *Sociological methods*

research paper commissioned by TransForum, vol. 10, no. 2, pp. 141-163.

Binz, CA, Ferguson, KE, Pieper, TM & Astrachan, JH 2017, 'Family business goals, corporate citizenship behaviour and firm performance: disentangling the connections', *International Journal of Management Enterprise Development*, vol. 16, no. 1-2, pp. 34-56.

Blackburn, S, Freeland, M & Grätner, D 2017, *Digital Australia: Seizing opportunities from the Fourth Industrial Revolution*, Digital McKinsey, viewed 07.09.2019, <https://www.mckinsey.com/featured-insights/asia-pacific/digital-australia-seizing-opportunity-from-the-fourth-industrial-revolution>.

Blandy, R & Brummitt, W 1990, *Labour productivity and living standards*, Allen & Unwin Sydney, North Sydney.

Bledow, R, Frese, M, Anderson, N, Erez, M & Farr, J 2009, 'A dialectic perspective on innovation: Conflicting demands, multiple pathways, and ambidexterity', *Industrial and Organizational Psychology*, vol. 2, no. 3, pp. 305-337.

Block, JH 2012, 'R&D investments in family and founder firms: An agency perspective', *Journal of business venturing*, vol. 27, no. 2, pp. 248-265.

Bluhm, DJ, Harman, W, Lee, TW & Mitchell, TR 2011, 'Qualitative research in management: A decade of progress', *Journal of Management Studies*, vol. 48, no. 8, pp. 1866-1891.

Bocconcelli, R, Cioppi, M, Fortezza, F, Francioni, B, Pagano, A, Savelli, E & Splendiani, S 2018, 'SMEs and marketing: a systematic literature review', *International journal of management reviews*, vol. 20, no. 2, pp. 227-254.

Bockshecker, A, Hackstein, S & Baumöl, U 2018, 'Systematization of the term digital transformation and its phenomena from a socio-technical perspective–A literature review', in *ECIS*.

Boeije, H 2002, 'A Purposeful Approach to the Constant Comparative Method in the Analysis of Qualitative Interviews', *International Journal of Methodology*, vol. 36, no. 4, pp. 391-409.

Boeije, H 2010, *Analysis in qualitative research*, Sage Publishing, Los Angeles.

Bogdan, R & Biklen, SK 1997, *Qualitative research for education*, Allyn & Bacon Boston, MA, Boston

Bohak, Z, Borec, A & Turk, J 2010, 'An appraisal of family farm succession studies: a review', *Agricultura*, vol. 7, no. 1, pp. 9-13.

Bohnet, IC, Roberts, B, Harding, E & Haug, KJ 2011, 'A typology of graziers to inform a more targeted approach for developing natural resource management policies and agricultural extension programs', *Land Use Policy*, vol. 28, no. 3, pp. 629-637.

Bouchard, TJ 1976, 'Field research methods: Interviewing, questionnaires, participant observation, systematic observation, unobtrusive measures', *Handbook of industrial organizational psychology*, vol. 1, p. 363.

Bouma, J, Montanarella, L & Evanylo, G 2019, 'The challenge for the soil science community to contribute to the implementation of the UN Sustainable Development Goals', *Soil Use Management*, vol. 35, no. 4, pp. 538-546.

Bowen, GA 2009, 'Document analysis as a qualitative research method', *Qualitative research journal*, vol. 9, no. 2, pp. 27-40.

Boyatzis, RE 1998, *Transforming qualitative information: Thematic analysis and code development*, Sage Publishing, Thousand Oaks, CA.

Boza, S, Mora, M, Osorio, F & Muñoz, J 2019, 'Family farmers’ reluctance toward incorporating into the formal economy', *Economía Agraria y Recursos Naturales-Agricultural and Resource Economics*, vol. 18, no. 2, pp. 75-92.

Bramley, RGV 2009, 'Lessons from nearly 20 years of Precision Agriculture research, development, and adoption as a guide to its appropriate application.', *Crop and Pasture Science*, vol. 60, no. 3, pp. 197-217.

Branco, MICdA 2019, 'Digitization of the manufacturing sector across the EU: assessing readiness for industry 4.0', thesis.

Braun, V & Clarke, V 2006, 'Using thematic analysis in psychology', *Qualitative research in psychology*, vol. 3, no. 2, pp. 77-101.

Braun, V, Clarke, V, Hayfield, N & Terry, G 2012, 'Thematic analysis', in *Handbook of research methods in health social sciences*, Springer, Singapore, pp. 51-71.

Brennen, S & Kreiss, D 2014, 'Digitalization and digitization', *Culture digitally*, vol. 8.

Brettel, M, Friederichsen, N, Keller, M & Rosenberg, M 2014, 'How virtualization, decentralization and network building change the manufacturing landscape: An Industry 4.0 Perspective', *International journal of mechanical, industrial science and engineering*, vol. 8, no. 1, pp. 37-44.

Brinkmann, S 2014, 'Interview', in *Encyclopedia of critical psychology*, Springer, pp. 1008-1010.

Brookfield, H & Parsons, H 2007, *Family farms: survival and prospect: A world-wide analysis*, Routledge, London

Brown, S 2019, *Amazon rainforest fires: Everything we know and how you can help*, cnet, viewed 01.09.2019, <https://www.cnet.com/how-to/amazon-rainforest-fire-whats-happening-now-and-how-you-can-help-update-indigeous-tribes/>.

Bryan, BA, Meyer, WS, Campbell, CA, Harris, GP, Lefroy, T, Lyle, G, Martin, P, McLean, J, Montagu, K & Rickards, LA 2013, 'The second industrial transformation of Australian landscapes', *Current Opinion in Environmental Sustainability*, vol. 5, no. 3-4, pp. 278-287.

Bryman, A, Bresnen, M, Beardsworth, A & Keil, TJHr 1988, 'Qualitative research and the study of leadership', vol. 41, no. 1, pp. 13-29.

Burdon, J, Pratley, J, Gibson, B, Gleadow, R, Gillanders, B, Hatcher, S, Higgins, T, Leigh, R, McNeill, A & Powles, S 2017, *Grow. Make. Prosper.: The decadal plan for Australian Agricultural Sciences 2017-26*, Australian Academy of Science, 0858475448, <https://www.science.org.au/files/userfiles/support/reports-and-plans/2017/agricultural-decadal-plan-2017-26.pdf>.

Burgess, RG 2003, *Field research: A sourcebook and field manual*, Routledge, London.

Burton, RJ 2004, 'Reconceptualising the ‘behavioural approach’in agricultural studies: a socio-psychological perspective', *Journal of rural studies*, vol. 20, no. 3, pp. 359-371.

Burton, RJ 2012, 'Understanding farmers' aesthetic preference for tidy agricultural landscapes: a Bourdieusian perspective', *Landscape Research*, vol. 37, no. 1, pp. 51-71.

Burton, RJ, Kuczera, C & Schwarz, G 2008, 'Exploring farmers' cultural resistance to voluntary agri-environmental schemes', *Sociologia Ruralis*, vol. 48, no. 1, pp. 16-37.

Burton, RJ & Riley, M 2018, 'Traditional Ecological Knowledge from the internet? The case of hay meadows in Europe', *Land Use Policy*, vol. 70, pp. 334-346.

Byrne, M 2001, 'Sampling for qualitative research', *AORN journa*, vol. 73, no. 2, pp. 494-494.

Cabrera-Suárez, K, De Saá-Pérez, P & García-Almeida, D 2001, 'The succession process from a resource-and knowledge-based view of the family firm', *Family business review*, vol. 14, no. 1, pp. 37-48.

Calabrò, A, Vecchiarini, M, Gast, J, Campopiano, G, De Massis, A & Kraus, S 2019, 'Innovation in family firms: a systematic literature review and guidance for future research', *International journal of management reviews*, vol. 21, no. 3, pp. 317-355.

Carlisle, L, Montenegro de Wit, M, DeLonge, MS, Iles, A, Calo, A, Getz, C, Ory, J, Munden-Dixon, K, Galt, R & Melone, B 2019, 'Transitioning to sustainable agriculture requires growing and sustaining an ecologically skilled workforce', *Frontiers in Sustainable Food Systems*, vol. 3, p. 96.

Carney, M 2005, 'Corporate governance and competitive advantage in family-controlled firms', *Entrepreneurship Theory and Practice*, vol. 29, no. 3, pp. 249-265.

Carolan, M 2020, 'Automated agrifood futures: robotics, labor and the distributive politics of digital agriculture', *The Journal of Peasant Studies*, vol. 47, no. 1, pp. 184-207.

Cassia, L, De Massis, A, Pizzurno, E & Research 2012, 'Strategic innovation and new product development in family firms: An empirically grounded theoretical framework', *International Journal of Entrepreneurial Behavior*, vol. 18, no. 2, pp. 198-232.

Castelo-Branco, I, Cruz-Jesus, F & Oliveira, T 2019, 'Assessing Industry 4.0 readiness in manufacturing: Evidence for the European Union', *Computers in Industry*, vol. 107, pp. 22-32.

Chakraborty, S, Das, P & Pal, S 2020, 'IoT Foundations and Its Application', in *IoT and Analytics for Agriculture*, Springer, Singapore, pp. 51-68.

Charmaz, K 2006, *Constructing grounded theory: A practical guide through qualitative analysis*, Sage Publishing, London.

Chaudhuri, S, Dayal, U & Narasayya, V 2011, 'An overview of business intelligence technology', *Communications of the ACM*, vol. 54, no. 8, pp. 88-98.

Chavas, JP & Nauges, C 2020, 'Uncertainty, Learning, and Technology Adoption in Agriculture', *Applied Economic Perspectives and Policy*, vol. 42, no. 1, pp. 42-53.

Cheng, J, Law, KH & Kumar, B 2003, 'Integrating project management applications as web services', in *2nd International Conference on Innovation in Architecture, Engineering and Construction*, Loughborough, UK.

Cherryholmes, CH 1992, 'Notes on pragmatism and scientific realism', *Educational researcher*, vol. 21, no. 6, pp. 13-17.

Chiesa, V, Frattini, F, Lazzarotti, V & Manzini, R 2007, 'How do measurement objectives influence the R&D performance measurement system design? Evidence from a multiple case study', *Management Research News*, vol. 30, no. 3, pp. 187-202.

Chilenski, SM, Greenberg, MT & Feinberg, ME 2007, 'Community readiness as a multidimensional construct', *Journal of Community Psychology*, vol. 35, no. 3, pp. 347-365.

Chonko, LB, Jones, E, Roberts, JA & Dubinsky, AJ 2002, 'The role of environmental turbulence, readiness for change, and salesperson learning in the success of sales force change', *Journal of Personal Selling*, vol. 22, no. 4, pp. 227-245.

Chrisman, JJ, Chua, JH, De Massis, A, Frattini, F & Wright, M 2015, 'The ability and willingness paradox in family firm innovation', *Journal of Product Innovation Management*, vol. 32, no. 3, pp. 310-318.

Chrisman, JJ & Patel, PC 2012, 'Variations in R&D investments of family and nonfamily firms: Behavioral agency and myopic loss aversion perspectives', *Academy of management journal*, vol. 55, no. 4, pp. 976-997.

Christensen, C, Baumann, H, Ruggles, R & Sadtler, TJHbr 2006, 'Disruptive innovation for social change', vol. 84, no. 12, pp. 94-101, 163.

Chung, JE, Park, N, Wang, H, Fulk, J & McLaughlin, M 2010, 'Age differences in perceptions of online community participation among non-users: An extension of the Technology Acceptance Model', *Computers in Human Behavior*, vol. 26, no. 6, pp. 1674-1684.

CID 2000, *Readiness for the Networked World, A Guide for Developing Countries*, viewed 19.06.2019, <http://www.cid.harvard.edu/ciditg>.

Ciruela-Lorenzo, AM, Aguila-Obra, D, Rosa, A, Padilla-Meléndez, A & Plaza-Angulo, JJ 2020, 'Digitalization of Agri-cooperatives in the Smart Agriculture Context. Proposal of a Digital Diagnosis Tool', *Sustainability*, vol. 12, no. 4, p. 1325.

Clark, M, Eaton, M, Lind, W, Pye, E & Bateman, L 2011, *Key statistics. Australian Small Business*, viewed 16.07.2019, <www.innovation.gov.au>.

Classen, N, Van Gils, A, Bammens, Y & Carree, M 2012, 'Accessing resources from innovation partners: The search breadth of family SMEs', *Journal of Small Business Management*, vol. 50, no. 2, pp. 191-215.

Cofre-Bravo, G, Engler, A, Klerkx, L, Leiva-Bianchi, M, Adasme-Berrios, C & Caceres, C 2019, 'Considering the farm workforce as part of farmers' innovative behaviour: a key factor in inclusive on-farm processes of technology and practice adoption', *Experimental Agriculture*, vol. 55, no. 5, pp. 723-737.

Cohen, WM & Levin, RC 1989, 'Empirical studies of innovation and market structure', *Handbook of industrial organization*, vol. 2, pp. 1059-1107.

Coleman, JS 1958, 'Relational analysis: the study of social organizations with survey methods', *Human organization*, vol. 17, no. 4, p. 28.

Coleman, JS 1988, 'Social capital in the creation of human capital', *American journal of sociology*, vol. 94, pp. 95-120.

Colli, M, Berger, U, Bockholt, M, Madsen, O, Møller, C & Wæhrens, BV 2019, *A maturity assessment approach for conceiving context-specific roadmaps in the Industry 4.0 era*, Annual Reviews in Control.

Conboy, K, Fitzgerald, G & Mathiassen, L 2012, 'Qualitative methods research in information systems: motivations, themes, and contributions', *European Journal of Information Systems*, vol. 21, no. 2, pp. 113-118.

Cook, S, Lacoste, M, Evans, F, Ridout, M, Gibberd, M & Oberthür, T 'An On-Farm Experimental philosophy for farmer-centric digital innovation', Montreal, QC, Canada,

Cooksey, RW & McDonald, GM 2011, *Writing Up Your Research: Surviving and thriving in postgraduate research*, Tilde University Press, Prahran, VIC.

Cooper, JR 1998, 'A multidimensional approach to the adoption of innovation', *Management decision*, vol. 36, no. 8, pp. 493-502.

Corbin, J & Strauss, A 2008, *Basics of qualitative research: Techniques and procedures for developing grounded theory*, Sage Publishing, Thousand Oaks, CA.

Covin, TJ 1994, 'Perceptions of family-owned firms: the impact of gender and education level', *Journal of Small Business Management*, vol. 32, no. 3, p. 29.

Crabtree, BF & Miller, WF 1992, 'A template approach to text analysis: developing and using codebooks', in *Doing qualitative research* Sage Publishing, Newbury Park, CA, pp. 163–177.

Creswell, JW 2017, *Research design: Qualitative, quantitative, and mixed methods approaches*, Sage Publishing, Thousand Oaks, CA.

Creswell, JW & Clark, VLP 2017, *Designing and conducting mixed methods research*, Sage Publishing, Thousand Oaks, CA.

Creswell, JWa & Poth, CN 2018, *Qualitative inquiry & research design : choosing among five approaches*, Fourth edition. edn, Qualitative inquiry and research design, Sage Publishing, Los Angeles.

Crookes, P 1998, *Research into practice: essential skills for reading and applying research in nursing and health care*, Bailliere Tindall Limited, New York.

Crossan, MM & Apaydin, M 2010, 'A multi-dimensional framework of organizational innovation: A systematic review of the literature', *Journal of Management Studies*, vol. 47, no. 6, pp. 1154-1191.

Crotty, M 1998, *The foundations of social research: Meaning and perspective in the research process*, Sage Publishing, New York.

Cunningham, CE, Woodward, CA, Shannon, HS, MacIntosh, J, Lendrum, B, Rosenbloom, D & Brown, J 2002a, 'Readiness for organizational change: A longitudinal study of workplace, psychological and behavioural correlates', *Journal of Occupational and Organizational Psychology*, vol. 75, no. 4, pp. 377-392.

Cunningham, CE, Woodward, CA, Shannon, HS, MacIntosh, J, Lendrum, B, Rosenbloom, D & Brown, J 2002b, 'Readiness for organizational change: A longitudinal study of workplace, psychological and behavioural correlates', *Journal of Occupational Organizational psychology*, vol. 75, no. 4, pp. 377-392.

Curado, C, Muñoz-Pascual, L & Galende, J 2018, 'Antecedents to innovation performance in SMEs: A mixed methods approach', *Journal of Business Research*, vol. 89, pp. 206-215.

Damanpour, FJAomj 1991, 'Organizational innovation: A meta-analysis of effects of determinants and moderators', *Academy of management journal*, vol. 34, no. 3, pp. 555-590.

Darnhofer, I & Strauss, A 'Resilience of family farms: understanding the trade-offs linked to diversification', pp. 1-4.

Daspit, JJ, Chrisman, JJ, Sharma, P, Pearson, AW & Long, RG 2017, 'A Strategic Management Perspective of the Family Firm: Past Trends, New Insights, and Future Directions', *Journal of Managerial Issues*, vol. 29, no. 1, pp. 6-29.

Davenport, TH 1994, 'Managing in the new world of process', *Public Productivity Management Review*, vol., pp. 133-147.

Davila, T, Epstein, M & Shelton, R 2012, *Making innovation work: How to manage it, measure it, and profit from it*, FT press, Upper Saddle River, NJ.

Davis, PE & Bendickson, JS 2020, 'Strategic antecedents of innovation: Variance between small and large firms', *Journal of Small Business Management*, vol., pp. 1-26.

De Carolis, A, Macchi, M, Negri, E & Terzi, S 'A maturity model for assessing the digital readiness of manufacturing companies', Springer, pp. 13-20.

De Haes, S, Caluwe, L, Huygh, T & Joshi, A 2020, 'Learning from Peers', in *Governing Digital Transformation*, Springer, Cham, pp. 29-45.

De Jong, JP & Den Hartog, DN 2007, 'How leaders influence employees' innovative behaviour', *European Journal of Innovation Management*, vol. 10, no. 1, pp. 41-64.

De Massis, A, Frattini, F & Lichtenthaler, U 2013, 'Research on technological innovation in family firms: Present debates and future directions', *Family business review*, vol. 26, no. 1, pp. 10-31.

de Sousa Jabbour, ABL, Jabbour, CJC, Foropon, C & Godinho Filho, M 2018, 'When titans meet–Can industry 4.0 revolutionise the environmentally-sustainable manufacturing wave? The role of critical success factors', *Technological Forecasting Social Change*, vol. 132, pp. 18-25.

Deloitte 2018, *How Cloud Can Boost Innovation*, The Wall Street Journal CIO Journal, <https://deloitte.wsj.com/cio/2018/06/15/how-cloud-can-boost-innovation-2/>.

Deng, W 2017, 'Variable-rate Technology: A Critical Element in Precision Water-saving Irrigation', *Irrigat Drainage Sys Eng*, vol. 6, no. 2, p. e128.

Denti, L & Hemlin, S 2012, 'Leadership and innovation in organizations: A systematic review of factors that mediate or moderate the relationship', *International Journal of Innovation Management*, vol. 16, no. 3, p. 1240007.

Denzin, N 1989, *The Research Act: A Theoretical Introduction to Sociological Methods* Prentice Hall, New York.

Denzin, NK & Lincoln, YS 2008, *The landscape of qualitative research*, Sage Publishing, Los Angeles, CA.

Denzin, NK & Lincoln, YS 2011, *The Sage handbook of qualitative research*, Sage Publishing, Los Angeles, CA.

Denzin, NK & Lincoln, YS 2018, *The Sage handbook of qualitative research*, Fifth edition. edn, Sage Publishing, Los Angeles.

Depczynski, J, Franklin, RC, Challinor, K, Williams, W & Fragar, LJJoAS 2005, 'Farm noise emissions during common agricultural activities', *Journal of Agricultural Safety, Health and Psychology*, vol. 11, no. 3, pp. 325-334.

Devereaux, M, Drynan, A, Lowry, S, MacLennan, D, Figdor, M, Fancott, C & Sinclair, L 2006, 'Evaluating organizational readiness for change: a preliminary mixed-model assessment of an interprofessional rehabilitation hospital', *Healthcare quarterly*, vol. 9, no. 4, pp. 66-74.

Dewar, RD & Dutton, JE 1986, 'The adoption of radical and incremental innovations: An empirical analysis', *Management science*, vol. 32, no. 11, pp. 1422-1433.

Dey, I 2003, *Qualitative data analysis: A user friendly guide for social scientists*, Routledge, London.

Dodgson, M, Gann, DM & Salter, A 2008, *The management of technological innovation: strategy and practice*, Oxford University Press Oxford.

Dong, JQ & Wu, W 2015, 'Business value of social media technologies: Evidence from online user innovation communities', *The Journal of Strategic Information Systems*, vol. 24, no. 2, pp. 113-127.

Douaioui, K, Fri, M & Mabroukki, C 'The interaction between industry 4.0 and smart logistics: concepts and perspectives', IEEE, pp. 128-132.

Draucker, CB, Martsolf, DS, Ross, R & Rusk, TB 2007, 'Theoretical sampling and category development in grounded theory', *Qualitative health research*, vol. 17, no. 8, pp. 1137-1148.

Dreux IV, DR 1990, 'Financing family business: Alternatives to selling out or going public', *Family business review*, vol. 3, no. 3, pp. 225-243.

Drisko, JW 1997, 'Strengthening qualitative studies and reports: Standards to promote academic integrity', *Journal of social work education*, vol. 33, no. 1, pp. 185-197.

Drucker, P 1985, *Innovation and Entrepreneurship: practice and principles*, Routledge, Oxfordshire.

Dubé, L & Paré, G 2003, 'Rigor in information systems positivist case research: current practices, trends, and recommendations', *MIS quarterly*, vol., pp. 597-636.

Duerr, S, Holotiuk, F, Wagner, H-T, Beimborn, D & Weitzel, T 2018, 'What is digital organizational culture? Insights from exploratory case studies', in *Proceedings of the 51st Hawaii International Conference on System Sciences*, Hawaii, US.

Duke, A & Anumba, C 1997, 'Enabling collaboration for virtual construction project teams', in *Concurrent Engineering In Construction*, IStructE, pp. 163-172.

Dunn, B 1995, 'Success themes in Scottish family enterprises: Philosophies and practices through the generations', *Family business review*, vol. 8, no. 1, pp. 17-28.

Duran, P, Kammerlander, N, Van Essen, M & Zellweger, T 2016, 'Doing more with less: Innovation input and output in family firms', *Academy of management journal*, vol. 59, no. 4, pp. 1224-1264.

Dyer Jr, WG & Whetten, DA 2006, 'Family firms and social responsibility: Preliminary evidence from the S&P 500', *Entrepreneurship theory practice*, vol. 30, no. 6, pp. 785-802.

Easterby-Smith, M, Thorpe, R & Lowe, A 2002, *Management Research: An Introduction*, 2 edn, Sage Publishing, London.

Eastwood, C, Chapman, D & Paine, M 2009, 'Farmers as co-developers of innovative precision farming systems', in *EFITA (European Federation of Information Technology in Agriculture) Conference*.

Eby, LT, Adams, DM, Russell, JE & Gaby, SH 2000, 'Perceptions of organizational readiness for change: Factors related to employees' reactions to the implementation of team-based selling', *Human relations*, vol. 53, no. 3, pp. 419-442.

Eby, LT, Hurst, CS & Butts, MM 2009, 'The redheaded stepchild in organizational and social science research', *Statistical and methodological myths and urban legends: Doctrine, verity and fable in the organizational social sciences*, vol., pp. 219-246.

Edhlund, BM 2011, *NVIVO 9 Essential*, Form & Kunskap AB, Sweden.

Edmondson, AC & McManus, SE 2007, 'Methodological fit in management field research', *Academy of management review*, vol. 32, no. 4, pp. 1246-1264.

Eisenhardt, KM 1989, 'Building theories from case study research', *Academy of management review*, vol. 14, no. 4, pp. 532-550.

Eisenhardt, KM & Graebner, ME 2007, 'Theory building from cases: Opportunities and challenges', *The Academy of Management Journal*, vol. 50, no. 1, pp. 25-32.

Eisenhardt, KM & Tabrizi, BN 1995, 'Accelerating adaptive processes: Product innovation in the global computer industry', *Administrative science quarterly*, vol. 40, no. 1, pp. 84-110.

Ekboir, J & Initiative, C 2012, 'How to build innovation networks', *Agricultural Innovation Systems. An Investment Sourcebook*, vol., pp. 44-51.

El Bilali, H & Allahyari, MS 2018, 'Transition towards sustainability in agriculture and food systems: Role of information and communication technologies', *Information Processing in Agriculture*, vol. 5, no. 4, pp. 456-464.

El Bilali, H, Bottalico, F, Palmisano, GO & Capone, R 'Information and Communication Technologies for Smart and Sustainable Agriculture', Springer, pp. 321-334.

Elferink, M & Schierhorn, F 2016, 'Global Demand for Food Is Rising. Can We Meet It?', *Harvard business review*, vol. 7, no. 4.

Emerick, K & Dar, MH 2020, 'Farmer Field Days and Demonstrator Selection for Increasing Technology Adoption', *Review of Economics and Statistics*, vol., pp. 1-41.

Erol, S, Schumacher, A & Sihn, W 'Strategic guidance towards Industry 4.0–a three-stage process model', pp. 495-501.

European Commission 2017, *European Union funds digital research and innovation for agriculture to tackle societal challenges*, viewed 25.08.2019, <https://ec.europa.eu/info/news/european-union-funds-digital-research-and-innovation-agriculture-tackle-societal-challenges_en>.

European Commission 2019, *Benefits and impact of digital technologies*, viewed 12.07.2019, <https://ec.europa.eu/eip/agriculture/en/digitising-agriculture/benifits-and-impact-digital-technologies>.

Evans, JD & Johnson, RO 2013, 'Tools for managing early-stage business model innovation', *Research-Technology Management*, vol. 56, no. 5, pp. 52-56.

Evans, KJ, Terhorst, A & Kang, BH 2017, 'From data to decisions: helping crop producers build their actionable knowledge', *Critical reviews in plant sciences*, vol. 36, no. 2, pp. 71-88.

Evans, ND 2016, 'Future skills', *ITNOW*, vol. 58, no. 1, pp. 50-51.

Evers, J & De Boer, F 2012, *The qualitative interview: Art and skill*, Eleven international publishing, Amsterdam.

EY 2019, *Agricultural Innovation — A National Approach to Grow Australia's Future*, viewed 06.09.2019, <http://www.agriculture.gov.au/SiteCollectionDocuments/agriculture-food/innovation/full-report-agricultural-innovation.PDF>.

Faems, D, Van Looy, B & Debackere, K 2005, 'Interorganizational collaboration and innovation: Toward a portfolio approach', *Journal of Product Innovation Management*, vol. 22, no. 3, pp. 238-250.

Fagerberg, J, Mowery, DC & Nelson, RR 2005, *The Oxford handbook of innovation*, Oxford university press, Oxford.

Fahad, A, Alshatri, N, Tari, Z, Alamri, A, Khalil, I, Zomaya, AY, Foufou, S & Bouras, A 2014, 'A survey of clustering algorithms for big data: Taxonomy and empirical analysis', in *IEEE transactions on emerging topics in computing*, pp. 267-279.

FAO 2014, *The state of food and agriculture: Innovation in family farming*, Rome, FAO.

FAO 2017a, *The State of Food Security and Nutrition in the World 2017: Building Resilience for Peace and Food Security*, FAO.

FAO 2017b, *Water Scarcity – One of the greatest challenges of our time*, viewed 24.08.2019, <http://www.fao.org/zhc/detail-events/en/c/880881/>.

FAO 2018, *e-agriculture*, viewed 26.08.2019, <http://www.fao.org/e-agriculture/news/power-digital-technologies-future-agriculture-and-food-security-agenda-2030>.

FAO 2019, *Introducing the UN Decade of Family Farming: Key Facts*, viewed 18.04.2020, <http://www.fao.org/family-farming-decade/en/>.

FAO 2020a, *Countries requiring external assistance for food*, viewed 28.06.2020, <http://www.fao.org/giews/country-analysis/external-assistance/en/>.

FAO 2020b, *Q&A: COVID-19 pandemic – impact on food and agriculture*, viewed 04.07.2020, <http://www.fao.org/2019-ncov/q-and-a/impact-on-food-and-agriculture/en/>.

FAO & IFAD 2019, *United Nations Decade of Family Farming 2019-2028. Global Action Plan*, Rome, 978-92-5-131472-2, <http://www.fao.org/3/ca4672en/ca4672en.pdf>.

FAO, IFAD, UNICEF, WFP & WHO 2019, *The state of food security and nutrition in the world. Safeguarding against economic slowdowns and downturns.*, 2663-8061, FAO, Rome, <http://www.fao.org/3/ca5162en/ca5162en.pdf>.

Fasick, FA 1977, 'Some uses of untranscribed tape recordings in survey research', *The Public Opinion Quarterly*, vol. 41, no. 4, pp. 549-552.

Fathian, M, Akhavan, P & Hoorali, M 2008, 'E-readiness assessment of non-profit ICT SMEs in a developing country: The case of Iran', *Technovation*, vol. 28, no. 9, pp. 578-590.

Federation, NF 1993, *New Horizons: A Strategy for Australia's Agrifood Industries*, National Farmers' Federation Australia.

Fereday, J & Muir-Cochrane, E 2006, 'Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development', *International journal of qualitative methods*, vol. 5, no. 1, pp. 80-92.

Ferràs-Hernández, X 2018, 'The Future of Management in a World of Electronic Brains', *Journal of Management Inquiry*, vol. 27, no. 2, pp. 260-263.

Fichman, RG, Dos Santos, BL & Zheng, ZE 2014, 'Digital innovation as a fundamental and powerful concept in the information systems curriculum', *MIS quarterly*, vol. 38, no. 2.

Fielke, S, Taylor, B & Jakku, E 2020, 'Digitalisation of agricultural knowledge and advice networks: A state-of-the-art review', *Agricultural systems*, vol. 180, p. 102763.

Fiore, SM, Ross, KG, Jentsch, F & Making, D 2012, 'A team cognitive readiness framework for small-unit training', *Journal of Cognitive Engineering*, vol. 6, no. 3, pp. 325-349.

Fischer, K, Sjöström, K, Stiernström, A & Emanuelson, U 2019, 'Dairy farmers' perspectives on antibiotic use: A qualitative study', *Journal of dairy science*, vol. 102, no. 3, pp. 2724-2737.

Fishbein, M & Ajzen, I 1975, *Belief, attitude, intention and behavior: An introduction to theory and research*, Addison-Wesley, Reading, MA.

Fishman, R 2016, 'More uneven distributions overturn benefits of higher precipitation for crop yields', *Environmental Research Letters*, vol. 11, no. 2, p. 024004.

Fitz-Koch, S, Cooper, S & Cruz, AD 2019, 'Entrepreneurship and rural family identity: Understanding portfolio development in a family farm business', in *The Family Business Group Phenomenon*, Springer, Cham, pp. 353-383.

Fitzgerald, M, Kruschwitz, N, Bonnet, D & Welch, M 2014, 'Embracing digital technology: A new strategic imperative', *MIT sloan management review*, vol. 55, no. 2, p. 1.

Fleming, A, Jakku, E, Lim-Camacho, L, Taylor, B & Thorburn, P 2018, 'Is big data for big farming or for everyone? Perceptions in the Australian grains industry', *Agronomy for sustainable development*, vol. 38, no. 3, p. 24.

Flick, U 2018, *An introduction to qualitative research*, Sage Publishing, Los Angeles, CA.

Fontana, A & Frey, JH 2005, 'The interview: From neutral stance to political involvement', vol.

Food Agility CRC 2019, *Food Agility: Food for the future* viewed 06.04.2020, <https://www.foodagility.com/about>.

Fraga, H, Pinto, JG, Viola, F & Santos, JA 2020, 'Climate change projections for olive yields in the Mediterranean Basin', *International Journal of Climatology*, vol. 40, no. 2, pp. 769-781.

Fram, SM 2013, 'The constant comparative analysis method outside of grounded theory', *The qualitative report*, vol. 18, no. 1, pp. 1-25.

Francis, D & Bessant, J 2005, 'Targeting innovation and implications for capability development', *Technovation*, vol. 25, no. 3, pp. 171-183.

Franco, D, Singh, DR & Praveen, KV 2018, 'Evaluation of adoption of precision farming and its profitability in banana crop', *Indian Journal of Economics and Development*, vol. 14, no. 2, pp. 225-234.

Freeman, C 1974, *The Economics of industrial innovation*, Routledge, London.

Fuller, BE, Rieckmann, T, Nunes, EV, Miller, M, Arfken, C, Edmundson, E & McCarty, D 2007, 'Organizational readiness for change and opinions toward treatment innovations', *Journal of Substance Abuse Treatment*, vol. 33, no. 2, pp. 183-192.

Gandhi, PK, Somesh; Ramaswamy, Sree 2016, 'Which Industries Are the Most Digital (and Why)?', *Harvard business review*, <https://hbr.org/2016/04/a-chart-that-shows-which-industries-are-the-most-digital-and-why>.

García, L, Parra, L, Jimenez, JM, Lloret, J & Lorenz, P 2020, 'IoT-Based Smart Irrigation Systems: An Overview on the Recent Trends on Sensors and IoT Systems for Irrigation in Precision Agriculture', *Sensors*, vol. 20, no. 4, p. 1042.

Gasson, R & Errington, A 1993, *The farm family business-Cab International-Wallingford*, Oxford.

Gault, F 2018, 'Defining and measuring innovation in all sectors of the economy', *Research Policy*, vol. 47, no. 3, pp. 617-622.

Gent, DH, De Wolf, E & Pethybridge, SJ 2011, 'Perceptions of risk, risk aversion, and barriers to adoption of decision support systems and integrated pest management: an introduction', *Phytopathology*, vol. 101, no. 6, pp. 640-643.

Gichoya, D 2005, 'Factors affecting the successful implementation of ICT projects in government', *The Electronic Journal of e-government*, vol. 3, no. 4, pp. 175-184.

Gist, ME & Mitchell, TR 1992, 'Self-efficacy: A theoretical analysis of its determinants and malleability', *Academy of management review*, vol. 17, no. 2, pp. 183-211.

Glaser, B & Strauss, A 1967, *The Discovery of Grounded Theory: Strategies for Qualitative Research (Weidenfeld and Nicholson, London)*, Routledge, London.

Global Agriculture 2019, *Industrial Agriculture and Small-scale Farming*, <https://www.globalagriculture.org/report-topics/industrial-agriculture-and-small-scale-farming.html>.

Godin, B 2002, 'The rise of innovation surveys: Measuring a fuzzy concept', in *Canadian Science and innovation indicators consortium, project on the history and sociology of S&T statistics*.

Golafshani, N 2003, 'Understanding reliability and validity in qualitative research', *The qualitative report*, vol. 8, no. 4, pp. 597-606.

Goodman, LAJTaoms 1961, 'Snowball sampling', vol., pp. 148-170.

Gopalakrishnan, S & Damanpour, FJO 1997, 'A review of innovation research in economics, sociology and technology management', vol. 25, no. 1, pp. 15-28.

Gosnell, H, Gill, N & Voyer, M 2019, 'Transformational adaptation on the farm: Processes of change and persistence in transitions to ‘climate-smart’regenerative agriculture', *Global Environmental Change*, vol. 59, p. 101965.

Gou, Z, Lau, SS-Y & Prasad, D 2013, 'Market readiness and policy implications for green buildings: case study from Hong Kong', *Journal of Green Building*, vol. 8, no. 2, pp. 162-173.

Goulding, JS & Lou, EC 2013, 'E-readiness in construction: an incongruous paradigm of variables', *Architectural Engineering and Design Management*, vol. 9, no. 4, pp. 265-280.

Government of Canada 2018, *Government of Canada to invest in national initiatives for automation and digital technologies in the agriculture and agri-food sector*, viewed 11.11.2019, <https://www.canada.ca/en/innovation-science-economic-development/news/2018/12/government-of-canada-to-invest-in-national-initiatives-for-automation-and-digital-technologies-in-the-agriculture-and-agri-food-sector.html>.

Government of Western Australia 2019, *Digital Farm Grants program*, viewed 11.11.2019, <https://www.agric.wa.gov.au/r4r/digital-farm-grants-program-closed>.

Green, J & Brown, J 2005, *Principles of social research*, Open University Press, Maidenhead.

Greenhalgh, T, Robert, G, Macfarlane, F, Bate, P & Kyriakidou, OJTMQ 2004, 'Diffusion of innovations in service organizations: systematic review and recommendations', vol. 82, no. 4, pp. 581-629.

Greenhalgh, T & Taylor, R 1997, 'How to read a paper: Papers that go beyond numbers (qualitative research)', *Bmj*, vol. 315, no. 7110, pp. 740-743.

Greiner, R & Gregg, D 2011, 'Farmers’ intrinsic motivations, barriers to the adoption of conservation practices and effectiveness of policy instruments: Empirical evidence from northern Australia', *Land Use Policy*, vol. 28, no. 1, pp. 257-265.

Greiner, R, Patterson, L & Miller, O 2009, 'Motivations, risk perceptions and adoption of conservation practices by farmers', *Agricultural systems*, vol. 99, no. 2-3, pp. 86-104.

Groborz, A & Juliszewski, T 2013, 'Comparison of farmers workload by manual and mechanical tasks on family farms', *Annals of Agricultural Environmental Medicine*, vol. 20, no. 2.

Grundke, R, Marcolin, L & Squicciarini, M 2018, *Which skills for the digital era?*, viewed 20.05.2019, <http://jobsanddevelopmentconference.org/wpcontent/uploads/2018/05/lmarcolin_s6r301.pdf>.

Guba, EG & Lincoln, YS 1989, 'What is This Constructivist Paradigm Anyway?', in *Fourth generation evaluation*, Sage Publishing, Newbury Park, CA, pp. 79-90.

Guest, G, MacQueen, KM & Namey, EE 2011, *Applied thematic analysis*, Sage Publishing, Los Angeles, CA.

Guion, LA, Diehl, DC & McDonald, D 2001, *Conducting an in-depth interview*, University of Florida Cooperative Extension Service.

Gummesson, E 2000, *Qualitative methods in management research*, Sage Publishing, Thousand Oaks, CA.

Gunday, G, Ulusoy, G, Kilic, K & Alpkan, L 2011, 'Effects of innovation types on firm performance', *International Journal of production economics*, vol. 133, no. 2, pp. 662-676.

Haar, P 2018, 'Measuring innovation: A state of the science review of existing approaches', *Intangible Capital*, vol. 14, no. 3, pp. 409-428.

Halewood, M, Chiurugwi, T, Sackville Hamilton, R, Kurtz, B, Marden, E, Welch, E, Michiels, F, Mozafari, J, Sabran, M & Patron, N 2018, 'Plant genetic resources for food and agriculture: opportunities and challenges emerging from the science and information technology revolution', *New Phytologist*, vol. 217, no. 4, pp. 1407-1419.

Hamilton, RJ & Bowers, BJ 2006, 'Internet recruitment and e-mail interviews in qualitative studies', *Qualitative health research*, vol. 16, no. 6, pp. 821-835.

Handcock, MS & Gile, KJ 2011, 'Comment: On the concept of snowball sampling', *Sociological methodology*, vol. 41, no. 1, pp. 367-371.

Hanson, SK, Hessel, HM & Danes, SM 2019, 'Relational processes in family entrepreneurial culture and resilience across generations', *Journal of Family Business Strategy*, vol. 10, no. 3, p. 100263.

Healy, M & Perry, C 2000, 'Comprehensive criteria to judge validity and reliability of qualitative research within the realism paradigm', *Qualitative market research: An international journal*, vol. 3, no. 3, pp. 118-126.

Heck, RK & Trent, ES 1999, 'The prevalence of family business from a household sample', *Family business review*, vol. 12, no. 3, pp. 209-219.

Heritage, J & Atkinson, JM 1984, 'Structures of social action', in *Studies in Conversation Analysis*, Cambridge University Press, Cambridge, pp. 346-369.

Hermans, F, Geerling-Eiff, F, Potters, J & Klerkx, L 2019, 'Public-private partnerships as systemic agricultural innovation policy instruments–Assessing their contribution to innovation system function dynamics', *NJAS-Wageningen Journal of Life Sciences*, vol. 88, pp. 76-95.

Hess, T, Matt, C, Benlian, A & Wiesböck, F 2016, 'Options for formulating a digital transformation strategy', *MIS Quarterly Executive*, vol. 15, no. 2.

Higginbottom, GMA 2004, 'Sampling issues in qualitative research', *Nurse researcher*, vol. 12, no. 1, p. 7.

Hirsch-Kreinsen, H 2015, 'Innovation in low-tech industries: Current conditions and future prospects', in *Low-tech innovation*, Springer, Cham, pp. 17-32.

Hofmann, E & Rüsch, M 2017, 'Industry 4.0 and the current status as well as future prospects on logistics', *Computers in Industry*, vol. 89, pp. 23-34.

Holmström, J 2018, 'Recombination in digital innovation: Challenges, opportunities, and the importance of a theoretical framework', *Information and Organization*, vol. 28, no. 2, pp. 107-110.

Holstein, JA & Gubrium, JF 1995, *The active interview*, Sage Publishing, Johanneshov.

Holt, DT, Armenakis, AA, Feild, HS & Harris, SG 2007, 'Readiness for organizational change: The systematic development of a scale', *The Journal of Applied Behavioral Science*, vol. 43, no. 2, pp. 232-255.

Holt, DT, Armenakis, AA, Harris, SG & Feild, HS 2007, 'Toward a comprehensive definition of readiness for change: A review of research and instrumentation', in *Research in organizational change and development*, Emerald Group Publishing Limited, Bingley, pp. 289-336.

Holt, DT, Bartczak, SE, Clark, SW & Trent, MR 2007, 'The development of an instrument to measure readiness for knowledge management', *Knowledge Management Research & Practice*, vol. 5, no. 2, pp. 75-92.

Holt, DT & Daspit, JJ 2015, 'Diagnosing innovation readiness in family firms', *California Management Review*, vol. 58, no. 1, pp. 82-96.

Horton, J, Macve, R & Struyven, G 2004, 'Qualitative research: experiences in using semi-structured interviews', in *The real life guide to accounting research*, Elsevier, Amsterdam, pp. 339-357.

Hossain, M & Kauranen, I 2016, 'Open innovation in SMEs: a systematic literature review', *Journal of Strategy Management*, vol. 9, no. 1, pp. 58-73.

Hourali, M, Fathian, M, Montazeri, A & Hourali, M 2008, 'A model for e-readiness assessment of Iranian small and medium enterprises', *Journal of Faculty of Engineering*, vol. 41, no. 7, pp. 969-985.

Howden, M, Nelson, R & Zammit, K 2018, 'Australian agriculture overview', *Agricultural Commodities*, vol. 8, no. 2, p. 11.

Hu, J, Gao, L, Bai, X, Li, T & Liu, X 2015, 'Review of research on automatic guidance of agricultural vehicles', *Transactions of the Chinese Society of Agricultural Engineering*, vol. 31, no. 10, pp. 1-10.

Huang, J, Henfridsson, O, Liu, MJ & Newell, S 2017, 'growing on steroids: rapidly scaling the user base of digital ventures through digital innovation', *MIS quarterly*, vol. 41, no. 1.

Huber, F, Wainwright, T & Rentocchini, F 2020, 'Open data for open innovation: managing absorptive capacity in SMEs', *R&D Management*, vol. 50, no. 1, pp. 31-46.

Hund, A & Wagner, H-T 2019, 'Innovation networks and digital innovation: how organizations use innovation networks in a digitized environment', in *Wirtschaftsinformatik* Association for Information Systems.

Iizumi, T & Ramankutty, N 2015, 'How do weather and climate influence cropping area and intensity?', *Global Food Security*, vol. 4, pp. 46-50.

Iizumi, T, Yokozawa, M, Sakurai, G, Travasso, MI, Romanenkov, V, Oettli, P, Newby, T, Ishigooka, Y & Furuya, J 2014, 'Historical changes in global yields: major cereal and legume crops from 1982 to 2006', *Global ecology biogeography*, vol. 23, no. 3, pp. 346-357.

Inwood, S, Clark, JK & Bean, M 2013, 'The differing values of multigeneration and first-generation farmers: Their influence on the structure of agriculture at the rural-urban interface', *Rural Sociology*, vol. 78, no. 3, pp. 346-370.

Inwood, SM & Sharp, JS 2012, 'Farm persistence and adaptation at the rural–urban interface: Succession and farm adjustment', *Journal of rural studies*, vol. 28, no. 1, pp. 107-117.

IPCC, IPoCC 2014, 'Climate Change 2014 Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects', *Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, vol., p. pp. 688.

Issa, AM, Tufail, W, Hutchinson, J, Tenorio, J & Baliga, MP 2009, 'Assessing patient readiness for the clinical adoption of personalized medicine', *Public health genomics*, vol. 12, no. 3, pp. 163-169.

Ivanov, D, Dolgui, A, Sokolov, B, Werner, F & Ivanova, M 2016, 'A dynamic model and an algorithm for short-term supply chain scheduling in the smart factory industry 4.0', *International journal of production research*, vol. 54, no. 2, pp. 386-402.

Jackson, T, Hatfield-Dodds, S & Zammit, K 2020, *Snapshot of Australian Agriculture 2020*, Austrlian Government, ABARES, viewed 22.04.2020, <https://www.agriculture.gov.au/abares/publications/insights/snapshot-of-australian-agriculture-2020#around-70-of-agricultural-output-is-exported>.

Jakobsen, M 2017, 'Consequences of intensive use of non-financial performance measures in Danish family farm holdings', *Qualitative Research in Accounting & Management*, vol. 14, no. 2, pp. 137-156.

Johnston, WJ, Leach, MP & Liu, AH 1999, 'Theory testing using case studies in business-to-business research', *Industrial marketing management*, vol. 28, no. 3, pp. 201-213.

Jones, I 1997, 'Mixing qualitative and quantitative methods in sports fan research', *The qualitative report*, vol. 3, no. 4, pp. 1-8.

Jones, R & Noble, G 2007, 'Grounded theory and management research: a lack of integrity?', *Qualitative Research in Organizations and Management: An International Journal*, vol. 2, no. 2, pp. 84-103.

Jones, RA, Jimmieson, NL & Griffiths, A 2005a, 'The impact of organizational culture and reshaping capabilities on change implementation success: The mediating role of readiness for change', *Journal of management studies*, vol. 42, no. 2, pp. 361-386.

Jones, RA, Jimmieson, NL & Griffiths, A 2005b, 'The impact of organizational culture and reshaping capabilities on change implementation success: The mediating role of readiness for change', *Journal of Management Studies*, vol. 42, no. 2, pp. 361-386.

Jung, K, Kulvatunyou, B, Choi, S & Brundage, MP 'An overview of a smart manufacturing system readiness assessment', Springer, pp. 705-712.

Kagermann, H, Lukas, W-D & Wahlster, W 2011, 'Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. industriellen Revolution', *VDI nachrichten*, vol. 13, no. 1.

Kakatkar, C, Bilgram, V & Füller, J 2020, 'Innovation analytics: Leveraging artificial intelligence in the innovation process', *Business Horizons*, vol. 63, no. 2, pp. 171-181.

Kaler, J & Ruston, A 2019, 'Technology adoption on farms: Using Normalisation Process Theory to understand sheep farmers' attitudes and behaviours in relation to using precision technology in flock management', *Preventive Veterinary Medicine*, vol. 170, no. 104715.

Kamble, SS, Gunasekaran, A & Gawankar, SA 2020, 'Achieving sustainable performance in a data-driven agriculture supply chain: A review for research and applications', *International Journal of production economics*, vol. 219, pp. 179-194.

Kane, GC, Palmer, D, Phillips, AN, Kiron, D & Buckley, N 2015, *Strategy, not technology, drives digital transformation*, Deloitte University Press.

Kanter, RM 1984, *Change masters*, Simon and Schuster, London.

Kaplan, RS & Norton, DP 2004, 'Measuring the strategic readiness of intangible assets', *Harvard business review*, vol. 82, no. 2, pp. 52-63.

Karanasios, S & Burgess, S 2008, 'Tourism and Internet adoption: a developing world perspective', *International Journal of Tourism Research*, vol. 10, no. 2, pp. 169-182.

Karanasios, S & Slavova, M 2019, 'How do development actors do "ICT for development"? A strategy-as-practice perspective on emerging practices in Ghanaian agriculture', *Information Systems Journal*, vol. 29, no. 4, pp. 888-913.

Karp, P 2019, *Climate change has cut Australian farm profits by 22% a year over past 20 years, report says*, The Guardian, viewed 24.04.20, <https://www.theguardian.com/australia-news/2019/dec/18/climate-change-has-cut-australian-farm-profits-by-22-a-year-over-past-20-years-report-says>.

Katyal, N & Pandian, BJ 2020, 'A Comparative Study of Conventional and Smart Farming', in *Emerging Technologies for Agriculture and Environment*, Springer, Singaapore, pp. 1-8.

Keast, R & Hampson, K 2007, 'Building constructive innovation networks: Role of relationship management', *Journal of Construction Engineering and Management*, vol. 133, no. 5, pp. 364-373.

Keller, R & König, C 2014, 'A reference model to support risk identification in cloud networks', in *35th International Conference on Information Systems*.

Keogh, M & Henry 2016, *The Implications of Digital Agriculture and Big Data for Australian Agriculture: April 2016*, Australian Farm Institute.

Kernecker, M, Knierim, A, Wurbs, A, Kraus, T & Borges, F 2020, 'Experience versus expectation: farmers' perceptions of smart farming technologies for cropping systems across Europe', *Precision Agriculture*, vol. 21, no. 1, pp. 34-50.

Khalfan, MM & Anumba, CJ 2006, 'Readiness assessment for concurrent engineering in construction', in *Concurrent Engineering in Construction Projects*, Routledge, London, pp. 44-70.

Khalfan, MM, Anumba, CJ & Carrillo, PM 2001, 'Development of a readiness assessment model for concurrent engineering in construction', *Benchmarking: An International Journal*, vol. 8, no. 3, pp. 223-239.

Kijne, JW, Barker, R & Molden, DJ 2003, *Water productivity in agriculture: limits and opportunities for improvement*, Oxford University Press, Wallingford.

King, N, Horrocks, C & Brooks, J 2019, *Interviews in qualitative research*, Sage Publishing, Los Angeles, CA.

Klein, KJ & Kozlowski, SW 2000, 'From micro to meso: Critical steps in conceptualizing and conducting multilevel research', *Organizational Research Methods*, vol. 3, no. 3, pp. 211-236.

Kohli, R & Melville, NP 2019, 'Digital innovation: A review and synthesis', *Information Systems Journal*, vol. 29, no. 1, pp. 200-223.

König, A, Kammerlander, N & Enders, A 2013, 'The Family Innovator's Dilemma: How Family Influence Affects the Adoption of Discontinuous Technologies by Incumbent Firms', *Academy of management review*, vol. 38, no. 3, pp. 418-441.

Kosior, K 2018, 'Digital transformation in the agri-food sector–opportunities and challenges', *Roczniki (Annals)*, vol. 2018, no. 1230-2019-3703.

Kotey, B 2005, 'Goals, management practices, and performance of family SMEs', *International Journal of Entrepreneurial Behavior & Research*, vol. 11, no. 1, pp. 3-24.

Kotkin, J 2015, *The Uncelebrated Places Where America's Farm Economy Is Thriving*, Forbes, viewed 06.07.2019, <https://www.forbes.com/sites/joelkotkin/2015/05/20/the-uncelebrated-places-where-americas-farm-economy-is-thriving/#541c2e2f4922>.

Kotrlik, J & Higgins, C 2001, 'Organizational research: Determining appropriate sample size in survey research appropriate sample size in survey research', *Information technology, learning, performance journal*, vol. 19, no. 1, p. 43.

Kountios, G, Ragkos, A, Bournaris, T, Papadavid, G & Michailidis, A 2018, 'Educational needs and perceptions of the sustainability of precision agriculture: survey evidence from Greece', *Precision Agriculture*, vol. 19, no. 3, pp. 537-554.

Kryukov, V & Gorin, A 2016, 'Digital technologies as education innovation at universities', *Journal of Internet Banking*, vol. 21, no. 3, p. 1.

Kuehne, G, Llewellyn, R, Pannell, DJ, Wilkinson, R, Dolling, P, Ouzman, J & Ewing, M 2017, 'Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy', *Agricultural systems*, vol. 156, pp. 115-125.

Kuhn, TS 1962, *The structure of scientific revolutions*.

Kulkarni, AA, Dhanush, P, Chetan, B, Thamme Gowda, C & Shrivastava, PK 2020, 'Applications of Automation and Robotics in Agriculture Industries; A Review', in *IOP Conference Series. Materials Science and Engineering*.

Kvale, S 1994, *Interviews: An introduction to qualitative research interviewing*, Sage Publishing, Thousand Oaks, CA.

Lam, C & Law, R 2019, 'Readiness of upscale and luxury-branded hotels for digital transformation', *International Journal of Hospitality Management* vol. 79, pp. 60-69.

Lancaster, G & Crowther, D 2012, *Research methods: A concise introduction to research in management and business consultancy*, Routledge, London.

Langley, A, Smallman, C, Tsoukas, H & Van de Ven, AH 2013, 'Process studies of change in organization and management: Unveiling temporality, activity, and flow', *Academy of management journal*, vol. 56, no. 1, pp. 1-13.

Langner, T, Kamoun, S & Belhaj, K 2018, 'CRISPR crops: plant genome editing toward disease resistance', *Annual review of phytopathology*, vol. 56, pp. 479-512.

Laursen, K & Salter, A 2014, 'The paradox of openness: Appropriability, external search and collaboration', *Research Policy*, vol. 43, no. 5, pp. 867-878.

Lazovic, ST 2020, 'Cybernetics in function of ambitious future of agriculture', *Economics of Agriculture*, vol. 67, no. 1, pp. 69-85.

LeCompte, MD & Goetz, JP 1982, 'Problems of reliability and validity in ethnographic research', *Review of educational research*, vol. 52, no. 1, pp. 31-60.

Lee, S & Csaszar, FA 2020, 'Cognitive and Structural Antecedents of Innovation: A Large-Sample Study', *Strategy Science*, vol.

Lee, S, Park, G, Yoon, B & Park, J 2010, 'Open innovation in SMEs—An intermediated network model', *Research policy*, vol. 39, no. 2, pp. 290-300.

Lees, JW & Reeve, I 1991, *Competencies for farming*, Rural Development Centre, University of New England, Armidale, NSW.

Lei, D, Hitt, MA & Bettis, R 1996, 'Dynamic core competences through meta-learning and strategic context', *Journal of management*, vol. 22, no. 4, pp. 549-569.

Leininger, M & Morse, J 1994, 'Evaluation Criteria', in *Critique of Qualitative Research studies*, Evaluation Criteria, Thousand Oaks, pp. 95-115.

Leininger, MM 1985, 'Ethnography and ethnonursing: Models and modes of qualitative data analysis', *Qualitative research methods in nursing*, vol., pp. 33-72.

Leonard, B, Kinsella, A, O'Donoghue, C, Farrell, M & Mahon, M 2017, 'Policy drivers of farm succession and inheritance', *Land Use Policy*, vol. 61, pp. 147-159.

Leonard, E, Rainbow, R, Trindall, J, Baker, I, Barry, S, Darragh, L, Darnell, R, George, A, Heath, R, Jakku, E, Laurie, A, Lamb, D, Llewellyn, R, Perrett, E, Sanderson, J, Skinner, A, Stollery, T, Wiseman, L, Wood, G & Zhang, A 2017, *Accelerating precision agriculture to decision agriculture: Enabling digital agriculture in Australia.*, Cotton Research and Development Corporation, Australia, < http://farminstitute.org.au/LiteratureRetrieve.aspx?ID=160984>.

Levitt, T 1960, 'Growth and profits through planned marketing innovation', *Journal of marketing research*, vol. 24, no. 4, pp. 1-8.

Leyh, C, Martin, S & Schäffer, T 'Industry 4.0 and Lean Production—A matching relationship? An analysis of selected Industry 4.0 models', IEEE, pp. 989-993.

Li, L, Su, F, Zhang, W & Mao, JY 2018, 'Digital transformation by SME entrepreneurs: A capability perspective', *Information Systems Journal*, vol. 28, no. 6, pp. 1129-1157.

Li, Y, Guan, K, Schnitkey, GD, DeLucia, E & Peng, B 2019, 'Excessive rainfall leads to maize yield loss of a comparable magnitude to extreme drought in the United States', *Global change biology*, vol. 25, no. 7, pp. 2325-2337.

Lichtblau, K, Stich, V, Bertenrath, R, Blum, M, Bleider, M, Millack, A, Schmitt, K, Schmitz, E & Schröter, M 2015, *IMPULS-industrie 4.0-readiness*.

Lim, CSC 2010, 'Designing inclusive ICT products for older users: taking into account the technology generation effect', *Journal of Engineering Design*, vol. 21, no. 2-3, pp. 189-206.

Lin, A & Chen, N-C 2012, 'Cloud computing as an innovation: Percepetion, attitude, and adoption', *International Journal of Information Management*, vol. 32, no. 6, pp. 533-540.

Lincoln, YS & Guba, EG 1985, *Naturalistic inguig*, Sage Publishing, Beverly Hills.

Lincoln, YS, Lynham, SA & Guba, E 2011, 'Paradigmatic controversies, contradictions, and emerging confluences, revisited', in *The Sage handbook of qualitative research*, Sage Publishing, Thousand Oaks, CA, pp. 97-128.

Litz, RA 1995, 'The family business: Toward definitional clarity', *Family business review*, vol. 8, no. 2, pp. 71-81.

Liu, Y & Xu, X 2017, 'Industry 4.0 and cloud manufacturing: A comparative analysis', *Journal of Manufacturing Science & Engineering*, vol. 139, no. 3, p. 034701.

Llewellyn, S & Northcott, D 2007, 'The “singular view” in management case studies', *Qualitative Research in Organizations Management: An International Journal*, vol. 2, no. 3, pp. 194-207.

Lobell, DB, Schlenker, W & Costa-Roberts, J 2011, 'Climate trends and global crop production since 1980', *Science*, vol. 333, no. 6042, pp. 616-620.

Local Farm Produce 2019, *Australian Farm Associations*, viewed 08.08.2019, <https://www.localfarmproduce.com.au/About/Farm-Associations>.

Loch, A, Hatt, M, Mamun, E, Xu Johnny , Bruce, S, Heyhoe, E, Nicholson, M & Ritman, K 2012, *Farm risk management in a changing climate*, ABARES.

Loecher, U 2000, 'Small and medium-sized enterprises–delimitation and the European definition in the area of industrial business', *European Business Review*, vol. 12, no. 5, pp. 261-264.

Lofland, J & Lofland, LH 1971, *Analyzing social settings*.

Lokuge, S & Sedera, D 2014, 'Enterprise Systems Lifecycle-Wide Innovation Readiness', in *PACIS*.

Lokuge, S, Sedera, D, Grover, V & Dongming, X 2019, 'Organizational readiness for digital innovation: Development and empirical calibration of a construct', *Information & Management*, vol. 56, pp. 445-461.

Lou, E, Lee, A & Goulding, J 2020, 'E-readiness in construction (ERiC): self-assessment framework for UK small and medium enterprise building services providers', *Architectural Engineering Design Management*, vol. 16, no. 1, pp. 3-33.

Lowitt, K, Hickey, GM, Saint Ville, A, Raeburn, K, Thompson-Colón, T, Laszlo, S & Phillip, LE 2020, 'Knowledge, Markets and Finance: Factors Affecting the Innovation Potential of Smallholder Farmers in the Caribbean Community', in *Food Security in Small Island States*, Springer, pp. 179-197.

Lozoya, C, Mendoza, C, Aguilar, A, Román, A & Castelló, R 2016, 'Sensor-based model driven control strategy for precision irrigation', *Journal of Sensors*, vol. 2016.

Lu, Y 2017, 'Industry 4.0: A survey on technologies, applications and open research issues', *Journal of Industrial Information Integration*, vol. 6, pp. 1-10.

Lutz, W 2013, *The future population of the world: what can we assume today*, Routledge, London.

Lynch, JP & Loh, KJ 2006, 'A summary review of wireless sensors and sensor networks for structural health monitoring', *The Shock and Vibration Digest*, vol. 38, no. 2, pp. 91-130.

Lyytinen, K, Yoo, Y & Boland Jr, RJ 2016, 'Digital product innovation within four classes of innovation networks', *Information Systems Journal*, vol. 26, no. 1, pp. 47-75.

MacQueen, KM & Milstein, B 1999, 'A systems approach to qualitative data management and analysis', *Field Methods*, vol. 11, no. 1, pp. 27-39.

Madsen, SR, Miller, D & John, CR 2005, 'Readiness for organizational change: do organizational commitment and social relationships in the workplace make a difference?', *Human Resource Development Quarterly*, vol. 16, no. 2, pp. 213-234.

Mahto, RV, Vora, G, McDowell, WC & Khanin, D 2020, 'Family member commitment, the opportunity costs of staying, and turnover intentions', *Journal of Business Research*, vol. 108, pp. 9-19.

Malerba, F & Orsenigo, L 1995, 'Schumpeterian patterns of innovation', *Cambridge Journal of Economics*, vol. 19, no. 1, pp. 47-65.

Maness, SB, Reitzel, LR, Hernandez, DC, Maria, DS, Batson, MA, Zingg, T, Kendzor, D & Businelle, MS 2019, 'Modifiable Risk Factors and Readiness to Change among Homeless Adults', *American journal of health behavior*, vol. 43, no. 2, pp. 373-379.

ManMohan, S & Tang, CS 2018, 'Corporate social sustainability in supply chains: a thematic analysis of the literature', *International journal of production research*, vol. 56, no. 2, pp. 882-901.

Manyika, J, Ramaswamy, S, Khanna, S, Sarrazin, H, Pinkus, G, Sethupathy, G & Yaffe, A 2015, *Digital America: A tale of the haves and have-mores*, McKinsey Global Institute, viewed 22.06.2019, <https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/digital-america-a-tale-of-the-haves-and-have-mores>.

Markus, ML & Lee, AS 2000, 'Special issue on intensive research in information systems: Using qualitative, interpretive, and case methods to study information technology--third', *MIS quarterly*, vol. 24, no. 3, p. 473.

Marshall, A, Dezuanni, M, Burgess, J, Thomas, J & Wilson, CK 2019, *Australian farmers' low levels of digital inclusion–findings from the Australian Digital Inclusion Index*.

Marshall, C & Rossman, GB 2014, *Designing qualitative research*, Sage Publishing, Thousand Oaks, CA.

Marshall, M 1996a, 'The key informant technique', *Family practice*, vol. 13, no. 1, pp. 92-97.

Marshall, M 1996b, 'Sampling for qualitative research', *Family practice*, vol. 13, no. 6, pp. 522-526.

Martínez-Caro, E, Cegarra-Navarro, JG & Alfonso-Ruiz, FJ 2020, 'Digital technologies and firm performance: The role of digital organisational culture', *Technological Forecasting and Social Change*, vol. 154, no. C.

Matt, C, Hess, T & Benlian, A 2015, 'Digital transformation strategies', *Business & Information Systems Engineering*, vol. 57, no. 5, pp. 339-343.

Matzler, K, Veider, V, Hautz, J & Stadler, C 2015, 'The impact of family ownership, management, and governance on innovation', *Journal of Product Innovation Management*, vol. 32, no. 3, pp. 319-333.

McAfee, A, Brynjolfsson, E, Davenport, TH, Patil, D & Barton, D 2012, 'Big data: the management revolution', *Harvard business review*, vol. 90, no. 10, pp. 60-68.

McCracken, G 1988, *The long interview*, Sage Publishing, Newbury Park, CA.

McLellan, E, MacQueen, KM & Neidig, JL 2003, 'Beyond the qualitative interview: Data preparation and transcription', *Field Methods*, vol. 15, no. 1, pp. 63-84.

McMurray, A, Pace, R & Scott, D 2004, *Research: A commonsense approach*, Thomson Social Science Press, Southbank, VIC.

Meijer, SS, Catacutan, D, Ajayi, OC, Sileshi, GW & Nieuwenhuis, M 2015, 'The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa', *International Journal of Agricultural Sustainability*, vol. 13, no. 1, pp. 40-54.

Menon, K, Kärkkäinen, H & Lasrado, LA 2016, 'Towards a Maturity Modeling Approach for the Implementation of Industrial Internet', in *PACIS*, p. 38.

Menzel, G 2015, *Is the Speed of Technology Development really“Speeding” up?*, Capgemini viewed 09.12.2019, <https://www.capgemini.com/2015/06/is-the-speed-of-technology-development-really-speeding-up/>.

Merriam, SB 1988, *Case study research in education: A qualitative approach*, Jossey-Bass, San Francisco, CA.

Merriam Webster Dictionary 2020, *Agriculture* viewed 06.06.19, <https://www.merriam-webster.com/dictionary/agriculture>.

Meyer, JP & Herscovitch, L 2001, 'Commitment in the workplace: Toward a general model', *Human resource management review*, vol. 11, no. 3, pp. 299-326.

Miake-Lye, IM, Delevan, DM, Ganz, DA, Mittman, BS & Finley, EP 2020, 'Unpacking organizational readiness for change: an updated systematic review and content analysis of assessments', *BMC health services research*, vol. 20, no. 1, p. 106.

Miles, MB, Huberman, AM, Huberman, MA & Huberman, M 1994, *Qualitative data analysis: An expanded sourcebook*, Sage Publishing, Thousand Oaks, CA.

Miles, MB, Huberman, AM & Saldaña, J 2014, *Qualitative data analysis: A methods sourcebook*, 3rd edn, Sage Publishing, Thousand Oaks, CA.

Miller, N, Griffin, T, Ciampitti, I & Sharda, A 2019, 'Farm adoption of embodied knowledge and information intensive precision agriculture technology bundles', *Precision Agriculture*, vol. 20, no. 2, pp. 348-361.

Minichiello, V, Aroni, R & Minichiello, V 1990, *In-depth interviewing: Researching people*, Pearson, Sydney, NSW.

Mintert, JR, Widmar, D, Langemeier, M, Boehlje, M & Erickson, B 2016, 'The challenges of precision agriculture: Is big data the answer?', in *Southern Agricultural Economics Association (SAEA) Annual Meeting*, San Antonio, Texas.

Mittal, S, Khan, MA, Romero, D & Wuest, T 2018, 'A critical review of smart manufacturing & Industry 4.0 maturity models: Implications for small and medium-sized enterprises (SMEs)', *Journal of manufacturing systems*, vol. 49, pp. 194-214.

Moerkerken, A, Blasch, J, Van Beukering, P & Van Well, E 2020, 'A new approach to explain farmers’ adoption of climate change mitigation measures', *Climatic Change*, vol. 159, no. 1, pp. 141-161.

Molla, A 2008, 'E-Readiness and Successful E-Commerce Diffusion in Developing Countries', in *Global Information Technologies: Concepts, Methodologies, Tools, and Applications*, IGI Global, pp. 239-255.

Molla, A, Cooper, V, Corbitt, B, Deng, H, Peszynski, K, Pittayachawan, S & Teoh, SY 2008, 'E-readiness to G-readiness: Developing a green information technology readiness framework', in *ACIS* pp. 669–678.

Mont, O 2004, *Product-service systems: panacea or myth?*, Lund University.

Moore, K 1990, *Learning on the farm: the educational background and needs of New Zealand farmers*, New Zealand Council for Educational Research.

Morehouse, RE & Maykut, P 2002, *Beginning qualitative research: A philosophical and practical guide*, Routledge, London.

Morse, JM 1994, *Critical issues in qualitative research methods*, Sage Publishing, Thousand Oaks, CA.

Morse, JM & Field, PA 1996, *Nursing research: The application of qualitative approaches*, 2nd edn, Springer, Boston, MA.

Moser, CA & Kalton, G 2017, *Survey methods in social investigation*, Routledge, London.

Mulla, S, Singh, SK, Singh, K & Praveen, B 2020, 'Climate Change and Agriculture: A Review of Crop Models', in *Global climate change and environmental policy: agriculture perspectives*, Springer, Singapore, pp. 423-435.

Murphy, E, Dingwall, R, Greatbatch, D, Parker, S & Watson, P 1998, 'Qualitative research methods in health technology assessment: a review of the literature', *Health Technology Assessment*, vol. 2, no. 16, pp. Iii-Ix.

Murphy, JP 1990, *Pragmatism from Peirce to Davidson*, Westview Press, Boulder, CO.

Mwangi, M & Kariuki, S 2015, 'Factors determining adoption of new agricultural technology by smallholder farmers in developing countries', *Journal of Economics and sustainable development*, vol. 6, no. 5.

Myers, MD 2013, *Qualitative research in business and management*, Sage Publishing, London.

Myers, MD & Newman, M 2007, 'The qualitative interview in IS research: Examining the craft', *Information and organization*, vol. 17, no. 1, pp. 2-26.

Myers, S & Marquis, DG 1969, *Successful Industrial Innovations: A Study of Factoring Undelying Innovation in Selected Firms*, National Science Foundation.

Najafi-Tavani, S, Najafi-Tavani, Z, Naudé, P, Oghazi, P & Zeynaloo, E 2018, 'How collaborative innovation networks affect new product performance: Product innovation capability, process innovation capability, and absorptive capacity', *Industrial marketing management*, vol. 73, pp. 193-205.

Nambisan, S, Lyytinen, K, Majchrzak, A & Song, M 2017, 'Digital Innovation Management: Reinventing innovation management research in a digital world', *MIS quarterly*, vol. 41, no. 1.

Nambisan, S, Lyytinen, K & Yoo, Y 2020, *Digital innovation: towards a transdisciplinary perspective*, Handbook of Digital Innovation, Edward Elgar Publishing, Cheltenham.

Nambisan, S, Wright, M & Feldman, M 2019, 'The digital transformation of innovation and entrepreneurship: Progress, challenges and key themes', *Research Policy*, vol. 48, no. 8, p. 103773.

Nanji, A 2017, *Social Media and Blog Usage by Fortune 500 Companies in 2017*, Marketing Profs, viewed 03.05.2019, <https://www.marketingprofs.com/charts/2017/33156/social-media-and-blog-usage-by-fortune-500-companies-in-2017>.

National Farmers' Federation 2017, *Food, Fibre & Forestry Facts: A Summary of Australia's Agriculture Sector*

Neiva, ER, Ros, M & Paz, M 2005, 'Attitudes towards organizational change: validation of a scale', *Psychology in Spain*, vol. 9, no. 1, pp. 81-90.

Nelson, RR 2009, *An evolutionary theory of economic change*, Harvard university press, Cambridge, MA.

Neuman, WL 1997, *Social research methods: qualitative and quantitative approaches* Allyn & Bacon, Needham Heights, MA.

Newton, JE, Nettle, R & Pryce, JE 2020, 'Farming smarter with big data: Insights from the case of Australia's national dairy herd milk recording scheme', *Agricultural systems*, vol. 181, p. 102811.

Nguyen, DK, Broekhuizen, T, Dong, JQ & Verhoef, P 2019, 'Digital readiness: construct development and empirical validation', in *International Conference on Information Systems Proceedings*, Association for Information Systems

Nicholas-Davies, P, Fowler, S, Midmore, P, Coopmans, I, Draganova, M, Petitt, A & Senni, S 2020, 'Exploring attributes of resilience: robustness, adaptability and transformation in European farmer narratives', in *173rd EAAE Seminar*, European Association of Agricultural Economists.

Nonaka, I & Takeuchi, H 1995, *The knowledge-creating company: How Japanese companies create the dynamics of innovation*, Oxford university press, Oxford.

Norris, FH, Stevens, SP, Pfefferbaum, B, Wyche, KF & Pfefferbaum, RL 2008, 'Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness', *American journal of community psychology*, vol. 41, no. 1-2, pp. 127-150.

Nylén, D & Holmström, J 2015, 'Digital innovation strategy: A framework for diagnosing and improving digital product and service innovation', *Business Horizons*, vol. 58, no. 1, pp. 57-67.

Nylén, D & Holmström, J 2019, 'Digital innovation in context', *Information Technology and People*, vol.

O'Neill, S 2019, 'e-Agricultural Systems: Towards a Human-Centred Framework for e-Readiness and Technology Adoption', thesis, Waterford Institute of Technology.

OECD 2005, *Oslo Manual*, <https://www.oecd-ilibrary.org/docserver/9789264013100-en.pdf?expires=1536491893&id=id&accname=guest&checksum=4BCBF3DECDEA833BF4A18D9D079C0AAB>.

OECD 2009, *Innovation in firms: A microeconomic perspective*, Organisation for Economic Co-operation and Development (OECD).

OECD 2019, *Agricultural Policy Monitoring and Evaluation 2019*, OECD Publishing, Paris, <https://www.oecd-ilibrary.org/agriculture-and-food/agricultural-policy-monitoring-and-evaluation-2019_39bfe6f3-en>.

OECD 2020a, *Covid-19 and international trade: issues and actions*, <https://read.oecd-ilibrary.org/view/?ref=128_128542-3ijg8kfswh&title=COVID-19-and-international-trade-issues-and-actions>.

OECD 2020b, *COVID-19 and the food and agriculture sector: Issues and policy responses*, <http://www.oecd.org/coronavirus/policy-responses/covid-19-and-the-food-and-agriculture-sector-issues-and-policy-responses-a23f764b/>.

OECD 2020c, *Scheme for the Application of International Standards for Fruit and Vegetables, Preliminary Report: Evaluation of the Impact of the Coronavirus (Covid-19) on Fruit and Vegetables Trade*, <https://www.oecd.org/agriculture/fruit-vegetables/oecd-covid-19-impact-on-fruit-and-vegetables-trade.pdf>.

OECD/FAO 2019, *OECD/FAO Agricultural Outlook 2019-2028*, OECD Publishing, Paris, <https://www.oecd-ilibrary.org/docserver/agr_outlook-2019-en.pdf?expires=1566779127&id=id&accname=guest&checksum=44CDA4928FBCBB99E07EE8A0AB9C0308>.

Olson, PD, Zuiker, VS, Danes, SM, Stafford, K, Heck, RK & Duncan, KA 2003, 'The impact of the family and the business on family business sustainability', *Journal of business venturing*, vol. 18, no. 5, pp. 639-666.

Omari, M, Lee, J, Faqeerzada, M, Joshi, R, Park, E & Cho, B 2020, 'Digital image-based plant phenotyping: a review', *Korean Journal of Agricultural Science*, vol. 47, pp. 119-130.

Oztemel, E & Gursev, S 2020, 'Literature review of Industry 4.0 and related technologies', *Journal of Intelligent Manufacturing*, vol. 31, no. 1, pp. 127-182.

Paine, M & Kenny, S 'Intentional Learning: interplays between farmers and service providers', in FaRSRaELIa Globalisation (ed.), Florence, Italy, European Group International Farming Systems Association, pp. 509-516.

Palazzeschi, L, Bucci, O & Di Fabio, A 2018, 'Re-thinking innovation in organizations in the industry 4.0 scenario: New challenges in a primary prevention perspective', *Frontiers in psychology*, vol. 9, p. 30.

Pardey, PG, Beddow, JM, Hurley, TM, Beatty, TK & Eidman, VR 2014, 'A bounds analysis of world food futures: Global agriculture through to 2050', *Australian Journal of Agricultural Resource Economics*, vol. 58, no. 4, pp. 571-589.

Pathak, HS, Brown, P & Best, T 2019, 'A systematic literature review of the factors affecting the precision agriculture adoption process', *Precision Agriculture*, vol., pp. 1-25.

Patton, MQ 1990, *Qualitative evaluation and research methods*, Sage Publishing, Los Angeles, CA.

Patton, MQ 2002, *Qualitative, research & evaluation methods*, Sage Publishing, Thousand Oaks, California

Paun, F 2012, 'The demand readiness level scale as new proposed tool to hybridise market pull with technology push approaches in technology transfer practices', in *Technology Transfer in a Global Economy*, Springer, Boston, MA, pp. 353-366.

Payne, GT 2019, 'Truckin'on at Family Business Review', *Family business review*, vol. 32, no. 1, pp. 6-9.

Peach, M, Jimmieson, NL & White, K 2005, 'Beliefs underlying employee readiness to support a building relocation: A theory of planned behavior perspective', *Organization Development Journal*, vol. 23, pp. 9-22.

Peräkylä, A & Ruusuvuori, J 2011, 'Analysing text and talk', in N Denzin & Y Lincoln (eds), *The Sage Handbook of Qualitative Research*, Sage Publishing, Los Angeles, pp. 529–543.

Perez, T 2016, 'Digital agriculture—opportunities & challenges', in *Landwise 14th Annual Conference*, Havelock North, New Zealand.

Perrow, C, Reiss, AJ & Wilensky, HL 1986, *Complex organizations: A critical essay*, McGraw-Hill New York.

Pessot, E, Zangiacomi, A, Battistella, C, Rocchi, V, Sala, A & Sacco, M 2020, 'What matters in implementing the factory of the future', *Journal of manufacturing technology management*, vol. ahead-of-print, pp. ahead-of-print.

Peters, T 2001, *Spanning the digital divide: Understanding and tackling the issues*, Washington/Durbanville.

Pettigrew, AM 1990, 'Longitudinal field research on change: Theory and practice', *Organization science*, vol. 1, no. 3, pp. 267-292.

Pfeffer, J 1982, *Organizations and organization theory*, Pitman Boston, Boston, MA.

Phillips, DC & Burbules, NC 2000, *Postpositivism and educational research*, Rowman & Littlefield, Lanham, MD.

Phiri, A, Chipeta, GT & Chawinga, WD 2019, 'Information behaviour of rural smallholder farmers in some selected developing countries: A literature review', *Information Development*, vol. 35, no. 5, pp. 831-838.

Pickett, TD & Han, S 2017, *Controlling the position of an agricultural implement coupled to an agricultural vehicle based upon three-dimensional topography data*, Google Patents.

Pisano, GP 2015, 'You need an innovation strategy', *Harvard business review*, vol. 93, no. 6, pp. 44-54.

Pitt, M, Clarke, K & Management, S 1999, 'Competing on competence: A knowledge perspective on the management of strategic innovation', *Technology Analysis*, vol. 11, no. 3, pp. 301-316.

Pittaway, L, Robertson, M, Munir, K, Denyer, D & Neely, A 2004, 'Networking and innovation: a systematic review of the evidence', *International journal of management reviews*, vol. 5, no. 3-4, pp. 137-168.

Poland, B & Pederson, A 1998, 'Reading between the lines: Interpreting silences in qualitative research', *Qualitative inquiry*, vol. 4, no. 2, pp. 293-312.

Pooja, S, Uday, D, Nagesh, U & Talekar, SG 'Application of MQTT protocol for real time weather monitoring and precision farming', IEEE, pp. 1-6.

Popa, S, Soto-Acosta, P & Martinez-Conesa, I 2017, 'Antecedents, moderators, and outcomes of innovation climate and open innovation: An empirical study in SMEs', *Technological Forecasting and Social Change*, vol. 118, pp. 134-142.

Pope, C, Ziebland, S & Mays, N 2000, 'Analysing qualitative data', *Bmj*, vol. 320, no. 7227, pp. 114-116.

Popkova, EG, Ragulina, YV & Bogoviz, AV 2019, 'Fundamental differences of transition to industry 4.0 from previous industrial revolutions', in *Industry 4.0: Industrial Revolution of the 21st Century*, Springer, Cham, pp. 21-29.

Popova, I, Popov, O & Dalin, R 2005, *ICT4ICT ICT-Knowledge for ICT Diffusion*, Department of Information Technology and Media.

Prajogo, DI & Sohal, AS 2001, 'TQM and innovation: a literature review and research framework', *Technovation*, vol. 21, no. 9, pp. 539-558.

Pramanik, P, Krishnan, P, Maity, A, Mridha, N, Mukherjee, A & Rai, V 2020, 'Application of Nanotechnology in Agriculture', in *Environmental Nanotechnology* Springer, Singapore, pp. 317-348.

Preindl, R, Nikolopoulos, K & Litsiou, K 'Transformation strategies for the supply chain: the impact of industry 4.0 and digital transformation', Taylor & Francis, pp. 1-9.

Pulford, J 2018, *Victoria, The Ag Tech Hub Of Australia*, Austalian Government, viewed 19.09.2019, <https://www.premier.vic.gov.au/wp-content/uploads/2018/03/180313-Victoria-The-Ag-Tech-Hub-Of-Australia.pdf>.

Püschel, L, Röglinger, M & Schlott, H 2016, 'What's in a smart thing? Development of a multi-layer taxonomy', in *37th International Conference on Information Systems*, Dublin, Ireland.

Qu, S & Dumay, J 2011, 'The qualitative research interview', *Qualitative Research in Accounting and Management*, vol. 8, no. 3, pp. 238-264.

Qu, SQ, Dumay, JJQria & management 2011, 'The qualitative research interview', vol. 8, no. 3, pp. 238-264.

Rafferty, AE & Simons, RH 2006, 'An examination of the antecedents of readiness for fine-tuning and corporate transformation changes', *Journal of Business Psychology*, vol. 20, no. 3, p. 325.

Rai, A, Jirli, B & Singh, A 2018, 'e-Readiness: Its Relational Perspectives with Profile of Extension Functionaries', *Journal of Global Communication*, vol. 11, no. 1, pp. 65-75.

Rajnai, Z & Kocsis, I 'Assessing industry 4.0 readiness of enterprises', IEEE, pp. 000225-000230.

Randolph, JJ 2009, 'A guide to writing the dissertation literature review', *Practical assessment, research evaluation*, vol. 14, no. 13, pp. 1-13.

Randøy, T, Dibrell, C & Craig, JB 2009, 'Founding family leadership and industry profitability', *Small Business Economics*, vol. 32, no. 4, pp. 397-407.

Rathi, A 2020, 'Is Agrarian Resilience limited to Agriculture? Investigating the “farm” and “non-farm” processes of Agriculture Resilience in the rural', *Journal of rural studies*, vol. in press.

Rawnsley, MM 1998, 'Ontology, epistemology, and methodology: A clarification', *Nursing science quarterly*, vol. 11, no. 1, pp. 2-4.

Reay, T, Zilber, TB, Langley, A & Tsoukas, H 2019, *Institutions and Organizations: A Process View*, Oxford University Press, Oxford.

rev 2019, *Audio Transcription Made Simple*, viewed 08.08.2019, <https://www.rev.com/transcription?utm_source=tc-nb&opti_ca=1012546279&opti_ag=52472555409&opti_ad=352530578319&opti_key=kwd-295106242706&gclid=EAIaIQobChMIy8HHtbKE5AIVVqmWCh0HOwT3EAAYASAAEgI1bPD_BwE>.

Richards, L & Morse, JM 2012, *Readme first for a user's guide to qualitative methods*, Sage Publishing, Los Angeles, CA.

Robertson, M, Moore, A, Henry, D & Barry, S 2018, *Digital agriculture: what's all the fuss about?*, CSIRO, viewed 08.10.2019, <https://blog.csiro.au/digital-agriculture-whats-all-the-fuss-about/>.

Robertson, TS 1967, 'The process of innovation and the diffusion of innovation', *Journal of marketing*, vol. 31, no. 1, pp. 14-19.

Roblek, V, Meško, M & Krapež, A 2016, *A complex view of industry 4.0*, Sage Open.

Rockwell Automation 2014, *The connected enterprise maturity model*, Rockwell Automation, viewed 12.06.2019, <http://literature.rockwellautomation.com/idc/groups/literature/documents/wp/cie-wp002_-en>.

Rogers, EM 2010, *Diffusion of innovations*, Simon and Schuster, New York.

Rolfe, G 2006, 'Validity, trustworthiness and rigour: quality and the idea of qualitative research', *Journal of advanced nursing*, vol. 53, no. 3, pp. 304-310.

Rondi, E, De Massis, AV & Kotlar, J 2019, *Unlocking the innovation potential of family firms: An assessment tool*.

Roos, J & Nilsson, VO 2020, 'Driving Organizational Readiness for Change through Strategic Workshops', *International Journal of Management and Applied Research*, vol. 7, no. 1, pp. 1-28.

Rose, DC, Sutherland, WJ, Parker, C, Lobley, M, Winter, M, Morris, C, Twining, S, Ffoulkes, C, Amano, T & Dicks, LV 2016, 'Decision support tools for agriculture: Towards effective design and delivery', *Agricultural systems*, vol. 149, pp. 165-174.

Roser, M 2019, *Employment in Agriculture*, OurWorldInData.org, viewed 27.11.2019, <https://ourworldindata.org/employment-in-agriculture>.

Ross, J 2014, *Do You Have a Great Digital Business Strategy?*, MIT Center for Information Systems Research, viewed 22.09.2019, <http://cisr.mit.edu/blog/blogs/2014/09/24/digital-business-strategy/ >.

Rothwell, R 1994, 'Towards the fifth-generation innovation process', *International marketing review*, vol. 11, no. 1, pp. 7-31.

Rowley, JJMRR 2012, 'Conducting research interviews', vol. 35, no. 3/4, pp. 260-271.

Rubin, HJ & Rubin, IS 2011, *Qualitative interviewing: The art of hearing data*, Sage Publishing, Los Angeles, CA.

Ruikar, K, Anumba, C & Carrillo, P 2006, 'VERDICT—An e-readiness assessment application for construction companies', *Automation in construction*, vol. 15, no. 1, pp. 98-110.

Ryan, G 2010, *Analyzing qualitative data: systematic approaches*, Sage Publishing Thousand Oaks, CA.

Ryynänen, T & Hakatie, A 2014, '"We must have the wrong consumers"–a case study on new food product development failure', *British Food Journal*, vol. 116, no. 4, pp. 707-722.

Sachs, CE 1993, 'Growing public concern over pesticides in food and water', in *The Pesticide Question*, Springer, New York, pp. 380-389.

Saggi, MK & Jain, S 2018, 'A survey towards an integration of big data analytics to big insights for value-creation', *Information Processing & Management*, vol. 54, no. 5, pp. 758-790.

Salam, A 2020, 'Internet of Things in Agricultural Innovation and Security', in *Internet of Things for Sustainable Community Development*, Springer, Cham, pp. 71-112.

Saldaña, J 2015, *The coding manual for qualitative researchers*, Sage Publishing, Los Angeles, CA.

Saleem, I, Siddique, I & Ahmed, A 2019, 'An extension of the socioemotional wealth perspective', *Journal of Family Business Management*, vol. in print.

Sam, AS, Padmaja, SS, Kächele, H, Kumar, R & Müller, K 2020, 'Climate change, drought and rural communities: Understanding people's perceptions and adaptations in rural eastern India', *International Journal of Disaster Risk Reduction*, vol. 44, p. 101436.

Sanaei, MR 2014, 'E – readiness assessment of large organization in a developing country: the case of iran', *Indian Journal of Fundamental and Applied Life Sciences*, vol. 4, no. 1, pp. 250-258.

Sandelowski, M 1986, 'The problem of rigor in qualitative research', *Advances in nursing science*, vol. 8, no. 3, pp. 27-37.

Sanders, KT & Masri, SF 2016, 'The energy-water agriculture nexus: the past, present and future of holistic resource management via remote sensing technologies', *Journal of cleaner production*, vol. 117, pp. 73-88.

Santos-Neto, JBSd & Costa, APCS 2019, 'Enterprise maturity models: a systematic literature review', *Enterprise Information Systems*, vol. 13, no. 5, pp. 719-769.

Sarker, S, Xiao, X & Beaulieu, T 2013, 'Guest editorial: qualitative studies in information systems: a critical review and some guiding principles', *MIS quarterly*, vol. 37, no. 4, pp. iii-xviii.

Sayer, RA 1992, *Method in social science: A realist approach*, Routledge, London.

Scaccia, JP, Cook, BS, Lamont, A, Wandersman, A, Castellow, J, Katz, J & Beidas, R 2015, 'A practical implementation science heuristic for organizational readiness: R= MC2', *Journal of Community Psychology*, vol. 43, no. 4, pp. 484-501.

Schewe, RL & Stuart, D 2017, 'Why don't they just change? contract farming, informational influence, and barriers to agricultural climate change mitigation', *Rural Sociology*, vol. 82, no. 2, pp. 226-262.

Schuh, G, Anderl, R, Gausemeier, J, Ten Hompel, M & Wahlster, W 2017, *Industrie 4.0 Maturity Index: Managing the Digital Transformation of Companies*, Herbert Utz Verlag, Munich.

Schultz, JS, Sjøvold, E & Andre, B 2017, 'Can group climate explain innovative readiness for change?', *Journal of Organizational Change Management*, vol. 30, no. 3, pp. 440-452.

Schultz, JS, Sjøvold, E & André, B 2017, 'Can formal innovation training improve group-and organizational-level innovativeness in a healthcare setting?', *Journal of Innovation and Entrepreneurship*, vol. 6, no. 1, p. 13.

Schumacher, A, Erol, S & Sihn, W 2016, 'A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises', *Procedia Cirp*, vol. 52, pp. 161-166.

Schumpeter, JA 1934, *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*, Transaction Publishers, Cambridge, MA.

Scolari, CA, Aguado, JM & Feijóo, C 2012, 'Mobile Media: Towards a definition and taxonomy of contents and applications', *International Journal of Interactive Mobile Technologies*, vol. 6, no. 2.

Scott, D & Usher, R 2010, *Researching education: Data, methods and theory in educational enquiry*, Bloomsbury Publishing, London, New York.

Sedera, D & Lokuge, S 2017, 'The Role of Enterprise Systems in Innovation in the Contemporary Organization', *The Routledge Companion to Management Information Systems*, vol., p. 608.

Sedera, D, Lokuge, S, Grover, V, Sarker, S & Sarker, S 2016, 'Innovating with enterprise systems and digital platforms: A contingent resource-based theory view', *Information & Management*, vol. 53, no. 3, pp. 366-379.

Seth, A & Ganguly, K 2017, 'Digital technologies transforming Indian agriculture', *The Global Innovation Index*, vol., pp. 105-111.

Setiawan, AAR, Sulaswatty, A, Meliana, Y & Haryono, A 2018, 'Innovation readiness assessment toward research commercialization: Case of surfactants for food processing', *International Journal of Innovation*, vol. 6, no. 2, pp. 180-193.

Shakoor, N, Northrup, D, Murray, S & Mockler, TC 2019, 'Big data driven agriculture: Big data analytics in plant breeding, genomics, and the use of remote sensing technologies to advance crop productivity', *The Plant Phenome Journal*, vol. 2, no. 1, pp. 1-8.

Shamim, S, Cang, S, Yu, H & Li, Y 'Management approaches for Industry 4.0: A human resource management perspective', IEEE, pp. 5309-5316.

Sharma, P, Chrisman, JJ & Gersick, KE 2012, *25 years of family business review: reflections on the past and perspectives for the future*, Sage Publishing, Los Angeles, CA, 0894-4865.

Shepherd, M, Turner, JA, Small, B & Wheeler, D 2020, 'Priorities for science to overcome hurdles thwarting the full promise of the ‘digital agriculture’revolution', *Journal of the Science of Food and Agriculture*, vol. 100, no. 14, pp. 5083-5092.

Shirazi, A, Mortazavi, S & Azad, NP 2011, 'Factors affecting employees' readiness for knowledge management', *European journal of economics, Finance and Administrative Sciences*, vol. 7, no. 33, pp. 167-177.

Siddig, K, Stepanyan, D, Wiebelt, M, Grethe, H & Zhu, T 2020, 'Climate change and agriculture in the Sudan: Impact pathways beyond changes in mean rainfall and temperature', *Ecological Economics*, vol. 169, p. 106566.

Siemieniuch, C & Sinclair, M 2004, 'A framework for organisational readiness for knowledge management', *International Journal of Operations & Production Management*, vol. 24, no. 1, pp. 79-98.

Silverman, D 2006, *Interpreting qualitative data : methods for analyzing talk, text and interaction*, 3rd edn, Sage Publications, London.

Silverman, D 2016, *Qualitative research*, 4th edn, Sage Publishing, London.

Silvestri, S, Richard, M, Edward, B, Dharmesh, G & Dannie, R 2020, 'Going digital in agriculture: how radio and SMS can scale-up smallholder participation in legume-based sustainable agricultural intensification practices and technologies in Tanzania', *International Journal of Agricultural Sustainability*, vol., pp. 1-12.

Singh, N & Singh, AN 2020, 'Odysseys of agriculture sensors: Current challenges and forthcoming prospects', *Computers and Electronics in Agriculture*, vol. 171, p. 105328.

Sirmon, DG & Hitt, MA 2003, 'Managing resources: Linking unique resources, management, and wealth creation in family firms', *Entrepreneurship theory practice*, vol. 27, no. 4, pp. 339-358.

Smith, H 1975, *Strategies of social research. The methodological imagination.* , Prentice Hall International, London.

Smith, JK 1983, 'Quantitative versus qualitative research: An attempt to clarify the issue', *Educational researcher*, vol. 12, no. 3, pp. 6-13.

Snyder-Halpern, R 2001, 'Indicators of organizational readiness for clinical information technology/systems innovation: a Delphi study', *International journal of medical informatics*, vol. 63, no. 3, pp. 179-204.

Sony, M & Naik, S 2019, 'Key ingredients for evaluating Industry 4.0 readiness for organizations: a literature review', *Benchmarking: An International Journal*, vol. 27, no. 7, pp. 2213-2232.

Soomro, MA, Hizam-Hanafiah, M & Abdullah, NL 2020, 'Digital readiness models: a systematic litearture review', *Compusoft*, vol. 9, no. 3, pp. 3596-3605.

Sottomayor, M, Tranter, R & Costa, L 2011, 'Likelihood of Succession and Farmers' Attitudes towards their Future Behaviour: Evidence from a Survey in Germany, the United Kingdom and Portugal', *International Journal of Sociology of Agriculture & Food Security*, vol. 18, no. 2.

Spector, BA 1989, 'From bogged down to fired up: Inspiring organizational change', *Sloan Management Review*, vol. 30, no. 4, pp. 29-34.

Spithoven, A, Vanhaverbeke, W & Roijakkers, N 2013, 'Open innovation practices in SMEs and large enterprises', *Small Business Economics*, vol. 41, no. 3, pp. 537-562.

Sreih, JF, Lussier, RN & Sonfield, MC 2019, 'Differences in management styles, levels of profitability, and performance across generations, and the development of the Family Business Success Model', *Journal of Organizational Change Management*, vol. 32, no. 1, pp. 32-50.

Stafford, JV 2019, *Precision agriculture '19*, Wageningen Academic Publishers, Wageningen.

Steensland, A & Zeigler, M 2018, *Global Agricultural Productivity Report*, Global Harvest Initiative, Washington, D.C., viewed 16.09.2019, <https://globalagriculturalproductivity.org/data-resources/>.

Stentoft, J, Jensen, KW, Philipsen, K & Haug, A 2019, 'Drivers and Barriers for Industry 4.0 Readiness and Practice: A SME Perspective with Empirical Evidence', in *52nd Hawaii International Conference on System Sciences*.

Stephenson, KA, Kuismin, A, Putnam, LL & Sivunen, A 2020, 'Process Studies of Organizational Space', *Academy of Management Annals*, vol. 14, no. 2, pp. 797-827.

Stjepić, A-M, Ivančić, L & Vugec, DS 2020, 'Mastering digital transformation through business process management: Investigating alignments, goals, orchestration, and roles', *Journal of Entrepreneurship, Management and Innovation*, vol. 16, no. 1, pp. 41-74.

Storey, DJ 2004, 'Exploring the link, among small firms, between management training and firm performance: a comparison between the UK and other OECD countries', *The International Journal of Human Resource Management*, vol. 15, no. 1, pp. 112-130.

Strauss, A & Corbin, J 1990, *Basics of qualitative research*, Sage Publishing, Thousand Oaks, CA.

Strauss, A & Corbin, J 1994, 'Grounded theory methodology', in *Handbook of qualitative research*, Sage Publishing, Thousand Oaks, CA, pp. 273-285.

Stuart, D & Houser, M 2018, 'Producing compliant polluters: seed companies and nitrogen fertilizer application in US corn agriculture', *Rural Sociology*, vol. 83, no. 4, pp. 857-881.

Suchiradipta, B & Raj, S 2018, 'The online culture of agriculture: exploring social media readiness of agricultural professionals', *CSI Transactions on ICT*, vol. 6, no. 3-4, pp. 289-299.

Suess-Reyes, J & Fuetsch, E 2016, 'The future of family farming: A literature review on innovative, sustainable and succession-oriented strategies', *Journal of rural studies*, vol. 47, pp. 117-140.

Sunaert, P, Vandekerckhove, M, Bastiaens, H, Feyen, L, Bussche, PV, De Maeseneer, J, De Sutter, A & Willems, S 2011, 'Why do GPs hesitate to refer diabetes patients to a self-management education program: a qualitative study', *BMC family practice*, vol. 12, no. 1, p. 94.

Sundmaeker, H, Verdouw, C, Wolfert, S & Pérez Freire, L 2016, 'Internet of food and farm 2020', *Digitising the Industry-Internet of Things connecting physical, digital and virtual worlds*, vol. 2, pp. 129-150.

Suri, H 2011, 'Purposeful sampling in qualitative research synthesis', *Qualitative research journal*, vol. 11, no. 2, pp. 63-75.

Sutherland, L-A, Burton, RJ, Ingram, J, Blackstock, K, Slee, B & Gotts, N 2012, 'Triggering change: towards a conceptualisation of major change processes in farm decision-making', *Journal of environmental management*, vol. 104, pp. 142-151.

Swanson, EB 1994, 'Information systems innovation among organizations', *Management science*, vol. 40, no. 9, pp. 1069-1092.

Świadek, A, Dzikowski, P, Tomaszewski, M & Gorączkowska, J 2019, 'Sectoral patterns of innovation cooperation in Polish industry', *Equilibrium. Quarterly Journal of Economics and Economic Policy*, vol. 14, no. 1, pp. 183-200.

Symon, G, Cassell, C & Johnson, P 2018, 'Evaluative practices in qualitative management research: A critical review', *International journal of management reviews*, vol. 20, no. 1, pp. 134-154.

Tackenberg, M, Volkmar, C & Dammer, KH 2016, 'Sensor-based variable-rate fungicide application in winter wheat', *Pest management science*, vol. 72, no. 10, pp. 1888-1896.

Tagiuri, R & Davis, JAJFBR 1992, 'On the goals of successful family companies', *Family business review*, vol. 5, no. 1, pp. 43-62.

Tanggaard, L 2009, 'The research interview as a dialogical context for the production of social life and personal narratives', *Qualitative inquiry*, vol. 15, no. 9, pp. 1498-1515.

Tao, L, Probert, D & Phaal, R 2010, 'Towards an integrated framework for managing the process of innovation', *R&D Management*, vol. 40, no. 1, pp. 19-30.

Tapscott, A & Tapscott, D 2017, 'How blockchain is changing finance', *Harvard business review*, vol. 1, no. 9, pp. 2-5.

Teagarden, MB, Von Glinow, MA & Mellahi, K 2018, 'Contextualizing international business research: Enhancing rigor and relevance', *Journal of World Business*, vol. 53, no. 3, pp. 303-306.

Teece, DJ 1998, 'Capturing value from knowledge assets: The new economy, markets for know-how, and intangible assets', *California Management Review*, vol. 40, no. 3, pp. 55-79.

Teece, DJ 2017, *5G mobile: disrupting the automotive sector*, UC Berkeley.

Teece, DJ 2018, 'Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world', *Research Policy*, vol. 47, no. 8, pp. 1367-1387.

Tether, BS 2002, 'Who co-operates for innovation, and why: an empirical analysis', *Research Policy*, vol. 31, no. 6, pp. 947-967.

The Economist 2009, *E-readiness rankings 2009 - The usage imperative. A report from the Economist Intelligence Unit*, The Economist Intelligence Unit

The Regional Australia Institute (ed.) 2018, *Riding the next wave of automation in rural Australia: Safeguarding agriculture and rural labour markets through migrant work and skills development.*, The Regional Australia Institute, Canberra.

The World Bank 2012, *World Development Indicators*, Washington, DC.

The World Bank 2019a, *Agriculture & Rural Development* viewed 07.01.2020, <https://data.worldbank.org/topic/agriculture-and-rural-development>.

The World Bank 2019b, *Agriculture, forestry, and fishing, value added (% of GDP)*, viewed 07.01.2020, <https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS>.

The World Bank 2019c, *Employment in agriculture*, viewed 07.01.2020, <https://data.worldbank.org/indicator/sl.agr.empl.zs>.

Thirlwell, M 2017, *Australia's export performance in FY2017*, viewed 07.01.2020, <htps://www.austrade.gov.au/News/Economic-analysis/australias-export-performance-in-fy2017t >.

Thomas, DR 2006, 'A general inductive approach for analyzing qualitative evaluation data', *American journal of evaluation*, vol. 27, no. 2, pp. 237-246.

Thomas, E, Riley, M & Spees, J 2020, 'Knowledge flows: Farmers' social relations and knowledge sharing practices in 'Catchment Sensitive Farming'', *Land Use Policy*, vol. 90, no. in print.

Ticehurst, GW & Veal, AJ 2000, *Business research methods: A managerial approach*, Addison Wesley Longman, South Melbourne, VIC.

Tidd, J, Bessant, J & Pavitt, K 2005, *Managing innovation integrating technological, market and organizational change*, John Wiley and Sons Ltd, Chichester.

Tidd, J, Bessant, JR & Pavitt, K 1997, *Managing innovation: integrating technological, market and organizational change*, Wiley, Chichester.

Tiffin, R & Irz, X 2006, 'Is agriculture the engine of growth?', *Agricultural Economics*, vol. 35, no. 1, pp. 79-89.

Tilson, D, Lyytinen, K & Sørensen, C 2010, 'Research commentary—Digital infrastructures: The missing IS research agenda', *Information systems research*, vol. 21, no. 4, pp. 748-759.

Trendov, NM, Varas, S & Zeng, M 2019, *Digiatl Technologies in agricultre and rural areas - Status report*, Rome.

Trindall, J, Bainbow, R & Leonard, E 2018, 'Enabling Digital Agriculture in Australia ', *Farm Policy Journal*, vol. 15, no. 1, pp. 1-6.

Trochim, WM & Donnelly, JP 2001, *Research methods knowledge base*, Atomic Dog Publishing Cincinnati, , Mason, OH.

Trotta, D & Garengo, P 2019, 'Assessing Industry 4.0 Maturity: An Essential Scale for SMEs', in *8th International Conference on Industrial Technology and Management (ICITM)*, IEEE, pp. 69-74.

Tumbas, S, Berente, N & Brocke, Jv 2018, 'Digital innovation and institutional entrepreneurship: Chief Digital Officer perspectives of their emerging role', *Journal of Information Technology*, vol. 33, no. 3, pp. 188-202.

Turner, D & Crawford, M 1998, *Change power: Capabilities that drive corporate renewal*, Business & Professional Publishing, Warriewood.

Turner III, DW 2010, 'Qualitative interview design: A practical guide for novice investigators', *The qualitative report*, vol. 15, no. 3, pp. 754-760.

Tushman, M & Nadler, D 1986, 'Organizing for innovation', *California Management Review*, vol. 28, no. 3, pp. 74-92.

Uddin, MA, Ayaz, M, Mansour, A, Le Jeune, D & Aggoune, E 2016, 'Wireless senors for modern agriculture in KSA: A survey', in *7th International Conference on Computer Science and Information Technology (CSIT)*, IEEE, pp. 1-7.

Uhl, A, Born, M, Koschmider, A & Janasz, T 2016, 'The importance of technological trends and how to exploit them for business excellence', in *Digital enterprise transformation*, Routledge, London, pp. 1-25.

United Nations 2012, *Scaling Up Global Food Security and Sustainable Agriculture*, UN Global Compact Office.

United Nations 2019, *World population prospects 2019*, viewed 20.10.2019, <https://population.un.org/wpp/Graphs/Probabilistic/POP/TOT/900>.

Urban, GL, Weinberg, BD & Hauser, JRJJom 1996, 'Premarket forecasting of really-new products', vol. 60, no. 1, pp. 47-60.

US Department of Agriculture 2014, *Digital Strategy at USDA*, viewed 25.08.2019, <https://www.usda.gov/digital-strategy>.

USAID 2019, *Digital Frontiers*, DAI, viewed 25.08.2019, <https://www.ictworks.org/wp-content/uploads/2019/03/usaid-digital-agriculutre-contracts.pdf>.

Üsdiken, B 2014, 'Centres and Peripheries: Research Styles and Publication Patterns in 'Top'US Journals and their European Alternatives, 1960–2010', *Journal of Management Studies*, vol. 51, no. 5, pp. 764-789.

Utterback, J 1994, *Mastering the dynamics of innovation: How companies can seize opportunities in the face of technological change*, Harvard Business School Press, Boston.

Utterback, JM 1971, 'The process of technological innovation within the firm', *Academy of management journal*, vol. 14, no. 1, pp. 75-88.

Van de Ven, A 1986, 'Central problems in the management of innovation', *Management science*, vol. 32, no. 5, pp. 590-607.

Van de Ven, AH 2007, *Engaged scholarship: A guide for organizational and social research*, Oxford University Press on Demand, New York.

Van de Ven, AH & Huber, GP 1990, 'Longitudinal field research methods for studying processes of organizational change', *Organization science*, vol. 1, no. 3, pp. 213-219.

Van Es, H & Woodard, J 2017, 'Innovation in agriculture and food systems in the digital age', in *The Global Innovation Index*, Palgrave Macmillan, London, pp. 97-104.

Van Etten, J, Beza, E, Calderer, L, Van Duijvendijk, K, Fadda, C, Fantahun, B, Kidane, YG, Van de Gevel, J, Gupta, A & Mengistu, DK 2016, 'First experiences with a novel farmer citizen science approach: Crowdsourcing participatory variety selection through on-farm triadic comparisons of technologies (tricot)', *Experimental Agriculture*, vol., pp. 1-22.

Van Meijl, H, Havlik, P, Lotze-Campen, H, Stehfest, E, Witzke, P, Domínguez, IP, Bodirsky, BL, van Dijk, M, Doelman, J & Fellmann, T 2018, 'Comparing impacts of climate change and mitigation on global agriculture by 2050', *Environmental Research Letters*, vol. 13, no. 6, p. 064021.

van Rij, M & Zellweger, T 2019, *How the world's largest family businesses are responding to the Transformative Age*, EY and the University of St. Gallen, viewed 10.08.2019, <https://www.ey.com/en_gl/growth/how-the-world-s-largest-family-businesses-are-responding-to-the-transformative-age>.

Vasconez, JP, Kantor, GA & Cheein, FAA 2019, 'Human–robot interaction in agriculture: A survey and current challenges', *Biosystems engineering*, vol. 179, pp. 35-48.

Vayro, C, Brownlow, C, Ireland, M & March, S 2020, ''Farming is not Just an Occupation [but] a Whole Lifestyle': A Qualitative Examination of Lifestyle and Cultural Factors Affecting Mental Health Help-Seeking in Australian Farmers', *Sociologia Ruralis*, vol. 60, no. 1, pp. 151-173.

Vecchio, Y, Agnusdei, GP, Miglietta, PP & Capitanio, F 2020, 'Adoption of Precision Farming Tools: The Case of Italian Farmers', *International Journal of Environmental Research and Public Health*, vol. 17, no. 3, p. 869.

Vega, A & Chiasson, M 2019, 'A comprehensive framework to research digital innovation: The joint use of the systems of innovation and critical realism', *The Journal of Strategic Information Systems*, vol. 28, no. 3, pp. 242-256.

Verma, S, Bhatia, A, Chug, A & Singh, AP 2020, 'Recent Advancements in Multimedia Big Data Computing for IoT Applications in Precision Agriculture: Opportunities, Issues, and Challenges', in *Multimedia Big Data Computing for IoT Applications*, Springer, Singapore, pp. 391-416.

Vial, G 2019, 'Understanding digital transformation: A review and a research agenda', *The Journal of Strategic Information Systems*, vol. 28, no. 2, pp. 118-144.

Victoria State Government 2018, *Digital Agriculture*, viewed 25.08.2019, <https://economicdevelopment.vic.gov.au/connecting-victoria/connecting-regional-communities-program/digital-agriculture>.

Virk, AL, Noor, MA, Fiaz, S, Hussain, S, Hussain, HA, Rehman, M, Ahsan, M & Ma, W 2020, 'Smart Farming: An Overview', in *Smart Village Technology: concepts and developments*, Springer, Cham, pp. 191-201.

Vogel, E, Donat, MG, Alexander, LV, Meinshausen, M, Ray, DK, Karoly, D, Meinshausen, N & Frieler, K 2019, 'The effects of climate extremes on global agricultural yields', *Environmental Research Letters*, vol. 14, no. 5, p. 054010.

Von Krogh, G 1998, 'Care in knowledge creation', *California Management Review*, vol. 40, no. 3, pp. 133-153.

Vorotnikov, IL, Ukolova, NV, Monakhov, SV, Shikhanova, JA & Neyfeld, VV 2020, 'Economic aspects of the development of the" digital agriculture" system', *Scientific Papers: Management, Economic Engineering in Agriculture & Rural Development*, vol. 20, no. 1.

Vrchota, J, Mařiková, M, Řehoř, P, Rolínek, L & Toušek, R 2020, 'Human Resources Readiness for Industry 4.0', *Journal of Open Innovation: Technology, Market, and Complexity*, vol. 6, no. 1, p. 3.

Vrontis, D & Christofi, M 2019, 'R&D internationalization and innovation: A systematic review, integrative framework and future research directions', *Journal of Business Research*, vol. in press.

Walczuch, R, Lemmink, J & Streukens, S 2007, 'The effect of service employees' technology readiness on technology acceptance', *Information & Management*, vol. 44, no. 2, pp. 206-215.

Wan, F, Williamson, PJ & Yin, E 2015, 'Antecedents and implications of disruptive innovation: Evidence from China', *Technovation*, vol. 39, pp. 94-104.

Wang, CL & Ahmed, PK 2004, 'The development and validation of the organisational innovativeness construct using confirmatory factor analysis', *European Journal of Innovation Management*, vol. 7, no. 4, pp. 303-313.

Wanzenried, G 2018, *Family control and environmental, social and govern-ance (ESG) engagement–Evidence from Austria, Germany and Switzerland*, CARF Luzern, <https://www.wiwi.uni-siegen.de/banken/dokumente/konferenzband_carf_luzern_2018.pdf#page=324>.

Warner, KS & Wäger, M 2019, 'Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal', *Long range planning*, vol. 52, no. 3, pp. 326-349.

Warren, CR, Burton, R, Buchanan, O & Birnie, RV 2016, 'Limited adoption of short rotation coppice: The role of farmers' socio-cultural identity in influencing practice', *Journal of rural studies*, vol. 45, pp. 175-183.

Watanabe, A, Sakakibara, S, Ban, K, Yamada, M, Shen, G & Arai, T 2005, 'Autonomous visual measurement for accurate setting of workpieces in robotic cells', *CIRP annals*, vol. 54, no. 1, pp. 13-18.

Watts, S & Harrison, J 2015, *Farming on the verge of a workforce crisis*, Deloitte, viewed 26.08.2019, <https://www2.deloitte.com/au/en/pages/consumer-business/articles/farming-verge-workforce-crisis.html>.

Webb, NP, Marshall, NA, Stringer, LC, Reed, MS, Chappell, A & Herrick, JE 2017, 'Land degradation and climate change: building climate resilience in agriculture', *Frontiers in Ecology the Environment*, vol. 15, no. 8, pp. 450-459.

Weeks, WA, Roberts, J, Chonko, LB & Jones, E 2004, 'Organizational readiness for change, individual fear of change, and sales manager performance: An empirical investigation', *Journal of Personal Selling Sales Management*, vol. 24, no. 1, pp. 7-17.

Weersink, A, Fraser, E, Pannell, D, Duncan, E & Rotz, S 2018, 'Opportunities and challenges for Big Data in agricultural and environmental analysis', *Annual Review of Resource Economics*, vol. 10, pp. 19-37.

Weick, KE 1995, *Sensemaking in organizations*, Sage Publishing, Thousand Oaks, CA.

Weiner, BJ 2009, 'A theory of organizational readiness for change', *Implementation science*, vol. 4, no. 1, p. 67.

Weiner, BJ, Amick, H & Lee, S-YD 2008, 'Conceptualization and measurement of organizational readiness for change: a review of the literature in health services research and other fields', *Medical Care Research and Review*, vol. 65, no. 4, pp. 379-436.

Weiner, BJ, Clary, AS, Klaman, SL, Turner, K & Alishahi-Tabriz, A 2020, 'Organizational Readiness for Change: What We Know, What We Think We Know, and What We Need to Know', in *Implementation Science 3.0*, Springer, Cham, pp. 101-144.

Weltzien, C 2016, 'Digital agriculture or why agriculture 4.0 still offers only modest returns', *Landtechnik*, vol. 71, no. 2, pp. 66-68.

Westerman, G, Tannou, M, Bonnet, D, Ferraris, P & McAfee, A 2012, *The Digital Advantage: How digital leaders outperform their peers in every industry*, MITSloan Management and Capgemini Consulting, MA.

Wiebe, K, Robinson, S & Cattaneo, A 2019, 'Climate Change, Agriculture and Food Security: Impacts and the Potential for Adaptation and Mitigation', in *Sustainable Food and Agriculture*, Academic Press, Cambridge, MA, pp. 55-74.

Wiener, N 1948, *Cybernetics or Control and Communication in the Animal and the Machine*, Technology Press, Cambridge, MA.

Williams, I 2011, 'Organizational readiness for innovation in health care: some lessons from the recent literature', *Health Services Management Research*, vol. 24, no. 4, pp. 213-218.

Williams, IJHSMR 2011, 'Organizational readiness for innovation in health care: some lessons from the recent literature', vol. 24, no. 4, pp. 213-218.

Williams Jr, RI, Pieper, TM, Kellermanns, FW & Astrachan, JH 2018, 'Family firm goals and their effects on strategy, family and organization behavior: A review and research agenda', *International journal of management reviews*, vol. 20, pp. 63-82.

Wiseman, L, Sanderson, J, Zhang, A & Jakku, E 2019, 'Farmers and their data: An examination of farmers' reluctance to share their data through the lens of the laws impacting smart farming', *NJAS-Wageningen Journal of Life Sciences*, vol. 90, p. 100301.

WITSA, WITaSA 2000, *International Survey of E-Commerce*, viewed 10.06.2019, <http://www.witsa.org/papers/EcomSurv.pdf >.

Wójcik, M, Jeziorska-Biel, P & Czapiewski, K 2019, 'Between words: A generational discussion about farming knowledge sources', *Journal of rural studies*, vol. 67, pp. 130-141.

Wolf, M, Kleindienst, M, Ramsauer, C, Zierler, C & Winter, E 2018, 'Current and future industrial challenges: demographic change and measures for elderly workers in industry 4.0', *Annals of the Faculty of Engineering Hunedoara-international journal of engineering*, vol. 16, no. 1.

Wolfert, J, Sørensen, CG & Goense, D 2014, 'A future internet collaboration platform for safe and healthy food from farm to fork', in *Annual Global Conference SRII*, San Jose, CA, pp. 266–273

Woodside, AG & Wilson, EJ 2003, 'Case study research methods for theory building', *Journal of Business and Industrial marketing management*, vol. 18, no. 6/7, pp. 493-508.

World Population Review 2020, *2020 World Population by Country*, viewed 20.03.2020, <http://worldpopulationreview.com/>.

Wortman, MS 1994, 'Theoretical foundations for family-owned business: A conceptual and research-based paradigm', *Family business review*, vol. 7, no. 1, pp. 3-27.

Wraikat, H, Bellamy, A & Tang, H 2017, 'Exploring organizational readiness factors for new technology implementation within non-profit organizations', *Open Journal of Social Sciences*, vol. 5, no. 12, pp. 1-13.

Wyers, R 2019, *Australia eyes Agriculture 4.0 opportunity: Can Down Under come out on top?*, Food Ingridiens First, viewed 23.08.2019, <https://www.foodingredientsfirst.com/news/australia-eyes-agriculture-40-opportunity-can-down-under-come-out-on-top.html>.

Xu, L, Liang, N & Gao, Q 2008, 'An integrated approach for agricultural ecosystem management', *IEEE Transactions on Systems, Man and Cybernetics*, vol. 38, no. 4, pp. 590-599.

Xu, LD & Duan, L 2019, 'Big data for cyber physical systems in industry 4.0: a survey', *Enterprise Information Systems*, vol. 13, no. 2, pp. 148-169.

Yen, HR, Wang, W, Wei, C-P, Hsu, SH-Y & Chiu, H-C 2012, 'Service innovation readiness: Dimensions and performance outcome', *Decision Support Systems*, vol. 53, no. 4, pp. 813-824.

Yin, RK 2003, *Case study research design and methods third edition*, Applied social research methods series, Sage Publishing, Thousand Oaks.

Yin, RK 2015, *Qualitative research from start to finish*, Guilford Publications, New York.

Yoffie, DB 1996, 'Competing in the age of digital convergence', *California Management Review*, vol. 38, no. 4, p. 31.

Yoo, Y, Boland Jr, RJ, Lyytinen, K & Majchrzak, A 2012, 'Organizing for innovation in the digitized world', *Organization science*, vol. 23, no. 5, pp. 1398-1408.

Yoo, Y, Henfridsson, O & Lyytinen, K 2010, 'Research commentary—the new organizing logic of digital innovation: an agenda for information systems research', *Information systems research*, vol. 21, no. 4, pp. 724-735.

Yusof, NAB, Shafiei, MWM, Said, I & Abidin, NZ 2010, 'Factors influencing firms' readiness towards innovation in house building industry: a multi-dimensional construct', *International Journal of Organizational Innovation*, vol. 2, no. 3.

Zaidi, MFA & Belal, H 2019, 'A perliminary study to understand the SME's readiness on IoT in Malaysia ', *International Journal of Accounting Information Systems*, vol. 4, no. 19, pp. 1-12.

Zambon, I, Cecchini, M, Egidi, G, Saporito, MG & Colantoni, A 2019, 'Revolution 4.0: Industry vs. agriculture in a future development for SMEs', *Processes*, vol. 7, no. 1, p. 36.

Zanero, S 2017, 'Cyber-physical systems', *Computers in Human Behavior*, vol. no. 50 pp. 14-16.

Zangiacomi, A, Pessot, E, Fornasiero, R, Bertetti, M & Sacco, M 2020, 'Moving towards digitalization: A multiple case study in manufacturing', *Production Planning & Control*, vol. 31, no. 2-3, pp. 143-157.

Zhang, A, Baker, I, Jakku, E & Llewellyn, R 2017, *Accelerating precision agriculture to decision agriculture: The needs and drivers for the present and future of digital agriculture in Australia. A crossindustries producer survey for the Rural R&D for Profit 'Precision to Decision' (P2D) project.*, CSIRO and Cotton Research and Development Corporation, Australia

Appendices

Appendix A: Prominent definitions of Innovation

Definition of Innovation as Outcome	Innovation as a Process
Innovation is reflected in novel outputs: a new good or a new quality of a good; a new method of production; a new market; a new source of supply; or a new organisational structure, which can be summarised as 'doing things differently' (Schumpeter 1934)	'Innovation is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service. It is capable of being presented as a discipline, capable of being learned, capable of being practiced.' (Drucker 1985, p.19)
'Radical change in business processes' (Davenport 1994, p.137)	'The development and implementation of new ideas by people who over time engage in transactions with others within an institutional order' (Van de Ven, A 1986, p.590)
'An invention which has reached market introduction in the case of a new product, or first use in a production process, in the case of a process innovation' (Utterback, JM 1971, p.77)	'The innovation process in firms is a process of accumulating and creating new knowledge' (Nonaka & Takeuchi 1995, p.510)
'building new and novel products, production processes, and marketing schemes' (Levitt 1960, p.2)	Process of transforming an opportunity into fresh ideas and being widely used in practice (Tidd, Joseph, Bessant & Pavitt 1997)
'the wide range of variegated processes by which man's technologies evolve over time' 'an innovation in the economic sense is accomplished only with the first commercial transaction' (Freeman 1974, p.22)	'The process of bringing any new problem solving ideas into use' (Kanter 1984, p.20)
'the development and intentional introduction of new and useful ideas by individuals, teams, and organisations' (Bledow et al. 2009, p.305)	'Innovation is the purposeful orchestration and directed application of organisational skills and knowledge' (Pitt, Clarke & Management 1999, p.21)
'Innovation is the creation of any product, service, or process which is new to a business unit' Tushman and Nadler (1986, p.75)	Innovation takes place via a process whereby a new 'thought, behaviour, or thing,' which is 'qualitatively different from existing forms' is conceived of and brought into reality (Barnett 1953, p.7; Robertson, TS 1967)
'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations' (OECD 2005, p.146)	

Appendix B: Examples of digital innovations

Type of Innovation Output	Digital Innovation
Product	Mobile internet and in particular the currently rolled out 5G as well as the IoT enables innovative products such as autonomous vehicles. (Teece, David J 2017).
Process	Cloud computing and analytics enable organisations to store and process documents online, considerably speeding up processes and additionally omitting human involvement (Deloitte 2018).
Organisational and Marketing	Social media such as LinkedIn, Twitter and Instagram have fundamentally changed how organisations place and promote their products as well as their hiring practice, searching and approaching candidates being conducted online (Aral, Dellarocas & Godes 2013; Nanji 2017).

Appendix C: Detail overview of the literature review on innovation readiness

Organisational readiness for innovation has been subject of interest in multiple contexts, such as e.g. healthcare, building industry, enterprise systems and service innovation.

It has been commonly coupled with theoretical models, which supports the goal of this thesis being redefining and specifying the concept of readiness for innovation in the context of digitalisation in agriculture. In the articles of the review readiness for innovation either (1) served as foundation to develop a new model, in particular the ‘Demand Readiness Level Scale’ (Paun 2012), intended to improve management of the technology transfer relationship, the ‘Organisational Information Technology/Systems Innovation Model’ (Snyder-Halpern 2001), which is a conceptual assessment framework to guide decision-making processes for clinical IT/S innovation in health care organisations and a ‘layer model of assessing the readiness of universities to implement digital technologies based education innovations’ (Kryukov & Gorin 2016), the ‘Readiness for Innovation in Family Firms’ framework, enabling the assessment of the extent of preparedness to adopt an innovation by family managers and the concept of service innovation readiness (SIR), which ‘signifies a firm's self-assessment of its readiness for effectively implementing service innovation’ (Yen et al. 2012, p. 814) and the ‘Innovation Readiness Level’, which is a readiness model for managing innovation throughout its lifecycle (Tao, Probert & Phaal 2010); (2) was referred to as a building block of an existing model, in particular the ‘Greenhalgh Model’ (Sunaert et al. 2011), which reviews the Diffusion of innovations in service organisations (Greenhalgh et al. 2004); Or (3) was developed based on an existing model, in particular ‘A Victory Model’ (Lokuge & Sedera 2014), through which innovation readiness in an organisation is conceived.

Innovation, as part of the ‘readiness for innovation’ concept was viewed from diverse angles. The majority of the publications refer to innovation as a multi-stage process (Evans, JD & Johnson 2013; Holt & Daspit 2015; Paun 2012; Schultz, Joseph S, Sjøvold & André 2017; Setiawan et al. 2018; Tao, Probert & Phaal 2010; Williams, I 2011). Singular papers refer to innovation as an outcome (Scaccia et al. 2015), service innovation (Yen et al. 2012) and enterprise system innovation (Lokuge & Sedera 2014), or the specific innovation of digital technology based education innovations (Kryukov & Gorin 2016). The remaining publications do not specify their conceptualisation of innovation.

The conceptualisation of readiness is equally dispersed. If defined, it has been referred to as either ‘ a shared psychological state, where an organisation attempts to influence the beliefs, attitudes, intentions, and ultimately the behaviour of their organisational members’ (Schultz, Joseph S, Sjøvold & André 2017, p.441), or ‘the extent to which an organisation is both willing and able to implement a particular innovation’ (Scaccia et al. 2015, p.485).

Based on the various contexts, perspectives and definitions of innovation and readiness, there is little consensus on the concept of readiness for innovation. Publications explicitly mentioning the applied view on readiness for innovation refer to it as ‘the degree to which those involved in the family firm (including both family and non-family members) are collectively and individually able, primed, and motivated to successfully move through the adoption process’ (Holt & Daspit 2015), the ‘firm's readiness for adopting service innovation based on assessment of its adopting contexts’ (Yen et al. 2012, p.815), and the ‘level of fit between new IT/S and the organisation’ (Snyder-Halpern 2001, p.180). An overview of all publications, their applied definitions as well as academic examples of the application of each particular conceptualisation is given in Table 20.

Table 20: Summary of the publications of the systematic literature review

Publication	Topic	Definition of Innovation	Definition of Readiness
		Or Innovation Readiness	
(Lokuge & Sedera 2014)	Organisational readiness for innovation in the context of enterprise systems	Innovation as a process: ‘the process whereby an innovation adoption unit transforms ideas, skills, resources, and technology into new/improved products, processes, or service’ (Lokuge & Sedera 2014, p. 3)	Not defined
(Schultz, Joseph Samuel, Sjøvold & Andre 2017)	Organisational readiness for innovation in the context of eldercare	Not defined	‘a shared psychological state, where an organisation attempts to influence the beliefs, attitudes, intentions, and ultimately the behaviour of their organisational members’ (Schultz, Joseph Samuel, Sjøvold & Andre 2017, p.441)
(Williams, IJHSMR 2011)	Organisational readiness for innovation in health care	Innovation as a process: ‘multi-stage process whereby organisations transform ideas into new/improved products, service or processes’ (Williams, I 2011, p.1)	Not defined
(Kryukov & Gorin 2016)	Organisational readiness for innovation in higher education institution to apply modern digital technologies	Not defined	Not defined

(Holt & Daspit 2015)	Family firm's underlying organisational readiness for innovation	Innovation as a process: 'multi-stage process whereby organisations transform ideas into new/improved products, service or processes' (Holt & Daspit 2015, p.82)	'represents the degree to which those involved in the family firm (including both family and non-family members) are collectively and individually able, primed, and motivated to successfully move through the adoption process' (Holt & Daspit 2015, p.83)
(Yen et al. 2012)	Firm's readiness for adopting service innovation	Innovation as outcome: 'create value for customers, employees, business owners, alliance partners, and communities through new and/or improved service offerings, service processes, and service business models' (Yen et al. 2012, p.814)	'Firm's readiness for adopting service innovation based on assessment of its adopting contexts' (Yen et al. 2012, p.814)
(Paun 2012)	Organisational innovation (process) Readiness	Not defined (focus on process)	Not defined
(Tao, Probert & Phaal 2010)	Innovation-readiness level for organisations	Not defined	Not defined
(Scaccia et al. 2015)	Heuristic for organisational readiness for service innovation	Innovation as outcome: 'program, process, or policy that is new to an organisation' (Scaccia et al. 2015, p.1)	'extent to which an organisation is both willing and able to implement a particular innovation' (Scaccia et al. 2015, p.2)
(Snyder-Halpern 2001)	Organisational IT/S innovation readiness for clinical technology	Innovation as a process: IT/S innovation, referring to IT/S implementation	Organisational readiness for innovation: 'the level of fit between new IT/S and the organisation' (Snyder-Halpern 2001, p.180)
(Yusof et al. 2010)	Readiness for Innovation in the House Building Industry	Innovation as an outcome: multidimensional perspective - product, process, service, technological and market innovations	Readiness: 'antecedent to behaviours that are associated with adoption or resistance' (Yusof et al. 2010, p.80)
(Evans, JD & Johnson 2013)	Innovation readiness level	Innovation as outcome (leading to a new business model)	the 'stretch' that the organisation will have to go through to be successful in the new business model (Evans, JD & Johnson 2013, p.53)
(Setiawan et al. 2018)	readiness of research toward commercialisation	Not defined	maturity of the technology
(Sunaert et al. 2011)	readiness for innovation among GPs	Not defined	Not defined

While the final sample of 14 papers differs in aspects considered to constitute organisational readiness for innovation, they can be classified in the seven categories: Strategy, Resources, Values, Abilities, Attitude, Support and Relationships, which are detailed in the following.

Strategy: Strategy has been emphasised as critical for organisational readiness for innovation. Essentially, scholars call for structure, openness, formalisation and clarity in regard to strategy. Defining a strategy (Evans, JD & Johnson 2013; Holt & Daspit 2015; Lam & Law 2019; Setiawan et al. 2018; Tao, Probert & Phaal 2010; Yen et al. 2012), establishing an adequate organisational structure (Lokuge & Sedera 2014; Scaccia et al. 2015; Snyder-Halpern 2001; Williams, I 2011; Yusof et al. 2010), assigning roles (Evans, JD & Johnson 2013; Holt & Daspit 2015; Setiawan et al. 2018; Tao, Probert & Phaal 2010; Yen et al. 2012), defining structured processes (Lokuge & Sedera 2014; Snyder-Halpern 2001; Yusof et al. 2010), and building up a network with partners for inter-organisational collaboration (Scaccia et al. 2015; Williams, I 2011; Yen et al. 2012) have been the mostly mentioned determinants of readiness for innovation. Once the strategic boundary conditions are set, assessment has been identified as the next step of strategic readiness for innovation. The assessment involves evaluating the availability of determinants necessary for the particular innovation (Holt & Daspit 2015; Kryukov & Gorin 2016; Williams, I 2011), as well as the risk and the implications of the particular innovation (Evans, JD & Johnson 2013; Setiawan et al. 2018; Tao, Probert & Phaal 2010). Additional strategic aspects to be considered include understanding the market (Evans, JD & Johnson 2013; Setiawan et al. 2018; Tao, Probert & Phaal 2010) ,and continuously focusing on the development of technology (Evans, JD & Johnson 2013; Setiawan et al. 2018; Tao, Probert & Phaal 2010).

Resources: The availability of resources has been one of the most discussed determinants of readiness for innovation (Kryukov & Gorin 2016; Lokuge & Sedera 2014; Paun 2012; Scaccia et al. 2015; Snyder-Halpern 2001; Yusof et al. 2010). The resources the publications mainly focused on are skilled employees (Holt & Daspit 2015; Kryukov & Gorin 2016; Lokuge & Sedera 2014; Scaccia et al. 2015; Snyder-Halpern 2001; Yusof et al. 2010), and budget (Lokuge & Sedera 2014; Snyder-Halpern 2001; Yusof et al. 2010). Skilled employees were repeatedly highlighted as a key resource in order to successfully innovate (Evans, JD & Johnson 2013; Holt & Daspit 2015; Kryukov & Gorin 2016; Lokuge & Sedera 2014; Snyder-Halpern 2001; Tao, Probert & Phaal 2010; Yusof et al. 2010). The discussion around budget stresses on the need for monetary resources to finance R&D as well as operations (Lokuge & Sedera 2014; Snyder-Halpern 2001; Yusof et al. 2010).

Values: While a multitude of values necessary for readiness for innovation has been identified, organisation culture and collaboration were mentioned most commonly. An organisational culture supporting readiness for innovation was characterised by, for example, a positive organisational climate, a shared culture throughout hierarchical level and flexible organisational policies (Holt & Daspit 2015; Lokuge & Sedera 2014; Scaccia et al. 2015; Schultz, Joseph Samuel, Sjøvold & Andre 2017; Williams, I 2011; Yusof et al. 2010). Collaboration, describing inter-organisational exchange of knowledge and experience, was highlighted as means of readiness for innovation (Holt & Daspit 2015; Kryukov & Gorin 2016; Yen et al. 2012).

Abilities: The literature reviewed has stressed on knowledge management as a determinant for innovation. Knowledge is a competitive advantage and substantial for innovation. To be utilised for an innovative purpose, it must be acquired, exploited and above all, managed, to capture its advantages and value (Holt & Daspit 2015; Kryukov & Gorin 2016; Scaccia et al. 2015; Snyder-Halpern 2001; Williams, I 2011; Yusof et al. 2010).

Attitude: Another factor highlighted in the literature reviewed is the attitude towards innovation. The respective studies have uncovered a positive attitude toward the innovation, expressed in excitement, enthusiasm and engagement to strengthen the organisations' readiness for innovation (Scaccia et al. 2015; Schultz, Joseph Samuel, Sjøvold & Andre 2017; Sunaert et al. 2011).

Support: The last factor, support, describes the managerial ability and willingness to support staff. The support includes leadership and principal support, which encourages, guides and assists individual members of the organisation with innovation and related matters (Holt & Daspit 2015; Lokuge & Sedera 2014; Scaccia et al. 2015; Williams, I 2011).

Appendix D: Prominent model assessing organisational readiness for Industry 4.0

Model assessing organisational readiness for Industry 4.0 all identify factors constituting readiness for Industry 4.0, labelled to assess either the organisational readiness or maturity. The difference in nomenclature originates from the differentiation in timing – readiness being assessed before engaging in maturing in regard to Industry 4.0, while maturity capturing the status-quo whilst the maturing process (Schumacher, Erol & Sihn 2016). As the goal of this thesis is uncovering factors influencing the readiness, the timing of evaluation in relation to engagement is irrelevant and hence both, readiness and maturity are included in the conceptualisation of readiness for Industry 4.0.

Prominent examples of readiness and maturity models, such as Impuls (Lichtblau et al. 2015), the VDMA-Toolbox (Anderl et al. 2015), DREAMY, the SMSRL (Smart Manufacturing Readiness Level) (De Carolis et al. 2017), the Acatech maturity dimensions (Schuh et al. 2017) and the Connected Enterprise Maturity Model (Rockwell Automation 2014) are presented and detailed in Table 21.

Table 21: Prominent examples of readiness and maturity models for Industry 4.0

Model	Specific Angle on readiness for Industry 4.0	Categories of Readiness for Industry 4.0
IMPULS – Industrie 4.0 Readiness (Lichtblau et al. 2015)	Assessing the organisations potential to transform to Industry 4.0 by identifying general categories enabling maturity stage transition	Organisation, Smart Factory, Smart Operations, Smart Products, Data-Driven Services, Employees
VDMA-Toolbox (Anderl et al. 2015)	Ideas and approaches to the company for implementing Industry 4.0	Product, Production
DREAMY (De Carolis et al. 2017)	Key manufacturing operation processes areas for digital transition to smart manufacturing	Design and engineering, Production management, Quality management, Maintenance management, Logistics management
SMSRL (Smart Manufacturing System Readiness Level) (Jung et al. 2016)	Measures a manufacturing company’s readiness for employing smart manufacturing, which is defined as the extensive use of ICT	Organisation, IT, Performance Management, Information connectivity
Acatech maturity dimensions (Schuh et al. 2017)	Focusing on data and connectivity it identifies generic archetypes related to the different digital maturity stages	Organisational structure, Resources, Information system, Culture
The Connected Enterprise Maturity Model (Rockwell Automation 2014)	Viewing technology as key enabler for a connected enterprise, technology related categories are identified	Information infrastructure, including hardware and software, Controls and devices, Networks, Security policies

Appendix E: Prominent conceptualisations of readiness for change

Reference	Definition of readiness for change	Industry Setting	Construct Level
(Armenakis, Harris & Mossholder 1993)	Beliefs, attitudes, and intentions of people regarding the extent to which changes are needed and the organisation's capacity to make those changes	General	Organisation
(Backer 1995, 1997)	The precursor of actual behaviours needed to adopt an innovation is the state of mind	Health care	Organisation
(Barrett, JH et al. 2005)	Perceived need for change and organisation's ability to implement change successfully	Business	Individual
(Chonko et al. 2002)	The cognitive precursors to the behaviours of either resistance to or support for change effort.	Business	Individual
(Cunningham et al. 2002b)	A noticeable need for change, a sense of one's ability to successfully accomplish change and the possibility to participate in the change process	Health care	Individual
(Devereaux et al. 2006)	Capacity to implement change designed to improve performance	Health care	Individual/Organisation
(Eby et al. 2000)	The cognitive precursors to the behaviours of either resistance to or support for change effort.	Business	Organisation
(Holt, Armenakis, Feild, et al. 2007)	A comprehensive attitude reflecting the extent to which individuals are inclined to accept, embrace, and adopt a particular change plan	General	Individual
(Jones, RA, Jimmieson & Griffiths 2005a)	Employees' positive views about the need for organisational change and the likeliness to have personal and organisation wide positive implications	Government	Individual
(Madsen, Miller & John 2005)	Because of a perceived need individuals are ready for change when they understand, believe, and intend to change	Health care	Individual
(Neiva, Ros & Paz 2005)	An organisation's plan for change and its ability to execute it	Health Care	Organisation
(Peach, Jimmieson & White 2005)	Employees' positive views about the need for organisational change and the likeliness to have personal and organisation wide positive implications	Business	Individual
(Rafferty & Simons 2006)	Beliefs, attitudes, and intentions of people regarding the extent to which changes are needed and the organisation's capacity to make those changes	Business	Individual
(Weeks et al. 2004)	Individual sales managers' beliefs, attitudes, and intentions regarding the extent to which changes are	Business	Individual

	needed and the organisation's capacity to make those changes under dynamic business conditions		
(Weiner 2009)	The organisational members' commitment to change and self-efficacy to implement organisational change	Business	Organisation

Appendix F: Digital technologies in the agriculture sector and their application

Cybernetics, which originally refers to control and communication in animals as well as the machines (Wiener 1948), is utilised in modern agriculture predominantly for decision support systems for better control and optimised production. Onc example is the growing of crop (Lazovic 2020). When growing crop, various decisions in regard to sowing, watering, fertilising, applying pesticides, harvesting, etc. must be made. Cybernetics can support informed decision making by evaluating the status quo as well as making prediction regarding all specified factors affecting the process, such as for example soil quality, weather and climate data (Bouma, Montanarella & Evanylo 2019; Xu, L, Liang & Gao 2008).

The foundation for cybernetics, and at the same time one of the currently most promising technological developments in agriculture is big data (Verma et al. 2020). The term big data and big data analytics is used to describe the large data sets of various nature and the advanced storage, analysis and visualisation technologies (Chaudhuri, Dayal & Narasayya 2011), which allow making sense of previously inaccessible knowledge in almost real-time (McAfee et al. 2012). The value created by big data in the agriculture sector is primary the insights gained through the integration and analysis of data from diverse areas, such as crop, animal breeding, farming systems, climatic information and soil nutrition (Burdon et al. 2017; Kamble, Gunasekaran & Gawankar 2020), which allow more informed decision making.

The application of sensors in agriculture is one of the central data sources in digital agriculture (García et al. 2020). Replacing the traditionally tethered monitoring systems, they are able to operate wireless, tracking a multitude of structural response data (Lynch & Loh 2006; Singh & Singh 2020). As sensors can be used for a wide range of applications, such as hydrogen sensors, temperature sensors, pressure sensors, movement sensors, etc. they have found wide applications in agriculture (Chakraborty, Das & Pal 2020; Katyal & Pandian 2020; Pramanik et al. 2020). They enable, for example, remotely controlled, automatic irrigation (Lozoya et al. 2016), variable-rate technology (Tackenberg, Volkmar & Dammer 2016) and autonomous vehicle guidance (Hu et al. 2015; Pickett & Han 2017).

As the examples indicate, sensors are the fundament for robotics, providing the data necessary for robot supported or enabled thinking and acting (Perez 2016; Vasconez, Kantor & Cheein 2019). As robotic sensing allows, for example, to detect weeds, localise fruits, monitor feeding and estimate crop yields, these data can be processed in a meaningful way, and used for robot enabled actions, such as the application of herbicides, harvesting ripe fruits and watering of crop (Burdon et al. 2017; Kulkarni et al. 2020).

Appendix G: Impact of digital innovation on the agriculture sector

The innovation, enabled by the application of digital technologies, has a strong positive impact on farms. Shifting the focus from manual to more cognitive work, allowing more informed decisions, its eases the on-farm work while ensuring more reliable and higher yields (Manyika et al. 2015; Trendov, Varas & Zeng 2019).

However, besides farm internal improvements, in the light of the previously detailed challenges of global scope agriculture is currently facing, digital technologies present an opportunity to secure the global food supply, while reducing the negative environmental impact of farming. In fact, technology is one of the five pillars of food security and sustainable agriculture identified by the United Nations (2012).

An increasing global population and individual consumption, a decreasing workforce in agriculture, the Covid-19 pandemic related consequences for the accessibility and reliability of labour, land use limitations and the biofuel market competing for agricultural goods, have been identified as factors endangering the global food supply. Digital technologies and the innovation in the agriculture sector they enable have the potential to meet the high demand for agricultural products while maintaining a price level, making the goods accessible where needed.

As introduced, digital technologies can, for example, provide more precise information on weather events that may endanger the yield (Pooja et al. 2017), allowing preventive measures. Real time data collection and processing allows for a better overview of actions needed to ensure a high yield, such as irrigation, spraying or livestock's medication, which in turn enables a more reliable and consistently higher yield (Stafford 2019). Furthermore, a more effective utilisation of land can be achieved by GPS mapping and soil testing which allow to determine the best cropping options for a paddock (Deng 2017). The last factor endangering the food supply is the diminishing workforce in the agriculture sector and the lack of availability and reliability of labour due to the Covid-19 related challenges. While each farm requires a number of individuals to operate the business, digital technologies can substitute manual labour by executing task automatically and in some cases autonomously (Bechar & Vigneault 2017). Consequently, the negative effects of a decreasing number of farm workers can, at least to some degree, be minimised by innovating the agricultural practice, applying digital technologies. Furthermore, a shift towards automated processes ensures the farms' ability to operate even in light of a pandemic such as the currently globally widespread Covid-19 disease.

In regard to reducing the environmental impact of agriculture, on-farm innovation with digital technologies provides a wide range of opportunities. For example, the extensive application of pesticides, which pose danger to human and livestock health, as well as other species living on the paddock (Sachs 1993) can be limited by using digital technologies. Sensors detecting pests in real time and providing information on the exact area of its occurrence, as well as robots capable of precise spraying, enable targeted pesticide control minimising its environmental impact.

Agriculture causes further damages to the environment by its high water use (Kijne, Barker & Molden 2003). While agriculture relies on water for livestock as well as plants, a more effective use of the resource can be achieved when utilising digital technologies. Digital technologies enable monitoring of soil moisture, precipitation and water levels in feeding stations, indicating more accurately when and what amount of water is needed as well as a more precise water distribution where necessary (Sanders & Masri 2016).

The application of digital technologies, making the agricultural practice more efficient and effective, can as well have a positive effect in regard to deforestation and the greenhouse emission of the sector. As digital technologies ensure higher and more reliable yields on the existing agricultural land (Stafford 2019), they decrease the need for further acquisition and hence help omitting deforestation. Furthermore, the ability of digital technologies to provide accurate, real time data and thereby optimise operations, helps as well to reduce unnecessary agricultural emissions caused by redundant and precautious actions (El Bilali & Allahyari 2018).

As this chapter outlines, the diversity of opportunities for innovation in farming enabled through the application of digital technologies is immense and they show high potential for contributing to the current global problems regarding food supply and the environment. However, despite the obvious positive effects of digital innovation in agriculture, it is the least digitalised sector (Gandhi 2016; Manyika et al. 2015).

Consequently, in light of the urgency as scope of the global challenges introduced earlier, digital innovation has been recognised as a promising solution, leading to a multitude of national and international programs supporting the cause. In fact, recently digitalisation is becoming the predominant imperative for agricultural innovation. Governments around the world, such as in the USA, Canada, Australia, India and all countries in the European Union invest in initiatives enabling digital innovation in agriculture (Bacco et al. 2019; European Commission 2017; US Department of Agriculture 2014; Victoria State Government 2018). Research grants and international cooperation programs to further explore the opportunities of digital technologies in the sector and develop viable technologies, monetary support for farmers transitioning towards the practice of digital innovation, informative and explorative topical workshops, any many more incentives and help is being offered to foster digital innovation in agriculture (Australian Government 2017; European Commission 2019; Government of Canada 2018; Seth & Ganguly 2017; USAID 2019).

Appendix H: Participant recruitment letter

RECRUITMENT LETTER

With this letter, we would like to inform you about the opportunity to participate in the research study titled '**Organisational Readiness for Digital Innovation'**. The goal of this study is to explore determinants of organisational readiness to innovate with digital technologies. Moreover, this research aims to identify influencing factors specific to the food industry.

This study is conducted by Monika Streuer and supervised by Professor Adela McMurray and Dr. Stan Karanasios, all affiliated with the RMIT University in Melbourne.

We would like to invite you to take part in this research because you possess industry expertise in innovating with digital technologies in the food sector. We hope you will be able to **spend approximately 60 min for an interview** (**via telephone, Skype or in-person**) with us and tell us about your perceptions on enabling and hindering factors for innovating with digital technologies in the food industry.

We believe your insights will be valuable in advancing the understanding on determinants for successfully using digital technologies to enhance innovation in the food industry and ultimately help in boosting the industry sector's innovation. Your contribution is important since you are a major stakeholder and a pioneer in the industry sector.

If you are interested in participating in this research, **please contact the responsible researcher of this project via email (monika.streuer@rmit.edu.au).** If you are located in Melbourne, kindly advise on a suitable time and place to meet. If you are located outside Melbourne, please advise on a suitable time along with your telephone number or Skype details. Please also let us know your preferred interview time, so we can try our best to suit your requirements. We have attached the participant information sheet and consent form, which detail the research study objectives and the processes involved.

Please note that participating in this project is entirely voluntary. You do not have to participate if you don't feel like so, and you can withdraw anytime during the study. In addition, the interview data will be kept strictly confidential. The researchers are ethically bound to keep all data confidential.

Please do not hesitate to contact us for further information. The contact details of the responsible researcher can be found below. Please be assured that request for more information does not obligate you to participate in the study.

On behalf of the entire research team, I thank you for your thought on being part of this important study and look forward to hearing back from you soon.

Monika Streuer

PhD Candidate, School of Management, RMIT University Melbourne

Appendix I: Participant Consent Form

Title	Organisational Readiness for Digital Innovation
Chief Investigator/Senior Supervisor	Prof. Adela McMurray
Associate Investigator/Associate Supervisors	Dr. Karanasios
Research Student	Monika Streuer

Acknowledgement by Participant

I have read and understood the Participant Information Sheet.

I understand the purposes, procedures and risks of the research described in the project.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time during the project without affecting my relationship with RMIT.

I understand that I will be given a signed copy of this document to keep.

Name of Participant (please print) ______________________________

Signature ______________________ Date ______________________

Declaration by Researcher†

I have given a verbal explanation of the research project, its procedures and risks and I believe that the participant has understood that explanation.

Name of Researcher† (please print) ______________________________

Signature ______________________ Date ______________________

† An appropriately qualified member of the research team must provide the explanation of, and information concerning, the research project.

Note: All parties signing the consent section must date their own signature.

I **would like a copy of the report:** ☐**NO** ☐**Yes**

If yes, please provide your email address: ______________________

Appendix J: Interview Guide - Qualitative Study Phase 1

Introduction

Please, tell me about your …

- organisation – what do you do, how many employees do you have, who is running it, how long has the farm existed
- your background and your current position within this company
- the digital technologies you use, in particular which technologies and for what purpose

General Questions

- Can you tell me about the types of digital technologies you have use over the last ten years….
- Who makes decisions around digital technology?
- How are they used on the farm – examples
- What have been the main challenges? And were there any facilitators that helped overcoming them?
- How do you feel about digital technologies?
- Why do/ don't you use digital technologies?
- Did any past experiences with change influence your decision?
- What is important to you when choosing digital technology - what characteristics must digital technologies have, so you would use them on your farm?
- When would you consider using digital technologies?
- How extensive is your knowledge in regard to digital technologies? What do you know about them?
- Are you well connected with your peers and if yes, how and why?
- Are you part of a related network and if yes, which and why?
- What distinguished you from your peers who do/don't use digital technologies?
- Do you have a strategic plan on your farm and if yes, how does it look like?
- What is the approach you follow to stay on top of the game?
- How do you feel about working more on the computer than out on the farm?

Questions for Digital Innovators

- Can you recall when you decided to start using digital technologies and what the trigger was?
- What drove the take up of digital technologies, when, how, why, who?
- How did your chose the digital technologies for your farm?
- Before purchasing any digital technology, how did you prepare for it? How did you prepare for its application? What were the steps taken?
- Tell me about the situation when you just acquired a new digital technology. What did you have to do to use it on your farm?
- Were there any barriers you needed to overcome? – How did you overcome them?
- When applying digital technologies, how does it normally work? Who does what? What is your focus on?
- How do you ensure that everyone on the farm is on board with using digital technologies?
- To what extent are your workers involved in the application of digital technologies and how do you manage their involvement? (roles, education, mindset, attitude)
- In your opinion, when using digital technologies …
    - Why are you successful?
    - What are the crucial enablers?
    - Are there any characteristics of your company that significantly contribute to it?
- What knowledge do you require in order to use digital technologies?
- How do you acquire this knowledge?
- Tell me about the learning process in this regard.
- Have you used any digital technologies in the past and or did you have to learn it from the start with the transfer to digital agriculture? Was the experience useful?
- What do you do if you run into troubles with using the digital technology?
- What resources are required to use digital technologies?
- What are your goals for your farm and why?
- How do you feel about working more on the computer than out on the farm?

Appendix K: Interview Guide - Qualitative Study Phase 2

Introduction

Please, tell me about your …

- background and your current position
- the organisation you are working for and how it is related to digital technologies
- the digital technologies you are mostly familiar with and why
-

Main Questionnaire

<u>1 – Factors Influencing Digital Innovation</u>

Summarising your experience with farms that innovate with digital technologies…

- What are the main triggers for farms to innovate with digital technologies?
- What are enablers (internal and external) to starting innovating with digital technologies?
- When would you recommend farms to starting innovating with digital technologies?
- What are prerequisites for innovating with digital technologies?
- What are factors influencing the success of innovating with digital technologies? (positively and negatively)
- Why do some farms not engaged in DI?
- Why are some farms challenged with DI?
- What are characteristics of farms exceptionally successful with DI?

Key-factor: People (specific to my framework)

What are characteristics of farmers that engage in DI?

What is the difference between farmers who do engage in DI compared to those who don't?

How important do you think are the following aspects for engaging in DI and why?

- *The perception of need for change?*
- *A cost-benefit ration?*
- A positive attitude towards DT?
- A specific mindset - what does it entail?
- Willingness to work on the computer and learn new ways of working?

External Capacity

What role does the external environment of a farm play in regard to its engagement in DI?

How important do you think are the following aspects for engaging in DI and why:

- Networks and their competency – what is required from network? What should be its characteristics?
- Peers?
- Understanding the distribution of knowledge?

Appendix L: Digital technologies applied by the farms investigated

Cropping

Irrigation monitoring involves the application of various sensors to measure the water penetration and evaporation in soil. This information is sent to an online application, which can be opened on a mobile phone and hence monitored in real time, regardless of the geographical location of the individual using the application. The information gained through the application of digital irrigation monitoring technology enables timely and informed decisions regarding the need for and the volume of irrigation necessary for each location monitored.

Yield mapping uses GPS data and various sensors to create detailed maps of crop yields on a paddock. When these data are collected over time, patterns can be recognised, which allow to divide paddocks into different zones and help gaining an understanding of what may be causing yield variation. This technology enables farmers to experiment on the paddock and optimise its use. By, for example, trying different crops in different paddock zones or applying varying amounts and kinds of fertiliser and reviewing the yield in comparison to before, yield mapping allows more precise and profitable paddock management.

Variable rate technology is based on yield mapping. Once a paddock is divided into different zones, prescription maps can be generated, which specify the amount farm inputs, such as fertiliser, chemicals and irrigation water to be applied in each of the zones. Thereby, variable rate technology enables optimal treatment of a paddock, optimising its yield.

Among other information, such as field activities, finances, inventory and workforce, farming performance visualised in the introduced yield maps are part of farm management software. Farm management software are powerful tools for data collection, storage and analysis. Based on these data, the software can be utilised to oversee farm activities, identify improvement potential (as for example described with yield maps and respective prescription maps) and forecast future events (such as profits and crop development), which all enable more informed decision making.

Digital weather stations, using multiple sensors, collect real time weather data in the location they are placed. These data are used for real-time weather tracking on the farm. Beyond this local application, these data are sent out to a central databank, which collects all measurements from digital weather stations in a region. Analysing these data in real time allows for highly accurate weather prediction and real time alerts, giving farmers a chance to respond quickly to unpredicted weather events such as storms.

GPS guidance systems allow autonomous steering of a tractor on a paddock. While an individual must be present at all times in the tractor cabin in case of an unpredicted event, such as a human being or animal occurring on the path of the tractor, the steering itself is done automatically without any human action. Some tractors are as well equipped with software that does not only allow to steer the unit along pre-defined lines in the paddock, and turn automatically, further limiting human action in the process.

Ground pressure mapping is a technology used for sowing. While a tractor is moving along the paddock, sensors measure the pressure of soil and automatically adjust the pressure with which the seeds are pushed into the ground. Thereby, each seed is located at the same depth, ensuring optimal conditions for growth, avoiding losses due to seeds being placed too deep in the ground and hence not growing or being too close to the surface and hence being washed away during rain.

Even without ground pressure measuring, digital sowing technologies, which use geomapping and sensors to plant seeds, have become a widely used and highly appreciated help on farms. Applying digital seeding technologies saves manual labour, as the task has been carried out manually until recently, time, as more ground can be covered in the same amount of time and leads to better results, as the spacing between planted seeds is more accurate contributing to higher yields.

Picking platforms consist of a self-searing unit that can navigate through the orchid and a platform, which moves vertically. This eliminates the need for an individual steering it, as well as farm workers using ladders to reach fruits growing higher up on the tree. Thereby, it helps decrease labour and increases the quality of produce, as fruits are not dropped from varying heights into picking baskets but can be placed in storage containers at hand's reach.

Controlled atmosphere technology for storage is a key-part of fruit and vegetable farming. These products ripen and rot within a very short time (around 1-2 weeks), depending on variables such temperature of the storage, oxygen and CO2 level in the air. As fruit orchids only harvest their fruits once a year, but sell them throughout the year until next harvest, the produce must be stored in an environment that maintains the fruit in a similar condition as when picked. Therefore, specific storage with controlled atmosphere, including a pre-set amount of oxygen and CO2 in the air, as well as a cool temperature are utilised. In order to ensure these specifications remain at the set level, which would otherwise lead to rotting of produce and hence loss of a year's harvest, sensors measure the respective variables and automatically regulate the environment, while sending information about the measured variables to the operator's mobile device.

Digital water supply monitoring measures in real time the water supplied on the farm, specifying each outlet's consumption. These data are sent to a mobile application, allowing real-time water supply tracking on mobile devices, such as mobile phones. This digital technology allows to detect unpredicted events such as pipe damage, which can be localised immediately. Being able to detect any water losses and their location in real time saves money for wasted water and at the same time ensures that no cropping areas are lacking irrigation, which could lead to damaged cropped and immense losses in harvest.

Livestock

Electronic ear tags are a digital technology placed at the animal's ear where it stays through its life. The ear tag contains information about the animal's origin and all steps of the supply chain up to slaughter. The use of electronic ear tags is compulsory for cattle in Australia as it provides traceability of each animal throughout the value chain. The information is valuable to, for example, identify animals at risk of disease in case of an outbreak, and enables feedback to the producer in case animals are identified with problems originating from their keeping.

GPS livestock tracking is a technology which locates each animal wearing a tracking device in real time. The location can be retrieved on a mobile device, enabling farmers to understand movement patterns of each livestock, locate missing animals or identify injured animals.

Electronic scales are used in livestock farming to measure the weight of animals. The data can be transferred to a computer or mobile applications, providing an overview of each animal's weight gain over time. It allows farmers to identify most valuable livestock for breeding, as well as potential for improvement in terms of their rearing.

Drones are unmanned aerial vehicles that can be navigated via control planes from the ground using a GPS tracking system. Drones in Agriculture are equipped with cameras that allow to capture farm images from an aerial view. The data can be used for surveillance as well as for information gathering on the paddock, allowing identification of problems and more localised treatment. The application of drones on farms can save time and effort, as large areas can be inspected quickly and remotely.

Intelligent spraying refers to a digital technology which can detect patches of weed and precisely spray only the affected area. Using image analysis, the technology identifies patches of individually pre-defined size and only treats the specific area, saving herbicide costs and allowing more environmentally friendly farming practice. This weed control technology can be applied on cropping land as well as pasture.

As in cropping, farm management software is as well available for livestock farms. It allows to collect, store and analyse farming data, such as cost of production, livestock sales, wearing reports, livestock gross margins, breeding data, etc. Providing an holistic overview on all key-variables relevant for livestock farming as well as recommendations for actions, farm management software allows more informed decision making.

Fishery

As already previously described, farm management software is as well available for fishery and aquaculture farming. Besides allowing the tracking of all farm activities and their financial side, it can continuously provide information on fish production, feeding, etc, allowing the identification of improvement potential and proactive measures that can be taken.

Automated water quality monitoring and management technology collects and manages water quality data. Water quality is a substantial factor for fishery and aquaculture farming. Factors such as increased water temperature and decreased oxygen levels greatly affect the growth and mortality of fish. This digital technology can monitor in real time the water quality and alarms farmers when specific measures fall below or exceed pre-defined values, giving the opportunity to react ad-hoc and save the fish stock.

Appendix M: Supporting evidence regarding the attribute strategic orientation

Long-term orientation	Continuous improvement
DI11: *'We gather all these other layers of data.* ***We've been using it since 2007****. I think it might have been before.* ***So quite a lot of data built up in that system where we can go back and start to see trends*** *in paddocks, so you're going to see where your constraints are in your field and that sort of thing. That is one thing in digital Ag is where we need to be getting that big data or that sort of thing, getting a critical mass of information so that we can start to get trends happening in our farming operation.'* *'****And the reason we've done that is to integrate all that tools to gather all data into one****. So it'd be great to be able to integrate the weather stations with other machines in the field. John Deere have their own weather station on the machines. But it's really a duplication, if they could develop to integrate the whole lot together. So there's no platform that I know of that we can actually do that. But if we could integrate all our different data collection tools into one system, that would fast track our ability to get more out of our data.'*	DI11: *'Every time we just started using the latest technology, with a thirst to actually become more efficient or suppose in* ***reducing your costs****. So the reason I talked about that prescription maps is a bit the reason we used them is to allocate our resources. So move your costs to the more productive areas of our farm. So we're* ***not wasting dollars on areas of the farm that aren't gonna be productive. We put it where we're going to get the most return from****.'* *'Our* ***strategy is to concentrate on that efficiency and economy of scale****. So, whatever item that is. So we will possibly install more weather stations to get more accurate weather information if that develops.'*
ADI2: *'This really difficult process implementing these technologies, knowing that* ***I have to just keep doing it because I know the benefits will outweigh the pain****.'*	ADI3: *'I guess* ***you're always looking for ways to do things better****. '* *'So, you look at your books and you say,* ***how can I do things better? How can I improve****?'*
ADI3: *'****So I had five or six years, I've just been collecting data for the purpose of collecting data because I knew I'd use it one day****.'* *'So being able before you get into buying any particular type of technology, just to make sure that yet, can I pull this data? And in what format would that be? And* ***will I be able to then put that into some other technology in the future****? '*	DI3: *'… we're always improving technologies. We're still looking at the new tech to* ***try and lower our costs of production and get the most out of our tech****.'*
DI7: *'****So it's a bit of a synergy if you use more than one of them****. They are separate programs, but they can connect. … I don't want to be opening three programs, all separately just to do it. It's better if it's all within the one. '*	DI10: *'Then look at our particular circumstances here, which is sort of unique again and* ***try to work out which things are best suited for us****.'*

Appendix N: Overview of knowledge acquisition methods applied to overcome rural limitation of knowhow

Methods applied	Industry-networks	Online search	Online communication with peers	Informative events on digital agriculture	Industry specific reports on digital technologies
ADI1	x	x	x	x	x
ADI2	x	x	x	x	
ADI3	x	x	x	x	
ADI4	x	x	x	x	
DI1	x	x			
DI2			x	x	
DI3	x			x	
DI4	x				x
DI5	x			x	
DI6	x	x	x		
DI7	x				x
DI8	x			x	x
DI9	x	x		x	x
DI10		x		x	x
DI11	x	x		x	
DI12	x			x	

Appendix O: Informants' statements regarding perceived benefits of digital technologies

Attributes	Quotes
Decreased labour	*DI9: 'We've got a new picking platform that I imported from Holland, from the Netherlands. It has a lot of sensors, and electronics, and that, on it. Very sophisticated machine. But very labour-saving.'* *DI1: 'But nowadays you just sit there doing nothing. Just push the button. No seriously. And what's more, it means that as old as I am now I can continue to do a hell of a lot of, you know, I can sit on the tractor and, and make sure it goes properly.'*
Cost saving	*ADI1: 'Cost effectively, it's a fifth of the cost of hand harvesting. It's saved us a large amount of money.'* *DI11: 'Every time we just started using the latest technology, with a thirst to actually become more efficient or suppose in reducing your costs.'* *DI4: 'Well, the guidance system was more logistics and workload and I suppose cost savings. So, it was an easy decision to do …'*
Improved mental health	*DI3: 'So, when you're sitting there on a tractor and stuff like that, utilising this technology, it opens up a world of things but also good for your mental health as well. I believe. So, it's actually, you're not stressed out about trying to steer straight down the paddock anymore.* *ADI1: 'Takes the stress off the operator …'*
Less operator error	*DI4: 'We employ staff and backpackers, so less mistakes are likely to happen in paddocks because they're, you know, self-steering tractors I suppose. So there's less possible human error.'* *ADI1: 'It removes some operator error.'*
Environmentally friendly farming	*DI3: 'So we've been able to reduce our overall chemicals, our chemical bill by $50,000 or something like that by just implementing and new sprayer that can spray perfectly to the line of where you need to spray.'* *ADI1: 'And then in the vineyard, the sprays are all run by technological applications and recovery processes, so that they'll reduce spray loss.'*
Informed decision making	*DI11: 'The weather station, that's handy. Particularly when we're out spraying, we can see when it's good to spray and when it is not. So that can guide us in decision making in our application of applying herbicides.'* *ADI2: 'In Farming making real time decision is key. So, for me it's making smarter decisions, knowing the implications of those decisions.'*

Appendix P: Selected quotes of managing farm owners stating their driving influence on enabling digital innovation

Respondents	Quotes
ADI1	*‘**I usually pick and select the ones that I think are relevant** to the technology or the particular issue to address in managing a vineyard.’*
ADI2	*‘I was one of the early adopters. **I was the first in my network to start to take up these technologies. So, I had to work it out by myself**.’*
ADI3	*‘**I tended to do the free trials** of all of them. I used back paddock, a paddock recording and they're starting to move into that space. I have also tried farm works, so I guess **I tried them all before I decided on SMS**, which I found the easiest and most intuitive one to use and it had good **online tutorials that enabled me to teach myself** rather than relying on a specific advisor.*
DI1	*‘**I've always got my eyes and ears wide open** and so is my son. To do anything new. If it's going to help us, then we might get into it.’*
DI4	*‘**I attend a lot of their field days** and seminars, and I suppose, you hear it from there, or just reading, any sort of GRDC **grains research development magazines** that come out or any sort of **workshop days** that you may be interested in and go to.’*
DI5	*‘**We had 10 years of yield maps** over various seasons and **we sat down with our agronomist** at the time and he got a guy who **made the business of it**. So we used a yield map to show where the productive areas in the paddocks are, and the less productive and we created zones in the paddocks and then hence the variable rate sewing.’**
DI6	*‘**We have really poor mobile reception** here at the house. So normally you wouldn't be able to talk on the phone or get Internet. **So we're bouncing Telstra signal to a shipping container on the edge of our neighbour’s property**, which is in the 14 kilometre radius. And from that shipping container, we put up a TV tower with a satellite receiver. And so we're bouncing WIFI signal from there to three houses.’**

*(When using ‘we’ the interviewees are including one or multiple family members who are also managing farm owners)

Appendix Q: Selected quotes of informants stating the engagement of external entities for support with digital technologies

Respondents	Quotes
ADI2	*'Some businesses employ a lot of consultants, we do as well.'*
ADI4	*'We have an agronomist. '* *'So for us, the guy at the tractor dealership, they have a sub branch, which he just deals with precision ag solutions. So if we have an issue with connectivity or communication between systems, he's usually the guy we would ask to try and help us fix it.'*
DI1	*'Number two, this stuff either will break down or something will go wrong and you will need some help and you go to the place where you know you're going to get service and, and that that goes form a machinery, goes through the big equipment and all big data stuff.'*
DI3	*'So, we've employed on our farm, an engineer, who brings his specific set of skills that really helps us with those innovation technologies.'* *'… we also pay for a consultant on our farm.'*
DI5	*'We had 10 years of yield maps over various seasons and we sat down with our agronomist at the time and he got a guy who made the business of it.'*
DI6	*'I'm using Agworld computer program software and free farm mapping programming, from another program that I can't think of the name, but we just keep using the free trial and that keeps working. Our Agronomist is using Echelon, a farm planning and spray record keeping technology.'*
DI7	*'The local agronomists, they did a lot of help with regards to that because I was using it and all the rest of us, so they made it as easy as possible.'*
DI9	*consultants too.'*
DI11	*'And we also work with our agronomists'*
DI12	*'I suppose go to your agronomist, they are the ones that have actually got to interpret it at the end of the day, and they know my situation.'* *'… we also pay for a consultant on our farm.'*

Appendix R: Selected quotes of informants explaining the purpose of engagement with innovation networks

Attributes	Quotes
Knowledge acquisition	*DI7: 'I mean, some of the farming magazines like the GRDC put out a very good sort of research paper. And the stuff they do, the farming groups, like cropping groups, have given me information, demonstration days, machinery companies as well. I suppose giving you what's available in terms of what they've got.'* *E3: … smart farm kind of extension days in your region. So some farms open up for farmers to come and see different applications and different businesses trialling their tech in a particular property …'*
Support with technology set-up	*DI1: 'I had the guys come out and set it up so that, so that it would do that in straight lines.'* *DI3: 'So, we've employed on our farm, an engineer … . And he's able to implement that tech really easily.'*
Support with repair	*DI5: 'If something breaks down, you can ring up and say, look, I've got this problem, and they say this is what fixes it and that sort of stuff.'* *DI11: 'So we prefer the machines for the reasons I said before, for the proximity of the dealer, the service they provide for us, that's a priority.'*
Support with data management	*DI12: 'I suppose go to your agronomist, they are the ones that have actually got to interpret it at the end of the day, and they know my situation.'* *DI5: 'We had 10 years of yield maps over various seasons and we sat down with our agronomist at the time and he got a guy who made the business of it.'*
Topical discussions	*E1: It's really important to have that and technically to discuss through that and decide, on a personal or social level, what are we willing to accept in terms of giving up data about ourselves in our businesses?'* *ADI2: 'It certainly helped to get sucked into this and certainly knowing that I can chat to other people. This has been quite important as well.'*

Appendix S: Ethics approval letter

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Notice of Approval

Date:	14 December 2018	
Project Number:	21840	
Project Title:	*Organizational Readiness for Digital Innovation*	
Risk Classification:	Low Risk	
Chief Investigator: **Student Investigator:** **Other Investigators:**	Professor Anne-Laure Mention Monika Streuer Dr Gerrit De Waal	
Project Approved:	**From: 14 December 2018**	**To: 3 December 2021**

Responsibilities of the Principal Investigator
It is the responsibility of the principal investigator to ensure that all other investigators and staff on a project are aware of the terms of approval and to ensure that the project is conducted as approved by BCHEAN. Approval is only valid while the investigator holds a position at RMIT University.

1. *Amendments*
   Approval must be sought from BCHEAN to amend any aspect of a project including approved documents. To apply for an amendment submit a request for amendment form to the BCHEAN secretary. This form is available on the Human Research Ethics Committee (HREC) website. Amendments must not be implemented without first gaining approval from BCHEAN.
2. *Adverse Events*
   You should notify BCHEAN immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
3. *Participant Information and Consent Form (PICF)*
   The PICF must be distributed to all research participants, where relevant, and the consent form is to be retained and stored by the investigator. The PICF must contain the RMIT University logo and a complaints clause including the above project number.
4. *Annual Reports*
   Continued approval of this project is dependent on the submission of an annual report.
5. *Final Report*
   A final report must be provided at the conclusion of the project. BCHEAN must be notified if the project is discontinued before the expected date of completion.
6. *Monitoring*
   Projects may be subject to an audit or any other form of monitoring by BCHEAN at any time.
7. *Retention and Storage of Data*
   The investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

Regards,

Appendix T: Publications

Streuer, M. McMurray A., Karanasios, S. 2020. What does it take to innovate with digital technologies? In Proceedings of Euram Conference: Dublin, Ireland, 4-6 December, 2020.