From Surviving to Thriving: A Social Systems Approach to Industry 4.0 and Future of Work Preparedness

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Glossary

Capability - The ability or competence to perform a specific task or function.

Cyber-physical Systems - A type of system that integrates physical and computational components to perform a specific function.

Employee/worker - An individual whom a company or organisation employs in exchange for compensation.

Future of work - Refers to the changing nature of work, including the impact of technology, globalisation, and other factors on the types of jobs and skills that will be in demand in the future.

ICT - Information and Communications Technology, a term used to describe the technologies used to create, store, process, and exchange information and communications.

Industry 4.0 - The fourth industrial revolution, characterised by the integration of advanced technologies such as the Internet of Things and artificial intelligence into manufacturing and other industries.

Internet of Things (IoT) - The interconnected network of physical devices, vehicles, buildings, and other objects embedded with sensors, software, and network connectivity, allowing them to collect and exchange data.

Job-Demands Resources Model - A model that explains how the demands of a job (e.g., workload, time pressure) and the resources available to an employee (e.g., autonomy, support) impact well-being and job performance.

Organisational culture - The shared values, beliefs, behaviours, and customs that characterise an organisation and influence the attitudes and behaviours of its members.

Psychosocial Safety Climate - The shared perception of policies, procedures and practices in place for the protection of workers' psychological health and safety.

Safety climate (organisational) - The current state of safety in an organisation, including policies, practices and conditions that impact employee safety, representing the current state of safety.

Safety culture (organisational) - The shared values, beliefs, attitudes and norms that shape employee behaviour towards prioritising safety in the workplace, representing an organisation's long-term beliefs and values towards safety.

Skill - A learned ability to perform a specific task or function effectively.

Social Systems - A system that involves human interaction and relationships, such as organisations, communities, and societies.

Social Systems Factors: Refers to the elements and structures within an organisation that influence and shape employee behaviour and interactions, including organisational culture and values, policies and procedures, leadership styles, and power dynamics among employees. Understanding these factors is crucial for creating a positive organisational culture and addressing workplace challenges.

Soft skills - Personal attributes and interpersonal skills that facilitate effective interaction with others, such as communication, teamwork, and leadership.

Society 5.0 - A term used to describe a future society that integrates advanced technologies, such as artificial intelligence and the Internet of Things, with human values to create a more sustainable and harmonious future.

Socio-Technical Systems - A system that integrates technical and social components to perform a specific function, such as organisations, communities, and societies.

T-shaped - A term used to describe individuals with a broad range of skills and knowledge; but also have deep expertise in a specific area.

Technical Systems - A system designed to perform a specific function, such as machines, computer systems, and technical infrastructure.

Summary of the Thesis

The rapidly increasing digitalisation of society has led to the introduction and implementation of Industry 4.0, having enormous impacts on industries, economies, and governments across the globe for the future of work (Büchi et al., 2020; Dalenogare et al., 2018). Organisations recognise the tremendous benefits of adopting Industry 4.0 technologies and are investing heavily in digital maturity and technological capabilities to stay competitive (Dalenogare et al., 2018; Dalmarco et al., 2019; Frank et al., 2019). Subsequently, the role of individual organisations is to holistically understand the needs of the future to develop robust business models that will increase their preparedness for implementing Industry 4.0 technologies.

Unfortunately, a critical aspect often overlooked in this pursuit of digitalisation is the consideration of human-centric social systems factors essential to prepare for the future of work. Therefore, it is imperative for researchers to understand the impact of social systems factors such as organisational culture, employee attitudes, and capabilities on preparedness for the future of work. From a 'social systems' perspective, organisations need to create a culture conducive to Industry 4.0 technology implementation and have a capable workforce that can prosper in the future of work. The increased need for human-centric preparedness elicits an important question; How can organisations holistically prepare themselves to sustain and thrive in the future of work? To answer this question, this thesis considers three specific gaps in knowledge and addresses them through empirical research. The gaps identified are as follows:

1. There is a lack of knowledge on the impact of social systems factors on industry 4.0 readiness for Industry 4.0. This gap is addressed by establishing a clear pathway (using responses from 192 business decision-makers) to explain the interaction of the identified social systems factors with preparedness for Industry 4.0.

2. There is a lack of knowledge on the impact of social systems factors on organisations' financial growth. This gap is addressed using the data linkage principles, and the findings revealed a lack of a direct financial relationship. The thesis also addresses how organisations can leverage this information to increase their preparedness for the future of work.

3. There is a lack of knowledge on the impact of organisational culture on enhancing the positive and mitigating the negative experiences of integrating Industry 4.0 technologies to prepare for the future of work. This gap is addressed through qualitative interviews with 16 industry leaders who shared their insights and perspectives on Future of Work preparedness.

The findings suggest that organisational culture is the most crucial factor to consider when preparing for the future of work.

The thesis culminates in a synthesis and summary of the research findings, highlighting the novel contributions made to advance the understanding of preparedness for the future of work and the implications these findings have for future research. Additionally, the appendices include two book chapters co-authored by the author of this thesis, demonstrating a continued commitment to increasing understanding and preparedness for Industry 4.0 and the future of work paradigm shift. The overall outcome of this thesis is a comprehensive understanding of the future of work preparedness using a social systems lens. With wide-ranging theoretical and practical contributions, this body of research exemplifies that the human element remains essential in the face of increasing digitalisation, and as such, a people-focused approach is crucial to success in the future of work. The findings of this study have important implications for researchers, policymakers, educators, and business leaders as they seek to prepare for and navigate the challenges of the future of work.

Declaration

This thesis presents work carried out by me and does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any university; to the best of my knowledge, it does not contain any materials previously published or written by another person except where due reference is made in the text; and all substantive contributions by others to the work presented, including jointly authored publications, are clearly acknowledged.



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Quotation

"Technology is nothing. What's important is that you have faith in people, that they're basically good and smart, and if you give them tools, they'll do wonderful things with them."

– Steve Jobs.

CHAPTER 1: Introduction

1.1 Research Background and Motivation

Steve Jobs, Bill Gates, Neil Gunther, Katalin Karikó, Elon Musk and Jeff Bezos are all recognised as some of the most notable contemporary tech leaders who have revolutionised the technology industry and are listed as the most influential people in the world (Forbes, 2020). They have pioneered many significant inventions and shaped how the world operates today by harnessing the power of technology (Gradinaru et al., 2020; Rimmer, 2018). In order to learn from their entrepreneurial and paradigm-shifting work, it is imperative to pay attention to their commonalities. Without much reflection, it is apparent that these individuals have made ground-breaking discoveries because of their willingness to take risks, their affinity for technology, and their capacity for innovation (Acs & Sany, 2009; Gallo, 2011; Rimmer, 2018). However, the fact that they worked in a conducive environment and had the luxury of time and money to devote to creative endeavours are some of the most crucial factors that empowered them to be entrepreneurial. Without these pioneers, the way the world would have appeared and functioned might have been very different. Consider a future with many visionaries just like Steve Jobs and Elon Musk, each with the power to change the course of history. Fortunately, owing to Industry 4.0, this reality is attainable with effort and preparation.

Also known as the Fourth Industrial Revolution, Industry 4.0 is a specific case of automation of systems due to increased digitalisation (Nagy et al., 2018; Schumacher et al., 2016; Xing et al., 2021). With the Internet of Things (IoT), Artificial Intelligence (AI), robotics and Cyber-Physical Systems (CPS) as its central pillars, Industry 4.0 continues to prove to be a drastic and important paradigm shift with a sweeping impact on people's daily lives (Cooper & James, 2009; Cropley & Cropley, 2021; Kamble et al., 2018; Kovacs, 2018; Sarfraz et al., 2021; Schumacher et al., 2016; Szabó-Szentgróti et al., 2021). In the context of the future of work, Industry 4.0 will result in interconnected systems where humans and machines work together to accomplish shared objectives, exploring the vast possibilities enabled by technological advancements. Robots and AI will continue to perform manual or repetitive jobs in Industry 4.0, permitting employees to become more involved in creative pursuits, undertake work that requires higher-order elements of human cognition and enrich their work in meaningful ways (Kadir & Broberg, 2021; Oppert et al., 2022). As a result, organisations can foster an environment for their employees that encourages them to take risks, be creative, solve complex problems, and become pioneers (much like the technology leaders mentioned in the previous paragraph) by adopting a human-centred approach and placing a strong emphasis on social systems factors (Jantunen et al., 2005).

Nevertheless, it is also important to remember that these developments in Industry 4.0 technologies are not free of unintended consequences for their users, humans. Even though firms have been attempting to

automate work for many years, people's fear of losing their jobs or replacing them with automation is steadily rising (Kessler, 2018). It is imperative that the implications of greater digitalisation are understood and that employees are prepared for the future of work in order to mitigate the unintended consequences of increased automation (Fernández-Macías, 2018). The crucial role humans/employees play in enabling the design and efficient operation of automated systems is frequently overlooked due to the fear of job displacement. Furthermore, the level of human preparedness required to integrate such technologies successfully is also underestimated. As a result, many organisations investing in and implementing Industry 4.0 technologies frequently struggle to train and upskill their personnel to incorporate the technologies into existing systems (Sony & Naik, 2020; Vrchota et al., 2019).

In today's world of limitless possibilities in technological developments alongside the fear of job displacements, it is pivotal to ask an important question, 'How can organisations employ a social systems approach to better prepare their employees for the future of work, especially with the digital change brought on by Industry 4.0?'. It is proposed that using a human-centric and social systems lens to view this issue may help uncover the answer to this question.

1.2 Preparedness for Industry 4.0

Industry 4.0, also known as the 'Fourth Industrial Revolution', refers to the automation of systems due to increased digitalisation (Nagy et al., 2018; Schumacher et al., 2016; Xing et al., 2021). The German government launched Industry 4.0 in 2011 to advance German manufacturing through the digitalisation and interconnection of products, value chains and business models (Schumacher et al., 2016). From a political standpoint, the German government launched this initiative to position Germany as a world leader in automated and digitalised manufacturing. Furthermore, Germany wanted to differentiate itself from countries with cheaper labour by providing more sophisticated and high-quality goods using digital manufacturing (Brettel et al., 2014; Sommer, 2015). Interestingly, the operationalisation of the concept has evolved and Industry 4.0 is now understood as the next step or a new industrial stage in which there is an integration between manufacturing, operations systems and Information and Communication Technologies (ICT) (Dalenogare et al., 2018). As a result of this interconnection, products, machines and processes can be equipped with artificial intelligence that adapts to spontaneous changes in the environment independently and makes data-driven decisions (Hecklau et al., 2016).

Industry 4.0 represents a shift towards an innovation-based economy with knowledge, data, Artificial Intelligence (AI) and the Internet of Things (IoT) as its central pillars (Morrar et al., 2017). An economy built on innovation means that there will be more focus on finding new solutions to issues rather than simply improving the speed or cost of production. Along with advances in automation and ICT, Industry 4.0 has created new opportunities enabling companies to offer unique, tailored and data-driven solutions to their

customers (Büchi et al., 2020; Dalenogare et al., 2018). As a result, many industrial leaders forecast that Industry 4.0 will deliver unprecedented growth and productivity over the next few years (Gilchrist, 2016). However, an improved understanding of transitioning to Industry 4.0 is necessary to reap the benefits of an innovation-based economy, including enhanced productivity.

The main feature of Industry 4.0 in the way it is currently understood is the use of heterogeneous data (also known as Big Data) and knowledge integration to produce Cyber-Physical Systems (CPS) (Sony & Naik, 2019). Industry 4.0 involves connecting and integrating the virtual and physical worlds through CPS and IoT, utilising intelligent objects that continually interact with each other with minimal human input. The Daily Mail Australia featured an excellent real-world example of Industry 4.0 techniques, describing how a London grocery business utilises robots to track, sort and deliver customers' online food orders (Chadwick, 2022). While machines replace laborious tasks, it enables employees to focus on important 'human' functions such as problem-solving and decision-making to ensure the smooth functioning of this store. The operation of the store exemplifies human-machine interactions and the use of data analytics to monitor automated systems and equipment, predict when a repair is necessary and avoid significant delays that can take production offline. Even though Industry 4.0 is the integration of new technologies and enhanced digitalisation that enables the mass customisation of products, processes, and services, it is crucial to remember that people still play a significant role in this interaction when considering real-world examples like the one provided (Kamble et al., 2018). Due to the fear of job displacement, what often gets overlooked is the essential role humans play in enabling the design and smooth functioning of automated systems and the level of human preparedness required to integrate such technologies successfully. It is evident that the future of work is propelling organisations into work that involves the integration of humans with automation, artificial intelligence and cyber-physical systems (Oppert et al., 2022; Schwartz et al., 2019). While the technical aspects of Industry 4.0 are now well understood and well researched, there is a need for further research to address how this technological advancement will impact the 'human' side of the future of work and enable the successful integration of technical systems with existing social systems in the current work context.

Despite the steadily rising popularity of Industry 4.0 technologies, many organisations are unprepared for and have delayed deploying these technologies. These businesses are either still preparing for the transition or are not at the desired level of Industry 4.0 maturity (Hamada, 2019). On a practical level, there is a need for a deeper understanding of Industry 4.0 and, subsequently for upskilling employees to meet future demands. Additionally, while it is indeed necessary to keep up with technological advancements to stay competitive, organisations must also learn how to prepare their employees for the journey of technological advancement. At the same time, it is equally essential to increase theoretical understanding and the relevance of preparing for Industry 4.0 to increase knowledge of how preparing employees for Industry 4.0

can provide organisations with a competitive edge and improve organisational performance (Büchi et al., 2020). While existing literature has been focusing on firms' awareness of Industry 4.0 and the enabling technologies that facilitate its implementation, very little is known about the social aspects of readiness for Industry 4.0 that could potentially assist organisations to be prepared for this future. In recent literature, Industry 4.0 is described as a complex multidimensional integration of technical and social systems (Sony & Naik, 2020). Thus, by identifying and exploring important factors necessary for this development from a social systems perspective, further research can enable these organisations to transition into the fourth industrial revolution and be better prepared for the future of work (Ainsworth & Knox, 2022; Singhal, 2021).

1.3 Humans in the Future of Work and Industry 4.0

A literature review by Szabó-Szentgróti et al. (2021) emphasises how Industry 4.0 is dramatically changing how organisations operate and move towards the future of work. The increased digitalisation and automation giving rise to the technological transformation is one of the most critical labour market topics and will be a strong catalyst in shaping and bringing about drastic changes in the future of work (Büchi et al., 2020; Gilchrist, 2016; Kamble et al., 2018; Kovacs, 2018; Sony & Naik, 2019). The phrase 'Future of Work' (FoW) refers to an overarching idea that explains how work will be done in the future, especially in light of the growth in digitalisation and automation (Berg et al., 2018; Manyika, 2017). Industry 4.0 is one example of this trend, specifically focusing on digital manufacturing. Therefore, the increase in the use of robotics, digitalisation and the use of CPS (as a result of Industry 4.0) has evoked the interest of many researchers and has led to the analysis of the impact of Industry 4.0 on the workforce and FoW (Szabó-Szentgróti et al., 2021). From a human resource and 'workforce planning' perspective, it is essential to explore and prepare for the significant employment changes resulting from the fourth industrial revolution and find efficient solutions that address the needs of the future of work (Fukuda, 2020; Szabó-Szentgróti et al., 2021). On an organisational level, leaders need to increase their Industry 4.0 preparedness and maturity to equip themselves with both technology and human skills and resources to maintain a competitive advantage in the future of work (Dalenogare et al., 2018).

Alongside the research that has started looking at the future of work for effective workforce planning, the threats to the health and safety of workers propagated as a result of the advancement of Industry 4.0 are also getting increasing attention (Potter et al., 2022). For many years, researchers have discussed the detrimental effects of the rise in digitalisation and the increased use of technologies on worker health (Diaz et al., 2012; Potter et al., 2022). It is evident that Industry 4.0 will influence the future of work by compelling employees to increasingly undertake work that requires higher-order elements of human cognition as AI and automation (are being designed to) assume more manual/repetitive tasks (Kadir & Broberg, 2021; Oppert et al., 2022). As robots continue to undertake unsafe or menial tasks, it will allow workers to become more involved in creative pursuits and enrich their work in meaningful ways. However,

increasing human-machine interactions, along with the increase in cognitive work, will expose employees to both physical (e.g., new work design with automated tools) and psychological health (e.g., new types of psychosocial hazards) risks (Kadir & Broberg, 2021; Leso et al., 2018). Due to the rate of growth with which society is advancing in Industry 4.0 and tackling health and safety threats, researchers must broaden their scope beyond the technical overview of Industry 4.0 and begin to include the social/human elements as well (Leso et al., 2018; Potter et al., 2022; Sony & Naik, 2020). To address the unique health and safety concerns arising from Industry 4.0, researchers and practitioners should focus on improving work design that allows for improved 'worker wellbeing' and as discussed above, take a human-centred approach to solve Industry 4.0 readiness issues (Potter et al., 2022)

1.4 The Human-centric Approach towards Industry 4.0 Preparedness

The upsurge in digitalisation and integrated cyber-physical systems at work enables new forms of interaction between humans and machines, changing how organisations function and employees work (Kadir & Broberg, 2021). Consequently, there is an increase in issues such as increased work demands, increased cognitive load, frustration with the uncertainty of work and risk of unemployment (Kadir & Broberg, 2021; Potter et al., 2022). These issues require immediate deliberation and further research to avoid impeding the smooth transition into Industry 4.0. To overcome these concerns, several publications and industry reports point to the importance of implementing human-centric design principles and ensuring employee well-being as a key priority for organisations to successfully implement Industry 4.0 technologies (Pacaux-Lemoine et al., 2017; Kyriacou, 2020; Sgarbossa et al., 2020; Sony & Naik, 2020). In their work, Kadir and Broberg (2021) also highlight a research gap where there is a clear need for more research focusing on the human-centric principles of Industry 4.0 implementation. Additionally, a recent publication by the International Ergonomics Association (IEA) and International Labour Organization (ILO) highlighted the increase in digitalisation and the growing need for integration of 'Human Factors Principles' into the design and management of work systems as well (ILO & IEA, 2021). Indeed, the impact of the fourth industrial revolution on humans will be widespread; therefore, it is pivotal to investigate the social systems factors relevant to Industry 4.0 preparedness to create efficient cyber-physical systems that are able to meet the demands of the future of work.

1.5 Why is this Research Important?

As organisations transition into the Future of Work and, more specifically, Industry 4.0, there is a continual increase in digitalisation at work with significant impacts on the economy and ways of working. Recognised as one of the megatrends shaping the future of work by PricewaterhouseCoopers and CSIRO, 'technological breakthroughs' and increased automation are evolving quickly, dramatically changing the nature and number of jobs available (Brown et al., 2017; Hajkowicz et al., 2016). However, if organisations are not

actively preparing employees for the future of work, technological breakthroughs also cause social discontent, political upheaval, and significant job displacements (Brown et al., 2017; Kovacs,2018). Understanding and leveraging these technologies in optimising employee performance can help mitigate the disruption caused by increased digitalisation and enable a better preparedness for the future of work.

The common opinion and widespread apprehension about technology suggest that the need for workers will decline as automation increases. However, based on current literature and anecdotal evidence, it is evident that while the nature of work may change, humans will still be central to the functioning and operations of organisations. It is indeed apparent that Industry 4.0 technologies will indefinitely change the kind of work humans engage in, resulting in a more significant interaction between humans and various technical and social systems (Sony & Naik, 2020). Kovacs (2018) explains how technology, digitalisation and artificial intelligence are intertwined with social relations. Not considering the social impact of increased digitalisation can be detrimental and a missed opportunity for organisations trying to prepare themselves for the future of work. Despite the projected increase in human-machine interactions, little attention has been paid to the social systems facets of readiness for Industry 4.0, such as culture, mindsets and capacity of the individuals in organisations that could potentially assist with better preparedness for the future. Therefore, it is essential to understand the elements of this integration, consider both social and technical aspects, and then integrate the social elements to better prepare for the future of work (Sony & Naik, 2020; Szabó-Szentgróti et al., 2021). This thesis furthers understanding the transition to Industry 4.0 through a social systems lens using organisational psychology principles and perspectives. From a practical standpoint, this improved understanding will assist organisations in determining their priorities as they prepare for Industry 4.0 and the future of work.

1.6 Current Gaps in Knowledge

By taking a more holistic approach and viewing Industry 4.0 through a social systems lens, this thesis addresses three key gaps in knowledge regarding advancement in Industry 4.0. The current literature clearly points to the need to understand Industry 4.0 as a socio-technical system that requires deliberation and forethought on both aspects when preparing for the future of work (Sony & Naik, 2019, 2020). While a vast body of research focuses on the integration of technology and technological systems as a key aspect of preparing for Industry 4.0, there is limited research examining the impact of this integration on humans and what steps organisations can undertake on a macro level to prepare their systems and workforce for the future of work. This is the first gap identified that the research in this thesis addresses. Secondly, while a vast body of literature points to the advantages of implementing Industry 4.0 technologies, it is unclear if a linear relationship exists between preparedness for Industry 4.0 and financial growth (Belazreg & Mtar, 2020; Dalenogare et al., 2018; Izadi Z.D et al., 2020). Therefore, the second gap this thesis addresses is

examining the impact of social systems factors on financial growth and establishing a relationship between Industry 4.0 preparedness and monetary growth. Lastly, it is evident in the current literature that the importance of organisational culture for organisational growth is often overlooked and undervalued (Durana et al., 2019; Odor, 2018). In the context of Industry 4.0, many existing studies also point to the possibility of better preparedness through enhanced organisational cultures and suggest further exploration of the cultural elements (Belias & Koustelios, 2014; Cropley & Cropley, 2017; Durana et al., 2019; Martínez-Caro et al., 2020). To close this knowledge gap and improve readiness for Industry 4.0, this thesis looks at how organisational culture and its social components can improve and mitigate the impacts of integrating technologies.

To reiterate, the key gaps being addressed in this thesis are as follows:

Gap 1 There is a lack of knowledge on the impact of social systems factors on industry 4.0 readiness.

Gap 2: There is a lack of knowledge on the impact of social systems factors and preparedness for Industry 4.0 on organisations' financial growth.

Gap 3: There is a lack of knowledge on the impact of organisational culture on enhancing the positive and mitigating the negative experiences of integrating Industry 4.0 technologies to prepare for the future of work.

This thesis addresses these gaps by taking a human-centred approach to preparedness for Industry 4.0. Alongside attempting to understand the monetary benefits of preparedness for Industry 4.0, this thesis also investigates the impact of social systems factors and organisational culture on readiness for Industry 4.0.

1.7 Aims and Research Questions

Using a human-centred approach, this thesis advances the understanding of how technological systems can be integrated into workplaces by focusing on specific social systems factors. This dissertation aims to answer the question: 'How can organisations employ a social systems approach to better prepare for the future of work, especially with the digital change brought on by Industry 4.0? '. To achieve this aim, this thesis considers three specific knowledge gaps and utilises empirical research to address them. The research questions being answered in the three studies are as follows:

1. Is there a clear pathway that can explain the impact of the identified social systems factors on preparedness for Industry 4.0? This research question is addressed in the first study.
2. How does social systems preparedness for Industry 4.0 impact the subsequent financial performance of organisations? This question is answered in the second study. This question is answered in the second study.

3. How might organisational culture and its social elements affect the way technical systems are integrated and improve readiness for the future of work? This question is answered in the third study.

1.8 Research Methodology

1.8.1 Ontology, Epistemology and methodology

1.8.1.1 Ontology In this research, the ontological stance adopted reflects a nuanced perspective that acknowledges both the objective and subjective dimensions of reality, drawing inspiration from the theories of Society 5.0, socio-technical theory and the PSC Model (using Job-demands and resources principles). Ontology, in the context of philosophy, pertains to the study of the nature of reality and what exists (Fleetwood, 2005). This research recognises that the impact of Industry 4.0, as a significant industrial change, constitutes an objective and measurable phenomenon that can be studied independently of human perceptions, aligning with a realist ontology. Realism ontology, within the realm of philosophy, emphasises the existence of objective realities that exist independently of human cognition (Wiltshire & Ronkainen, 2021). The JDR model, with its emphasis on objective relationships between job demands and resources and their impact on outcomes, exemplifies this perspective.

Simultaneously, the research also places a strong emphasis on the role of human perceptions, attitudes, and experiences in shaping the impact of Industry 4.0, resonating with a constructivist or interpretive ontology. Constructivism, in the philosophical sense, is concerned with how individuals construct meaning and understanding based on their experiences and interpretations (Kaminski, 2019). This blended ontological stance, which combines elements of realism and constructivism, is informed by socio-technical theory that explores the interaction between technological systems and social structures (Tcytcarev et al., 2019). It aims to provide a holistic understanding of the complex interplay between technological change and human responses, bridging the gap between objective realities and subjective interpretations.

1.8.1.2 Epistemology The epistemological stance employed in this research is characterised by its pragmatic and mixed-methods approach. Pragmatism, in the context of epistemology, is defined by its emphasis on the practical consequences and utility of beliefs and research methods (Kelly & Cordeiro, 2020). The study values both empirical data and subjective insights, recognising the practical utility of different research methods in addressing specific research questions (Mertens et al., 2016). Quantitative methods, including surveys comprising subjective scales and data linkage for financial data, were used to establish empirical relationships, measure variables, and draw generalisable conclusions based on observable data. These methods align with a positivist or empiricist epistemological stance, emphasising the importance of empirical evidence and objective facts (Ryan, 2006). In parallel, qualitative methods, such as hour-long interviews, were employed to gain a deep understanding of subjective experiences, meanings,

and perspectives related to the impact of Industry 4.0 and future of work preparedness. These qualitative insights reflect an interpretive epistemological stance, which values the richness of individual narratives and the influence of human subjectivity on research outcomes (Hiller, 2016). By embracing this pragmatic and mixed-methods epistemological stance, the research aims to provide a comprehensive and practical understanding of the research problem, leveraging the strengths of both quantitative and qualitative approaches.

1.8.1.3 Justification for the chosen methodology The decision to employ a mixed-methods approach for this thesis, integrating both qualitative and quantitative methodologies, is founded on several key considerations that collectively enhance the rigour and comprehensiveness of this research. Firstly, the multifaceted nature of the research questions, centred around Industry 4.0 readiness and organisational dynamics, necessitates a holistic exploration that goes beyond the limitations of a singular method (Stentoft et al., 2020). As supported by prior research, this approach recognises the necessity of combining quantitative rigour with qualitative insights to address the complexity of contemporary topics (Pham et al., 2018; Harrison et al., 2019; Dawadi et al., 2021). Moreover, the integration of both qualitative and quantitative data serves to triangulate findings, thereby enhancing the credibility, validity, and trustworthiness of research outcomes. While quantitative methodologies can aid in establishing causal relationships and testing hypotheses, qualitative methods provide the depth and context required to capture intricate nuances and participants' experiences and perceptions (Harrison et al., 2020). In addition to these considerations, the choice of a mixed-methods approach aligns with the pragmatic perspective, emphasising the selection of methods best suited to the research objectives, irrespective of strict philosophical paradigms (Tashakkori & Teddlie, 2021). This approach recognises mixed methods as a flexible and adaptive conceptual framework for comprehensive research.

Furthermore, it is essential to contextualise this methodological choice within the theoretical frameworks of this research. Industry 4.0, as posited by Sony and Naik (2020), can be understood as a socio-technical system. This perspective emphasises that comprehending Industry 4.0 requires both social and technical lenses to be comprehensively understood. Therefore, methodologically assessing Industry 4.0 as a socio-technical system aligns with the theoretical underpinnings of this study. By employing mixed methods, this research can investigate the social and technical aspects of Industry 4.0, thereby providing a more holistic understanding of the phenomenon under study.

In light of these methodological considerations and the robust precedents set by prior research (Pham et al., 2018; Stentoft et al., 2020; Harrison et al., 2019; Dawadi et al., 2021), the mixed-methods approach was not only deemed most appropriate but imperative to address the intricate research questions comprehensively. It offers the means to achieve a profound understanding of the multifaceted phenomena

under investigation (Industry 4.0 preparedness) and significantly enhances the rigour and comprehensiveness of this research.

1.8.2 Research Design

Study 1 employs a cross-sectional quantitative methodology, with path analysis used to address the first gap and test eight hypotheses. Study 2 uses data linkage and existing databases to extract financial growth information linked to the data collected in Study 1. This study addresses the second gap identified and tests six hypotheses. Finally, Study 3 is an exploratory qualitative study that uses inductive and deductive approaches to address the third gap identified. The subsections 1.8.3, 1.8.4, and 1.8.5 below list the specific hypotheses investigated in Studies 1 and 2 and the questions presented in Study 3. Subsequently in subsections 1.8.6 and 1.8.6.1, a justification for the employed scales is presented, accompanied by an explanation of the chronological sequence in which these scales were administered to the study participants.

1.8.3 Study One: Cross-sectional Quantitative Path Analysis with Business Decision Makers

In order to respond to the first research question listed in Section 1.7, this study tests eight distinct hypotheses (see Chapter 3 for the complete study):

- **Hypothesis 1** A high Psychosocial Safety Climate (PSC) will lead to better preparedness for Industry 4.0.
- **Hypothesis 2** A high innovation capacity will lead to organisations being better prepared for Industry 4.0.
- **Hypothesis 3** A high PSC will be a precursor for a higher innovative capacity.
- **Hypothesis 4** Innovation capacity mediates the relationship between PSC and Readiness for Industry 4.0.
- **Hypothesis 5** More positive attitude towards organisational change will lead to a higher capacity to innovate.
- **Hypothesis 6** More positive attitude towards organisational change will lead to better preparedness for Industry 4.0
- **Hypothesis 7** A high PSC will lead to a better attitude towards organisational change.
- **Hypothesis 8** Attitude towards organisational change will mediate the relationship between PSC and Readiness for Industry 4.0.

1.8.4 Study Two: Data Linkage using Databases and Pre-existing Data from Study 1

In order to respond to the second research question listed in Section 1.7, this study tests six distinct hypotheses (see Chapter 4 for the complete study):

- **Hypothesis 1** A high level of business and skills preparedness for Industry 4.0 will lead to higher financial growth in organisations.
- **Hypothesis 2** High innovation capacity will lead to higher financial growth in organisations.
- **Hypothesis 3** More positive attitudes towards organisational change will lead to higher financial growth in organisations.
- **Hypothesis 4** A high Psychosocial Safety Climate will lead to higher financial growth in organisations.
- **Hypothesis 5** After controlling for the effect of preparedness for Industry 4.0, high Innovation Capacity and positive Attitudes towards Organisational Change will still lead to higher financial growth in organisations.
- **Hypothesis 6** After controlling for the effect of preparedness for Industry 4.0, Innovation Capacity and Attitudes towards organisational change, a high PSC will still lead to higher financial growth in organisations.

1.8.5 Study Three: Qualitative Interviews with Industry Leaders

This study was designed to gather insights from leaders on their perception of their organisation's current state of preparedness and their opinions on what needs to happen to increase readiness for the future of work. To answer the third research question listed in Section 1.7, ten semi-structured interview questions were answered by each participant (see Appendix H for the complete interview protocol and see Chapter 5 for the complete study). The intent behind each question is listed below:

1. The first question measured general knowledge of "Industry 4.0."

2. Participants' views on the shift to Industry 4.0 and enhanced digitalisation were evaluated in the second question.

3. Opinions on how COVID-19 has altered perceptions about the future of work were the subject of the third question.

4. The fourth question generally evaluated participants' thoughts on the specific skills required for Industry 4.0.

5. Participants were questioned on their overall views of the specific business strategies required for Industry 4.0 in the fifth question (in a future of work context).

6. The sixth question measured if organisations become more innovative due to their Industry 4.0 preparedness.

7. Participants' general perceptions of the particular mindsets and attitudes required for Industry 4.0 were assessed in the seventh question.

8. The eighth question asked participants for their general perspectives on safeguarding their workers' psychological well-being at work.

9. The ninth question sought participants' opinions on how Industry 4.0 and the future of work would impact their jobs.

10. The final question was open-ended to allow participants to talk about anything they felt was essential to Industry 4.0 but wasn't covered in the interviews.

1.8.5 Measures

The selection of scales and measures for this research is underpinned by a thorough rationale that aligns with the research objectives and theoretical framework. Given the growing demands and the lack of evidence regarding the impacts of Industry 4.0 demands on psychosocial safety, it becomes imperative to employ the PSC-12 scale (Molino et al., 2020; Neumann et al., 2021). The utilisation of the PSC-12 scale to measure Psychosocial Safety Climate (PSC) is substantiated by its well-documented validity and reliability, as corroborated by previous research (Hall et al., 2010). PSC, a pivotal construct in comprehending the psychological well-being and safety of employees, is of paramount relevance within the scope of Industry 4.0 readiness. The PSC-12 comprehensively assesses key dimensions of PSC, encompassing management commitment, management prioritisation, organisational communication and organisational participation, thereby affording an important insight into the workplace safety climate.

Furthermore, the selection of the Innovation Phase Assessment Instrument (IPAI) to gauge Innovation Capacity aligns with the multifaceted nature of the research questions related to Industry 4.0 readiness. The IPAI, renowned for its robustness, assesses diverse facets of innovation, encompassing the organisational environment, attitudes, and innovation processes. These elements are indispensable in organisations' adaptation to Industry 4.0, and the IPAI's established reliability and validity bolster its suitability for conducting a nuanced exploration of innovation within the research context (Cropley et al., 2013).

In addition, the adoption of the Organisational Change Questionnaire-Change, Processes, and Readiness (OCQ-C, P, R) to gauge Attitude towards Organisational Change is justified by its extensive application in prior research (Bouckenooghe et al., 2009) and its congruence with the research's focal point on

organisational dynamics in the context of Industry 4.0 preparedness. This scale provides a comprehensive evaluation of participants' attitudes and preparedness for change, which assumes particular significance when considering the transformative influence of Industry 4.0.

Lastly, the questionnaire devised for evaluating Readiness for Industry 4.0 is rooted in the Australian context and harmonises effectively with the theoretical framework underpinning this study, which views Industry 4.0 as a socio-technical system. This questionnaire comprehensively captures critical dimensions of readiness, notably business and skills readiness, which bear direct relevance to the research questions (Xing et al., 2021). Moreover, the incorporation of data linkage to access organisational growth data from DatAnalyses Premium and Company 360 enhances the quantitative analysis by providing objective indicators of financial growth intrinsically tied to the data collected.

In conclusion, the chosen scales and measures were deliberately selected to conform to the research objectives, theoretical framework, and the intricate nature of the research questions. Their established validity and reliability, coupled with their alignment with the research context, render them apt instruments for assessing the pivotal constructs linked to Industry 4.0 readiness and organisational dynamics. This methodological approach ensures a comprehensive and rigorous examination of the research questions, thereby elevating the overall quality of the research.

1.8.5.1 Temporal order of scales For Study 1 and 2, the survey instruments were administered in a specific order: Demographics, Psychosocial Safety Climate (PSC), Attitudes towards Organisational Change, Innovation Capacity, and Business and Skills Readiness for Industry 4.0. This sequence was intentionally chosen to mirror the order of variables in the path analysis model utilised in Study 1, ensuring a logical progression. While the literature presents varying opinions regarding the order of scale presentation in surveys, this approach follows a systematic sequence that reflects the hypothesised causal relationships between these constructs (Manski & Molinari, 2008). Commencing with demographic information allowed for the establishment of participant context before delving into psychosocial factors, attitudes, and ultimately, readiness for Industry 4.0. This sequential arrangement safeguards against the potential influence of participants' responses to earlier questions on their perceptions of subsequent constructs, thereby preserving the model's validity (Rattray & Jones, 2007). Furthermore, this order corresponds to the conceptual flow of the research, facilitating a coherent understanding of the factors contributing to Industry 4.0 readiness.

Moreover, to ensure participants had a clear understanding of the nature of questions related to Industry 4.0, a comprehensive definition of Industry 4.0 was provided to them (included in Appendix D) before encountering any questions pertaining to Industry 4.0. This pre-emptive step was taken to enhance survey

clarity and ensure that participants could provide informed responses, thereby enhancing the overall validity of the research.

1.9 Contributions of the Thesis

The three studies undertaken for this thesis contribute to increasing knowledge and understanding of preparedness for Industry 4.0 and the future of work on an organisational level. This thesis identifies and investigates the social systems factors that businesses must invest in to be prepared for the future of work. The first study examines how readiness for Industry 4.0 is affected by psychosocial safety, employee attitudes towards organisational change, and innovative capacity. By exploring possible causal pathways between social system factors and other measures of Industry 4.0 preparedness, this study laid the foundation for future research to continue demonstrating the impact of Industry 4.0 on organisations in the future of work. Finally, this study sheds light on the precise actions that managers, leaders, and organisations could take to ensure their long-term survival in a world that is becoming increasingly digitalised.

The second study examines the connection between an organisation's financial development and readiness for Industry 4.0. While a wealth of literature highlights the benefits of adopting Industry 4.0 technology, Study 2 highlights the lack of a direct link between financial growth and readiness for Industry 4.0 (Belazreg & Mtar, 2020; Dalenogare et al., 2018; Izadi Z.D et al., 2020). The lack of a direct connection is nevertheless a significant contribution since it highlights the existence of other mediating and moderating elements driving financial growth and urges practitioners to adopt a more comprehensive approach to assessing it.

In Study 3, the findings from Studies 1 and 2 are expanded upon, and the viability of implementing particular solutions to improve Industry 4.0 readiness is qualitatively assessed. In order to determine how well practitioners comprehend Industry 4.0, this study collects insights from business decision-makers. Adding to both practice and existing theoretical understanding of Industry 4.0 preparedness, this study significantly contributes to improving the social systems understanding of Industry 4.0. This study also offers organisations specific guidelines and actions to better equip themselves and their workforce for the future of work.

The results of this thesis have clear theoretical and practical ramifications that help organisations understand the competencies and resources needed from a human-centric perspective to be better prepared for the increased digitalisation of the work that will occur as Industry 4.0 develops.

1.10 Structure of the Thesis

The core components of this dissertation comprise seven chapters. It commences with Chapter 1 (the current chapter) by outlining key ideas relating to Industry 4.0, the future of work and the necessity of

approaching Industry 4.0 readiness from a social systems perspective. By presenting the main gaps in the literature, general research issues, pertinent hypotheses, expected contributions, and the structure of this thesis, Chapter 1 also illustrates the broad objectives of this thesis.

In Chapter 2, a non-structured narrative review is conducted to explore and examine current and relevant literature in the relevant fields of study, including Industry 4.0, social systems factors and the necessity of increasing employee preparedness for the future of work. The gaps in current knowledge that this thesis seeks to fill will be identified in Chapter 2 using the existing Industry 4.0 theoretical and "maturity" models and the current understanding of Industry 4.0 preparation. This chapter also covers issues related to Industry 4.0, such as the impact of COVID-19, Industry 4.0 relevant theories, and the drawbacks of increasing digitalisation.

The knowledge acquired in Chapter 2 is expanded upon in Chapter 3 by looking at the relationships between the identified social system components and Industry 4.0 readiness. A linear theoretical model (pathway) is created using data from more than 150 business decision-makers to better understand Industry 4.0 as a social construct. This chapter has a thorough "Method" and "Results" section that includes pertinent information relevant to the study, followed by a "Discussion" section that explains the results and their implications. As a result, this study provides a new perspective on integrating Industry 4.0 technologies using a social systems lens. Additionally, it informs managers on how to foster a conducive environment that enables better preparedness for the future of work. Finally, the findings of this study guide the research questions and serve as a starting point for Studies 2 and 3.

Chapter 4 addresses the second gap in the literature (see Section 1.6) and examines the relationship between financial growth Industry 4.0 readiness and social systems factors. This chapter also includes sections on "Method" and "Results" that contain pertinent information related to the study, followed by a section on "Discussion." The "Discussion" portion of this chapter examines the lack of a direct correlation between Industry 4.0 readiness and organisational growth and what this finding means for future research.

Chapter 5 builds on the information covered in chapters 3 and 4 by examining the professional judgements and insightful observations made by 16 industry thought leaders regarding organisations' readiness for Industry 4.0. This information will be used to better understand the current barriers to increased digitalisation in organisations and solutions for approaching them at macro and organisational levels. The findings show where practitioners and researchers (in the field of organisational psychology) can focus their attention to assist organisations in overcoming persistent barriers they may face in Industry 4.0. The results of this study also guide future research efforts to help organisations become further prepared for the future of work.

Chapter 6 summarises the findings from all three studies discussing critical theoretical contributions and numerous practical implications that can be drawn from this thesis. This also includes the presentation of a new model emerging from the findings and allowing for a new theorisation at understanding Industry 4.0 from a social systems perspective. Following a concise summary of the practical implications, this thesis' distinctive contributions to the literature on Industry 4.0 readiness are also highlighted.

Chapter 7 acknowledges the limitations of this thesis and suggests broad future research directions that will continue to advance the field and improve the survival and sustenance of organisations in the future of work. The final conclusions of the thesis are then presented, bringing this significant body of research to an end.

Chapter 8 comprises a comprehensive list of references used throughout the thesis and lastly, the two book chapters in appendices J and K co-authored during this PhD also show ongoing efforts to further research into the social systems component of Industry 4.0 preparedness.

CHAPTER 2: Literature Review

2.1 Introduction to the Literature Review

Industry 4.0 is a vital catalyst in bringing about drastic changes in the future of work (Büchi et al., 2020; Gilchrist, 2016). Businesses that have adapted to Industry 4.0 agree that it is conducive to positive business outcomes (Hamada, 2019). Given its continual growth and promises of profitability, it is imperative to understand how organisations can better prepare themselves for the future of work and take advantage of the opportunities that Industry 4.0 offers.

This non- structured narrative literature review explores current research relevant to organisational preparedness for Industry 4.0 and its relevance to the future of work. The review begins by discussing a brief historical background of how the fourth industrial revolution (Industry 4.0) came about, followed by the importance, relevance, and implications of Industry 4.0. The review then explores current maturity models that assess organisations' readiness levels for Industry 4.0. Using a social systems approach, current Industry 4.0 maturity and readiness assessment models are examined and compared to gauge major themes, key factors and gaps in the literature relevant to Industry 4.0 preparedness. The effects of COVID-19 on the fourth industrial revolution, the dangers of transitioning to Industry 4.0 and the pandemic implications for the future of work are also reviewed. It is important to note that the main objective of this literature review is to understand Industry 4.0 readiness through a social systems lens as an essential practice for gathering evidence for better preparedness for the future of work. This chapter concludes with a summary of identified gaps and consequent research questions pertaining to transitioning to Industry 4.0, presenting a compelling foundation for future research.

2.2 From the First to the Fourth Industrial Revolution

To understand the impact of rapid technological change on western societies, it is useful first to explore how manufacturing has evolved over the years leading to the emergence of Industry 4.0. From the first industrial revolution to what is now understood as the fourth industrial revolution (or Industry 4.0) is marked by giant historical leaps in technologies. As illustrated in Figure 1, the first industrial revolution started with the mechanisation and the use of steam-powered engines; then, at the end of the 19th century, the second revolution began through the utilisation of assembly lines and mass manufacturing. The third revolution was marked by the widespread use of computers and electronics, leading to the fourth industrial revolution involving smart factories and digitalisation that allow the creation of self-regulating systems within organisations (Ludwig et al., 2018; Xing et al., 2021). With the Internet of Things (IoT), Artificial Intelligence (AI), robotics and Cyber-Physical Systems (CPS) as its central concepts, Industry 4.0 continues to prove to be a drastic and important paradigm shift with a sweeping impact on people's daily lives. (Cooper & James, 2009; Cropley & Cropley, 2021; Kamble et al., 2018; Kovacs, 2018; Sarfraz et al., 2021; Schumacher et al.,

2016; Szabó-Szentgróti et al., 2021). Considering the evolution and progress of the industrial revolutions, it is imperative to acknowledge that Industry 4.0 is an ongoing process that will continue to bring about impactful changes in the future of work (Büchi et al., 2020).

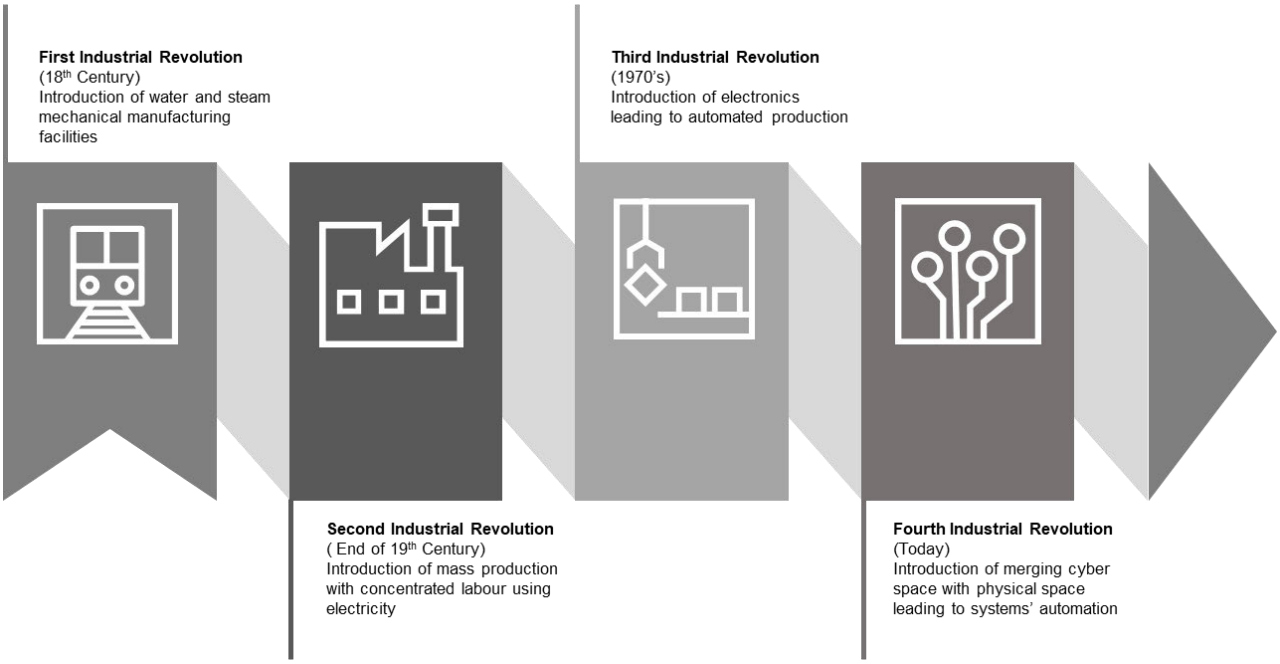
The model of the four industrial revolutions, which encompasses Industry 4.0, has become a popular way to conceptualise the impact of technological advancements on industry and society (Szabó-Szentgróti et al., 2021). Although criticised for oversimplifying the complex nature of technological change, this model remains useful in contextualising and analysing the rapid changes occurring today (Perez & Leach, 2022). It is important to recognise, however, that opinions on the impact of the fourth industrial revolution are varied. While it is often seen as a solution to future challenges, it has also been criticised for contributing to job losses, regional decline and other threats (Perez & Leach, 2022). Over the past decade, the term Industry 4.0 has gained significant attention, although it lacks a universal definition (Kowalikova et al., 2020).

Recent dialogues have ushered in the idea of 'Industry 5.0', which the European Commission introduced as a more human-centric evolution from the technology and efficiency-driven emphasis of Industry 4.0 (Breque et al., 2021). Industry 5.0 delves deeper into ensuring worker health, safety, and overall well-being. By intertwining socio-ecological objectives, this industrial phase accentuates the need for an encompassing workplace, attentive to both the physical and psychological aspects of worker health (Huang et al., 2022). While Industry 5.0's growing literature coincides with the intent of the research presented in this thesis, especially regarding the significance of Psychosocial Safety Climate (PSC), it's crucial to underscore that the primary thrust of this thesis remains anchored in the insights and intricacies of Industry 4.0.

Despite the complexities and debates surrounding these industrial revolutions, the model of the four industrial revolutions remains a valuable tool for contextualising and analysing contemporary changes. It goes beyond simply framing current changes; it also offers insight, highlighting potential paths of innovation and growth within both the industry and the wider society.

Figure 1

The Chronology of the Industrial Revolutions



The German government first used the term Industry 4.0 in 2011 when they announced its industrial development program (Bartodziej, 2017; Kamble et al., 2018; Szabó-Szentgróti et al., 2021; Xing et al., 2021). The fourth industrial revolution is marked by the creation of systems encompassing human-machine and machine-machine interactions, giving rise to 'smart factories'. The 'smart factory' is understood as a concept used to describe the combination of different Industry 4.0 technologies to create flexible and adaptable manufacturing processes. One of the key characteristics involved in the evolution of the 'smart factory' will be the integration of horizontal and vertical interfaces to enable the wireless and autonomous functioning of manufacturing processes (James, 2012). As a result of human-machine and machine-machine interactions in the 'smart factories', Industry 4.0 has produced global trends such as a decline in physically strenuous work, increased skill specialisation, remote teams and smaller workforces (Kadir & Broberg, 2021; Szabó-Szentgróti et al., 2021). The fourth industrial revolution is projected to affect hundreds of millions of jobs worldwide (Kadir & Broberg, 2021; Szabó-Szentgróti et al., 2021). According to the International Federation of Robotics, the future landscape of work will look completely different as robots in the workplace will continually increase up to 13% each year (Szabó-Szentgróti et al., 2021).

Soon after Germany's efforts to acquire a leadership position in the manufacturing sector, the rise of the fourth industrial revolution slowly started seeing its impact across the globe (Bartodziej, 2017). In 2011, the USA developed and launched the Advanced Manufacturing Partnership to innovate manufacturing by adopting intelligent systems to increase productivity and reduce costs (Baldassarre et al., 2017). A few years later, in 2015, France launched the 'Alliance for the Future' program to improve digitalisation and support

innovation, then in 2016, Italy approved the 'Industry 4.0' plan, and Japan also launched 'Connected Industries' with similar objectives (Baldassarre et al., 2017; Mason et al., 2022). While there aren't clear markers of when Australia started adopting Industry 4.0, it is well understood in the literature that the uptake of Industry 4.0 in the country is low and slow, creating a greater need for Australian businesses to understand and advance their Industry 4.0 digital maturity to stay competitive (Mason et al., 2022).

Throughout history, technological advancements have been driven by changes in consumer needs, observable throughout all three past industrial revolutions (Szabó-Szentgróti et al., 2021). However, the fourth industrial revolution has brought the most significant technological shift, where controlled machine automation underwent a digital transformation allowing devices to communicate autonomously throughout the value chain (Szabó-Szentgróti et al., 2021). To compete in the current market with constantly changing conditions and unpredictable market requirements, Cyber-Physical Systems have become the building blocks of future 'smart factories' that are self-managed through the interconnection of technologies driven by real-time data (Napoleone et al., 2020). Given the promises of improved profitability through increased digitalisation and continual growth of Industry 4.0, organisations must prepare themselves for the fourth industrial revolution by understanding the withstanding impact of increased digitalisation on the future of work.

2.3 Implications of Industry 4.0 on the Future of Work

A literature review by Szabó-Szentgróti et al. (2021) emphasises the rate at which Industry 4.0 is advancing, changing the way organisations operate and move towards the future of work. The increased digitalisation and automation giving rise to the technological transformation is one of the most critical labour market topics and will be a strong catalyst in shaping and bringing about drastic changes in the future of work (Büchi et al., 2020; Gilchrist, 2016; Kamble et al., 2018; Kovacs, 2018; Sony & Naik, 2019). The importance of organisations keeping up with technological advancements and equipping themselves with relevant technical systems as a prerequisite for organisations to stay competitive is observed as a recurrent theme in literature (Büchi et al., 2020; Dalenogare et al., 2018; Gilchrist, 2016; Szabó-Szentgróti et al., 2021).

Transitioning from this macro perspective, it's vital to understand the core features of Industry 4.0. The main feature of Industry 4.0 in the way it is currently understood is the use of heterogeneous data (also known as Big Data) and knowledge integration to produce Cyber-Physical Systems (CPS) (Sony & Naik, 2019). Industry 4.0 involves the connection and integration of the virtual and physical worlds through CPS and IOT with intelligent objects that continually interact with each other with minimal human input. With these cyber-physical systems becoming an essential part of new ways of working, there will be continuous interactions and exchange of information between machines and between humans and machines in the future of work (Kamble et al., 2018). This envisioned paradigm not only propels organisations towards a

future integrated with automation and AI but also highlights a significant gap (Oppert et al., 2022; Schwartz et al., 2019).

While the technological aspects of Industry 4.0 are now well understood and well researched, there is a need for further research to address how this technological advancement will impact the 'human' side of the future of work and enable the successful integration of technical systems with existing social systems in the current work context. The increase in the use of robotics, digitalisation and the use of CPS has evoked the interest of many researchers and has led to the analysis of the impact of Industry 4.0 on the workforce (Szabó-Szentgróti et al., 2021). Furthermore, from a human resource and 'future needs' perspective, Szabó-Szentgróti et al. (2021) also emphasise the importance of exploring the significant employment changes resulting from the fourth industrial revolution. Therefore, researchers and practitioners must focus on finding efficient and socially sustainable solutions that address replacing human work with automation and the need for workers and organisations to adapt to the changing condition (Fukuda, 2020).

Building upon this, on a systems level, Industry 4.0 promises the integration of cyber and physical worlds through technology to improve the efficiency of processes, the productivity of people and the profitability of organisations resulting in economic and societal gains (Kovacs, 2018; Schumacher et al., 2016; Sony & Naik, 2020). It is therefore imperative for organisations to continually advance in Industry 4.0 to stay competitive and survive the ever-changing demands of the industry. Keeping in mind both technological and social aspects, organisations and their leaders need to equip themselves with the necessary resources and skills to prepare for the future of work (Dalenogare et al., 2018). To this effect, the paramount roles of the designed CPSs are to keep abreast of the agile and dynamic requirements of production and improve the efficiency and effectiveness of the organisations (Sony & Naik, 2019). It is well-researched that technologies and technological elements, including the Internet of Things (IoT), Internet of Services (IoS), cloud-based manufacturing, radio frequency identification (RFID), enterprise resource planning (ERP), social product development, robotics and Artificial Intelligence (AI) are pivotal to preparing for Industry 4.0 and the future of work (Frank et al., 2019; Gupta et al., 2019; Jiménez-Zarco et al., 2019). However, there are still many inconsistencies in the understanding of Industry 4.0 as a social construct, emphasising a need for further research.

To investigate the social perspective, current research has also started delving into the threats to the health and safety of workers propagated due to the advancement of Industry 4.0 (Potter et al., 2022). For many years, researchers have discussed the detrimental effects of the rise in digitalisation and the increased use of technologies on worker health (Diaz et al., 2012; Potter et al., 2022). It is evident that Industry 4.0 will influence the future of work by compelling employees to increasingly undertake work requiring higher-order elements of human cognition as AI and automation (are being designed to) assume more

manual/repetitive tasks (Oppert et al., 2022). This shift, while facilitating the transition of workers towards more creative and value-driven roles, also presents a double-edged sword.

The delegation of unsafe, mundane or menial tasks to robots empowers workers to delve deeper into creative endeavours, enhancing their professional satisfaction and meaning. Yet, the augmentation of human-machine interactions combined with elevated cognitive expectations exposes workers to both physical and psychological health risks (Kadir & Broberg, 2021; Leso et al., 2018). In the context of Industry 4.0, marked by increased digitalisation, employees grapple with intensified psychological and physical demands (Berg et al., 2018; Oakman et al., 2020; Wang & Siau, 2019). On the psychological front, the perpetual need to upgrade digital proficiency can evoke cognitive tension and heightened stress. Factors such as Information overload from digital data, multitasking, and challenges in maintaining work-life boundaries further contribute to cognitive burden. Physically, sedentary work practices can lead to health issues (Berg et al., 2018), prolonged device use may cause repetitive strain injuries (Oakman et al., 2020), and inadequate ergonomics exacerbate physical discomfort. Additionally, blurred work-life boundaries, cybersecurity concerns, and privacy issues heighten stress levels (Wang & Siau, 2019). Addressing these multifaceted challenges is crucial to safeguard employee well-being amid Industry 4.0's digital transformation. Molino (2020) and Neumann et al. (2021) further add to this discourse by shedding light on the growing significance of psychosocial risk assessments in the era of Industry 4.0. As new technological demands arise, workers find themselves facing the challenge of rapidly adapting to evolving technological environments. This can foster feelings of inadequacy and fear of redundancy, thus intensifying psychosocial risks. Such situations demand organisations to focus on psychosocial safety measures to buffer the negative impacts and protect their workforce. These emerging psychological demands at work point to the necessity of proactive approaches to ensure that as companies harness the potential of Industry 4.0, they also prioritise and implement measures that safeguard the well-being and mental health of their employees.

Understanding these intricate dynamics underscores the significance of psychosocial safety in the realm of Industry 4.0. The pioneering work of Kadir and Broberg (2021) reveals the emerging job demands on employees— reduced autonomy, increased cognitive demands, and the potential for information overload. Their case studies demonstrate how a lack of worker involvement in the introduction of new work design can lead to decreased worker well-being, increased stress, low motivation, and other psychosocial hazards. These elements play a key role in preparing the workforce for the changes brought about by Industry 4.0. While there is still much to discover and understand, one consistent theme emerges: as the transition into Industry 4.0 deepens, the emphasis on psychosocial safety measures becomes paramount. Integrating these concerns is essential for a comprehensive discussion on the future of work in an ever-evolving digital landscape.

Addressing the health and safety challenges of Industry 4.0, there is an emerging consensus that current well-being practices might be insufficient. The technological evolutions characteristic of Industry 4.0 introduce a spectrum of challenges and intricacies that potentially exceed the scope of current wellbeing frameworks (Mathekga & Sekudu, 2019). The pace and depth of technological shifts, while promising, are revealing concerns that have been thus far overlooked or undervalued regarding their repercussions on worker health and well-being (Kadir & Broberg, 2021; Mathekga & Sekudu, 2019). In light of this challenge, there is a pressing need for researchers and practitioners to re-evaluate and innovate work designs that comprehensively cater to 'worker well-being' (Potter et al., 2022). Given the health challenges presented by Industry 4.0 innovations, the upcoming work scenarios compel a meticulous rethinking of workplace health and safety protocols. This thesis, with its focus on human readiness for Industry 4.0, offers a foundation for further exploration of the dynamics affecting worker health and safety in the emerging work landscape.

2.4 The Impact of COVID-19 on Industry 4.0 and Future of Work

The COVID-19 pandemic is recognised as one of the most pertinent and impactful phenomena of the twenty-first century, with enormous social and economic consequences globally (Cruz-Cárdenas et al., 2021; Javaid et al., 2020). The remarkable features of the pandemic that are uniquely impacting the globe and the future of work have resulted in a spike in the literature surrounding the social and economic impacts of COVID-19 (Cruz-Cárdenas et al., 2021; Kirk & Rifkin, 2020; Zwanka & Buff, 2021). Research and anecdotal evidence indicate the pandemic's significant impact on current and future work practices (Antova, 2020; McMahon, 2020; Sarfraz et al., 2021). While the progress of Industry 4.0 adoption and advancement was already rapid, the pandemic further propelled various institutions into the future of work. It has become a key driver of digital growth for many organisations. Pre-existing trends such as remote work, flexible work, online meetings and social media engagement gained popularity during the pandemic and have become a part of people’s daily work experience (Cruz-Cárdenas et al., 2021; Potter et al., 2022).

It is also important to acknowledge that many organisations and sectors have suffered the repercussions of rapid digitalisation worsened by the global pandemic (Bartsch et al., 2020). The current literature shows that the global pandemic has catalysed digital growth within workplaces and accelerated the transition to Industry 4.0 (Leso et al., 2018). As the fourth industrial revolution creates a self-managing network between humans, machines, products, and other related objects, workers will need to continue upskilling to avoid risks associated with job automation (Leso et al., 2018). From an Industry 4.0 advancement perspective, organisations have gone through an unforeseen Industry 4.0 maturity assessment as a result of the pandemic. Their supply chains, technologies, innovation capacity, attitudes, skills and business practices were all challenged by the onset of COVID-19. A survey of manufacturers in Asia by Mckinsey (2021) identified struggles with material shortages, a drop in demand, and worker unavailability as significant issues affecting the respondents. This change in the work and worker demands elicits important questions

surrounding human resource and workforce planning in organisations as a crucial consideration when preparing for the future of work. Organisations were also afforded an essential unforeseen benefit of experimentation with various technology use approaches (Sarfraz et al., 2021). Organisations with advanced technological systems and a high capacity for innovation have made gains from the opportunities created by the pandemic (Woolliscroft, 2020). These progressive organisations have managed to use their innovative abilities to quickly switch production facilities to produce high-demand goods: hand sanitisers, personal protection equipment and ventilators. COVID-19 caused a shift in people's attitudes toward organisational change and change in general as well (Finsterwalder & Kuppelwieser, 2020). This shift resulted in more people working from home, food companies finding innovative ways to manufacture hand sanitisers, remote work meetings, families and friends feeling more connected and acquiring skills and knowledge that may help them with further change in the future (Cattivelli & Rusciano, 2020; Sampat & Shadlen, 2021). It is evident that organisations equipped with Industry 4.0 technologies and digital solutions were better equipped to weather the consequences of the pandemic and would therefore be able to withstand other unforeseen changes more efficiently (Farzad et al., 2020).

As organisations continue to digitally evolve to survive the current business climate while grappling with external factors (outside the control of organisations) like the COVID-19 pandemic, it is critical to understand and explore the implications of implementing Industry 4.0 technologies whilst recognising how organisations can create robust systems that can endure the external factors more effectively (Martínez-Caro et al., 2020). This understanding will pave the way for future research and will assist organisations in developing systems and strategies optimal for employee and organisational outcomes. More people started working remotely to keep their businesses running during the pandemic. While some people are 'returning back to normal', there are implications for the future of work triggered by COVID-19. The pandemic has caused an unprecedented economic and social crisis that organisations must deal with. It is evident that the literature has not 'caught up' to the impacts COVID-19 has had on workplace practices relevant to Industry 4.0 advancement. More specifically, there is a greater need for research to further unpack the impact of the pandemic on organisational culture and business practices to highlight how organisations can best support their workers through unprecedented changes whilst leveraging the opportunities provided by Industry 4.0 (Bartsch et al., 2020).

2.5 Industry 4.0 Maturity and Readiness Models

Along with advances in automation and ICT, Industry 4.0 has created many new opportunities for individuals to explore (Büchi et al., 2020; Dalenogare et al., 2018; Gilchrist, 2016). Businesses that have adapted early and implemented elements of Industry 4.0 understand how advantageous and conducive it can be to positive business outcomes (Hamada, 2019; Kovacs, 2018; Yilmaz et al., 2021). As a result, many government bodies, organisations and individuals want to equip themselves with the necessary resources

and skills required to advance in and take advantage of the fourth industrial revolution (Hecklau et al., 2016). With this desire to advance Industry 4.0 maturity and increase digitalisation, an important question emerges; How can organisations operationalise their transition to Industry 4.0 and compare themselves against industry norms?

The answer to this question lies in the current methods and tools of Industry 4.0 assessments. Advancement in Industry 4.0 is a major strategic decision, and therefore implementing elements of Industry 4.0 requires thorough planning. Before committing to critical decisions surrounding the implementation of technologies and practices related to Industry 4.0, organisations need to consider their current capacity and Industry 4.0 maturity levels to take the journey and assess their readiness for digital transformation or advancement (Rajnai & Kocsis, 2018; Schumacher et al., 2016; Sony & Naik, 2019). The most common way to undertake this assessment is through maturity models. The purpose of using readiness or digital maturity models to understand organisational readiness is to preserve or improve competitiveness and productivity in Industry 4.0. This understanding then enables organisations to plan their strategic business objectives considering the level of maturity they aspire to achieve (Rajnai & Kocsis, 2018; Schumacher et al., 2016; Sony & Naik, 2019).

The most used and popular maturity models (as reported by Ramanathan and Samaranayake (2021) and Mason et al. (2022) are listed below, along with the factors they assess (see Table 1). The elements within the model are categorised using the five key dimensions recognised by Xing et al. (2021); Business Practices, Technology, Skills, Supply Chain and Innovation, along with an additional category for social systems factors.

Table 1

Themes Utilised in Industry 4.0 Readiness and/or Maturity

Readiness/ Maturity Model	Dimensions/Themes (Xing *et al.,* 2021)					Social Systems Factors	
	Business Practices/ Processes	Technology	Skills	Supply Chain	Innovation	Organisational Culture	People Readiness
IMPULS industrie 4.0 readiness framework (2015)	✓	✓	✓				
WMG The University of Warwick Industry 4.0 Readiness Assessment Tool	✓	✓		✓		✓	
Yanez Maturity Index Framework (2018)	✓	✓		✓	✓		✓
Akdil, Ustungdag and Cevikcan Maturity and Readiness Model for Industry 4.0 (2018)	✓	✓		✓	✓		
Wagire *et al.* (2021)	✓	✓	✓	✓	✓	✓	✓

Readiness/ Maturity Model	Dimensions/Themes (Xing *et al.,* 2021)					Social Systems Factors	
	Business Practices/ Processes	Technology	Skills	Supply Chain	Innovation	Organisational Culture	People Readiness

Lichtblau *et al.* (2015)	✓	✓					
Pirola, Cimini and Pinto (2019)	✓	✓	✓				
Singapore Smart Industry Readiness Index	✓	✓		✓			✓
Veile, Kiel, Muller and Voigt	✓	✓	✓			✓	
Sony and Naik	✓	✓	✓	✓	✓	✓	✓
Schumacher, Erol and Sihn	✓	✓	✓			✓	
Santos and Martinho	✓	✓				✓	
Schuh, Anderl, Dumitrescu, Kruger, Hompel	✓	✓	✓			✓	✓

The differing factors used in each of these models suggest that there isn't a standard, widely accepted model that effectively measures the readiness for Industry 4.0 through different lenses. However, an insight into the maturity models quickly reveals some common essential factors that can enable organisations to be better prepared for the future of work, explicitly surrounding technological advancements. It is interesting to note that most models focus on Industry 4.0 maturity mainly from a technical perspective, identifying a meaningful gap in the emphasis on technical vs social systems factors. Specifically, more 'human-centric' factors such as psychosocial safety, innovation capacity, employee attitudes and employee preparedness to change are clearly missing from these Industry 4.0 readiness and maturity models. In line with this observation, the need for a holistic view for measuring Industry 4.0 maturity was emphasised by Schumacher et al. (2016), explaining how it is difficult for organisations to identify the actions, projects and strategies to adopt without holistically understanding their current state of technological development. In a literature review on Industry 4.0, Szabó-Szentgróti et al. (2021) also identify how current research addressing the labour market needs primarily looks at the need for organisations and their workers to adapt to Industry 4.0 whilst understanding the social and economic impact on the future of work. From a social systems perspective, these models highlight critical research gaps in knowledge and understanding of how organisations can be better prepared for transitioning to Industry 4.0. It is becoming increasingly important for research to address this gap in the literature and broaden the understanding of Industry 4.0 preparedness as a multidimensional and multidisciplinary concept. Therefore, this thesis will focus on emphasising, exploring, and understanding organisational readiness for adaption to Industry 4.0 (through increased digitalisation) through a social systems lens.

2.6 Theoretical Background

2.6.1 Industry 4.0; A Socio-Technical System

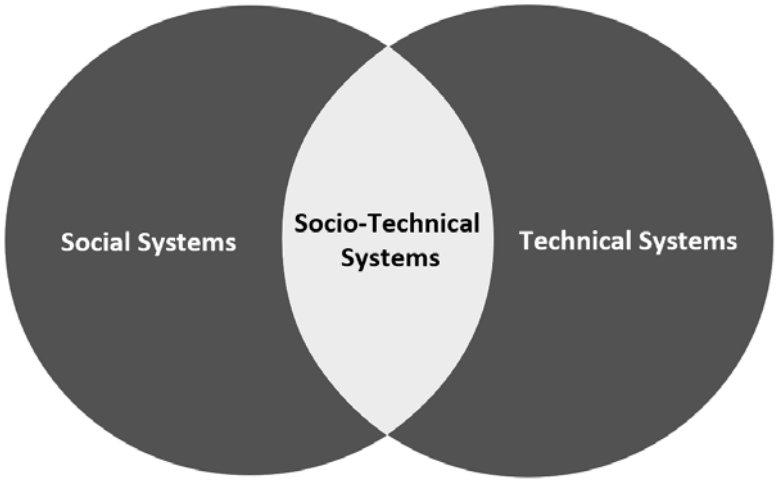
The term Socio-technical Systems (STS) is used to describe systems that involve complex interactions between humans, machines and environmental elements of organisations (Appelbaum, 1997; Bednar & Welch, 2020). It has been well-established in literature for decades that for successful technological advancements, organisations need change models that take a human-centred approach and incorporate the needs of their social networks (Appelbaum, 1997; Ludwig et al., 2018). Considering the profound impact Industry 4.0 has on modern work practices, socio-technical systems theory has regained popularity in recent literature for being an effective theory that enables a systematic view of this industrial revolution (Davies et al., 2017; Imran & Kantola, 2018; Ludwig et al., 2018; Margherita & Braccini, 2021; Sony & Naik, 2020).

The social system aims to design a work structure responsive to workers' psychological needs, improving their sense of belonging, intrinsic motivation and improved social outcomes (Appelbaum, 1997; Margherita & Braccini, 2021; Schulte et al., 2022). This system is experienced within organisations through factors like

culture, climate, communication, and behaviour patterns that emerge as a result of the interaction between the social factors within the networks of organisations (Appelbaum et al., 2015; Kruglanski et al., 2018). On the other hand, the technical system comprises the tools, methods and equipment used to produce or deliver goods and services to clients (Appelbaum, 1997; Ludwig et al., 2018; Sony & Naik, 2020). As exemplified in a case study by Margherita and Braccini (2021), combining the two systems and viewing Industry 4.0 through a socio-technical lens results in work design that connects workers with their organisations' technology and humanises the social systems. Therefore, when considering the STS theory in an Industry 4.0 context, it is essential that the complex social and technical elements of organisations and their environments all be considered and amalgamated to form cyber-physical systems with the goal of improved technological and psychosocial outcomes (see Figure 2) (Appelbaum, 1997; Davies et al., 2017; Ludwig et al., 2018).

Figure 2

A Conceptualisation of Socio-Technical Systems



It is well understood in current literature that Industry 4.0 will continue to change the way people work and how they interact with technology (Davies et al., 2017; Sony & Naik, 2020). The STS theory proclaims that changes to one system within an organisation will lead to changes in another; it is therefore pivotal for organisations to consider the social, technological and cyber systems when designing work for modern cyber-socio-technical environments. (Kopp et al., 2019; Sony & Naik, 2020) Ludwig et al. (2018) and Bednar and Welch (2020) argue that theoretically, Industry 4.0 principles have a significant impact on the way organisations function, in practice however, the implementation of those principles fail to consider individual differences between organisations and between the people implementing the technologies. The implications of the interactions between humans-machines and machines-machine are still unclear and will likely emerge as the future unfolds (Davies et al., 2017). When trying to understand factors relevant to Industry 4.0 preparedness, there is a clear imbalance between the vast amount of literature relating to the

technical systems when compared to the social systems. This thesis therefore will particularly aim to increase the understanding of how organisations can be better prepared for the future of work (in an Industry 4.0 context) from a social systems lens.

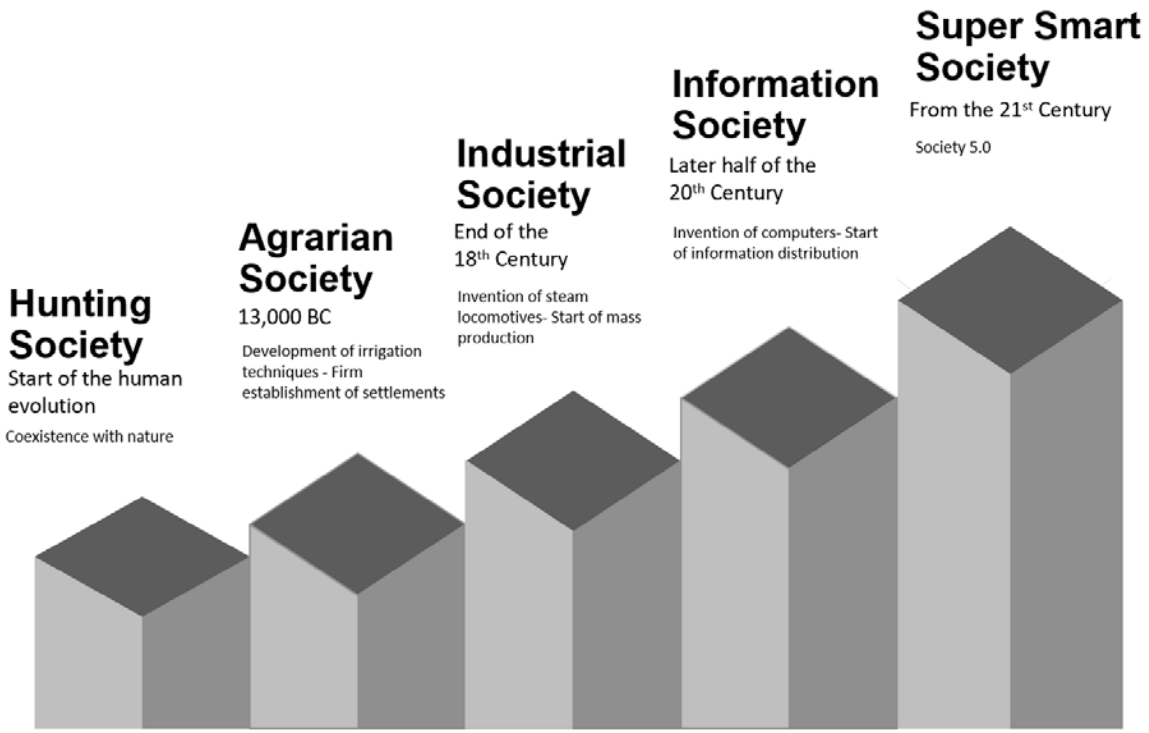
2.6.2 Society 5.0

Taking the STS approach a step further, current research regarding the future of work is slowly becoming more human-centred, moving towards something now understood as 'Society 5.0'. While there isn't extensive literature surrounding 'Society 5.0', its principles align with the STS theory with a stronger focus on the social and psychological aspects of work (Deguchi et al., 2020). The underlying mechanism behind Society 5.0 is to merge cyberspace with physical space (using Industry 4.0 technologies) with the intent to keep the needs of 'humans' at the forefront (Gladden, 2019). In an era of drastic change, Society 5.0 looks beyond Industry 4.0 to build a 'super-smart' society in which knowledge and values are created with the purpose of contributing to economic growth and social welfare (Fukuda, 2020). Society 5.0 also aims to offer resolutions for social problems by providing goods and services addressing latent needs regardless of locale, age, gender or language (Fukuda, 2020). As a result of this integration, humans can live a high-quality life full of comfort and vitality with a higher focus on their wellbeing (Deguchi et al., 2020).

As illustrated below, society has continued to evolve due to many industrial revolutionary attempts (see Figure 3): Society 1.0 (hunter-gatherer), Society 2.0 (agricultural), Society 3.0 (industrialised) and Society 4.0 (information). It is evident that the transition of society towards Society 5.0 stems from and is heavily influenced by the technologies of Industry 4.0 (Nair et al., 2021). According to Fukuda (2020), Society 5.0 will use Industry 4.0 technologies to create an ecosystem that provides sustainability at all levels – economic, environmental, social and political. While Industry 4.0 is focused on the concept of system automation through increased digitalisation, Society 5.0 is centred around the integration of cyber and physical systems for the greater benefit of society/humanity. Both Industry 4.0 and Society 5.0 involve increased digitalisation and automation of systems, however, Industry 4.0 was created with the objective of improved manufacturing using smart factories, while the main objective of Society 5.0 is the creation of a super-smart society with the intent of holistically benefiting civilisation (Deguchi et al., 2020). Though there are strong commonalities and differences between Industry 4.0 and Society 5.0, the biggest difference is in the 'human-centred' approach of Society 5.0 (Gladden, 2019). This human-centred approach can be utilised to further understand the STS theory from a social systems perspective and apply it to improve human preparedness for Industry 4.0.

Figure 3

Economic and Social Innovation by Deepening of Society 5.0



Upon observation of the STS theory and Society 5.0, it is evident there is a substantive understanding of merging the 'technical' with the 'social' elements to optimise the benefits of and prepare for advancement in Industry 4.0 (Fukuda, 2020; Sony & Naik, 2020). It is also evident in current literature that having resilience on a socio-technical systems level enables ecosystems to sustain and recover to their 'stable' states more quickly after experiencing short-term shocks, therefore playing an important role in the growth and development of societies as a whole (Fukuda, 2020). However, before the social elements can be integrated into the cyber-physical systems, there remains a large imbalance of knowledge between the technical systems and the social systems understanding of the industrial revolution. As mentioned in previous sections, this thesis aims to address this imbalance and further the understanding of preparedness for Industry 4.0 through the social systems and organisational psychology perspective.

While this research primarily centres on examining the socio-technical systems perspective and the principles of 'Society 5.0,' it's essential to recognise and acknowledge the growing academic discussions concerning 'Industry 5.0 (Carayannis & Morawska-Jancelewicz, 2022; Huang et al., 2022; Paschek et al., 2022). Interestingly, Industry 5.0 shares significant similarities with the ideas of Society 5.0, including the integration of digital and physical aspects, a strong emphasis on human-centric values, and a commitment to addressing evolving societal needs (Potočan et al., 2020; Tiwari et al., 2022). Both concepts share a common emphasis on digitalisation and automation, but they differ in their core objectives. Industry 5.0

primarily aims to improve manufacturing processes and create smart factories. While Industry 5.0 isn't the central focus of this research, it presents intriguing ideas that deserve further exploration in future studies. Particularly, the profound impact of Industry 5.0 on the world of work and its intersection with socio-technical systems theory warrants further exploration.

2.7 Industry 4.0 Through a Social Systems Lens

It is apparent that the continuous development and adaption of new technologies are pivotal to maintaining competitiveness in Industry 4.0 (Kamble et al., 2018; Szabó-Szentgróti et al., 2021). Upon evaluation of current maturity models, it is evident that while some common factors have the potential to enable a smoother transition and advancement in Industry 4.0, it must be recognised that readiness for Industry 4.0 does not occur in a vacuum. Industry 4.0 is somewhat complex and a multi-level procedure requiring a more systematic approach and attention to different aspects of organisations. This supports a growing body of literature strongly suggesting that Industry 4.0 is an open, adaptive, complex socio-economic innovation ecosystem (Kovacs, 2018; Mazzucato, 2021). Successful advancement and adoption of Industry 4.0 depend not only on technical feasibility but also on the social acceptability of digital transformation. Kovacs (2018) envisages that the absence or lack of social acceptability supporting the transformation could be excessively destabilising for organisations. Moreover, the current literature also supports the opinion that advancement in Industry 4.0 should not be reduced to technical aspects, as it results from a complex interaction of varied technical and social factors and environmental factors (Prodi et al., 2021; Sony and Naik, 2020). Sony and Naik (2020) go a step further and discuss the importance of viewing Industry 4.0 as a Socio-technical system where the interaction between the technical and social elements is just as, if not more important, than considering them separately. They also explain how technology, digitalisation and artificial intelligence are intertwined with social relations. Therefore, not incorporating the social elements can be detrimental and a missed opportunity for organisations trying to advance themselves in the future of work. Despite this, little attention has been paid to the social aspects of readiness for Industry 4.0, such as culture, mindsets and capacity of the individuals in organisations that could potentially assist with better preparedness for this future. Indeed, there is evidence that many businesses hesitate to transition toward Industry 4.0 because they do not have sufficient information and resources to assist them with the social transition (Hamada, 2019). Further research focusing on crucial social systems factors pertaining to advancement in Industry 4.0 will better enable organisations to exploit opportunities that arise in the fourth industrial revolution.

The conventional belief and a common fear of technology amongst people suggest that the rise in automation will decrease the need for humans at work. However, based on current literature and anecdotal evidence, it is apparent that Industry 4.0 will indefinitely change the nature of work humans engage in, resulting in a more significant interaction of humans with the designed Cyber-Physical Systems (Sony &

Naik, 2020). Therefore, it is essential to consider both social and technical aspects and then integrate the social elements to better prepare for the future of work (Sony & Naik, 2020; Szabó-Szentgróti et al., 2021). The systems designed using the Socio-technical systems theory incorporate methods of joint optimisation and are therefore able to better manage environmental complexity, dynamism, new technology and competition (Sony & Naik, 2020; Walker et al., 2008). To this effect, Bhattacharya et al. (2017) highlight the importance of adopting a holistic perspective to Industry 4.0 implementation, where the advancement is treated as a strategic initiative rather than a technology opportunity. Therefore, to safeguard employees from job displacement and buffer the effect of increased digitalisation, organisations must use STS principles to implement new technologies whilst conducting workforce planning that will prepare workers and meet the demands of the future of work.

2.8 Important Social Systems Factors Relevant to Industry 4.0

When trying to understand the social impact of Industry 4.0 on the future of work, it is well understood that organisations will need to become more open, multicultural, multidisciplinary, agile and collaborative, impacting the 'humans' within the businesses (Bag et al., 2021; Črešnar & Nedelko, 2020; Hecklau et al., 2017). Despite this, little attention has been paid to the social aspects of readiness for Industry 4.0, such as culture, mindsets and capacity of the individuals in organisations that could potentially assist with better preparedness for this future (Patriarca and Bergstr om, 2017). Looking at the current literature, it is apparent that preparing for Industry 4.0 is a complex phenomenon. Various interactions exist among the numerous technical, social, cyber and physical factors pertaining to digital transformation (Prodi et al., 2021). Any combination of these factors can influence how prepared organisations are for the future of work and how well-equipped they are to implement Industry 4.0 technologies (Patriarca et al., 2021; Sony and Naik, 2020). Therefore, it is necessary to consider the effect of specific social factors separately to better understand them and successfully predict their interaction with other technical factors. Previous research has also pointed towards a similar and important research gap that this thesis hopes to fill; the current research trend does not focus on investigating the relationship and social impact of identified important factors on Industry 4.0 (Kamble et al., 2018). This thesis will address this gap to enable a better theoretical understanding of Industry 4.0 and inform organisations on how they can advance in Industry 4.0 more efficiently, allowing for the creation of more holistic socio-technical systems in the future (Oesterreich & Teuteberg, 2016)

As categorised previously in Section 2.5, this thesis will continue to consider the five broad themes identified by Xing et al. 2021 as factors essential for overall readiness for Industry 4.0: Technology, Business (practices and processes), Supply Chain, Skills and Innovation. Beyond these broad factors, many studies have identified other factors relevant to transitioning to Industry 4.0 from a human-centred perspective. Adaption of core businesses and business practices, flexibility and autonomy of work, exchange of

resources, effective leadership and a positive digital organisational culture, have all been understood as essential factors that facilitate better preparedness for Industry 4.0. A literature review by Nadkarni and Prügl (2021) also identifies and discusses the transformative power of using adequate personnel (skilled employees and leaders) to facilitate digital advancement in organisations. From a social perspective, effective leadership, company culture, work environment and managerial and organisational perspectives are all recognised as fundamental factors that strongly impact digital transformation in Industry 4.0 (Nadkarni & Prügl, 2021). However, the social systems factors that specifically influence organisations' readiness for digital transformation and the future of work need further research and exploration. Some preliminary research by Sony and Naik (2020) has taken a socio-technical approach to understand Industry 4.0 preparedness and has discussed the importance of making a 'cultural shift' and creating 'social acceptance' of Industry 4.0 technologies as factors essential from the 'socio' point of view (Kovacs, 2018). This points to creating a suitable climate, culture and employee attitudes for organisations to prepare for increased digitalisation. Keeping in mind the social systems focus of this thesis and factors prevalent in current literature, this thesis will also explore organisational culture, climate and employee attitudes as plausible social systems factors that influence preparedness for Industry 4.0.

To summarise, based on some broader themes relating to Industry 4.0 maturity and advancement prevalent in current literature, along with the social systems factors present in preliminary research, the following sections will explore each of these themes using a social systems perspective. The identified themes include organisational culture (including leadership capabilities), attitudes towards organisational change/organisational resilience, technological maturity, business practices, skills, innovation capacity and supply chain (Nadkarni & Prügl, 2021; Sony & Naik, 2019; Xing et al., 2021).

2.8.1 Industry 4.0 Influencing Organisational Change

Many organisations have adopted Industry 4.0 technologies without considering the impact on their whole firm, including physical infrastructure, human resources, process management, manufacturing operations, technologies, or social acceptance of the technologies (Cimini et al., 2020; Gilchrist, 2016). Consequently, organisations are at different levels of maturity on their digital transformation journeys. Research in organisational development suggests that improving readiness for Industry 4.0 requires focusing on "soft" dimensions and using processes, strategies, and principles that effectively drive change, taking into account organisational structure and culture (Cimini et al., 2020; Hamada, 2019; Levasseur, 2010).

According to Hall and Hord (2006), some organisations still view change as an event rather than a process, with serious consequences for employees involved in the change process. This approach denies them the opportunity to learn the "new" way and grieve over the loss of the "old" way. Many past change processes have been subject to fundamental flaws, preventing the successful management of change (Todnem, 2005).

Attitudes and behaviours of employees towards organisational change play an important role in implementing change (Herold et al., 2007). Therefore, employee input and effective work design are vital considerations when planning change initiatives (Schwarzmüller et al., 2018).

One explanation for unsuccessful change initiatives is that organisations fail to consider individual attitudes towards change and how employees' resistance to change can limit the efficient transition into Industry 4.0 (Hamada, 2019). Negative attitudes or resistance towards change have been shown to have an impact on levels of self-esteem, motivation, productivity, need for achievement, and locus of control (Oreg, 2006). Thus, it is important for organisations to embed a healthy attitude towards organisational change in their culture, know where they want to be in the future, and how they will manage changes to get there by setting clear resilience goals and objectives (Appelbaum, 1997; Cameron & Green, 2009; Patriarca et al., 2021). Simply telling managers to become better change champions is not enough; it is important for organisations to embed a healthy attitude towards organisational change in their culture, know where they want to be in the future and how they will manage changes to get there by setting clear resilience goals and objectives (Appelbaum, 1997; Cameron & Green, 2009; Patriarca et al., 2021). Keeping in mind the needs of Industry 4.0, organisations need to shift their attitudes and manage change effectively to better prepare for the future of work.

As discussed in several studies and books, a large proportion of time spent at work will involve learning new skills, training, and upskilling (Cropley & Cropley, 2021; Frunzaru & Corbu, 2020; Khallash & Kruse, 2012). Given the amount of ‘changes’ individuals and organisations have to go through in the future of work, it is pivotal to understand the impact of undergoing change and ‘attitudes towards change’ on preparing for the future of work (Frunzaru & Corbu, 2020). This suggests that the nature of work will continue to evolve, requiring a different level of openness to change on an individual and organisational level. To this effect, Cropley and Cropley (2021) also emphasise the importance of ‘lifelong learning’ as one of the core capabilities addressing the needs for Industry 4.0, pointing towards increased openness and curiosity to learn. They further mention that knowledge that will be needed in the future of work may not even exist at the time of receiving formal education. Therefore, individuals and organisations must equip themselves with the necessary capabilities, mindsets and attitudes to better prepare for digital transformations and learn to embrace change. It is well-researched that the organisation's collective attitude impacts the organisation's culture, affecting its ability to weather the changes (Kursunoglu & Tanrıogen, 2009). Keeping in mind the number of changes that will occur as a result of increased digitalisation and implementation of Industry 4.0 technologies, organisations must learn to become more resilient and have more positive attitudes towards organisational change (Hamada, 2019).

2.8.2 Organisational Culture- Psychosocial Safety Climate

Building on previous discussions, Industry 4.0 technologies are poised to instigate significant organisational shifts and enable organisations to incorporate automated systems, substantially increasing human-machine interactions. In Industry 4.0, people will be expected to work with more sophisticated systems in more controlled environments threatening their mental and physical health (Kovacs, 2018). On the one hand, the workforce will be able to undertake activities that are more meaningful and fulfilling and are less physically intensive resulting in the reduction of work accidents and work illness (Margherita & Braccini, 2021). While the workforce stands to benefit from engaging in more meaningful activities with reduced physical intensity, the rise of cobots presents new challenges and a higher demand to engage in tasks requiring soft skills, new threats to work health and safety and the need for new policies and practices also increases. Competing with machines may leave employees feeling stressed, exhausted and more susceptible to burnout (Kovacs, 2018). In line with the Job-Demands Resources model by Bakker and Demerouti (2007), It is critical for organisations, and more specifically leaders, to provide their employees with the necessary resources to cope with the demands of the future of work.

An important factor that can help facilitate an improved balance between job demands and resources is a healthy psychosocial safety climate (PSC) (Garrick et al., 2014). PSC is defined as the shared perception of policies, procedures and practices in place for the protection of worker psychological health and safety (Dollard & Karasek, 2010). Compared to the physical focus of occupational health and safety, psychosocial safety focuses on protecting and promoting the psychological health and safety of employees in organisations (Dollard & McTernan, 2011). PSC is enhanced through management's prioritisation of employee wellbeing, management commitment to stress prevention and organisational systems for participation and communication regarding psychosocial issues that may affect employee psychological health (Lee & Idris, 2017). Organisational culture, defined by shared values and norms, distinctly varies from climate. While both influence workplace safety, culture reflects long-standing beliefs, whereas climate speaks to the present state of affairs (Dollard & Bakker, 2010; Ng & Ng, 2014).

Organisations with high PSC levels provide employees with support, have open organisational communication, and have positive psychosocial health and safety policies, procedures and practices. As a result, organisations can successfully equip their employees with job resources to cope with the demands of their jobs and also manage psychological health issues that may arise (Bailey et al., 2015; Dollard & Karasek, 2010; Dollard & McTernan, 2011; Dollard et al., 2012; Idris et al., 2014). Numerous studies have also highlighted the importance of PSC as a precursor to positive outcomes in an organisation, such as job satisfaction, employee motivation, employee wellbeing, lower work stress and decreased absenteeism (Bailey et al., 2015; Idris et al., 2014). As illustrated in Figure 4, the PSC model can predict and explain employees' psychological health and work engagement through an increased PSC and better balance

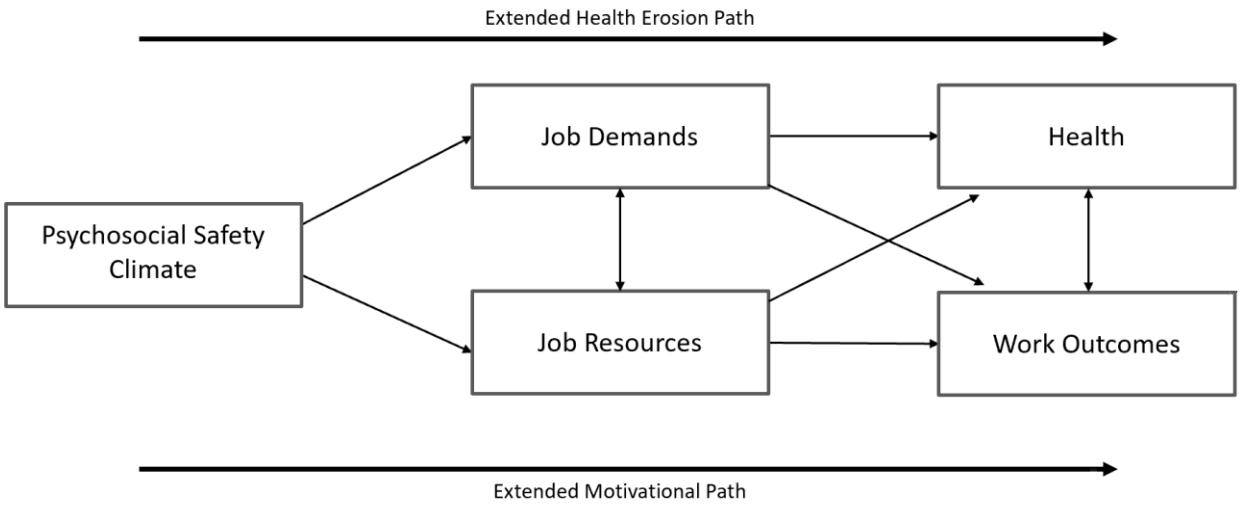
between job demands and resources (Dollard & Bakker, 2010). The digital transformation integral to Industry 4.0 introduces specific cognitive and physical job demands(Molino et al., 2020; Neumann et al., 2021). The continual pressure to enhance digital acumen results in cognitive stress, exacerbated by challenges such as information overload and heightened cybersecurity concerns (Wang & Siau, 2019). Physically, the shift towards digitalised, sedentary tasks spurs ergonomic concerns and repetitive strain injuries (Oakman et al., 2020). Additionally, blurred work-life boundaries further compound stress levels (Bag et al., 2021; Berg et al., 2018; Dollard et al., 2012). While grappling with these emerging physical and psychological demands, both the PSC and JDR models underscore the importance of providing adequate job resources to help employees manage these new demands (Bag et al., 2021). Resources such as comprehensive training can prepare workers for the challenges of digital transformation. Peer support is also invaluable, as more experienced employees can guide their colleagues through technological changes(Bag et al., 2021). Ergonomic interventions can address physical strain, while ensuring regular breaks can mitigate both physical and cognitive fatigue. Emphasising cybersecurity not only protects organisational assets but also alleviates employee stress associated with potential breaches (Bag et al., 2021; Kadir & Broberg, 2021; Mathekga & Sekudu, 2019)

Research in the domain of organisational psychology emphasises the importance of maintaining a balance, particularly in Industry 4.0 environments, to enhance employee well-being (Mathekga & Sekudu, 2019). Practical recommendations include providing digital skills training, emphasising the importance of ergonomics, ensuring regular breaks, and ramping up cybersecurity measures (Bag et al., 2021). Implementing these strategies will not only help navigate the challenges of digitalisation but also serve as a defense to safeguard employee well-being (Potter et al., 2022).

According to recent literature, there is evidence that suggests the presence of psychological factors that contribute to negative attitudes towards the adoption of Industry 4.0. For instance, Hamada (2019) has posited that inertia experienced by individuals within organisations can impede their ability to adapt to this new technological paradigm. In response, improving organisational PSC has been proposed as a potential remedy to this challenge. By acting as a safeguard against psychological pressures, PSC holds promise in facilitating a smoother transition to Industry 4.0, empowering organisations to overcome inertia and fully embrace the potential benefits of emerging technologies.

Figure 4

Psychosocial Safety Climate Model (Re-illustrated)



Based on a review of the current literature, it is apparent that there is a growing need for research around understanding how top management support impacts an organisation's Industry 4.0 readiness (Sony & Naik, 2019). Understanding the impact of senior management in the implementation and transitioning to Industry 4.0 will address an important gap in literature and will, from a practical perspective, enable organisations to understand what they can invest in to be better prepared for the future of work. Furthermore, a study by Lee and Idris (2017) discusses the differences between team climate and psychosocial safety climate and emphasises how PSC is a precursor to better working conditions and indirectly affects job engagement and performance.

In summary, considering the number of changes organisations will continually need to adapt to when implementing Industry 4.0 technologies, organising and monitoring adequate workplace health and safety is recognised as an important challenge. In order to face this challenge, the focus on worker health and safety is shifting towards a culture of prevention. According to International Labour Organisation (2019), policymakers will continue to focus on identifying, assessing and preventing risks for the safety management of organisations and combat challenges arising from increased digitalisation. At the same time, given the projected impact of Industry 4.0 technologies on decreased manual labour and increased cognitive load, it is important to consider the implications of the safety culture and climate on these new and evolving job demands for organisations and employees (Oppert et al., 2022). Due to the social systems focus of this thesis, the research undertaken will explore the impact of psychosocial safety climate on readiness for implementation of Industry 4.0 technologies from a human-centred perspective.

2.8.3 Innovation and Industry 4.0

As mentioned in Section 2.8.1, organisations need to be resilient and manage change effectively in order to increase their preparedness for Industry 4.0. One way to effectively manage change is through an increased capacity to innovate. Innovation is the result of the way society responds to change. Even organisations that exclusively focus on financial aspects innovate not to make money but as a response to change (Cropley & Cropley, 2015). The demands of Industry 4.0 require organisations to have strategic business models and goals that align with the needs of the future of work with a specific focus on innovation management (Metallo et al., 2018). One of the biggest challenges hindering organisations from preparing for and stepping into Industry 4.0 is the volatility of the market, with shorter product lifecycles, higher complexities and global supply chains. With consumerism at its peak, it is becoming increasingly important for organisations to improve their innovation capacity to provide innovative business solutions that meet the constantly changing needs of consumers (Morrar et al., 2017). Self-driving cars, delivery robots and increasing production capacity of hand sanitisers during COVID-19 are all strong examples of innovations that responded to consumer needs and converted potential opportunities into marketable outcomes (Baldassarre et al., 2017; Cruz-Cárdenas et al., 2021; Metallo et al., 2018; Potter et al., 2022)

For reasons other than increased profitability, a higher innovation capacity can also aid in fulfilling the increased demand for customised and tailored services in the future of work (Bigdeli et al., 2015). Current literature suggests that to increase the customisation of products and services, organisations need to be open to interdisciplinary collaborations and have employees with a broader knowledge base (Kovacs, 2018). While there is abundant research exploring the relationship between digital innovation and skills required to prepare for the future of work, many businesses are not ready for the future of work due to a lack of technological advancements, a lack of social acceptance of those technologies, a lack of interdisciplinary knowledge and a lack of understanding of their innovative capacities (Dhondt et al., 2022; Lee et al., 2018; Sony & Naik, 2019). Based on current literature, it is recommended that organisations focus on increasing their knowledge and innovative capacities and enhance their core competencies and preparedness through the development of innovative value-added services for their customers (Lee et al., 2014). However, it is important to note that only some challenges or solutions need a new approach. Sometimes, innovation is about knowing when to continue applying the same solution to problems/consumer needs and when there is room for incremental and disruptive innovation (Cropley & Cropley, 2021). In conclusion, if decision-makers within a company are self-aware of their capacity to innovate, have a positive attitude towards change and are willing to take risks through interdisciplinary collaboration, it would be relatively more straightforward for them to implement Industry 4.0 technologies and be better prepared for the future of work (Hamada, 2019).

2.8.4 Skills in Industry 4.0

With the rise of automation and Cyber-Physical Systems (CPS) in Industry 4.0, radical changes in the nature of work are projected with workers requiring different skills, capabilities a higher level of education (Cropley & Cropley, 2021; Szabó-Szentgróti et al., 2021). While workforce disruption caused by Industry 4.0 is inevitable, many researchers suggest that implementing Industry 4.0 technologies will not reduce the amount of work for humans. However, they will need to have a different set of skills and capabilities to survive and thrive in the fourth industrial revolution (Cropley & Cropley, 2021; Sony & Naik, 2020; Szabó-Szentgróti et al., 2021). Therefore, in order to have effective human capital management and human resource management, it would be beneficial for the organisation to create a framework and aligns its business strategy with the needs of Industry 4.0, allowing for appropriate training and upskilling for their employees in the future (Szabó-Szentgróti et al., 2021). Innovation and Business Skills Australia drew an important link between learning, skills acquisition, Industry 4.0 and employment (McCormack et al., 2017). Supporting the idea of proactive lifelong learning in employees, they emphasised the importance of analysis of data and trends, automation management, human-machine interaction management, cyber security management, data management, agile development and design thinking. What organisations should learn from this crucial message is that it is fundamental to have employees that are lifelong learners with data analytics capabilities to drive a successful digital transformation and transition to Industry 4.0 (Kamble et al., 2018).

In their book Core Capabilities for Industry 4.0, Cropley and Cropley (2021) discuss the importance of capabilities over skills. While skills are clearly defined sequences of actions with specific applicability, capabilities on the other hand are complex systems encompassing cognitive, affective and social domains. From a human resource or a 'skills' perspective, it is implicit that workers in Industry 4.0 will need to have broader capabilities rather than specific skills in order to thrive in the future of work (Cropley & Cropley, 2021). They will need to become more T-shaped individuals who possess domain knowledge and are capable of thinking broadly to apply and communicate their domain-specific knowledge to other fields or disciplines (Gianecchini et al., 2022; Oskam, 2009). Cropley and Cropley (2021) recognised a few important capabilities that the employees in Industry 4.0 need: a tolerance for uncertainty, acceptance of risk, enjoyment of challenges, comfort with complexity, self-efficacy and the courage to resist social pressures to conform. Industry 4.0 capable people are good at acquiring knowledge, challenging themselves and have the self-efficacy to succeed (Cropley & Cropley, 2021). More importantly, people with these capabilities are better prepared for the future of work and are less likely to face the unintended consequences of transitioning to Industry 4.0.

From an employee perspective, it is also necessary to take into consideration the increase in stress around job loss along with the fear of 'technological unemployment' amongst workers (Peters et al., 2019). Adding

to this increasing fear, the theory of technological unemployment also suggests that technology will replace human jobs before new jobs are created (Szabó-Szentgróti et al., 2021). While not all jobs are likely to be fully displaced, prior research suggests that almost 50% of jobs are susceptible to automation with contemporary technology, and there is a negative relationship between wages and educational attainment with an occupation's probability of computerisation (Frey & Osborne, 2017). Researchers are indeed positive that transitioning to Industry 4.0 will provide a greater benefit to organisations in the long run, meanwhile in the short term, some jobs will disappear, making it even more critical for organisations to prepare themselves and their workforce with the skills and processes necessary for the future of work (Szabó-Szentgróti et al., 2021).

To summarise, based on the current literature, it is evident that the workforce of Industry 4.0 will need to stop relying solely on the knowledge acquired through formal education (schools/universities/diplomas) and develop a growth and learning mindset (Cropley & Cropley, 2021). Following the principles of 'lifelong learning', the future workforce must also be open to acquiring knowledge as it emerges and develop suitable capabilities over skills (Cropley & Cropley, 2021). However, it is also important to keep in mind and be assured that the automation resulting from this cyber dominance does not result in reduced human interaction or workerless production; it instead simply demands a different type of human contribution and respective skills (Patriarca et al., 2021)

2.8.5 Business Practices and Industry 4.0

Transitioning to Industry 4.0 is a major strategic decision; therefore, implementing elements of Industry 4.0 requires thorough planning. Organisations must consider their capacity and preparedness to undertake a technological transformation, as different technologies may impact various functions of their operations. Once this is assessed, organisations can design business policies and practices to reach their desired level of technological maturity (Dhondt et al., 2022; Rajnai & Kocsis, 2018; Schumacher et al., 2016). From a technical perspective, it is well understood in literature that integrating Industry 4.0 technologies with process management can yield significant economic benefits for organisations (Kamble et al., 2018). However, the social systems factors discussed in the previous section, such as organisational culture, innovation and skills, are all strongly influenced by and have the ability to influence business practices. From a social systems perspective, organisational practices aimed at shaping the desired culture and skills can be instrumental in helping organisations prepare for Industry 4.0

2.8.6 Technology and Supply Chain from a Social Perspective

Technology and supply chain are both essential factors necessary for the successful integration of Industry 4.0 technologies and are well discussed in literature. Fatorachian and Kazemi (2021), Koh et al. (2019), Ghadge et al. (2020), Hahn (2020) and many other studies have all discussed these factors in detail. It is

evident that the current literature tends to focus predominantly on the technological aspects of Industry 4.0 integration. This makes sense as CPS, AI, robotics and innovation surrounding these technologies are the central concepts that Industry 4.0 revolves around. The purpose of this thesis is not to downplay the significance of technology and supply chains in the transition to Industry 4.0. Rather, it aims to promote an understanding of the social implications of preparedness and progress towards the future of work to facilitate the development of cyber-physical systems that adhere to the principles of the socio-technical theory. Within the scope of this thesis, these factors will be briefly considered from a social systems perspective.

Despite having the funds and technological infrastructure required to implement Industry 4.0, the decline of many large organisations, such as Nokia and Polaroid, was due to their inability to adapt to the changing needs of their consumer (Cropley & Cropley, 2021). Domain-specific knowledge alone could not save these organisations from the effects of change as they could not apply their skills in an Industry 4.0 setting (Cropley & Cropley, 2021). As discussed in Section 2.4, COVID-19 was able to showcase the digital maturity of organisations challenging their technologies and supply chains. The pandemic highlighted the gaps in Industry 4.0 readiness and demonstrated the importance of the social systems factors above and beyond having the key infrastructure in place. It is apparent that while Industry 4.0 is all about technological systems integration requiring the support of robust supply chains, these technologies are designed for and have the most impact on humans, creating a need for further consideration of the social impact of technological advancements.

2.9 The Dark Side of Industry 4.0

Industry 4.0 is a strong catalyst in bringing about drastic changes at work. While most of the changes promise to offer increased profitability for organisations, it is important to note that the future of work will also have to deal with the negative consequences arising as a result of transitioning to Industry 4.0 (Kovacs, 2018). It is quite peculiar that majority of the literature solely focuses on the positive aspects of advancement in Industry 4.0 while ignoring the dark corners, i.e. the unintended negative consequences of technological advancements and innovations (Kovacs, 2018) when it is indeed evident that technological development in digitalising solutions also has negative impacts. These issues arising as a result of the technological environment will include cybersecurity, employability, legislation, ethics and threats to the psychosocial safety climate of organisations. It is also critical to view and understand Industry 4.0 readiness as a complex, multidimensional phenomenon with both positive and negative consequences (Kovacs, 2018; Szabó-Szentgróti et al., 2021).

The transformative power of Industry 4.0 does not come without consequences. This digitalisation calls for a systematic view and a much broader policy and business perspective to better understand the interactions

of various elements of the socio-technical systems (Kovacs, 2018). A multidisciplinary approach to policymaking and solving problems may provide a greater scope to account for the unintended consequences of advancement in Industry 4.0 (Kovacs, 2018). While governments all around the world are designing interventions to promote Industry 4.0 transitions, it is important to consider whether those designed interventions will also offer enough capacity to offset and counterbalance the organisations and individuals who are not equipped to deal with Industry 4.0 advancements or cannot survive the fourth industrial revolution (Kovacs, 2018; Mazzucato, 2021). It is important to acknowledge that while capturing the negative impact of digital advancements on organisations is outside the scope of this thesis, it is nevertheless an important impact that needs to be considered when designing cyber-physical systems for the future of work.

2.10 Conclusion

While the popularity and awareness of Industry 4.0 concepts amongst researchers and practitioners as a part of the broader digital transformation continue to grow, and organisations continue to make incremental digital advancements, there is a range of barriers and enablers from a social perspective that is yet to be explored. As a result, organisations continue to be challenged by a limited viewpoint and may struggle to effectively employ technological systems within their workplaces due to a limited understanding of how to create systems, policies and business practices that holistically capture the importance of the associated social elements. The existing Industry 4.0 maturity models currently used by organisations to guide their transition into Industry 4.0 are more technological in nature and are unable to capture the impact of the social work environment, therefore presenting limited capacity for application in a broader range of practical settings. Some newer theoretical models, such as the cyber-socio-technical approach and Society 5.0, support the importance of integrating social, technical and cyber subsystems and designing systems with a human-centred approach (Gladden, 2019; Margherita & Braccini, 2021; Sony & Naik, 2020). However, as mentioned in Sections 2.7 and 2.8, in order to achieve the successful integration described within these models, it is first necessary to alleviate the imbalance of knowledge between the social and technical systems. There is also a definitive need for more evidence regarding how social systems factors influence digital transformations and preparedness for the future of work. The improvement in the understanding of social systems will also pave the way for organisations and governing bodies to have a clearer direction about factors, methods and practices that will be effective in better employment of digital transformations whilst ensuring an increase in sustainability and profitability of such entities.

There is a growing awareness and interest in industry, the field of work, and organisational psychology about how social organisational constructs play a critical role in organisational success. As a result, there is a stronger focus and need for human-centred approaches that include employee involvement, worker wellbeing, soft skills and people-centric business policies and practices to ensure organisations stay

competitive and meet future demands. The social-systems insight into Industry 4.0 provides a unique opportunity to advance the understanding of how these social organisational factors contribute to better preparedness for the future of work. Studies exploring the role of social systems factors in digital transformations in a workplace can contribute by identifying specific barriers and enablers that organisations can use to better navigate when approaching the future of work. Further interpretation of these outcomes will also provide an effective evidence base for effective change management in both policy and practice.

This thesis advances this knowledge base by investigating three key questions arising from the gaps in literature.

1. Is there a clear pathway that can explain the impact of the identified social systems factors on preparedness for Industry 4.0?
2. How does social systems preparedness for Industry 4.0 impact the subsequent financial performance of organisations?
3. How might organisational culture and its social elements affect the way technical systems are integrated and improve readiness for the future of work?

To answer these questions, this thesis undertakes three distinct studies that form Chapters 3, 4 and 5 of this thesis.

CHAPTER 3: Ready, Set, Industry 4.0: Explaining Readiness for Industry 4.0 using Social Systems Factors (Study 1)

The content of this chapter has been used as a basis for a journal publication. It is currently being prepared for publication.

3.1 Abstract

Industry 4.0 will bring about drastic changes in the future of work (Büchi et al., 2020; Gilchrist, 2016). Businesses that have already adapted to Industry 4.0 agree that it is conducive to positive business outcomes (Hamada, 2019). However, little is known about the social systems factors that may influence organisations' readiness for Industry 4.0 and how to prepare the workforce for the future of work.

The aim of this study was:

a) To gain a deeper understanding of how social systems factors aid in preparing employees for increased digitalisation occurring through Industry 4.0 technology implementation and;

b) To investigate three specific social systems factors and their effect on readiness for Industry 4.0:

- Psychosocial Safety Climate,
- Innovation Capacity and
- Attitude towards Organisational Change

Business decision makers from 192 different organisations completed a self-report survey assessing their organisation's readiness for Industry 4.0 and the three social systems factors relating to organisational safety climate, employee attitudes and innovation capacity. The results from a path analysis revealed an indirect link between Psychosocial Safety Climate and Readiness for Industry 4.0, with Attitude towards Organisational Change and Innovation Capacity acting as mediators. The modelled pathway also accounted for 59% of the variance in Readiness for Industry 4.0. This study presents a new theorisation of viewing Industry 4.0 readiness through a 'social systems' lens and the importance of organisational cultural factors in improving preparedness for the future of work. The results inform managers on creating a safety climate that promotes employee well-being and enables organisations to be better prepared for Industry 4.0 technologies. The findings from this study: a) pave the way for future research to further the 'social systems' understanding of Industry 4.0, and; b) enable organisations to enter the fourth industrial revolution better equipped with some of the skills and resources necessary.

3.2 Introduction

Also known as the 'Fourth Industrial Revolution', Industry 4.0 is a specific case of automation of systems resulting from increased digitalisation. Industry 4.0 was a strategic initiative launched by the German government in 2011 to advance local manufacturing through the digitalisation and interconnection of products, value chains and business models (Schumacher et al., 2016). From a political standpoint, the German government launched this initiative to position Germany as a world leader in automated and digitalised manufacturing. Interestingly, the operationalisation of the concept has evolved, and Industry 4.0 is now understood as the next step or a new industrial stage integrating manufacturing, operations systems and Information and Communication Technologies (ICT) (Dalenogare et al., 2018). As a result of this interconnection, products, machines and processes can be equipped with artificial intelligence that adapts to spontaneous changes in the environment independently and makes data-driven decisions (Hecklau et al., 2016).

With knowledge, data and the Internet of Things (IoT) as its central pillars, Industry 4.0 represents a shift towards an innovation-based economy (Morrar et al., 2017). This shift, along with advances in automation and ICT, has created new opportunities for organisations to increase profitability by offering their customers novel, tailored and data-driven solutions (Büchi et al., 2020; Dalenogare et al., 2018). In addition, many industry leaders have also forecasted Industry 4.0 to deliver unprecedented growth and productivity over the next decade (Gilchrist, 2016). Therefore, businesses, academics and the government are constantly working towards developing a better understanding of Industry 4.0 to increase digital maturity and improve preparedness for the future of work (Gilchrist, 2016). However, to harness the full potential of increased digitalisation and avail the opportunities offered by Industry 4.0, there is a need for deeper and further exploration of factors that enable and hinder the implementation of Industry 4.0 technologies from an 'employee-readiness' perspective.

Organisations that have already adapted to Industry 4.0 agree that it is conducive to positive business outcomes (Hamada, 2019). Many companies, however, have delayed adopting Industry 4.0 and are either still preparing for the transition or have not reached the desired level of Industry 4.0 maturity (Hamada, 2019). To understand the importance of preparing for Industry 4.0 and how it offers organisations a competitive edge and influences organisational performance, existing literature has focused on firms' awareness of Industry 4.0 and the enabling technologies that facilitate its implementation (Büchi et al., 2020). However, very little is known about the social aspects of readiness for Industry 4.0 that could potentially assist organisations to be prepared for this future. Many organisations hesitate to commence the transition to Industry 4.0 because they either lack sufficient information and resources to assist them with the transition or the knowledge and expertise to prepare their workforce for digital transformation (Hamada, 2019). Furthermore, there are minimal theoretical links and clear pathways established in the

current literature that enable better preparedness for Industry 4.0. Therefore, identifying and exploring the essential social systems factors necessary for increased Industry 4.0 preparedness can enable these organisations to transition further into the fourth industrial revolution. As discussed in Sections 2.6 and 2.7, there is a clear imbalance between the technical and social understanding of Industry 4.0 technologies. This study explores the social systems factors relevant to Industry 4.0 technology implementation and investigates the importance of social systems factors such as culture, innovation and organisational attitudes that enable organisations to be equipped and thrive in the fourth industrial revolution. It focuses on two key gaps in the literature (as identified in Chapter 2).

This study involved: (1) investigating the social systems factors that impact readiness for Industry 4.0 and (2) exploring the relationship between the psychosocial safety climate an organisation and its Readiness for Industry 4.0 while considering its capacity to innovate and its attitudes towards organisational change. Considering the broad themes emerging in the literature review (organisational culture, employee attitudes and innovation) in Chapter 2, the three social systems factors explored in this study are: Psychosocial Safety Climate, Attitudes towards Organisational Change and Innovation Capacity. These factors are discussed below in the context of Industry 4.0.

3.2.1 Industry 4.0 and Psychosocial Safety Climate

As mentioned previously, Industry 4.0 is characterised by digitalisation and automation of systems. Research suggests that Industry 4.0 will bring new paradigm shifts that will inevitably impact the management of occupational health and safety and will therefore influence the future of work (Badri et al., 2018). On the one hand, while automation will increase efficiency in more straightforward tasks, on the other hand, employees will be required to engage in tasks requiring the use of soft skills (such as decision-making, communication management, cobots and machine interaction), which may result in greater exposure to psychosocial stress (Badri et al., 2018; Sadłowska-Wrzesińska, 2019).

Organising and monitoring adequate workplace health and safety, whether physical or mental, is recognised as an important challenge that needs to be managed in the fourth industrial revolution. A study by Lee and Idris (2017) discusses the differences between team climate and psychosocial safety climate and emphasises how PSC is a precursor to better working conditions and indirectly affects job engagement and performance. PSC is defined as the shared perception of policies, procedures and practices in place for the protection of worker psychological health and safety (Dollard & Karasek, 2010). As opposed to the physical focus of occupational health and safety, psychosocial safety focuses on protecting and promoting the psychological health and safety of employees in organisations (Dollard & McTernan, 2011). PSC is improved through management prioritising employee well-being (Lee & Idris, 2017). Numerous studies have highlighted the importance of PSC as a precursor to positive outcomes in an organisation. Simply put, organisations with higher PSC have better organisational outcomes such as job performance, job

satisfaction, employee motivation, employee wellbeing, lower work stress and decreased absenteeism (Bailey et al., 2015; Dollard & Karasek, 2010; Idris et al., 2012; Idris et al., 2011; Idris et al., 2014; Lee & Idris, 2017). It is, therefore necessary to understand what type of safety culture is required to transition to Industry 4.0 and whether having a strong safety culture is conducive to organisational improvements relating to Industry 4.0 readiness.

Recent literature suggests that there could be psychological reasons for the negative attitudes towards adopting Industry 4.0. The inertial pressures on individuals within organisations could militate against adapting to Industry 4.0 (Hamada, 2019). Nevertheless, PSC could act as a buffer against this inertia and enable a less challenging adoption of Industry 4.0. Furthermore, organisations with high Psychosocial Safety Climate levels are able to provide employees with support, maintain open organisational communication and establish positive psychosocial health and safety policies. As a result, organisations can successfully equip their employees with job resources to cope with the demands of their jobs and also manage psychological health issues that may arise (Bailey et al., 2015; Dollard & Karasek, 2010; Dollard & McTernan, 2011; M. F. Dollard et al., 2012; Idris et al., 2014). Upon evaluation of previous research and the demands of the fourth industrial revolution, it is hypothesised that:

> H1) *A high PSC will enable organisations to be better equipped and have better preparedness for Industry 4.0.*

3.2.2 Industry 4.0 and Innovation

The second social factor that may be an essential determinant of an organisation's preparedness for Industry 4.0 is its capacity for innovation. The introduction of new technologies into the operating environment of organisations, alongside the potential transition to Industry 4.0, represent fundamental changes for organisations. Some primary challenges for organisations preparing for Industry 4.0 include market volatility, shorter product lifecycles, higher complexities and global supply chains. With consumerism at its peak, it is becoming increasingly important for organisations to manage change efficiently, provide innovative solutions that meet consumers' ever-changing needs, and, as such, maintain a competitive edge (Cropley & Cropley, 2021; Morrar et al., 2017).

Although digital innovation and the skills required to prepare for the future of work have been researched by a number of studies, many businesses are not ready for Industry 4.0 due to a lack of technological advancements, social acceptance of these technologies, interdisciplinary knowledge, and an understanding of their innovative capabilities (Dhondt et al., 2022; Lee et al., 2018; Sony & Naik, 2019). By placing innovation at the heart of their business models, organisations can transform potential value-embedded technologies and processes into marketable outcomes (Metallo et al., 2018).

In essence, change is a key driver of innovation. Bordeleau and Felden (2019) emphasise in their study how innovative organisations typically deal with change better than organisations with a limited capacity for innovation (Cimini et al., 2020; Cropley & Cropley, 2021). Innovation is the result of the way society responds to change. Additionally, even organisations exclusively focused on the financial profitability of businesses still innovate not to make money but as a response to change (Cropley & Cropley, 2015). Therefore, to survive the changes introduced by increased digitalisation and Industry 4.0 technologies, organisations must implement strategic business models that focus on innovation management and technological advancements (Hamada, 2019; Metallo et al., 2018).

Therefore, it is hypothesised that organisations with a strong capacity for innovation will be better equipped to deal with the changes occurring as a result of Industry 4.0. Based on the literature, it is also evident that if decision-makers within a company are self-aware of their capacity to innovate, have a positive attitude towards change, and are willing to take risks, they will be better prepared to implement Industry 4.0 technologies (Hamada, 2019). To understand the role of innovation capacity in preparing organisations for Industry 4.0, it is hypothesised:

> H2) *A higher innovation capacity will lead to organisations being better prepared for Industry 4.0 (see Figure 5).*

It is well established that PSC is an important facet of an organisation's culture and a precursor to positive organisational outcomes such as higher productivity, lower stress and lower absenteeism (Kwan et al., 2020). Similarly, research has also drawn correlations between increasing an organisation's Innovation Capacity and improved production, business outcomes, and financial and marketing performance (Cropley et al., 2013; Izadi Z.D et al., 2020). However, a significant gap in literature has been identified due to the lack of information on how PSC relates to the Innovation Capacity of employees. This provides a unique opportunity to understand the contribution PSC can have in enhancing organisational innovation capacity with the potential to positively impact preparedness for Industry 4.0.

Dollard and Karasek (2010) emphasise that the work environment, comprising various elements such as the physical workplace, the organisational culture, leadership style, communication patterns, and the prevailing attitudes and behaviours of individuals within the organisation, plays a crucial role in employee engagement and can be improved by building a strong PSC in organisations. The work environment plays a pivotal role in shaping the experiences of employees and influencing their behaviours, attitudes, and well-being (Shier & Graham, 2011). A positive work environment is characterised by factors such as clear communication, supportive leadership, opportunities for skill development, a sense of psychological safety, and an organisational culture that values innovation and employee well-being. Conversely, a negative work environment may feature poor communication, high stress levels, a lack of support from leadership, and a

culture that stifles innovation and psychological safety (Dollard & Karasek, 2010; Donley, 2021; Shier & Graham, 2011; Verhaeghe et al., 2006).

In the context of this research, the work environment is considered as the backdrop against which the relationship between Psychosocial Safety Climate (PSC) and Innovation Capacity unfolds. This psychosocial work environment, shaped by interactions between employees and leadership, significantly influences employees' behaviours and their emotional experiences related to work (Donley, 2021). The underlying hypothesis posits that a robust PSC within the work environment functions as a catalyst, fostering an environment conducive to employee innovation and bolstering the overall innovative capacity of the organisation. Such an environment, positively influenced by a strong PSC, is expected to facilitate open communication, promote psychological safety, and cultivate a culture that encourages creativity and risk-taking – all factors known to support innovation (Dollard & Bakker, 2010). While there is research signalling the positive impact of the work environment on innovation and work culture and of organisations (Cropley et al., 2013), this idea needs further exploration through empirical research, as undertaken in this thesis. Based on previous literature and the indirect link between PSC and innovation through the work environment, it is theorised that having a strong PSC will act as a precursor and provide a 'suitable' climate for organisations to innovate and increase their capacity for innovation.

This conceptualisation of the work environment underscores its role as a dynamic and influential backdrop within which employees' attitudes, behaviours, and innovative potential are shaped. By examining how PSC interacts with and impacts the work environment (specifically through employee attitudes), this research aims to shed light on the mechanisms through which PSC indirectly influences Innovation Capacity and, consequently, an organisation's readiness for Industry 4.0. This research endeavour thus seeks to bridge the existing gap by exploring the interplay between PSC and innovation to contribute to a deeper understanding of how these factors collectively shape organisational readiness for the challenges of Industry 4.0. It is therefore hypothesised that:

H3) *A high PSC will enable organisations to have higher innovative capacity.*

Furthermore, if having a high PSC leads to an increased innovation capacity, and it is established that innovation could be a key driver of improving preparedness for Industry 4.0, it is hypothesised that:

H4) *Innovation Capacity will mediate the relationship between PSC and Readiness for Industry 4.0*.

3.2.3 Attitude towards change and Industry 4.0

To survive as a business in the current workforce, an organisation must adapt, and to adapt, it must change (Kursunoglu & Tanrıogen, 2009). As established in the previous section, change or the need for change is a fundamental driver of innovation and preparedness for Industry 4.0 (Cropley & Cropley, 2015; Simpson,

2017). Therefore, it is safe to presume that innovation and change are highly interconnected. Given the strong impact of attitudes on human behaviour (and vice versa), to improve the innovation capacity of organisations, practitioners must first focus on improving employee attitudes towards organisational change (Kashif et al., 2018). It is therefore hypothesised that:

> H5) More positive *Attitude towards Organisational Change will lead to a higher capacity to innovate.*

Attitude towards organisational change has been identified as a factor that can facilitate or inhibit Industry 4.0 adaption (Hamada, 2019). Negative attitudes or resistance towards change have been shown to impact self-esteem, motivation, productivity, need for achievement and locus of control (Oreg, 2006). As discussed previously, when entering the fourth industrial revolution, businesses must continually renew their direction, structure and capabilities to serve the ever-changing needs of internal and external stakeholders (Hamada, 2019; Todnem, 2005). The transitioning of industries will change not only the organisation's operations, marketing and technology but also the rules of staying competitive. Therefore, it is becoming increasingly important for organisations to adopt a healthy attitude towards change to survive the shift towards Industry 4.0.

Employees' attitudes and behaviours towards organisational change play a critical role in implementing change (Herold et al., 2007). It is indeed evident that to prepare for Industry 4.0 technology implementation, organisations need to develop a positive attitude towards change and implement robust change management practices and strategies. However, according to Hall and Hord (2006), some organisations still view change as an event rather than a process. This can lead to severe consequences for the employees involved in the change process, causing the change initiatives to fail and increasing employees experiencing change fatigue (Beaudan, 2006; Bernerth et al., 2011). One explanation for why change initiatives often fail, and lead to change fatigue, is a lack of consideration for the individuals' attitudes towards change. Organisations also often fail to account for how employees' resistance to change limits them from achieving their desired state of functioning/maturity. Keeping in mind the resilience organisations need to develop to deal with numerous changes when implementing newer technologies in Industry 4.0, organisations must take a human-centred approach. By creating a positive and psychologically safe organisational culture, organisations can increase the success of change initiatives and enable employees to feel more confident in their ability to handle change whilst managing the adverse effects of changing work environments and stressful job conditions (Herold et al., 2007). Consequently, it has been hypothesised that:

> H6) *Organisations with a more positive attitude towards change will display higher levels of readiness for Industry 4.0.*

The importance of organisational culture is also demonstrated through the impact of PSC levels on organisational outcomes. The behaviours of individuals within organisations, the attitudes they hold, the customs they follow and how they express themselves are all key factors that influence the 'culture' of an organisation (Simpson, 2017). Hence, it is hypothesised that:

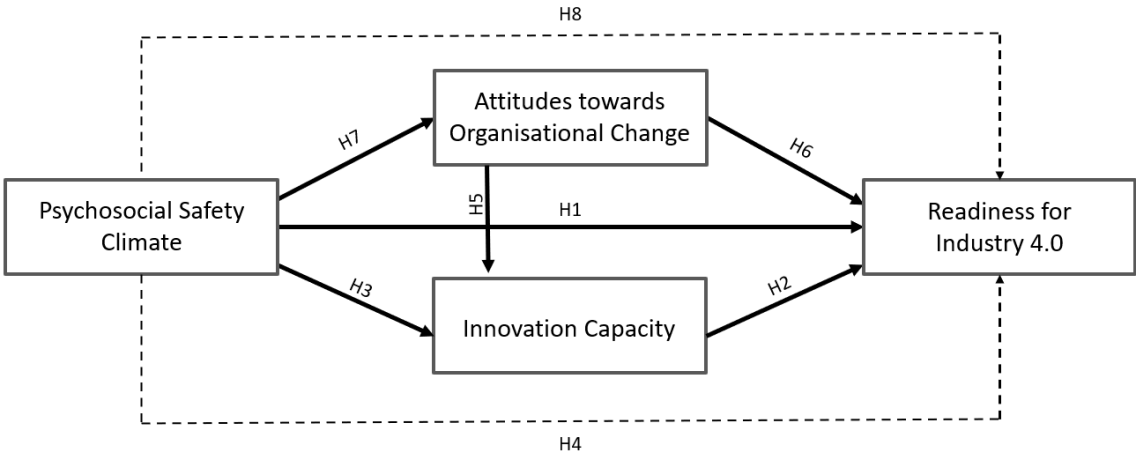
H7) *High levels of PSC will be conducive to having more positive attitudes towards change; and*

H8) *Attitude towards Organisational Change will also mediate the relationship between PSC and Readiness for Industry 4.0.*

Drawing together the arguments presented in the previous sections, these hypotheses have been formulated to tackle two research questions. Firstly, the hypotheses will try to answer; a) how the social systems factors may explain readiness for Industry 4.0 and b) do Innovation Capacity and Attitude towards Organisational Change mediate the relationship between Psychosocial Safety Climate and Readiness for Industry 4.0 (see Figure 5 for a visual representation of hypotheses).

Figure 5

Conceptual Model for Visual Representation of the Hypotheses



3.3 Method

3.3.1 Participants

Participants were recruited through Qualtrics academic services using bulk email invitations. A 91-item survey was completed by 192 participants who passed the screening questions. The participants understood their business processes and were decision-makers in their organisation (as assessed by the screening questions). Participants who did not identify as business decision-makers, who were not employed by publicly listed Australian organisations, or who were under the age of eighteen were excluded from the study. Personal demographic information such as age and gender were also not collected to ensure the anonymity of the participants.

3.3.2 Measures

The current study used four self-report scales to measure: (a) Innovation Capacity, (b) Attitude towards Organisational Change, (c) Psychosocial Safety Climate, and (d) Readiness for Industry 4.0. The scales are described below:

Psychosocial Safety Climate was measured using PSC-12 (Hall et al., 2010). The PSC-12 consists of four subscales, with three items in each subscale. The 12 statements relating to PSC are rated on a 5-point Likert scale (*1- strongly disagree to 5- strongly agree*) and examine four core dimensions of employee psychological health and safety: (1) management commitment; (2) management priority; (3) organisational communication, and; (4) organisational participation and involvement (see Appendix A). The reported validity and reliability of the scale are high (Hall et al., 2010). The Cronbach's α for the current study is .86.

Innovation Capacity was measured using the Innovation Phase Assessment Instrument (IPAI). The IPAI (extended version) has 168 true/false items measuring 42 nodes (Cropley et al., 2013). The current study used three subscales (consisting of 30 questions) from the IPAI focusing on: (1) the environment for innovation; (2) attitudes to innovation, and; (3) processes for innovation. The 30 statements relating to Innovation Capacity are rated on a 5-point Likert scale (*1- strongly disagree to 5- strongly agree*), with each statement having an ideal response. The respondents' answers are compared to the ideal answers, and an alignment percentage or level of Innovation Capacity score is generated. The three subscales measured were used to reduce participant burden and ensure the assessed content was relevant to the research questions (see Appendix B). The IPAI has been administered to several organisations and is a highly reliable measure (as a scale and as subscales) (Cropley et al., 2013). The Cronbach's α for the current study is .80.

Attitude towards Organisational Change was measured using the Organisational Change Questionnaire-Change, Processes and Readiness (OCQ-C, P, R) (Bouckenooghe et al., 2009). OCQ-C, P, R measures climate of change, attitudes towards the organisational change process and the readiness for change. It is a 52-item scale with 11 dimensions; five climate of change dimensions, three process-of-change dimensions and three

readiness-for-change dimensions (Bouckenooghe et al., 2009). The current study used six subscales from the OCQ- C, P, R. The selected subscales comprised 20 questions and were chosen based on the factor analyses of the scale; (1) participatory management; (2) involvement in the change process; (3) attitudes of top management; (4) intentional readiness for change; (5) cognitive readiness for change, and; (6) emotional readiness for change (Bouckenooghe et al., 2009). The number of questions was reduced to ensure that the assessed content was relevant to the research questions and reduced the participant burden (see Appendix C). The OCQ- C, P, R is rated on a 5-point Likert scale (*1- strongly disagree to 5- strongly agree*) and has been administered to more than 3000 organisational members from the private and public sectors and the analysis of their responses indicated high reliability for OCQ- C, P, R subscales (Bouckenooghe et al., 2009). The Cronbach's α for the current study is .80.

Readiness for Industry 4.0 was measured using a questionnaire developed for a local government project using existing literature and within the Australian context; The *Industry 4.0 Transformation: Embracing Digital Innovation in Manufacturing Industries* survey instrument (Xing et al., 2021). The Questionnaire consisted of 81 questions and five subscales measuring organisations: (1) business readiness; (2) technology readiness; (3) skills readiness; (4) supply chain readiness and; (5) innovation readiness. The 28 statements relating to Readiness for Industry 4.0 are rated on a 5-point Likert scale (*1- strongly disagree to 5- strongly agree*) and examine business and skills readiness of Industry 4.0. This study did not use the Innovation Readiness subscale as innovation readiness was already being measured through the IPAI. Business and skills readiness were measured to ensure that the assessed content was relevant to the research questions and focused on the 'social systems factors' (see Appendix D). The Cronbach's α for the current study is .78.

3.3.3 Procedure

The present study used a quantitative cross-sectional correlational design utilising an online self-report questionnaire measure. All data were collected through a questionnaire on an online platform, Qualtrics. All participants were presented with a participant information sheet before consenting and commencing the online survey. The information sheet detailed the participant's rights and briefly explained the premise of the study. The surveys took approximately 11 minutes to complete. Raw data from Qualtrics was then exported to SPSS for statistical analyses. This study was approved by the Human Research Ethics Committee of University of South Australia.

3.3.4 Statistical Analysis

Raw data from Qualtrics was exported to SPSS and AMOS for statistical analysis. Descriptive analyses were conducted to examine readiness for Industry 4.0 and the predicting variables (Innovation Capacity, Attitude towards Organisational Change and PSC). Next, Preliminary assumption testing was conducted to check for normality, linearity, outliers, and multicollinearity. Pearson coefficients were then computed to examine the

relationship of Readiness for Industry 4.0 with the predicting variables and the relationship between the predicting variables themselves. After the Preliminary tests, main analyses were conducted using Path Analysis in AMOS to answer specific research questions highlighted towards the end of Section 3.2.3.

Pathway Analysis was used to answer the research question, "Do Innovation Capacity and Attitude towards Organisational Change mediate the relationship between Psychosocial Safety Climate and Readiness for Industry 4.0?". To test the pathways from Psychosocial Safety Climate to Readiness for Industry 4.0 through Innovation Capacity and Attitude towards Organisational Change, Structural Equation Modelling in AMOS v26 was used. The use of pathway analysis allowed for the testing of a path diagram grounded in theory. It was used to confirm the significance of the modelled pathways and ensure the best model fit for the data. Furthermore, it was used to assess if Innovation Capacity and Attitude towards Organisational Change mediate the relationship between PSC and Readiness for Industry 4.0. Three models were assessed that offered complete mediation, partial mediation (modified) and no mediation (direct effect) pathways between PSC and Readiness for Industry 4.0. The models were tested using maximum likelihood estimation and bootstrapping and were compared using the Chi-Square Difference test.

The best fitting model (out of the three proposed models) was used for further analysis and conclusions (see Figure 7 for the best fitting model) (see Appendix E for the other two models proposed). The models consist of one observed exogenous variable; Psychosocial Safety Climate and three observed endogenous variables; Innovation Capacity, Attitude towards Organisational Change and Readiness for Industry 4.0.

To assess model fit, the following fit indices were used: Goodness of fit index (GFI), comparative fit index (*CFI*); root mean square error of approximation (*RMSEA*) with *p* of close fit (*PCLOSE*); and chi-square (χ^2).

The χ^2 index measured the discrepancy between the proposed model and our data; the larger the χ^2, the greater the discrepancy. As such, small non-significant ($p > .05$) χ^2 values indicate good model fit. However, this measure of model fit is sensitive to sample sizes; as such, to overcome this limitation, three additional fit indices were utilised – *GFI, CFI* and *RMSEA* (*PCLOSE*). Models that fit the data well have a *GFI* > .95 (Byrne, 2016). Models that have a good fit between the proposed model and data have a *CFI* index score that is > .95 (Byrne, 2016) and the *RMSEA* score should be < .08 with a non-significant *PCLOSE* ($p > .05$) (Browne & Cudeck, 2016).

3.4 Results

3.4.1 Normality and Preliminary Analysis

Preliminary assumption testing was conducted to check for normality, linearity, outliers, and multicollinearity. Multivariate normality was violated as Innovation Capacity and Readiness for Industry 4.0 were moderately positively skewed but were accounted for in the analyses. To assess the potential impact of common method bias on the results, a Harman's single-factor test for common method variance was conducted. The analysis revealed that the single factor explained 23.33% of the total variance, which fell below the recommended threshold of 50%. This finding suggests that the data did not exhibit significant common method bias (Kock et al., 2021).

Preliminary analysis was then conducted using descriptives and Pearson's correlations. Table 2 contains the correlations - Pearson *r,* means, number of participants and standard deviations of the variables in the study. As anticipated, all three independent variables were positively and significantly correlated with each other and with Readiness for Industry 4.0. That is, higher Innovation Capacity corresponded with a more positive attitude towards Organisational Change, higher Psychosocial Safety Climate, and higher levels of Readiness for Industry 4.0. Similarly, positive Attitude towards Organisational Change corresponded to higher levels of Psychosocial Safety Climate and higher levels of Readiness for Industry 4.0. Lastly, a high Psychosocial Safety Climate was positively and significantly linked with higher Readiness for Industry 4.0.

Table 2

Pearson's Correlations and Descriptive Statistics for the Variables being Assessed

	Pearson's r					
Variable	IC	ATOC	PSC	RI4	*M*	*SD*
Innovation Capacity (IC)	-				57.45	9.14
Attitude towards Organisational Change (ATOC)	.60**	-			3.67	0.41
Psychosocial Safety Climate (PSC)	.51**	.75**	-		3.93	0.56
Readiness for Industry 4.0 (RI4)	.75**	.58**	.51**	-	3.99	0.46

*Note. N= 192. *p < .05, ** p < .001*

Path Analysis

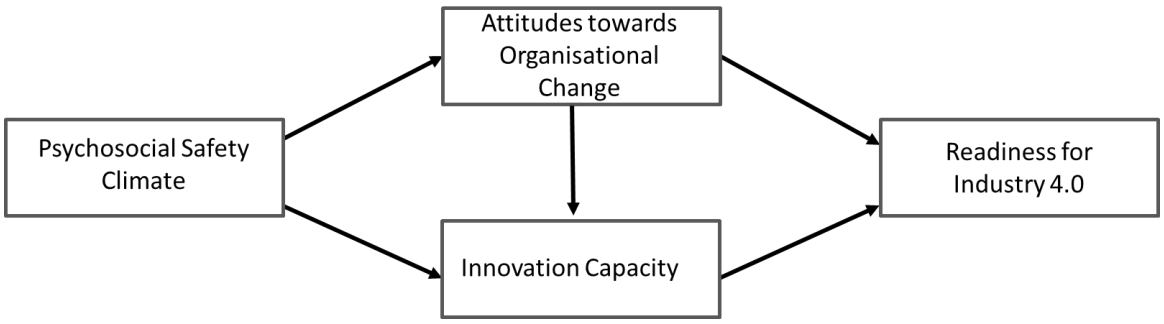
To test the pathways from Psychosocial Safety Climate to Readiness for Industry 4.0 through Innovation Capacity and Attitude towards Organisational Change, Structural Equation Modelling in AMOS v26 was used. The proposed models consisted of one observed exogenous variable; Psychosocial Safety Climate and three observed endogenous variables; Innovation Capacity, Attitude towards Organisational Change and

Readiness for Industry 4.0. As hypothesised, Innovation Capacity and Attitude towards Organisational change will mediate the relationship between Psychosocial Safety Climate and Readiness for Industry 4.0.

The data used violated the assumption of multivariate normality (Critical Ratio >5). Bootstrapping was utilised with 2000 iterations with bias-corrected confidence intervals for standard errors and Bollen-Stine bootstrap for model fit (Akins et al., 2005; Cifuentes-Faura & Faura-Martínez, 2023). The asymptotically distribution-free (ADF) estimation method could not be used as the sample size was below 1000 observations. Therefore, three models (full mediation, partial mediation (modified) and direct effect) were tested using maximum likelihood estimation and bootstrapping. Model 1 assessed full mediation (see Figure 6) with no direct relationship between PSC and Readiness for Industry 4. Model 2 needed to be modified due to model saturation. The modified model assessed partial mediation. The modification in this model involved the removal of the effect of Attitude towards Organisational Change on Innovation Capacity to allow for a minimum number of degrees of freedom. Model 3 assessed the direct relation (direct effect) between PSC and Innovation Capacity, Innovation and readiness and Attitude towards Organisational Change and readiness for Industry 4.0 (see Appendix E). Both models 2 and 3 presented a poorly fitting model for the data (see Table 3). Model 1 (Full mediation), however, proposed a good fit to the data (see Figure 6).

Figure 6

Full Mediation Model (Model 1) from PSC to Innovation Capacity Mediated by Innovation Capacity and Attitude towards Organisational Change



The results from the path analysis (see Table 3) suggests that Model 1 was the only model that proposed a good fit to the data. The chi-square test (χ^2 (1) = 1.78, p = .18) was not significant, indicating a good fit between the model and the data. The GFI and CFI both exceeded the .95 cut-off for a good-fitting model. The RMSEA was 0.6, indicating an acceptable fit, with a PCLOSE value greater than 0.05. The models were also compared with each other using the chi-square difference test. The difference between the chi-squares of Model 0 (null model) and Model 1 was significant M0vM1 (5)67.85 with p <.001, indicating that Model 1

has a better fit. Model 1 and Model 2 had the same degrees of freedom and could be compared directly. Comparing the fit indices shows that Model 1 is a better fit for the data. Lastly, the difference between the chi-squares of Model 3 and Model 1 was also significant M3vM1 (1) 79.18 with p <.001 once again, indicating that Model 1 has a better fit.

Table 3

Model Fit Indices for the Pathway Analysis from Psychosocial Safety Climate to Readiness for Industry 4.0

	CFI	*GFI*	*RMSEA*	*PCLOSE*	*df*	χ^2
Null Model (Model 0)	.00	.46	.60	<.001	6	69.63^{***}
Full Mediation Model (Model 1)	.99	.99	.06	.281	1	1.78^{ns}
Partial Mediation Model (Model 2- modified)	.93	.93	.38	<.001	1	29.31^{***}
Direct Effect (Model 3)	.61	.79	.64	<.001	2	80.96^{***}

Note. $^{ns}p > .05$, $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

3.4.2 Direct and Indirect effects

The results indicated that Model 1, where the relationship between PSC and Readiness for Industry 4.0 was mediated by Attitude towards Organisational Change and Innovation Capacity, was the best fitting model to the data (see Figure 7). The significance of the direct and indirect effects within the model was tested using bootstrapping procedures with 2000 iterations with a 95% confidence interval. The standardised direct effect of PSC on Attitude towards Organisational Change, Attitude towards Organisational Change on Innovation Capacity, Attitude towards Organisational Change on Readiness for Industry 4.0 and the direct effect of Innovation Capacity on Readiness for Industry 4.0 were all statistically significant (see Table 4). However, the standardised direct effect of PSC on Innovation Capacity was not statistically significant (see Table 4). The significance of the standardised indirect effect of PSC on Readiness for Industry, PSC on Innovation Capacity and Attitude towards Organisational Change on Readiness for Industry 4.0 were also statistically significant, indicating mediation. Specific user-defined pathways were also tested. The indirect effect of PSC on Readiness for Industry 4.0 through Innovation Capacity was statistically not significant. However, the indirect effect of PSC on Readiness for Industry 4.0 through Attitude towards Organisational Change and the indirect effect of PSC on Readiness for Industry 4.0 through Attitude towards Organisational Change and then Innovation Capacity were both statistically significant. Therefore, this exemplifies how Attitude towards Organisational Change mediates the relationship between PSC and Readiness for Industry

4.0, both with and without including Innovation Capacity in the pathway. Therefore, two of the three pathways were statistically significant (see Table 3).

Figure 7

User Defined Regression Paths for Model 1

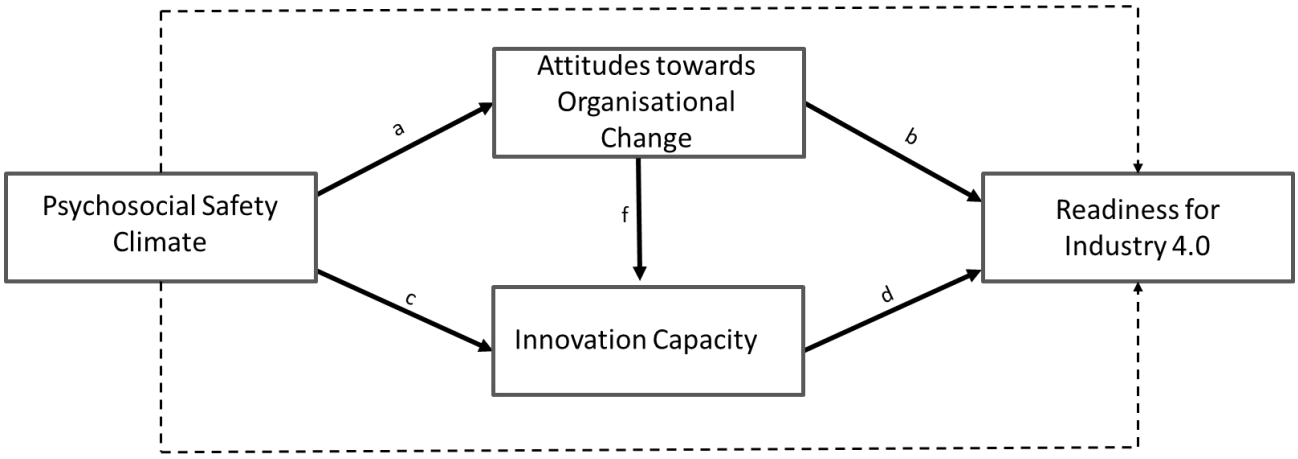


Table 4

Regression Weights for Direct, Indirect and User Defined Pathways for Model 1

Direct Effects	*β*	*Standard Error*	*95%CI* [LL,UL]
PSC → Innovation Capacity	.14^{ns}	.12	-.08, .34
Innovation Capacity → Readiness for Industry 4.0	.63**	.05	.52, .74
PSC → Attitude towards Organisational Change	.75**	.04	.67, .81
Attitude towards Organisational Change → Readiness for Industry 4.0	.21**	.07	.07, .33
Attitude towards Organisational Change → Innovation Capacity	.49**	.10	.30, .68
Indirect Effects	***β***	***Standard Error***	***95%CI*** [LL,UL]
PSC → Readiness for Industry 4.0	.47**	.05	.37, .58
PSC → Innovation Capacity (through ATOC)	.37**	.76	.23, .52

Attitude towards Organisational Change → Readiness for Industry 4.0	.31**	.66	.18, .44
User Defined Paths	*β*	*Standard Error*	*95%CI* [LL,UL]
Path a x b	.13**	.04	.05, .20
Path c x d	.72ns	.06	-.04, .19
Path a x f x d	.19**	.05	.11, .30

Note. ns $p > .05$, * $p < .05$, ** $p < .01$.

The preliminary analysis results revealed positive and significant correlations between PSC and Attitude towards Organisational Change, PSC and Innovation Capacity, PSC and Readiness for Industry 4.0, Innovation Capacity and Attitude towards Organisational Change, and Attitude towards Organisational Change and Readiness for Industry 4.0. In particular, the correlations between PSC and Attitude towards Organisational Change and Innovation Capacity and Readiness for Industry 4.0 were strong (see Table 2).

The best-fitting model (Model 1) accounted for 58.9% of the variance in Readiness for Industry 4.0. All direct pathways except the one from PSC to Innovation Capacity (H3) were significant, reconfirming hypotheses 2, 5, 6 and 7. The best-fitting model did not include the pathway assessing the direct effect of PSC on Readiness for Industry 4.0; therefore, Hypothesis 1 was partially supported by Model 1. Lastly, it was hypothesised that Innovation Capacity and Attitude towards Organisational change would mediate the relationship between Psychosocial Safety Climate and Readiness for Industry 4.0. As the indirect effect of PSC on Readiness for Industry 4.0 was significant through Attitude towards Organisational Change both with and without including Innovation Capacity in the pathway, Hypotheses 8 was fully supported, and Hypotheses 4 was partially supported.

3.5 Discussion

The results from this study highlight the importance of social system factors and mindsets of organisations in preparing themselves for transitioning to Industry 4.0. Businesses that have adapted early and implemented Industry 4.0 technologies understand how advantageous it can be for positive business outcomes (Hamada, 2019; Yilmaz et al., 2021). This understanding, combined with the results of this study, reiterates the importance of organisations creating a suitable organisational climate for employees to be prepared for Industry 4.0 technologies and the future of work.

This study examined the social systems factors that influence organisations' ability to prepare for Industry 4.0. This study also assessed the mediating effect of Innovation Capacity and Attitude towards Organisational Change on the relationship between Psychosocial Safety Climate (PSC) and Readiness for Industry 4.0. Overall, the results were able to statistically identify and explain that when organisations have high PSC, both Attitude towards Organisational Change and Innovation Capacity help improve the 'skills' and 'business' Readiness for Industry 4.0.

The significance of a predefined pathway (grounded in theory) was assessed through this research. The results from the analysis were able to identify the factors in an organisation that support advancement into the future of work; having high psychological safety, a positive attitude towards organisational change and high innovation capacity. In line with the findings from a study by Lee & Idris, 2017; the results suggested that when managers took a proactive approach towards safeguarding employee well-being, they were able to provide the resources to create a climate that makes employees feel safe and valued and empowered to be better prepared for the future of work (Lee & Idris, 2017). More specifically, the results reveal that when organisations have a high PSC, it enables and encourages employees to have more positive attitudes towards organisational change, become more resilient, and, in turn, have a higher capacity for innovation, making them ready for better prepared to transition into the fourth industrial revolution.

The primary goal of using path analyses using Structural Equation Modelling (SEM) was to determine to what extent the hypothesised models fit or adequately describe the sample data. Upon analyses of the three different hypothesised models, the model with full mediation was able to statistically explain the pathway between PSC and Readiness for Industry 4.0 (see Table 4). The results from the path analyses revealed significant mediation, suggesting that having a positive attitude towards organisational change is a key determinant of how prepared individuals are for increased digitalisation in their workplace. As discussed in Section 3.2.2, change is a key driver of innovation. Therefore, the impact of this attitude on increased innovation capacity in this study reconfirms this theory and suggests that organisations that are more resilient and have a positive attitude towards change are able to create a suitable climate for employees to have higher innovation capacities. Interestingly, in the pathway, both attitudes towards organisational change and innovation capacity are significant mediators between PSC and Readiness for

Industry 4.0. This finding reaffirms the importance of having a positive psychosocial climate with supportive managers who can create a suitable environment for employees to have a positive and open attitude towards organisational change and be innovative. The model also suggests that organisations that are committed to and prioritise creating a culture where employees feel safe and supported are more likely to have better attitudes and have the 'correct' climate to ideate and implement novel ideas. All three social systems factors form a meaningful chain of interactions to equip organisations with many essential skills and resources needed to enhance their business and skills readiness for Industry 4.0. Furthermore, The results enhance our understanding of how readiness for Industry 4.0 does not occur in a vacuum; instead, it is a multi-level procedure requiring attention to different aspects of organisations (social and technological).

In addition to the pathway explained, another interesting finding from the results revealed that removing the direct relationship between PSC and Readiness for Industry 4.0 strengthened the mediation pathways through Attitude towards Organisational Change and Innovation Capacity. This again confirms that having managers who value employee well-being is conducive to organisations being more productive, innovative and better prepared for the future. However, simply having supportive managers who prioritise employee well-being is insufficient to improve preparedness for Industry 4.0. Nevertheless, it is evident that an organisation's PSC has significant indirect impacts on Industry 4.0 readiness with a strong influence on employee attitude towards organisational change and organisational innovation capacity.

Model fit indices from the pathway analyses indicate that overall, the hypothesised pathway is robust and suggests that predictive relationships exist between the variables as described by the model. The findings support the notion that PSC is a precursor to having a higher innovation capacity and more positive attitudes towards change, making it an essential element to consider when preparing for Industry 4.0. If the association between PSC and Readiness for Industry 4.0 is mediated by Innovation Capacity and Attitude towards Organisational Change, there is cause to believe that high PSC affects an organisations' ability to be innovative and be more comfortable with changes at work. As a result, they will be better equipped to face the difficulties associated with preparing for Industry 4.0.

Upon comparing the direct and indirect effects of the three social systems factors, it is evident that Innovation Capacity was the most significant contributor ($\beta = .63$, $p < .01$) towards explaining and predicting organisations' Readiness for Industry 4.0. This finding is in line with previous literature and theoretical assumptions made in the current study. When trying to understand what social systems factors help organisations prepare for Industry 4.0, Innovation Capacity had the strongest ability to predict organisations' readiness. Therefore, organisations must focus on creating a suitable climate that enables and empowers employees if they want to optimise their innovative capacity. This suitable organisational climate can be created through management prioritising employee wellbeing and open communication

channels. Managers can also ensure employees have positive attitudes towards change through effective change management and avoiding change fatigue.

Finally, the path analysis also accounted for 59% of the variance in Readiness for Industry 4.0. A high percentage of variance explained in a given model indicates stronger strength of association between the variables. This implies that focusing on improving variables that predict Readiness for Industry 4.0 can enable organisations to be better equipped to deal with the challenges of preparing for the future of work.

3.5.1 Theoretical Implications

The majority of literature discussing readiness for Industry 4.0 focuses on the technological advancements and technical skills necessary to progress into the future of work. This study, in contrast, is built upon a theoretical assumption: that there is a lack of knowledge about social systems factors that might impact organisations' readiness for Industry 4.0. This study presents a new theorisation and a new theoretical model that looks at the future of work through a 'social systems' lens. This study then also tests the theoretical model, significantly contributing to the literature by providing a psychological and social perspective that will change how people understand technological advancements. This supports a growing body of literature that strongly suggests that Industry 4.0 should not be reduced to technical elements, as it results from a complex interaction of varied technical and social factors (Prodi et al., 2021; Sony and Naik, 2020). The increased understanding of Industry 4.0 also alleviates the imbalance in the current literature between technical and social systems factors allowing for the creation of more holistic Cyber-Physical Systems in the future.

3.5.2 Practical Implications

Given the exponential growth of production and competition, businesses are trying to keep up with technological advancements to increase their productivity (Hamada, 2019). From a practical perspective, this research informs practitioners to go beyond the technical aspects to prepare for Industry 4.0. It advises managers on how to create a climate that fosters innovative capacity and positive attitudes towards organisational change by improving their PSC levels, promoting employee well-being and creating open communication channels. It highlights the importance of these critical factors that can help practitioners and businesses prepare for Industry 4.0 and reiterates that focusing on employee health and wellbeing is beneficial for employees and has a significant impact on productivity outcomes as well (Bailey et al., 2015). This study also points to the importance of PSC and a positive attitude towards change in improving innovation capacity (statistically, the strongest predictor of Industry 4.0 readiness). Finally, this study also informs practitioners not just to look externally to improve business value but also to focus on the organisation's inner workings, interpersonal dynamics and competencies to prepare for Industry 4.0. The

findings from this research could also inform industries on ‘best practice’ guidelines that can enable an easier transition into Industry 4.0.

3.5.3 Strengths, Limitations and Future Directions

Given that this study aimed to understand the importance of social systems factors in preparing organisations for Industry 4.0, one of the primary strengths of this study is an increase in the understanding of Industry 4.0. Another strength was that each participant (n=192) belonged to a different organisation, and no two participants came from the same organisation.

A few limitations of the current study have also been identified, which may have impacted the results. The data from this study was cross-sectional and was collected using self-report surveys. While pathway analyses enable the establishment of causal relationships, having cross-sectional might limit the ability to draw conclusions that are ‘causal’. This also suggests that social desirability bias may have affected the study’s outcomes. Furthermore, the study’s reliance on data collected solely from organisational decision-makers introduces a notable influence on the interpretation of the results. While this approach allowed for a focused examination of managerial perspectives, it may introduce a potential limitation in terms of overestimation bias. Previous research (Huang et al., 2007) has indicated that individuals in leadership roles may sometimes overestimate or misperceive certain organisational aspects, including safety culture. Additionally, studies (Loh et al., 2021; Loh et al., 2019) have highlighted the importance of considering variations in perceptions across different levels within an organisation. Decision-makers' viewpoints, while valuable, may not fully capture the nuances and diversity of perspectives that exist among employees at various hierarchical levels, potentially leading to an overestimation of certain organisational factors. Another limitation worth noting is that this study adopted a breadth-focused approach, utilising one person per organisation as the unit of analysis, to explore Industry 4.0 preparedness. This choice prioritised broad representation from multiple organisations but may have limited the depth of insights gained.

Future research could address these limitations by conducting comprehensive assessments of Psychosocial Safety Climate (PSC) involving employees at various hierarchical levels and incorporating qualitative analyses of Industry 4.0 preparedness to provide more profound insights complementing quantitative findings. Longitudinal data collection could also be considered, especially when studying how social system factors evolve with increasing Industry 4.0 readiness. Employing a mixed-method approach, including qualitative, quantitative, and objective measures, can offer a multi-dimensional understanding of optimising Industry 4.0 readiness. Additionally, further exploration is warranted to understand the unexplained 41% of social readiness variance. Future research avenues should also investigate how these social system factors impact financial outcomes, personnel diversity, and technological advancements, essential for organisations aiming to thrive in the context of Industry 4.0.

3.6 Conclusion

This study presents a new outlook in theorising Industry 4.0 through a 'social systems' lens. The hypothesised pathway accounted for almost 60% of the variance in explaining business and skills readiness for Industry 4.0. 'Readiness for Industry 4.0' as a construct is more multidimensional than originally understood through existing literature (i.e., encompassing the integration of social systems factors). This research reiterated the importance of prioritising employee wellbeing to create a suitable climate for employees to develop a positive attitude towards organisational change and become more innovative. This chain of interactions amongst the described variables in this study will lead to organisations being better prepared to implement Industry 4.0 technologies. The impactful findings from this study provide avenues for future research to further this social systems understanding and improve organisational performance and outcomes related to Future of Work preparedness. The conclusions of this research will also help design social systems interventions aimed at improving the social systems aspects of businesses as they adopt Industry 4.0 and prepare themselves for the future of work.

CHAPTER 4: Bottom Line at the Top; Leveraging Social Systems Factors for Organisational Growth in Industry 4.0 (Study 2)

The research described in this chapter designated Study 2, builds on the findings from Study 1 (Chapter 3). This chapter uses data linkage methodology to investigate the effect of social systems factors on the bottom line i.e., the financial growth of organisations.

4.1 Abstract

While there is extensive literature promoting the implementation of Industry 4.0 technologies for improved business outcomes, there still exists a shortage of empirical studies demonstrating a concrete relationship between Industry 4.0 preparedness and the financial growth of organisations (Kamble et al., 2018). More specifically, from a social systems perspective, there is limited literature examining the impact of increased 'human' preparedness (for Industry 4.0) of organisations on monetary business outcomes. To bridge this gap, this study examines the link between readiness for Industry 4.0, social systems factors and the financial growth of organisations.

For this study, business decision-makers from 192 different organisations completed a self-report survey about their organisation's readiness for Industry 4.0 and the three social systems factors relating to organisational safety climate, employee attitudes and innovation capacity. Using data linkage, the participants' organisations' financial performance data was sourced and linked to the self-reported data set (also used in Study 1). The results from a hierarchical multiple regression analysis revealed that the addition of the variables 'Attitudes towards Change' and 'Innovation Capacity' and then of 'Psychosocial Safety Climate' did not improve the prediction of Financial Organisational Growth over and above Readiness for I4.0 alone. While the full model could predict a 7.6% variance in financial growth, the results were not significant. This study contributes to the literature by pointing to the importance of using longitudinal data and leading measures to understand the impact of specific factors on financial growth. The results also encourage a more holistic outlook on organisational growth, acknowledging that numerous factors interact with and impact organisations' financial growth. The findings from this study: a) establish a foundation for future research to further explore the indirect effect of social systems factors and readiness for Industry 4.0 on financial profitability, and; b) enable organisations to enter the fourth industrial revolution more informed on what steps to take to be better equipped to handle the demands of Future of Work.

4.2 Introduction

Industry 4.0 is the integration of complex physical machinery and devices with networked sensors and software used to predict, control and plan for better organisational and societal outcomes (Kamble et al., 2018). As introduced in the previous chapter, rapid digitalisation and globalisation in Industry 4.0 have placed exceptional pressure on organisations to keep abreast of technological advancements and adapt to changing consumer needs and government policies (Eslami et al., 2021; Kusiak, 2022). However, the number of key changes organisations need to undergo to transition to Industry 4.0 introduces new risks and threats to their business models, health and safety and financial profitability (Eslami et al., 2021; Potter et al., 2022; Schulte, 2020). Therefore, organisations must balance the pressure to increase digitalisation against the possible risk to their financial profitability and survival in the future of work (Kirby & Harter, 2003).

A literature review by Souissi & Zaoui, (2020) suggests that very few organisations are currently prioritising the financial risk of transitioning to Industry 4.0, with only nine per cent of the papers (31 total) focused on financial support, budgets and benefits as important factors necessary for transitioning to Industry 4.0. While there is some evidence that shows the potential lucrativeness of Industry 4.0, there is a clear need for further research to better understand the impact of implementing Industry 4.0 technologies on the bottom line of organisations (Kamble et al., 2018; Villar et al., 2020; Waschneck et al., 2016). As Study 1 (Chapter 3) discussed, social systems factors such as Psychosocial Safety Clime (PSC), Attitude towards Organisational Growth, and Innovation Capacity are pivotal in increasing preparedness for Industry 4.0. It is, however, also essential to consider whether an investment in these social systems factors is in line with the strategic financial goals set by the organisations. As organisations continue to understand the indirect benefits of implementing Industry 4.0 technologies to increase their digital maturity and preparedness for Industry 4.0, there is a growing need to understand why financing and R&D (research and development) of these technologies is a valuable investment (Alekseev et al., 2018; Bashtannyk et al., 2020). It is well understood that organisational performance goes beyond just measuring financial growth; however, recognising the direct financial advantage of digitalisation on a systems level is particularly beneficial to plan for the future of work (Schiuma et al., 2012).

Industry 4.0 could be financially lucrative. However, there is limited research that explores the link between Industry 4.0 preparedness and the financial growth of organisations. Given the numerous benefits of implementing Industry 4.0 technologies and the established link between Industry 4.0 and financial growth by previous studies, it is hypothesised that:

H1- *Organisations with better preparedness for Industry 4.0 will have higher financial growth.*

This research aims to address a gap in literature and connect important factors vital for preparedness for the future of work to financial organisational growth. A more nuanced gap is also observable from a social systems perspective; the limited research that is available discussing Industry 4.0 and financial profitability fails to consider a human-centred perspective to understand how better workforce preparedness for Industry 4.0 relates to increased profitability. There is indeed a growing need for organisations to recognise how investments in social elements of the business, such as employee wellbeing, psychosocial safety, work design and innovation can yield better ROI (Return on Investments), specifically through higher financial growth. Therefore, this study aims to answer if investing in improving social systems factors and better preparedness for Industry 4.0 can lead to better financial outcomes for organisations. More specifically, this study will build on the impact of key factors discussed in Chapter 3; Psychosocial Safety Climate, Innovation Capacity, Attitudes towards Organisational Change and general Preparedness for Industry 4.0 on the financial performance of organisations.

To explore the impact of social systems factors (relevant for Industry 4.0 preparedness) on the financial growth of organisations, it is necessary to first understand the link between each of the established social systems factors to organisational growth and productivity, which is discussed in the subsequent sections.

4.2.1 Innovation and Financial Organisational Growth

In today's competitive and constantly changing business environment, it is becoming increasingly important for organisations to be adaptable and have the capacity to innovate continually. In addition to learning to adapt, the demands of Industry 4.0 also require organisations to develop strategic business models that focus on innovation management and technological advancements to stay relevant and competitive (Metallo et al., 2018). Interestingly, an organisation's ability and capacity to innovate are positively associated with its decision to adopt new information systems (Hamada, 2019). In line with the findings from Chapter 3 (Study1), social and technological innovation in Industry 4.0 could be a game changer for businesses trying to take advantage of the fourth industrial revolution (Izadi Z.D et al., 2020; Mollaahmetoğlu & Akçalı, 2019). However, some significant barriers to organisations' preparedness for Industry 4.0 in the current economic climate are the volatility of the market, shorter product lifecycles, higher complexities, and delays in global supply chains (Xing et al., 2021). To overcome these barriers, it is suggested that organisations keep innovation at the centre of their business models and convert potential value-embedded technologies and processes into profitable and marketable outcomes (Metallo et al., 2018; Rajapathirana & Hui, 2018).

According to Rajapathirana and Hui (2018), in addition to improving organisations' digital maturity and preparedness for Industry 4.0, innovation is also directly linked to firm survival and financial success. To this effect, Hurley et al. (2005) claim that the capacity to innovate is the most important factor in organisational growth and is fundamental in achieving strategic business objectives and goals. Furthermore, some studies

suggest that a lack of investment in organisational innovation through R&D expenditure, talents, personal capability and attitudes may create an environment that inhibits the capacity of individuals to continually innovate (Cropley & Cropley, 2012; Hall & Howell-Moroney, 2012). This finding adds value to the research from Study 1, suggesting that organisations must create a suitable environment for employees to innovate for better preparedness for Industry 4.0. Therefore, from a financial perspective, organisations must keep investing in initiatives that support employee growth to foster a favourable environment that encourages innovation.

On the contrary, the literature also shows a strong counter-argument that may suggest a lack of a linear relationship between innovation and financial growth (Zhu et al., 2020). In their studies, Zhu et al. (2020) and Demirel and Mazzucato (2012) explain how the positive effect of innovation on growth can be minimal or even insignificant depending on the funds available to the company. Therefore, organisations with high innovation capacities and abundant cash flow might not experience large financial growth. While a vast body of literature points to the interconnectedness of innovation with Industry 4.0 and with various organisational growth outcomes, it is unclear if a linear relationship exists between financial growth and innovation (Belazreg & Mtar, 2020; Izadi Z.D et al., 2020; Kyläheiko et al., 2017; Qamruzzaman & Jianguo, 2017). Therefore, this study aims to explore the direct link between innovation capacity and the financial growth of organisations. It is hypothesised that:

H2- *Higher innovation capacity will lead to organisations having higher levels of financial growth.*

4.2.2 Attitudes towards Organisational Change and Financial Organisational Growth

Across many decades, there has been strong evidence in literature that points to the detrimental effects of resistance to change on organisational growth and performance (Appelbaum et al., 2015; Daovisan & Chamaratana, 2020; Gray, 2002). Attitude towards organisational change has been identified as a critical factor that can facilitate or inhibit I4.0 adoption of new technologies, making it clear that to survive in Industry 4.0, an organisation must adapt and to adapt, it must change (Hamada, 2019; Kursunoglu & Tanrıogen, 2009). To prepare themselves for the future of work, businesses must continually renew their direction, structure and capabilities to serve the ever-changing needs of internal and external stakeholders (Hamada, 2019; Todnem, 2005). More specifically, negative attitudes towards change or resistance towards change have been shown to impact self-esteem, motivation, productivity, need for achievement and locus of control (Oreg, 2006). Therefore, without the social acceptability of technology, organisations may incur losses on the money spent purchasing new technologies. To avoid these consequences, it is becoming increasingly important for organisations to engage in effective change management practices and adopt a healthy attitude towards change to make their businesses more profitable (Cugno et al., 2021; Todnem, 2005)

From a social systems perspective, recent literature also suggests that there are psychological reasons for the negative attitudes towards adopting I4.0. The inertial pressures on organisations caused by this resistance could stop organisations from considerably prospering in the future of work and, in turn, being more profitable (Hamada, 2019). While literature has long recognised the need for effective change management, it is equally crucial to comprehend how people's attitudes towards organisational change affect their financial growth outcomes, particularly in light of the growing digital maturity of organisations (Bonekamp & Sure, 2015; Bordeleau & Felden, 2019; Gilley et al., 2008). Considering these important findings, this study will examine how attitudes towards organisational change explain organisations' financial growth. Therefore, it is hypothesised that:

> H3- *Organisations with a more positive attitude towards change will display higher levels of financial growth.*

4.2.3 Psychosocial Safety and Financial Organisational Growth

As mentioned above, I4.0 is characterised by the digitalisation and automation of systems such as automated machinery, remote sensing and monitoring, big data, and autonomous equipment. As a result, Industry 4.0 technologies will bring new paradigm shifts that will inevitably impact occupational health and safety management and will therefore influence the future of work (Badri et al., 2018; Moore, 2019). Within the literature, there is a consensus that psychosocial hazards will be more prevalent and pervasive than traditional occupational health and safety hazards (Dollard, 2018; Schulte, 2020). Employees increasingly report heightened levels of stress, along with instances of musculoskeletal disorders and job losses, all of which contribute to heightened psychosocial risks. The current literature also points to the negative impact of poor psychosocial safety in organisations affecting the bottom line through costs associated with poor health outcomes (such as burnout, presenteeism, absenteeism and depression) for employees (Dollard, 2018; Loh et al., 2020; Rugulies et al., 2019). Given the profound influence of cognitive demands on occupational health and safety policies and practices, it becomes evident that the significance of psychosocial safety and its associated costs cannot be overstated in the context of future work preparations.

The significance of organisational climate in enhancing organisational outcomes such as job performance and job satisfaction is well understood in the literature (Lee & Idris, 2017). As discussed in Chapter 3, workplace health and safety is a significant driver of productivity, organisational growth and sustainability in contemporary organisations (Ansah & Mensah, 2020). While extant research predominantly emphasises the indirect mechanisms through which psychosocial safety climate (PSC) influences various organisational outcomes, it becomes increasingly apparent that the exploration of a direct influence of PSC on financial outcomes remains underexplored. The intricate nature of organisational dynamics suggests that the relationship between PSC and financial growth extends beyond mere mediation. PSC, as an important aspect of the organisational climate, holds the potential for direct impact on an organisation's financial

performance. Consequently, this study aims to explore this direct relationship, seeking to delve deeper into the intricate interplay between PSC and financial outcomes to understand the transformative role of PSC within the digital era.

In light of the compelling evidence within the contemporary literature, underscoring the importance of psychosocial safety and its implications for the future of work (as discussed in Chapter 3), it becomes crucial to explore the connection between an organisation's PSC and its financial growth outcomes. It is therefore hypothesised that:

> H4- *Organisations with high levels of PSC will also have higher financial growth outcomes.* (A complete list of the hypotheses is presented at the end of section 4.2.4)

4.2.4 Theoretical Hypotheses

Drawing together the arguments presented in the previous sections, it is evident that organisations need to go beyond the mere introduction of Industry 4.0 technologies to fully realise their benefits and prepare for the future of work (Eslami et al., 2021). As established in Chapter 3, through positive worker attitudes (towards organisational change) and higher innovation capacity, an organisation's safety climate significantly influences its ability to increase its digital maturity and preparedness for the future of work. Considering these critical findings and their relevance to organisational growth, this study focuses on examining the role social systems factors and readiness for Industry 4.0 play in explaining organisations' financial growth. This study examines this role by answering this research question:

> *How much variance in Financial Organisational Growth do the Readiness for Industry 4.0, PSC, Attitudes towards Organisational Change and Innovation Capacity explain?*

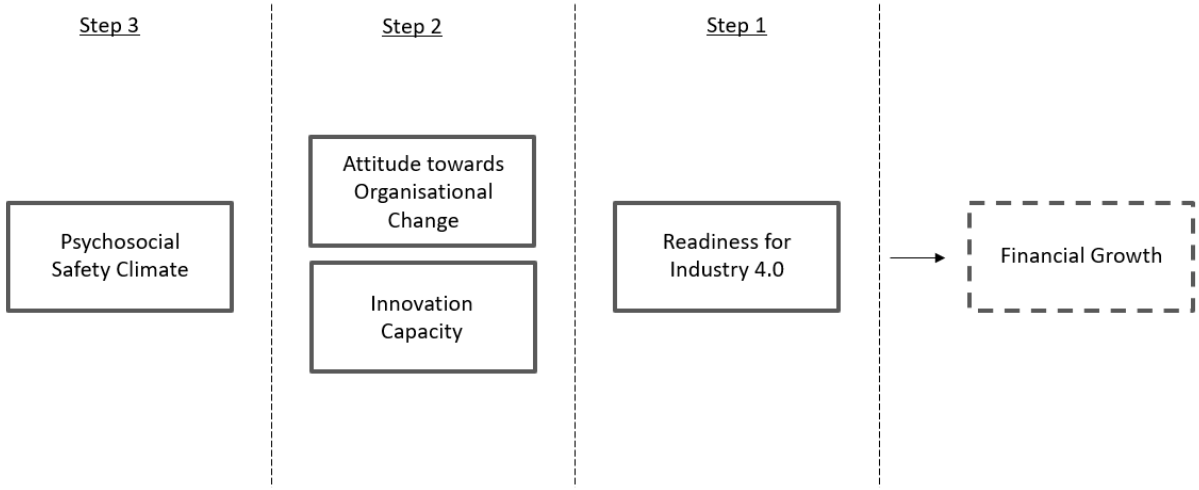
To answer the question, this study extends the theoretical pathway established in Chapter 3 and tests the established variables' impact on organisations' financial growth (see Figure 8). To test the degree to which each of the variables independently predicts financial growth, a Hierarchical Multiple Regression (HRM) will be utilised. Based on the current literature and theoretical assumptions, Readiness for Industry 4.0 is most closely related and will be added first. The effect of Readiness will then be controlled for, and Attitudes towards Organisational Change and Innovation Capacity will then be added. Finally, the effects of each 'step' (Attitude towards Organisational Change, Innovation Capacity and Readiness for Industry 4.0) will be controlled to examine the effect of PSC on Financial Organisational Growth (OG) above and over the other three predictor variables. Given the indirect link between PSC and Readiness for Industry 4.0, it is plausible that PSC will have the least direct effect on Financial Growth and will therefore be added last (see Figure 8 for a visual representation of the conceptual model used to justify the theoretical reasons for choosing the order of the variables entered). Based on these theoretical assumptions and due to the use of HRM, two new hypotheses will also be tested:

H5- *Attitude towards Organisational Change and Innovation Capacity will predict financial growth in organisations over and above readiness for Industry 4.0; and*

H6- *PSC will predict financial growth in organisations over and above Readiness for Industry 4.0, Attitude towards Organisational Change and Innovation Capacity.*

Figure 8

Theoretical Model for Hierarchical Multiple Regression



Complete list of hypotheses relevant to this study

1) Readiness for Industry 4.0 will predict financial growth in organisations.
2) Innovation Capacity will predict financial growth in organisations.
3) Attitude towards Organisational Change will predict financial growth in organisations.
4) PSC will predict financial growth in organisations.
5) Attitude towards Organisational Change and Innovation Capacity will predict financial growth in organisations over and above readiness for Industry 4.0.
6) PSC will predict financial growth in organisations over and above Readiness for Industry 4.0, Attitude towards Organisational Change and Innovation Capacity.

4.3 Method

4.3.1 Participants

Participants were recruited through Qualtrics academic services using bulk email invitations. A 91-item survey was completed by 192 participants who passed the screening questions. The participants understood their business processes and were decision-makers in their organisation (as assessed by the screening questions). Participants who did not identify as business decision-makers, who were not employed by a publicly listed Australian organisation, or who were under the age of eighteen were excluded from the study. Personal demographic information such as age and gender were also not collected to ensure the anonymity of the participants.

4.3.2 Measures

To address the hypotheses formulated in this chapter, this study used four self-report scales to measure: (a) Innovation Capacity; (b) Attitudes towards Organisational Change; (c) Psychosocial Safety Climate and; (d) Readiness for Industry 4.0. These scales are described below. Data linkage was then used to access organisational growth data using two business databases- 1) DatAnalyses Premium and; 2) Company 360 (see Appendix F for examples)

Psychosocial Safety Climate was measured using PSC-12 (Hall et al., 2010). The PSC-12 consists of four subscales, with three items in each subscale. The 12 statements relating to PSC are rated on a 5-point Likert scale (*1- strongly disagree to 5- strongly agree*) and examine four core dimensions of employee psychological health and safety: (1) management commitment; (2) management priority; (3) organisational communication, and; (4) organisational participation and involvement (see Appendix A). The reported validity and reliability of the scale are high (Hall et al., 2010). The Cronbach's α for the current study is .86.

Innovation Capacity was measured using the Innovation Phase Assessment Instrument (IPAI). The IPAI (extended version) has 168 true/false items measuring 42 nodes (Cropley et al., 2013). The current study used three subscales (consisting of 30 questions) from the IPAI focusing on: (1) the environment for innovation; (2) attitudes to innovation, and; (3) processes for innovation. The 30 statements relating to Innovation Capacity are rated on a 5-point Likert scale (*1- strongly disagree to 5- strongly agree*), with each statement having an ideal response. The respondents' answers are compared to the ideal answers, and an alignment percentage or level of Innovation Capacity score is generated. The three subscales measured were used to reduce participant burden and ensure the assessed content was relevant to the research questions (see Appendix B). The IPAI has been administered to several organisations and is a highly reliable measure (as a scale and as subscales) (Cropley et al., 2013). The Cronbach's α for the current study is .80.

Attitude towards Organisational Change was measured using the Organisational Change Questionnaire-Change, Processes and Readiness (OCQ-C, P, R) (Bouckenooghe et al., 2009). OCQ-C, P, R measures climate

of change, attitudes towards the organisational change process and the readiness for change. It is a 52-item scale with 11 dimensions; five climate of change dimensions, three process-of-change dimensions and three readiness-for-change dimensions (Bouckenooghe et al., 2009). The current study used six subscales from the OCQ- C, P, R. The selected subscales comprised 20 questions and were chosen based on the factor analyses of the scale; (1) participatory management; (2) involvement in the change process; (3) attitudes of top management; (4) intentional readiness for change; (5) cognitive readiness for change, and; (6) emotional readiness for change (Bouckenooghe et al., 2009). The number of questions was reduced to ensure that the assessed content was relevant to the research questions and reduced the participant burden (see Appendix C). The OCQ- C, P, R is rated on a 5-point Likert scale (*1- strongly disagree to 5- strongly agree*) and has been administered to more than 3000 organisational members from the private and public sectors and the analysis of their responses indicated high reliability for OCQ- C, P, R subscales (Bouckenooghe et al., 2009). The Cronbach's α for the current study is .80.

Readiness for Industry 4.0 was measured using a questionnaire developed for a local government project using existing literature and within the Australian context; The *Industry 4.0 Transformation: Embracing Digital Innovation in Manufacturing Industries* survey instrument (Xing et al., 2021). The Questionnaire consisted of 81 questions and five subscales measuring organisations: (1) business readiness; (2) technology readiness; (3) skills readiness; (4) supply chain readiness and; (5) innovation readiness. The 28 statements relating to Readiness for Industry 4.0 are rated on a 5-point Likert scale (*1- strongly disagree to 5- strongly agree*) and examine business and skills readiness of Industry 4.0. This study did not use the Innovation Readiness subscale as innovation readiness was already being measured through the IPAI. Business and skills readiness were measured to ensure that the assessed content was relevant to the research questions and focused on the 'social systems factors' (see Appendix D). The Cronbach's α for the current study is .78.

Organisational Growth (OG) was measured by using data linkage. The organisation's name (as reported by the participant) was entered into two databases- DatAnalyses Premium and Company 360. Organisational growth statistics such as Return on Investment (ROI), Gross percentage of growth and Net growth percentage were all available on these databases. The most recently available Net growth percentages (ranging between 2007-2017) for each organisation were extracted for analysis as it is a strong measure of financial growth for companies, indicating the profitability and operational efficiency of the business. This metric considers all factors that impact earnings, including revenue growth, expense management, and other income and expenses, providing a holistic view of a company's financial growth. Moreover, the net growth percentage is useful for comparing companies, as it is a standard financial metric that can help investors and stakeholders determine which companies are growing faster than others within the same industry (see Appendix F for examples of the databases' interfaces).

4.3.3 Procedure

Ethics was approved by the Human Research Ethics Committee of University of South Australia. Data about social systems factors and Industry 4.0 readiness for individual organisations were collected through a questionnaire on an online platform, Qualtrics. All participants were presented with a participant information sheet before consenting and commencing the online survey. The information sheet detailed the participant's rights and briefly explained the premise of the study. The surveys took approximately 11 minutes to complete. Screening questions included the participant selecting their organisation's name, checking if they were over eighteen, were a business decision maker and worked for a publicly listed company in Australia (to ensure the growth data can be extracted). Using data linkage, this information was used to extract financial growth outcomes. Raw data from Qualtrics and data linkage were then exported to SPSS for statistical analyses.

4.3.4 Statistical Analysis

The present study utilised a quantitative cross-sectional design using an online self-report questionnaire measure and data linkage. The data were analysed using Hierarchical Multiple regression using SPSS. Descriptive analyses were carried out to examine the financial organisational growth of organisations (OG) and the predicting variables. Predicting variables include Readiness for Industry 4.0, PSC, Attitudes towards Organisational Change and Innovation Capacity. Pearson coefficients were computed to examine the relationship of OG with the predicting variables and the relationship between the predicting variables themselves.

Next, to answer the research question, "How much variance in organisational growth do the Readiness for Industry 4.0, PSC, Attitudes towards organisational change, and Innovation Capacity explain?", a Hierarchical Multiple Regression (HRM) was utilised. The predictor (independent) variables in the regression were Readiness for Industry 4.0, Psychosocial Safety Climate (PSC), Innovation Capacity (IC) and Attitudes towards Organisational Change (ATOC) and the dependent variable was Financial Growth of Organisations (OG). The regression was used to test theoretical assumptions derived from the literature and examine the effects of the RI4 and the three social systems factors on Organisational Growth sequentially. There is sufficient literature to support the positive effect of Industry 4.0 on increasing competitiveness and financial growth. Therefore, the HRM allowed the assessment of the degree to which the predictor variables, PSC, ATOC and IC, could account for the variance in Organisational Financial Growth over and above Readiness for Industry 4.0. Strong evidence from the literature also supports the idea that innovation capacity and a positive attitude towards organisational change are important for achieving successful organisational growth outcomes. Lastly, as established in Chapter 3, it can easily be inferred that PSC has strong indirect effects on organisational growth outcomes. Therefore, while there is evidence supporting a

relationship between PSC and Organisational growth, there might not be a direct effect. Therefore, based on the theoretical assumptions, Readiness for Industry 4.0 will be added first. The effect of Readiness will then be controlled for, and Attitude towards Organisational change and Innovation Capacity will be added. Finally, the effects of both Attitude and Innovation Capacity will be controlled to examine the effect of PSC on Financial Organisational Growth above and over the other three predictor variables.

4.4 Results

4.4.1 Normality and Preliminary Analysis

Preliminary assumption testing was conducted to check for normality, linearity, outliers, and multicollinearity, with no serious violations noted. However, representing the natural world and in line with theoretical assumptions, IC and RI4 were moderately positively skewed.

Preliminary analysis was then conducted using descriptives and Pearson's correlations to better understand the data set and answer Hypotheses 1, 2, 3 and 4 (see Section 4.2.4). Table 5 contains the correlations: Pearson *r,* means and standard deviations of the variables in the study. As anticipated, the predictor variables all positively and significantly correlated with each other; however, the dependent variable, Organisational Financial Growth (OG), did not significantly correlate with any of the predictor variables.

Table 5

Pearson's Correlations and Descriptive Statistics for the Variables being Assessed

	Pearson's r					*Descriptives*	
Variable	OG	IC	ATOC	PSC	RI4	*M*	*SD*
Organisational Growth (OG)							
Innovation Capacity (IC)		-				57.45	9.14
Attitude towards Organisational Change (ATOC)		.597**	-			3.67	0.41
Psychosocial Safety Climate (PSC)		.509**	.752**	-		3.93	0.56
Readiness for Industry 4.0 (RI4)	-	.750**	.580**	.514**	-	3.99	0.46

*Note. N= 192. *p < .05, **p < .001*

4.4.2 Hierarchical Multiple Regression

A hierarchical multiple regression was run to determine if the addition of Attitude towards Organisational Change and Innovation Capacity and then of PSC improved the prediction of Organisational Growth over and above Readiness for I4.0 alone (see Table 6).

The assumptions essential to conduct a hierarchical multiple regression (linearity, homoscedasticity, multicollinearity, independence of residuals and normality) were met. For the analysis, the predictor

variables were entered within three successive steps. In the first step, Readiness for Industry 4.0 was introduced as the predictor variable to test the variance explained by RI4. After controlling for RI4, adding Attitudes towards Organisational Change and Innovation Capacity to the prediction of Organisational Growth in step 2 (Model 2) did not lead to a statistically significant increase in R^2 = .036, F(2, 108) = 2.100, p = 0.127. After controlling for RI4, ATOC and IC in Step 3, the addition of Psychosocial Safety Climate to the prediction of Readiness for I4.0 (Model 3) also did not change the model significantly. R^2 of .003, F(1, 107) = 0.350, p = 0.556. The full model (Model 3) was statistically not significant, R^2 = 0.076, F(4, 111) = 2.195, p = 0.074. Interestingly, while the full model could predict a 7.6 % variance in financial growth, the results are not significant.

Table 6

Hierarchical Multiple Regression Predicting Organisational Growth from Readiness for Industry 4.0, Innovation Capacity, Attitudes Towards Organisational Change and PSC

	Readiness for I4.0					
	Model 1		Model 2		Model 3	
Variable	B	*β*	B	*β*	B	*β*
Constant	-58.10		-102.05		103.82	
RI4	20.11*	0.19	17.02	0.16	17.10	0.16
ATOC			27.15*	0.24	21.29	0.19
IC			-0.76	-0.14	-0.86	-0.16
PSC					7.37	0.084
R^2	0.037		0.073		0.076	
F	4.200*		2.828*		2.195	
$\triangle R^2$	0.037		0.036		0.003	
$\triangle F$	4.200*		2.100		0.350	

*Note. N= 112. *p < .05, ** p < .001*

4.5 Discussion

This study represents a novel attempt at examining the direct effect of an organisation's readiness for Industry 4.0, attitude towards organisational change, innovation capacity and psychosocial safety climate on financial growth. The purpose of the study was to address the theoretical gap in literature and examine what level of Industry 4.0 preparedness and which key social systems factors could directly contribute to explaining financial organisational growth. Through an enhanced theoretical and practical understanding of the financial importance of social systems factors, this study also aimed to pioneer the creation of dialogue that enables practitioners and researchers to justify spending their resources to enhance the social systems factors and, in turn, be better prepared for the future of work (specifically from a digital transformation perspective). However, contrary to expectations, this study found that none of the social systems factors or business and skills readiness for Industry 4.0 were associated with the financial growth of the organisations. Possible explanations for these unexpected findings are discussed next, followed by the implications and limitations of these findings.

Hypotheses 1, 2, 3 and 4 predicting a positive correlation between the predictor variables and financial growth were not supported (see Section 4.2.4). While the predictor variables positively correlated (see Table 2), contrary to the hypothesis, none significantly correlated with organisations' financial growth. The findings from Chapter 3 (Study 1) indeed suggested that when managers took a proactive approach towards safeguarding employee well-being, they can provide the resources to create a climate that makes employees feel safe and valued, have better innovative capacity and resilience and are better prepared for Industry 4.0. However, this significant interaction between the predictor variables established in Chapter 3 does not lead to a significant increase in organisations' financial growth or bottom line.

Similarly, hypotheses 5 and 6 (corresponding to Models 2 &3 in the HRM) that sequentially predicted financial organisational growth were also not supported. The results from the hierarchical multiple regression revealed that Readiness for Industry 4.0, Attitudes towards Organisational Change, Innovation Capacity, and PSC could not significantly predict Financial Organisational Growth. The test indicated that while the full model (with all predictor variables) could explain approximately 7% of the variance in Financial Organisational Growth, the results are not significant. This suggests that Readiness for Industry 4.0, Innovation Capacity, Attitudes towards Organisational Change and PSC do not have a causal effect on financial growth, and the social systems factors do not significantly explain any extra variation when added stepwise into the hierarchical model. In other words, having a good readiness for Industry 4.0, a positive attitude towards organisational change, and high levels of innovation capacity and PSC do not translate to organisations being remunerative. However, not seeing a direct relationship poses an important question: Without clearly defined immediate benefits to the bottom line, why should companies continue to invest in improving their social systems factors and get ready for Industry 4.0 (Schiuma et al., 2012)? To answer this

question, it is valuable to explore the results of the current research and use these to inform future research directions. The findings from this research are different from the theoretical assumptions made based on literature and findings from the previous study (Chapter 3). Furthermore, upon evaluation of the results of this study, it is also evident that an increase in financial revenue may not be one of the positive outcomes of socially being ready for Industry 4.0. There are several plausible reasons why that might be the case.

Financial growth is a multifaceted variable influenced by a myriad of factors, which may lead to complex relationships in empirical analyses, such as those observed in this study. One aspect that warrants consideration is the high correlation between predictor variables, including readiness for Industry 4.0, attitude towards organisational change and psychosocial safety climate, which could have impacted the study's results in various ways. Firstly, the presence of high correlations can introduce suppression effects, wherein the influence of a predictor variable on the dependent variable is underestimated or masked when other highly correlated predictors are included in the model (Tzelgov & Henik, 1991). Consequently, significant relationships that may have been observed in isolation, such as the positive correlations between these predictor, could become non-significant within a multifactorial model. Secondly, overlapping variance among highly correlated variables can pose challenges in isolating the unique contributions of each predictor to the dependent variable (financial growth), potentially leading to non-significant findings as the explained variance is shared among correlated factors (Lorenzo-Seva, 2013). Thirdly, complex interactions between highly correlated variables may give rise to non-linear or conditional effects that escape detection in a simple linear regression model, which could further obscure the relationships between social systems factors and financial growth (Bonate, 2017). Lastly, it's important to note that the impact of high correlations is more pronounced in smaller sample sizes, potentially reducing statistical power and increasing the likelihood of non-significant findings due to the shared variance among predictor variables (Bujang & Baharum, 2016).

It is crucial to keep in mind that organisational growth data is historical and serves as a lagging indicator that helps determine whether a previous goal was achieved. However, the model used in this research used leading measures (predicting the success of goals in the future) collected cross-sectionally at a single time point. Moreover, the net growth percentage data utilised to assess financial growth was collected from multiple years, which might have increased the variability of confounding variables due to changes in economic or market conditions and the company's operations over time. Therefore, the outcomes may not demonstrate a direct correlation with the bottom line owing to the temporal disconnect between data collection time points. To observe a clear return on investment in social systems factors, organisations may need to first invest time, money, and effort into improving their culture, innovation, workforce, readiness for Industry 4.0, and subsequently measure financial growth at a later time point. Given the lack of an

intervention, it can be presumed that the independent variables will remain stable and comparable to the historical growth data. Focusing solely on short-term financial gains may be misleading and harmful to the sustainable growth of organisations (Ahmad et al., 2004). Considering the time required to observe the effect of R&D on financial growth, this finding suggests that organisations should prioritise long-term financial planning when preparing for the future of work. Additionally, there is a strong likelihood of other factors mediating and moderating the relationship between social systems factors and financial growth. Previous research also suggests that organisational culture, supply chains, time, and investment in research and development (R&D) are critical factors to consider when exploring the financial growth of organisations (Bailey et al., 2015; Chang et al., 2016; Grewatsch & Kleindienst, 2017)

This leads to the final plausible explanation of the current results. It is indeed also likely that the social systems factors do not directly impact organisational growth. Existing literature already points to the importance of these factors in improving the competitiveness of organisations and influencing other growth outcomes such as job performance, job satisfaction, employee motivation, employee well-being, lower work stress and decreased absenteeism (Bailey et al., 2015). As discussed by Schiuma et al. (2012), there is substantial evidence to support the link between competitiveness and financial growth, suggesting that even when organisations may not be able to see a direct effect of their business practices on their bottom line, improving other organisational outcomes, by focusing on social systems factors and preparedness for the future work, may indirectly affect the financial outcomes. Consequently, not investing in these social systems factors may have detrimental effects. For example, from a change management perspective, organisations with a negative attitude towards change may continue to pour money (R&D) into other technologies and resources to improve their preparedness for the future of work. However, this investment could prove futile without the social acceptance of these technologies, thus, impacting the successful implementation of the desired change in the workplace (Del Giudice et al., 2019; Haffke et al., 2017; Martínez-Caro et al., 2020).

The combined findings from Study 1 (Chapter 3) and the current study (Chapter 4) reaffirm the importance of having a positive psychosocial climate with supportive managers who facilitate innovation resulting in employees having a positive and open attitude towards organisational change. All these factors combined equip organisations with many essential skills and resources needed to enhance their business and skills readiness for Industry 4.0. The findings indicated that organisations might not be able to adequately prepare for Industry 4.0 by relying only on technological components. In line with the results of a study by Audretsch et al. (2014), it furthers our understanding of how readiness for I4.0 does not occur in a vacuum; instead, it is a multi-level procedure requiring attention to different aspects of organisations, including other mediators and moderators that are yet to be explored.

4.5.1 Theoretical Implications

This study represents a novel attempt at theorising the direct effect of an organisation's readiness for Industry 4.0, attitude towards organisational change, innovation capacity, and psychosocial safety climate on their financial growth. The study's findings showed that, combined with "business" and "skills" preparedness for Industry 4.0, the primary social systems components highlighted in this study could not fully explain financial growth and address the identified theoretical gap. However, the findings have enabled a better understanding of measuring the impact of social systems factors on financial growth using leading and lagging measures at different time points. Through an enhanced theoretical understanding of the lack of a direct link between the identified factors, this study also paved the way for future research to explore organisational growth holistically while considering the existence of other mediating and moderating factors that impact this relationship. Finally, the results also support the findings from Study 1, further emphasising the multidimensionality of implementing digital transformation in organisations.

4.5.2 Practical Implications

Given the exponential rate at which production and competition are increasing globally, businesses are trying to keep up with technological advancements to increase their productivity (Hamada, 2019). From a practical perspective, this research contributes to existing literature and informs practitioners of the impact, or the lack thereof, of readiness for industry 4.0 and social systems factors on organisational financial growth. It highlights the importance of these critical factors that can help practitioners and businesses prepare for I4.0 and reiterates that focusing on employee health and wellbeing may not be directly beneficial to their bottom line but significantly impact other positive non-financial outcomes including employee well-being, job satisfaction, and innovation capacity (Bailey et al., 2015). Given the multifaceted nature of financial growth measurement within the Industry 4.0 landscape, where traditional ROI metrics may not fully capture the impact of social systems factors, organizations should adopt a long-term perspective when investing in employee health and well-being.

This study also informs businesses to not just look externally to improve business value but also focus on the organisation's internal operations, interpersonal dynamics and competencies to prepare for Industry 4.0. The findings from this research could also inform industries on 'best practice' guidelines that can enable a better preparedness for the future of work whilst encouraging practitioners to look beyond financial gains and make better decisions for organisations on a more holistic level.

4.5.3 Strengths, Limitations and Future Directions

This study aimed to understand the relationship between social systems factors and readiness for Industry 4.0 on the financial revenue of organisations whilst controlling for the effect of each independent variable added stepwise to the hierarchical regression. One of the major strengths of this study was that each

participant (n=192) belonged to a different organisation enabling the analysis of data linkage of financial growth with every company. The data linkage also allowed for the accurate measurement of the financial growth void of potential human error caused using self-reporting measures. The results of this study present new avenues for a longitudinal and comprehensive exploration of the effects of social systems factors on financial growth.

A few limitations of the current study have also been identified that may have potentially impacted the results and should be considered in future research endeavours. The data from this study was cross-sectional and correlated leading and lagging measures at the same time point. Future research could gather data on independent (leading) variables a few years before collecting data on financial growth (lagging), resulting in a more accurate depiction of the impact. Furthermore, the use of Net growth percentage data publicly available from different years added another limitation for the analysis of this study. While this allowed for a wider range of data to be included, it could potentially introduce additional variability and confounding factors due to differences in economic or market conditions and changes in the company's operations or industry regulations over time. Therefore, the use of data from different years should be taken into consideration when interpreting the results of this study. Another limitation of this study is the lack of demographic data on the companies included, which could potentially impact the results. Future research could gather demographic data on the companies and control for the impact of these variables on the results.

Along with the social desirability bias, the participants were only rewarded if they ‘passed’ the screening questions, which included their organisation's name. It is plausible that some participants had anonymity concerns and answered deceitfully to get the rewards associated with completing surveys. Future research may benefit from sending screening questions separately, using an open-ended question to ask the name of the organisation, and only sending the complete survey to the participants who meet the selection criteria. Next, while it might be impractical with large sample sizes, future research could collect longitudinal data to track changes in social systems factors and readiness and analyse the effect of this change on financial growth and other growth outcomes, as it would limit the impact of situational variables (mediators and moderators) on the outcomes. Furthermore, in order to overcome the limitations associated with high collinearity of the variables, and ensure the robustness of the model, future research with larger sample sizes could explore construct validity as an additional analysis. Future research can also build upon the findings of this study by utilising an insider econometric approach to further examine the relationship between the social systems preparedness for Industry 4.0 and financial growth, in order to gain a more nuanced understanding of the mechanisms driving this relationship. Finally, instead of relying solely on self-report methods, future researchers could also explore conducting a mixed-method analysis including qualitative, quantitative and even physiological (objective) measures to get a multi-level understanding of

how to optimise growth outcomes and future preparedness for organisations. Using a mixed-methods approach that combines quantitative measures of preparedness for Industry 4.0 and social systems factors with qualitative data on organisational practices and culture could provide a comprehensive understanding of the relationship between these variables and financial growth.

4.6 Conclusion

In conclusion, this study aimed to bridge the gap between socially being ready for the future of work and its impact on financial revenue. While the hypothesised models in the hierarchical regression were unable to explain the financial growth of organisations, the results of this study support the notion that 'Readiness for Industry 4.0' and social systems factors are complex and multidimensional and do not simply lead to increased financial revenue. The results also highlight the importance of not measuring leading and lagging measures together and using a more holistic approach that views organisational growth as more than financial viability. The insightful findings from this study establish a foundation for future research to further this understanding and improve organisational performance and outcomes. Additionally, the conclusions of this research are valuable in the design of socio-technical cyber-physical systems and intervention approaches aimed at enhancing organisational growth and preparing organisations for the future of work.

CHAPTER 5: Unlocking the 'Future of Work': Organisational Culture is Key (Study 3)

The research described in this chapter, designated Study 3, delves deeper and takes on a nuanced approach to understanding Industry 4.0 preparedness from a leadership perspective. The findings from this research are currently being written up as a journal paper for submission in the International Journal of Qualitative Methods.

5.1 Abstract

While the technological aspects of Industry 4.0 are now well understood and well researched, there is a clear need for further research to address how this technological advancement will impact the 'human' side of the future of work and enable the successful integration of technical systems with existing social systems in the current work context. This study aimed to explore how organisations can better prepare for the future of work when considering the transition to Industry 4.0 through a social systems lens. To investigate how organisational culture and its social elements can enable the positive and mitigate the negative experiences of integrating technologies and transitioning to Industry 4.0, this study (using semi-formal interviews) sought the perspective of sixteen women in senior leadership positions. Analyses revealed that organisational culture is one of the most important factors to consider when looking at advancement in Industry 4.0 through a human-centred approach. The results of this study support the importance of good organisational cultures with high psychosocial safety, effective leadership, inclusive and growth mindsets, and people at the centre of organisational functioning as factors to enhance the experience of transitioning to Industry 4.0. This research also briefly captures the positive and negative impacts of COVID-19 on Industry 4.0. Using this knowledge and drawing on existing theoretical models, this research proposes new ways to conceptualise Industry 4.0 through a social systems lens and provides practical approaches leaders can employ for better preparedness for the future of work. It is recommended that future research should continue to evaluate and unpack this perspective and delve deeper to explore the specific enablers and barriers faced by women in leadership positions to ensure improved inclusivity and diversity in the future of work.

5.2 Introduction

The future of work is shaped strongly by organisations' digital advancement due to the fourth industrial revolution (Baldassari & Roux, 2017; Görmüş, 2019). More commonly known as Industry 4.0, the revolution began as a strategic initiative launched by the German government to advance the interconnection of products, value chains and business models. One of the main objectives of this initiative was to enable higher customisation of products and services and more flexible mass production (Bartodziej, 2017; Szabó-Szentgróti et al., 2021; Xing et al., 2021). The term 'Industry 4.0' is now used more broadly to denote creating and applying automated systems in the workplace with the Internet of Things (IoT), Big Data, Artificial Intelligence (AI), robotics and Cyber-Physical Systems (CPS) as its central pillars (Cropley & Cropley, 2021; Kamble et al., 2018; Sarfraz et al., 2021). This digital transformation and the use of CPS-enabled technologies have become some of the central features of Industry 4.0 and are increasingly being integrated into the contemporary work culture. It is well understood in the current literature that Industry 4.0 is an enormous paradigm shift that is sure to have a lasting impact on work and enables organisations to envisage and forecast the 'Future of Work' (Oppert et al., 2022). The future of work is propelling organisations into work that requires the integration of humans with automation, artificial intelligence and cyber-physical systems (Oppert et al., 2022; Schwartz et al., 2019). While the technological aspects of Industry 4.0 are now well understood and well researched, there is a gap in current literature that needs to be addressed to explore how this technological advancement will impact the 'human' side of the future of work and enable the successful integration of technical systems with existing social systems in the current work context.

The implementation of Industry 4.0 has been slow and is not yet fully incorporated in workplaces, despite the rapid integration of digital technologies. However, the increased digitalisation is likely to lead to automation of systems, which will have significant implications for organisations. This trend has already brought about changes in the business landscape, including market volatility, shorter product lifecycles, and global supply chains (Cropley & Cropley, 2021; Sony & Naik, 2020). For many years, researchers have also discussed the detrimental effects of increased digitalisation and the increased use of technologies on worker health (Diaz et al., 2012; Potter et al., 2022). It is evident that Industry 4.0 will influence the future of work by compelling employees to increasingly undertake work requiring higher-order elements of human cognition as AI and automation (designed to) assume more manual and repetitive tasks (Oppert et al., 2022). As robots continue to undertake unsafe or menial tasks, it will allow workers to become more involved in creative pursuits and enrich their work in meaningful ways. However, increasing human-machine interactions, along with the increase in cognitive work, will expose employees to both physical (e.g., new work design with automated tools) and psychological health (e.g., new types of psychosocial hazards) risks (Kadir & Broberg, 2021; Leso et al., 2018). Due to the rate of growth with which society is advancing in

Industry 4.0 and tackling health and safety threats, researchers must broaden their scope beyond the technical overview of Industry 4.0 and begin to include the social/human elements such as organisational culture, organisational climate, employee skills, capabilities and attributes (Leso et al., 2018; Potter et al., 2022; Sony & Naik, 2020). However, considering the Socio-Technical Systems theory discussed in Section 2.6.1, before designing systems that encompass 'socio-technical' factors, it is pivotal first to understand the social impact of Industry 4.0 on workers who need to change the way they work. Therefore, this study undertook this opportunity to delve deep and view Industry 4.0 through a 'social systems' lens to explore the current perceptions and unique challenges of advancement into the future of work. The relevant considerations pertaining to Industry 4.0 are discussed below.

5.2.1 Digital Advancements; Factors for Success

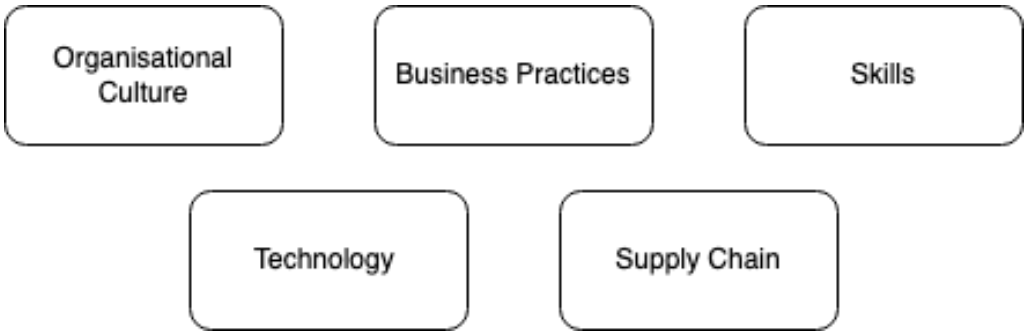
It is well understood in the literature that the digital advancement led by Industry 4.0 is more than just the implementation of the technology (Klein, 2020; Zaoui & Souissi, 2020). Industry 4.0 is recognised as one of the biggest drivers of change in how people and organisations work and is known to require a profound cultural shift in organisations led by effective leaders (Kazim, 2019; Nadkarni & Prügl, 2021). It is also well understood that organisations in Industry 4.0 will need to become more open, multicultural, multidisciplinary, agile and collaborative, thereby impacting the 'humans' within the businesses (Črešnar & Nedelko, 2020). Furthermore, this increase in digitalisation has led to significant shifts in organisations' operations, including their business models, products and organisational structures (Hess et al., 2016). In an attempt to facilitate more efficient digital transformations within organisations, many studies have identified pertinent factors when transitioning to Industry 4.0. Adaption of core businesses and business practices, flexibility and autonomy of work, exchange of resources, effective leadership and a positive digital organisational culture have all been understood as essential factors that facilitate the digital transition to Industry 4.0 (Nadkarni & Prügl, 2021; Pozzi et al., 2021; Singh & Hess, 2020). A literature review by Nadkarni and Prügl (2021) identifies and discusses the transformative power of using adequate personnel (skilled employees and leaders) to facilitate the digital advancement of organisations. They noted that leadership plays a crucial role in aiding the digital transformation (and the challenges that come along) by creating a cultural climate with effective exchange of resources. From a social-organisational perspective, transformational leadership, company culture, work environment and managerial and organisational perspectives were all recognised as fundamental factors that strongly impact digital transformation in Industry 4.0 (Nadkarni & Prügl, 2021). Another study by Zaoui and Souissi (2020) also conducted a literature review on digital transformation. It concluded that measuring the current maturity levels using the implementation of digitalisation, the strategic goals set by organisations and prior preparation for digital advancement were all critical factors to consider when undergoing the increasing implementation of Industry 4.0.

From a strategic viewpoint, it is essential that organisations pay special attention to the impact of leadership and, more broadly, the organisational culture to better prepare for the future of work (Črešnar & Nedelko, 2020). The integral role of leadership in the Industry 4.0 context is not well understood in the current literature, and organisations could therefore miss out on real opportunities to improve transitioning to Industry 4.0. There is an identified need for a more profound examination of the significance of future leaders for organisations within Industry 4.0 (Črešnar & Nedelko, 2020; Klein, 2020). Therefore, to address this gap, this study will attempt to understand the phenomena of transitioning to Industry 4.0 through a leadership perspective by calling upon the participation of individuals in senior leadership positions in semi-structured qualitative interviews.

In line with previous literature (and the findings from Study 1 of this thesis), it is clear that the involvement of management and leadership is a crucial cultural factor that enables the successful implementation of Industry 4.0 technologies (Pozzi et al., 2021). Moreover, Study 1 also concluded that Psychosocial Safety Climate (PSC) (influenced by leadership and business practices) has a significant impact on organisations' business and skills readiness for transitioning to Industry 4.0. Therefore using the results from Study 1 and Industry 4.0 readiness model used by Xing et al. (2021), the current study has identified five key factors essential for advancement in Industry 4.0, which will be used as broad themes to categorise the 'codes' or key ideas that emerge from the interviews (see Figure 9).

Figure 9

Factors Essential for Advancement in Industry 4.0



5.2.2 COVID-19 and Industry 4.0

It is essential to note that this study was designed and conducted in 2021, after the onset of the COVID-19 pandemic. Research and anecdotal evidence indicate the pandemic's significant impact on current and future work practices (Antova, 2020; McMahon, 2020; Sarfraz et al., 2021). While the growth of Industry 4.0 adoption and advancement was not necessarily rapid prior to the pandemic, it has become an essential driver of digital growth for many organisations since. The pandemic has propelled numerous institutions

towards the future of work, with trends such as remote work, flexible work, online meetings, and social media engagement gaining popularity and becoming part of daily work experiences (Potter et al., 2022).

As organisations continue to digitally evolve to survive the current business climate while grappling with external factors (outside the control of organisations) like the COVID-19 pandemic, it is critical to understand and explore the implications of transitioning to Industry 4.0 whilst recognising how organisations can create robust systems that can weather the external factors more effectively (Martínez-Caro et al., 2020). This understanding will pave the way for future research and assist organisations in developing systems and strategies optimal for employee and organisational outcomes. More people are working remotely to keep their businesses running during the pandemic. While some people are "returning to normal," COVID-19 has given rise to long-lasting implications for the workplace. The pandemic has caused an unprecedented economic and social crisis that leaders must deal with. There is limited literature on leadership and virtual work in the context of digital advancement. To unpack this new realm, research must focus on the impact of leadership practices on the cultures of organisations and employees' work performance when transitioning to Industry 4.0 (Bartsch et al., 2020).

It is evident in the current literature that the global pandemic has catalysed digital growth within workplaces and accelerated the transition to Industry 4.0 (Lepore et al., 2021). As the fourth industrial revolution creates a self-managing network between humans, machines, products, and other related objects, workers need to keep upskilling to avoid risks associated with automation (Leso et al., 2018). Interestingly, evidence also suggests that female workers face a significant risk surrounding job automation. The sectors deeply impacted by rapid digitalisation most frequently employ women (Global Gender Gap Report, 2021). In fact, according to a report by CSIRO, gender inequality is one of the most persistent and pervasive forms of inequality globally (Horton et al., 2018). Research by the ILO suggests that 5% of all employed women lost their jobs, compared with 3.9% of employed men, due to the pandemic. The COVID-19 pandemic has impacted the global gender gap significantly. Instead of an estimated 99.5 years to close the gender gap, the estimation has gone up to 135.6 years (Global Gender Gap Report, 2021). There are recognised social and political constraints placed on all women in preparing for work and the workplace (International Labour Organization, 2019). Research must highlight how organisations can best support women and ensure they can leverage all opportunities provided by Industry 4.0.

In addition to the effect of the pandemic on women, a study by Kazim (2019) also recommended that future research investigate the leadership perspective on digital transformation through a gendered approach. Furthermore, they recommended future research to explore the barriers and challenges leaders may be confronted with based on the gender they identify with (Kazim, 2019). Recognising the need for more gender-specific approaches, alongside the impact COVID-19 has explicitly had on women in the workforce, this research will demographically elect to interview women in senior leadership positions. This will be done

to gain a leadership perspective on transitioning to Industry 4.0 and understand the unique challenges and barriers experienced by leaders who identify as ‘women’. The current study will uncover a broad range of issues relating to women and Industry 4.0. For instance, how can organisations create and foster a climate that enables women to safely transition and successfully work in Industry 4.0? Are women being equipped with the skills needed? How can women overcome gender inequality barriers and take advantage of the new and emerging opportunities in the future of work? Informing the fields of organisational psychology and technology engineering, the results from this study will be translated into tangible outcomes to improve practice and policy to benefit leaders and women in various industries. The findings from this research will also advance the social systems understanding of Industry 4.0, allowing for more holistic creations of Cyber-Physical Systems.

5.2.3 Research Scope

Throughout the course of this research, a deliberate and strategic evolution in the study's scope emerged, driven by a nuanced understanding of the rapidly changing landscape of the future of work. Initially, the principal objective of this investigation was to explore the influence of Industry 4.0 on the 'human' dimension of work, with a specific emphasis on gendered aspects. The intention was to explore how Industry 4.0 shaped gender dynamics within the workplace, particularly considering the pronounced impact of the pandemic on women's employment. As the research advanced, an intricate narrative began to take form, propelled by the dynamic nature of the data and the insights gained from the thematic analysis. This shift in scope was not arbitrary but rather a calculated decision founded on the recognition that the study could provide a more holistic exploration of pivotal facets of the future of work. Specifically, the focus broadened to encompass the multifaceted dynamics of leadership and work preparedness within the ever-evolving sphere of Industry 4.0.

This expansion in scope was motivated by the understanding that Industry 4.0 represents a multidimensional transformation with profound implications for the workforce. A comprehensive understanding of leadership and Industry 4.0 readiness was deemed imperative to capture the interplay between technological advancements and human elements in the continually shifting work landscape. Furthermore, the post-pandemic era marked a transformative juncture. Engaging with participants in this context revealed a significant shift in perceptions of work, work methodologies, and overarching work aspirations. This shift in how individuals perceived digitalisation and the future of work called for an expansion in scope to encapsulate this altered paradigm.

By embracing this extended scope and using a pragmatic approach, this research aspires to bridge the gap between theoretical constructs and real-world applications. It aims to provide a nuanced and comprehensive understanding of the challenges and opportunities brought about by Industry 4.0, particularly through the lens of female leadership. By doing this, it seeks to make a meaningful contribution

to the ongoing conversation about the future of work, offering valuable insights that resonate with scholars and professionals in the field.

5.2.4 Research Context and Aims

The literature exploring the impact of organisational culture on Industry 4.0 advancement in a human-centred context is limited. Most studies approach the issue by assessing technological maturity or 'actor-driven' activities within organisations (Nadkarni & Prügl, 2021). Given the importance of organisational culture in adopting technology and the lack of clarity on how it can be fostered, this study will view organisational culture through a human-centred approach to arrive at specific and practical measures leaders can employ to increase their preparedness for Industry 4.0.

Given the impact COVID-19 global pandemic has had on work trends and practices, this study also incorporated questions to capture and explore its impact on Industry 4.0. During the data collection for this study, participants were grappling with issues such as forced closures, state borders opening and closing, employees needing to isolate and ensuing safe work-from-home practices. The pandemic has changed the work and the future of work and has shed light on critical relationships between digital advancement, work practices and health (Potter et al., 2022). Therefore, it is essential to use drastic 'crises' like the COVID-19 pandemic as opportunities to learn what steps organisations can take to confront rapid changes whilst transitioning to Industry 4.0.

With a social systems perspective on the future of work, this study aimed to better understand how organisational cultures contribute to a smoother transition to Industry 4.0. In addition, the study seeks to offer a gendered leadership viewpoint on Industry 4.0 while taking into account how the pandemic has affected operational practices.

To reiterate, the key reasons reinforcing the importance of this study are:

- Industry 4.0 has been growing continually, yet there is limited qualitative research exploring and capturing the social impact of Industry 4.0 on existing workplace systems.
- Previous organisational research has typically investigated Industry 4.0 through a technological or socio-technological approach without fully understanding its impact on 'humans'.
- Previous research also does not address the psychological threats to individuals at work due to increased digitalisation in Industry 4.0. Instead, there is a broader focus on physical health and safety due to the increased integration of technology.

In this study, women in senior leadership roles were invited to participate and share their insights. This sample was selected because individuals in senior leadership often have a strategic role in shaping the

future direction of the organisation, including decisions about adopting new technologies and preparing for the future of work (Friedman & Carmeli, 2022; Lee & Kim, 2021). The sample brings together the perspective of people who have a thorough knowledge of the business models and practices and can strongly influence the culture of their organisations. Qualitative methods have been employed to gain in-depth insight from the leaders and broaden the understanding of Industry 4.0 advancement through a social-systems lens.

5.3 Method

5.3.1 Study Design

Ethics approval was obtained through the Human Research Ethics Committee at the University of South Australia.

To participate in the study, three inclusion criteria were established by the researcher; 1) they were in a senior leadership position, 2) their assigned sex was female, and 3) they had a thorough understanding of the strategic goals and business practices of the organisation. Participants who met the criterion were identified and contacted using a reverse snowballing approach, whereby participants were asked to pass on the researcher's email and contact information to other potential participants. The reason for using reverse snowballing is that 'snowball sampling'—that is, asking participants for contact details of other potential participants — is no longer considered ethically appropriate (Potter et al., 2022). Potential participants were identified and invited to participate in the research from November 2021 to January 2022.

Sixteen women in senior leadership positions participated in individual semi-structured interviews. It is essential to acknowledge that the assigned sex of all participants was 'female', however, their genders were varied. Out of the 16 individuals interviewed, 15 identified as 'female' and one as 'non-binary'. To ensure the anonymity of participation, the pronoun 'they' will be used for all participants throughout this study. The age of the participants ranged from 27-56 years.

Semi-structured interviews were conducted via Zoom (n=9) or in-person (n=7) and were audio-taped, transcribed using a transcribing software (Otter) and then double-checked by the primary researcher. Interviews ranged from 50-80 min in length, with most being approximately an hour (see Appendix H for interview protocol and Appendix I for two example transcripts). The interview transcripts were then imported into the software program; NVivo 12 (QRS International 2020) for analysis.

5.3.2 Participants

Participants comprise females working in senior leadership positions. A total of 16 participants were involved in a broad range of industries; engineering industry, education industry, business consultancy service sector, local government, service sector, disability service sector, retail and manufacturing. The job titles of the 16 participants are as follows; Senior Project Manager *(n* = 2*)*, Strategic Asset Manager *(n* = 1*)*, School Principal *(n* = 1*)*, Assistant School Principal *(n* = 1*)*, Managing Partner *(n* = 2*)*, CEO *(n* = 1*)*, Chief Innovation Officer *(n* = 1*)*, Managing Director *(n* = 1*)*, Chief Operating Officer *(n* = 1*)*, Operations Manager *(n* = 1*)*, Economic Development Officer *(n* = 1*)*, Senior Business Analyst *(n* = 1*)*, Chief Data Officer *(n* = 1*)*and Finance Manager *(n* = 1*)*. Participants' respective organisations' names have not been stated to ensure confidentiality. Except for one organisation in Victoria, the participants were all members of South Australian organisations.

5.3.3 Data Analysis

Interview transcripts were imported into the qualitative data analysis software NVivo 12 (QRS International, 2020). Both grounded theory and thematic analysis approaches were utilised in this research. The data (transcripts) were first coded into nodes based on the ideas that emerged from the interviews. The codes were then condensed into various categories using thematic analysis and grounded theory to establish broader themes that highlight relationships relevant to the research question (Braun & Clarke, 2006).

In this research, both inductive and deductive approaches, namely thematic analysis and grounded theory, were employed for qualitative data analysis. These approaches were utilised to ensure a comprehensive exploration of the data, combining the emergence of themes from the interviews with the integration of pre-existing concepts from the literature (Cropley, 2019).

Inductive analysis, using the thematic analysis approach, involved initially coding the interview transcripts into nodes based on emerging ideas and concepts (see Appendix G). These codes were then further organised into various categories, allowing for the identification of broader themes that underscored relationships pertinent to the research question. This method facilitated the generation of insights directly derived from the data itself. Conversely, deductive analysis was applied through elements of grounded theory and content analysis. During this phase, the codes obtained from the interviews were condensed and categorised into pre-existing, broader themes established through existing literature, including Organisational Culture, Business Practices, Knowledge and Skills, Technology, and Supply Chain. This grounded theory approach allowed for a theoretical framework to be applied to the data, enriching the identified themes with insights from established research concepts.

To bolster the reliability and rigor of the data analysis, a systematic approach to consistency checks was implemented, involving collaboration with two additional researchers at distinct junctures of the data collection and coding process. This meticulous approach aimed to verify the validity and ensure the consistency of the themes and relationships identified within the qualitative data. Initially, random samples of interview transcripts were selected for the consistency checks, encompassing a diverse range of participant responses and perspectives. These transcripts were then independently coded by the two other researchers who were not directly involved in the primary data analysis. Their independent coding aimed to evaluate the extent to which the emerging themes and categorisations were consistent and reproducible across different analysts. Any discrepancies or disparities in the coding were meticulously examined and discussed among the research team to reach a consensus on the final thematic framework. This iterative process of collaboration and cross-validation among researchers was instrumental in mitigating potential biases and ensuring the robustness of the identified themes. Incorporating several analysts, each possessing unique perspectives and specialised expertise, facilitated a rigorous evaluation and refinement of the qualitative findings.

The interviews produced six ‘manifest’ themes and one latent theme implicit throughout the interviews. It is evident that each theme could act as a barrier or enabler to transitioning to Industry 4.0, depending on the context in which it was spoken. The outcomes from this study are presented as enablers and barriers to preparedness for the future of work in an Industry 4.0 context. The results provide an overview of the relationships between organisational culture, business practices, knowledge and skills, technology, supply chains and innovation. It also considers the impact of external factors (outside of managerial control), such as the COVID-19 pandemic and societal expectations on readiness for Industry 4.0, enabling a better understanding of how organisations can build adaptive cultures better suited to address these factors. Data saturation was achieved by the 10th interview in this study, despite the original plan to conduct 16 interviews. Subsequent interviews yielded minimal new information or perspectives. Nonetheless, all 16 interviews were conducted. The recommended range for data saturation in qualitative studies is typically 9-17 interviews, and this study's sample size was within that range (Guest et al., 2020; Hennink & Kaiser, 2022).

Furthermore, this study sheds light on issues that will arise due to the advancement of the fourth industrial revolution, paving the way for further research to explore. The results (the barriers and enablers of Industry 4.0) are summarised and discussed in the subsequent sections, followed by practical implications of this research and future research directions.

5.4 Results

Preparing for transitioning to Industry 4.0 is a complex phenomenon that is influenced by both internal and external contextual factors. Using thematic analysis and the grounded theory approach, six key themes (internal) were identified (see Table 7). Depending on the context and 'sentiment' they were discussed in, all themes emerged as barriers and enablers to advancement in Industry 4.0. Other than the major themes related to internal factors, some external factors that emerged will also be discussed: COVID-19, Societal Expectations, Policy and Funding.

When asked about their perceptions of and preparedness for the future of work and Industry 4.0, the participants unanimously spoke the most about the importance of organisational culture, followed by business practices, knowledge skills and innovation, technology and lastly, supply chain (see Table 7). The participants also discussed some external factors that could influence Industry 4.0 advancement. The themes emerging from the interviews will be discussed in the subsequent paragraphs keeping in mind the importance of these factors through a social systems lens.

Before being presented with questions regarding Industry 4.0 advancement, the participants were first asked about their knowledge and understanding of 'Industry 4.0'. While several participants were familiar with 'Industry 4.0, some were unfamiliar with the terminology. It is interesting to note that the participants nevertheless could answer all the questions that contextually related to Industry 4.0. One participant stated, '*before speaking to you, I had never heard of Industry 4.0. I guess in my industry, we talk about these things but use different terminology'* suggesting that most people are familiar with the concepts emerging from Industry 4.0 but may have niche terminology specific to their respective industries. Many participants almost had an 'aha' moment when presented with the definition of Industry 4.0, thus feeling comfortable proceeding with the rest of the interview (see Appendix H for the definition given in the interviews).

Upon analysing the sentiment and tone of the interviews, it is evident that Industry 4.0 was typically discussed as a positive phenomenon. However, the context of the discussion had an impact on how Industry 4.0 was perceived as either a barrier or an enabler to its adoption. On the contrary, regardless of the context of the discussion, "External Factors" were generally discussed negatively. For instance, societal expectations were only discussed in a negative context as a barrier. This research uniquely focused on the social aspects and impacts of Industry 4.0 using a human-centred approach while keeping in mind the influence organisational culture exerts on other factors essential for progression into the future of work. The major internal and external themes that emerged are discussed below:

Table 7

Themes Emerged using Inductive and Deductive Approaches

Themes	Number of References (quotes) coded
Organisational Culture	463
Business Practices	233
Knowledge and Skills	215
Technology	192
Supply Chain	76
External Factors	183

5.4.1 Internal Factors Impacting Industry 4.0 Preparedness

5.4.1.1 Organisational Culture. Organisational culture was the strongest theme to emerge, with 463 references coded (see Table 7), making it essential to explore as both a barrier and enabler in transitioning to Industry 4.0. Benefits associated with having a positive organisational culture are evident in '*making that cultural shift within the organisation is key- we need to think about utilising the tools that are available and bring the workforce together to create the change mindset*' and another participant stated, *'you can have the greatest tools, but if you don't have the right culture, they won't work'*. During critical organisational transitions, having a positive and supportive culture allows workers to feel safe during uncertain times. From the participants' perspective, a solid strategy to successfully advance in Industry 4.0 is to focus on workers' well-being and create an ideal culture for the future of work. One participant stated, *'I think our people are our biggest assets. I don't think you can underestimate how someone's mental and physical well-being can impact how they show up at work, how they conduct their work, and how they can influence others',* exemplifying how the culture of the organisation is made up of not only what is accepted in an organisation but also of what is tolerated.

Organisational Culture as an enabler

A human-centred approach that keeps workers at the centre and focuses on the organisation's well-being was the most critical aspect of creating a positive organisational climate. A psychologically safe work environment and effective leadership practices were the most prevalent topics when discussing the barriers and facilitators of transitioning to Industry 4.0. Several participants showed effective leadership practices by explaining the importance of communicating and making workers feel safe, heard and supported. Participants expressed how they were '*prepared to invest'* and prioritise workers' mental health. One participant stated, '*I think it's always important just to hear people out and make them feel heard*'. Two other participants made statements that resonated with the sentiment many others expressed, summarised in the quotes below:

> *'We need to make sure that our people feel safe and can seek help when they need it, for whatever it might be. And I think prevention is better than just, you know, having to deal with someone when they are already feeling mentally unwell, burnt out or unsafe.'*

> *'It is absolutely important to ensure that your employees are happy and safe. And that they're in a good headspace is fundamental to business success. So, you've got to make sure that people feel good about coming to work and feel supported.'*

Having spoken to participants in leadership positions, it was evident that they understood their role in recognising and facilitating a positive culture in organisations. One participant stated, '*it is leadership… more than anything'* when asked what factors promote Industry 4.0 advancement. The importance of effective leadership is also evident in *'there is a lot of training that could be provided to leaders to ensure you have those open channels of communication (in the organisation) …which is so important.'*

'Inclusivity' was another topic that emerged in the context of having a positive organisational culture. '*We need to move away from stereotypes as they don't really serve us'*, said a participant in the context of becoming more inclusive as an organisation. Another participant specifically spoke about gender inclusivity as an enabler for organisations to prepare for the future of work, they stated, *'the leaders at our organisation completed an unconscious bias training (addressing gender bias) to ensure we were aware of our biases and making decisions free of them'*. This demonstrates that their organisation is preparing for the future of work by being more inclusive of the needs of their workers. Some participants also spoke about the importance of providing equal opportunities to workers and being aware of cultural, gender and disability biases when making decisions.

'Effective change management and growth mindset' also emerged as conducive to transitioning to Industry 4.0 and creating a positive organisational culture. Many participants recognised that *'change is not an event, it happens constantly',* and therefore, one participant eloquently stated, *'Change management needs to be embedded in the organisational structure, so people (workers) know that they are embarking on this journey with us and therefore become more resilient and adaptive to change'*. Participants also reflected on the importance of having a growth mindset as an organisation as crucial to being future-ready. This message is implicit in the following statement:

> *'So, in terms of mindsets, I feel that change is always good when it's done with you and not to you. And for that, you need to have an open and growth mindset. I think that you also need to have an optimistic mindset in which you can see both opportunities and challenges and not just one or the other.'*

A few participants also discussed workers 'Physical Safety' and using 'Knowledge Management' as enablers of transitioning to Industry 4.0.

Organisational Culture as a barrier

Based on the interviews, it was also evident how negative organisational culture can be unfavourable for staying successful in Industry 4.0. 'Negative Mindset' was the most crucial topic that emerged when considering the barriers that stop organisations from being future-ready. Participants passionately spoke about the fear of job loss, lack of autonomy, work-life balance and resistance to organisational change as some of the biggest reasons organisations cannot advance in Industry 4.0 to their full potential. When talking about the future of work, while most participants were confident that they would not lose their jobs, they expressed concern about addressing this fear in their organisations or recognised how some jobs might be '*replaced by automation of technologies and artificial intelligence'*. One participant expressed concern over not knowing how to deal with the challenging resistance and fear in their organisation. They said;

> *'What is fear? Why don't they want to change? Yeah, you know, are they afraid of losing their jobs? Because they may not be able to do it. So, what sort of help or support can we give them to make them more competent in their positions?'*

Another participant expressed their frustration with the misinformation present in society and stated, *'there's a huge misunderstanding that Industry 4.0 robotics, automation, and AI would replace someone in the workforce; I think a lot of the time Industry 4.0 has changed how someone works, it doesn't change that they work. So, there's a lot of misunderstanding and misinformation that needs to be tackled'*. It is important to note that when asked about overcoming these 'negative mindset challenges', participants unanimously spoke about the importance of having a growth mindset, effective change management practices and effective leadership (as discussed in 'Culture as an enabler'). 'Ineffective Leadership', 'Poor Change Management' and 'Lack of psychological safety/support' were therefore often discussed as the root cause of the negative mindsets of organisations. The importance of these topics is evident in the following quotes:

> *'The biggest challenge is actually against that 'people piece', that cultural shift. And it is taking people on a journey. This probably is a big thing for me. It's because I've seen so many things fail. Yeah. Because it's like, we've always done it this way. It works. Why would we change? So, it's taking them on that journey and showing them the benefit of making that shift? I Should say the technology piece is pretty simple. Yes. The technology is there, the analytics is there. It's getting people to use it and trust it.'*

'Yeah, and putting those systems in place to keep our staff safe. It might also be, you know , that generally is the psychological stuff that can do the most damage when it comes to health and safety. And that's the stuff that is also probably a bit tricky to look after all the time because there's not 100% right or wrong way.'

Lastly, also related to the mindset of organisations, the 'Rate of Growth' also emerged as a barrier to advancement. Many participants stated that people are often '*playing catch up, and as soon as they adapt to one technology or system, a new one comes out, and they are always in 'catch up mode'*. This reinstates the importance of not having proper change management systems and viewing the change as an event rather than a continuous process.

5.4.1.2 Business Practices. The second most recurrent theme that emerged from the interviews revolves around organisations' business practices. It is also evident from the data presented in Table 8 that the business practices of organisations are strongly linked with organisational culture. There were a total of 131 instances where participants spoke about business practices in the same sentence they discussed (or inferred to) organisational culture. The high co-occurrence of these 'references' might also indicate that an organisational culture strongly influences an organisation's business practices. It is also important to note that participants spoke about the two themes together in a more positive context (106 times) over a negative organisational culture context (25 times). The coexistence of a positive organisational culture and positive business practices is evident in the following quote:

'So the biggest enablers for your organisation would be to have the right people doing the right tasks, and then having that mindset of resilience to be able to do them'.

As a thought shared by many, this sentence is an example of the importance placed on having appropriate personnel, good business policies, a sound organisational structure and the correct mindset to enable a smoother advancement in Industry 4.0. Keeping the cultural context in mind, 'Business Practices' will be discussed both as enablers and barriers to progress in Industry 4.0.

Business Practices as an enabler

From a human resource perspective, the participants spoke about recruiting appropriate personnel and ensuring the training and upskilling of the current staff. Many participants spoke about how they want employees with a positive attitude who are willing to learn and upskill themselves. One interviewee stated how having the right people doing the right job is crucial said:

'we look for people who have the right attitude (who are resilient); the ones that may not have the technical knowledge or skill but have the curiosity to know and the drive to learn it'.

This statement also conveys the importance of training and upskilling. Some participants spoke more specifically about effective recruitment and training in an industry 4.0 context. One participant, in particular, stated, *'we want to hire people who have the subject matter expertise in Industry 4.0; so people who've lived it, breathed it and using them to upskill ourselves in particular areas'*. Another essential factor that participants discussed in the context of Business Practices being an enabler was having robust business strategies and leading the organisation with its strategic goals at the forefront. The importance of leading with strategy and its impact on workers is evident in the following quote:

> *'So, the company I work for puts their money where their mouth is and puts safety first. And it's incredible. We have talked about the increased physical danger of some tasks and using robots to avoid dangerous situations as an organisation. Even though it might cost more, we saw that as a way to keep our people safe. It wasn't just a 'money' decision. It was a 'this was the right thing to do' decision.*

Another participant eloquently explained the impact of technology on the future of work and how organisations can lead with a strategy to improve the productivity and profitability of the organisations through strategic and effective job design. They stated:

> *'With the greater use of technology, we're not treating people like machines; we're going to use people more as people. Job design is essential as a well-designed job leads to happy people who can achieve good things. With that, there's like this overlap of like psychological health and business productivity that we don't necessarily in Australia take too seriously or fully understand'.*

The conversations around business strategy naturally led to the topics of increased profitability. Most participants discussed the importance of 'benefits realisation', having good policies and sustainability, and how these act as enablers for advancement in Industry 4.0 through positive business practices. Some participants talked about having the 'basic understanding' as being crucial to business success, and one individual detailed the importance of needing examples and realising the benefits of Industry 4.0 through the following statement:

> *'Well, you know, before you buy a car, you get in and drive the thing somewhere. But your more significant investment of a house, we don't get to sleep in that thing and see how it goes first. So, in terms of industry 4.0, that try before you buy option, that industry collaboration to understand systems and processes better as a group is not their businesses don't talk to each other about these things freely. It'd be good to see them do that.'*

Business Practices as a Barrier

Interestingly, the participants discussing Business Practices spoke disproportionately about it as an enabler more than they discussed it as a barrier. Nevertheless, bureaucracy, damaging organisational policies (including recruitment), and not having appropriate strategic goals all emerged as topics that can be barriers to Industry 4.0. Participants spoke passionately about bureaucracy and red tape as the most significant and frustrating barriers that stop organisations from implementing Industry 4.0 technologies and how *'removing some of the bureaucracy might help'*. One participant articulated:

> *'It's almost like the organisation and its policies are a little bit behind society. So we might come up with fantastic solutions to some of our problems, but then it's blocked by all the bureaucracy, and that can be a barrier.'*

Many participants also spoke about how not having the right business policies is a barrier. For example, one individual said, *'some business policies are often quite restrictive and not applicable to all. So, I think at a policy level, we need to be super broad and unrestrictive to tackle the challenges of bureaucracy'.* More generally, participants also discussed the importance of having sound strategies and how a lack of strategic direction could deter organisations from successfully progressing in Industry 4.0.

Table 8

Co-occurrences of Major Themes with Organisational Culture

Organisational Culture	*Business Practices*	*Knowledge and Skills*	*Technology*	*Supply Chain*	External Factors	*Innovation*
Negative	25	11	17	9	28	3
Positive	106	67	39	17	25	30
Overall	131	78	56	26	53	33

5.4.1.3 Knowledge and Skills. The collective possession of knowledge and skills within an organisation was an important theme that emerged from the interviews. Most participants stressed the importance of understanding which skills and knowledge are necessary to prepare for the future of work. The data presented in Table 8 implies that an organisation's 'Knowledge and Skills' are also linked with organisational culture. In 78 instances, participants spoke about knowledge and skills in the same sentence they discussed organisational culture. More specifically, the data could indicate a correlation between positive organisational culture and higher levels of knowledge and skills within an organisation conducive to a smoother advancement in Industry 4.0. The importance of this theme in the context of organisational culture was evident in the way participants discussed the advancement in Industry 4.0, ensuring they have the necessary skills and knowledge to continue progressing. One participant said it is like *'preparing an*

army' for an organisation through training, upskilling and knowledge building. Most participants agreed that some specific knowledge and skillsets are more conducive than others for the future of work. Therefore, 'Knowledge and Skills' will, in consideration of the cultural context, be discussed both as enablers and barriers to advancement in Industry 4.0.

Knowledge and Skills as an enabler

When discussing knowledge and skills as enablers, participants consistently spoke about the importance of 'soft skills' as a tool for advancement into the future of work. One participant, in particular, said that *'one of the things that we forget sometimes is the human element of what we do. We are so driven about learning and technology that we sometimes neglect the human side'.* Another participant effectually articulated the importance of soft skills, evidenced in the following statement:

> *'I think that while technology has advanced a lot, and we can make very accurate decisions, we still need to operate as humans in a society. As Michelangelo said, people don't care about what you say; they care about how you make them feel. We must think about how a robot will make somebody (a client) feel versus a human connection. The tonality, the body language, the eye contact, all of those things are also important to learn things in a way that is useful to content delivered in context.'*

Many participants also went a step further to emphasise the importance of communicating with others outside one's area of specialisation to become more 'T-shaped' and future-ready. One participant with a background in engineering gave a practical example that explains the significance of being T-shaped in their field; '*something engineers are really bad at is presenting that information in a way that makes sense to non-engineers to support your decision. So, communication is actually a huge skill gap for engineers'*.

Another essential topic that emerged in the interviews was using and treating knowledge as an asset. Therefore, many participants acknowledged the importance of technical skills and conveyed how they would like to recruit people who are 'subject matter experts' and will be able to bring that knowledge to their organisations. Some participants also expressed interest in having better knowledge management systems in place. Lastly, 'research and analytic' skills and 'data science' skills also emerged as enablers of advancement in the future of work.

Knowledge and Skills as a Barrier

Participants mainly discussed 'Knowledge and Skills' as an enabler for advancement and did not have many negative thoughts on the topic. However, some participants commented on 'lack of knowledge' and not having the 'technical' skills necessary as barriers to advancement. One participant said, *'time can be an enabler or a barrier. Not having the time to invest in upskilling and education can be a barrier'*. Another

participant expressed that being unable to adapt to and integrate technology in systems (due to a lack of technical skills and knowledge) is a challenge. It is worth noting that 'time' was discussed as a potential barrier to upskilling, which is a common scenario in cultures that prioritise quick and efficient task completion. While this excerpt does not delve into extensive details, these connections align with the observation that in learning cultures, among other cultural factors, this upskilling effort may be better supported.

Finally, not having 'subject matter expertise' also emerged as a barrier. One participant stated, *'I think one of our biggest barriers is the fact that we have a lot of people who don't have a lot of experience and expertise to help us advance'.*

5.4.1.4 Technology. It is pertinent that technology is an integral part of the digital transformation that is Industry 4.0. Although it became clear that technology was a key theme for Industry 4.0 advancement, it was unexpectedly not covered as extensively as some other themes (culture, practices, skills and knowledge). As evident in Table 8, Technology was discussed 56 times in the context of organisational culture, which could indicate a correlation between organisational culture and the use/adoption of technology when preparing for the future of work. It is also interesting to note that technology was discussed positively and negatively, and the difference between the two 'sentiments' is not disproportionate. It must be acknowledged that while technology is integral for advancement in industry 4.0, this study looks at technology through a social lens and specifically in the context of organisational culture.

When discussing technology, one interviewee stated, '*we will need to focus on using technology, and we will have to have a lot more focus on data management, data security, and data interrogation, '* exemplifying the importance of technology in the future of work. 'Technology' will now be discussed both as an enabler and barrier to advancement in Industry 4.0.

Technology as an enabler

'Data' and 'Automation' were two of the most significant enablers that emerged in the context of technology. One participant said, *'there is a lot of knowledge that is hidden within all of this data. And unless you take a step back and look at it like a map of the world and start making those connections, you miss a big opportunity'.* Another participant said, '*Industry 4.0 is about having a strong marriage between technology and humans',* expressing a sentiment shared by many other interviewed participants. The importance of using data to increase the efficiency of 'human-machine interaction' and what can also be delivered surfaced as a topic and is apparent in the following quote:

> *'We need to realise the opportunity to have that beautiful balance between technology and what you offer as humans, and how you mix those two components to really deliver to a need to the end-user. There is a lot of value in the information we get from technology (data).*

Some participants also discussed how technology and automation allow humans to do what they do best; creative and effective problem-solving, while automation enables routine and mundane tasks to get done more efficiently. This is evidenced in the following quote.

> *'It will free up people from doing mundane work and focus more on problem-solving. It gives them time and space to think and add value. Without Industry 4.0, they are stuck doing the daily day-to-day grind. They are busy but not achieving anything real.'*

Some participants also acknowledged that there might be positive and negative implications of integrating technology in organisations and society.

Machine learning, artificial intelligence, robotics, the Internet of Things and having the proper technological infrastructure also emerged as topics when discussing technology as an enabler for advancement in Industry 4.0

Technology as an barrier

In contrast to the discussions around other themes, there were some concerns the participants shared about the increased use of technology. One of the biggest challenges that the participants addressed regarding technology was the issue of data security, cloud storage and ethics. A participant from the education field expressed their concerns about protecting their students' and teachers' privacy. They said:

> *We've had to be really careful about protecting all our students and staff because back in the day, you wouldn't have any contact with your students. But now, with social media, teachers are friends with parents, and it's just a bit of a nightmare to manage.*

Many shared the sentiment of protecting organisations' privacy and their employees' privacy. From an 'ethics perspective, some interviewees were concerned about the 'lag' associated with policy and legislature catching up to the use of new technologies. One participant in particular, expressed that the current policies and regulations are insufficient to keep up with the increased data security and privacy risk. Another participant presented an essential consideration around monitoring the workforce using technology. Their apprehension is evident in the following quote:

> *'when technology is used to monitor your workforce, hells bells are in an interesting place. I think the ethics and the moral dilemmas around Industry 4.0 (increase in technology) and where it could go in the future need to be considered.'*

'Human-to-machine' interactions, working with cobots, and 'machine-to-machine' interactions also emerged as a sub-theme in the interviews. One participant stated, '*now they're using robots in some of these food courts almost like waiters. And while I think that there is a place for that, I also feel that that has a lot of implications for work and society'.* These compelling statements demonstrate the need for future discussion of the unethical and morally ambiguous effects technology has and will continue to have on the future of work.

5.4.1.5 Supply Chain. Supply Chain emerged as the last central theme that was affected by the internal systems within organisations. While not discussed as frequently as the other themes, most participants considered supply chain practices and accessibility as both barriers and enablers of advancement in Industry 4.0. As evident in Table 8, Supply Chain was discussed 26 times in the context of organisational culture, potentially exemplifying a correlation between organisational culture and the use and importance of supply chains when preparing for the future of work. This theme will now be discussed as an enabler and barrier to advancement in Industry 4.0.

Supply chain as an enabler

When discussing advancement in Industry 4.0, the participants mainly discussed the importance of personalisation and automation of demand-supply processes and the need for supply chains to become more sophisticated and multifaceted. Some participants mentioned the need for having consistent technologies across different platforms within their organisations as an enabler from a supply chain perspective. One participant reflected on an important idea:

> *'We need to customise or tailor the technologies and create systems to suit the industry needs. It's not a one size fits all cookie-cutter. It's easy to say you want to automate, but realistically, which elements would you automate from a process? That decision needs a multifaceted approach.'*

This participant was talking about having consistent internal supply chains. It is worth noting that some participants that discussed supply chain as an enabler discussed 'within organisation' processes while others discussed the betterment of supply chains 'across organisations'. For example, another participant brought up the customisability of external supply chains as an enabler. They said, '*I think Industry 4.0 could help with that if we were to understand the demands better and make them work in Australia. Our country is so big, and we have different climates, but we don't necessarily supply to the different climates very well.'*

Supply chain as a barrier

The majority of the participants discussed supply chain as a barrier. The main concerns revolved around the delays caused by kinks in supply chains and the lack of compatibility of technologies across different processes. The need for supply chain preparedness is evidenced in the following quote:

> *'So, I think we need a future-proofing exercise where we look at key parts and key systems to ensure we are prepared to operate as best we can. So, if borders shut, we've got a secure system in place.*

Some participants also stressed the importance of supply chains in remote locations. One interviewee detailed this point through an example:

> *'We have a lot of remote branches, and they suffer due to the lack of access to proper internet coverage or the lack of the right resources to be able to receive goods and services to their branch. I think more investment into this would really enable the future of work'.*

Lastly, some participants also talked about the lack of interconnection of systems (within organisations) as a challenge to preparing for the future of work. One participant clearly articulated the importance of interconnection through the following statement:

> *'We need to improve our connectivity to our data. So, we have a lot of systems in use today and will have more systems in use over the next few years. We need to ensure that any upcoming system can be federated and become a part of a data ecosystem for our work. If it's not connected, we won't be able to gain the system's full benefits.'*

5.4.2 External Factors Impacting Industry 4.0 Preparedness

During the discussion of advancement in Industry 4.0, many external factors emerged. As presented in Table 8, 'External Factors' were discussed 53 times in the context of organisational culture. Interestingly, external factors were discussed more frequently in a negative context, whereas the internal factors that emerged were all predominantly discussed in a positive context. The co-occurrence of external factors with organisational culture may indicate a correlation between the two factors. The external factors that emerged in the interviews will now be discussed as enablers and barriers to advancement in Industry 4.0.

External factors as an enablers

When discussing advancement in Industry 4.0, the positive impact of COVID-19 and having access to sufficient funding and infrastructure surfaced as key enablers. It was evident that the pandemic greatly impacted how people understand the future of work. One participant mentioned that *'it's really reranked*

priorities at work in a massive way' and that it is *'probably the biggest thing that's happened to technology since maybe the Internet was invented'*. As an enabler, COVID-19 was discussed to have fast-tracked automation, improved awareness of Industry 4.0, improved organisational communication, and enhanced work-life balance. The impactful acceleration of automation as a result of COVID-19 is evidenced in the following statement:

> *'I think that's accelerated a shift in how people work. They're looking for other types of technology that can speed up some of the things that they do. Like, I think there's almost an increased organisational awareness of this adoption.'*

Some participants also spoke about the importance of investment and infrastructure as enablers of advancement in Industry 4.0. They understood that not having investment (including the investment of time) can often be a constraint to furthering the knowledge and skills of organisations, and having the proper infrastructure in place can be beneficial. An interviewee mentioned, *'I think the investment in technology needs to be significant, with a significant percentage increase of what the average is today. But, also keeping in mind what the return on investment would be'.*

External factors as a barrier

The most significant external barrier to emerge from the interviewees was 'societal factors'. Participants passionately discussed the impact of gender inequality and the generational barriers to advancement into the future of work. Due to society's gender roles, women can experience obstacles specific to their gender identity. This difference in perception is evident in the following quote:

> *'Women are quite often perceived differently as leaders by both men and women. As leaders, we are asked different questions and have different expectations put on us.'*

Some participants also spoke about how women need more representation in Industry 4.0 jobs. Many participants also agreed that Industry 4.0 should be inclusive of other genders, with one going a step further to reason that it should be 'genderless'. Another participant stated:

> *'I think one of the most powerful things when we consider gender equity across all roles in the workplace is that you can only be what you can see.'*

'Generational effect' also came up as a barrier in the interviews. Participants often discussed the generational effect in the context of how people from different generations think and learn differently. Therefore, how they adopt technology and fit into the future of work may differ. One participant highlighted the impact of the generational gap on change management practices. They stated:

> *'I mean, we've got workers that have been there for 30 years. We have to be mindful and can't ignore that. We cannot expect them to change overnight. You could try to force them to change, but that will cause problems.'*

This statement sheds light on how Industry 4.0 will need to be more inclusive of individual needs, and that having such diverse needs has the potential to cause some inertial barriers. This sentiment was shared by many, and one interviewee asserted, *'I think there's a perceived generational element; I think it might just be that maybe an older workforce hasn't been allowed to learn the way they might learn normally'*. It is relevant to mention that some participants also talked about needing to cater to different public perceptions of society.

The second biggest external factor that emerged as a barrier was the negative impact of COVID-19 on the future of work. Participants discussed the impact of the pandemic on employee well-being through feelings of disconnect and isolation and on manufacturing supply chains, as well as potential ethical and moral issues linked to progression through Industry 4.0. One participant described COVID-19 as an '*absolute nightmare'*. The negative impact from a mental health perspective is explicit in the following statement:

> *'I think there's a fear and risk in isolation. As we automate more, there will be more isolation. So, the psychological safety of an employee who is used to being a part of a team that now has to be on their own becomes a concern. And as leaders, that fear poses a psychological risk for us.'*

Many participants presented a similar viewpoint on the mental health effect of COVID-19 on the future of work. They expressed that they would often *'miss the social interactions while sitting in front of screens'*. Most interviews also addressed the detriment to supply chains and shed light on the potential shortcomings of these established supply chains. One participant supported this position through the following example:

> *'And I think it really made businesses within Australia realise that sourcing outside of Australia can actually be a real challenge. It is now obvious that, in terms of supplying goods and services, including digital services, a lot of what we get comes from overseas.'*

Throughout the interviews, a joint position shared by participants showed an increased need for on-shore manufacturing as a result of the pandemic. Some also discussed the moral implications of increased monitoring of workers due to the pandemic.

Lastly, the lack of access to sufficient funding for investment in Industry 4.0 also emerged as a substantial barrier to the future of work. Participants agreed that the lack of '*capital to afford these improvements is a big challenge'* that they cannot control. One participant mentioned, '*there needs to be a big investment in technology; that will help us achieve the outcomes in a way that is effective and useful for our customers'.*

The statements discussed within this section and the points raised by the participants provide a foundation for further investigation into how organisations can build adaptive cultures better suited to tackle these external factors.

5.4.3 Innovation

It is worth noting that during the discussion of advancement in Industry 4.0, many factors surfaced as barriers and enablers. Innovation was a latent theme that emerged implicitly throughout the interviews, predominantly in a positive context. The participants implied the importance of innovation in the future of work as a necessity for advancement in Industry 4.0. As presented in Table 8, Innovation was discussed 33 times in the context of organisational culture. While the co-occurrence of 'innovation' and organisational culture was not as frequent as the other themes, Innovation was identified as a latent theme omnipresent across the interviews.

5.5 Discussion

This study examines the perspectives of women leaders on Industry 4.0 and its implications for the future of work. It uses a qualitative research design to assess the impact of organisational culture on preparedness for Industry 4.0. The study presents enablers and barriers to readiness for Industry 4.0, focusing on organisational culture, business practices, knowledge and skills, technology, supply chains, and innovation. Additionally, the study evaluates the impact of external factors, such as the COVID-19 pandemic and societal expectations, in building adaptive cultures that are better suited to address these factors. The main findings are summarised in Table 9, providing insights for organisations preparing for Industry 4.0.

Table 9

Important Themes Pivotal for Transitioning to Industry 4.0 using a Human-centred Approach

Themes	Factors affecting advancement in Industry 4.0	
	Positive Context	Negative Context
Organisational Culture	Human-centred Leadership Inclusivity Growth mindset Effective change management	Lack of Human focus Poor Leadership Lack of Inclusivity Negative mindset- fear and resistance Ineffective change management
Business Practices	Human Resource- recruitment, training and upskilling Strong business strategies Benefit realisation Effective policies sustainability	Bureaucracy Poor Human Resource practices Not having a strategic direction Weak policies
Knowledge and skills	Soft skills Technical skills T-shaped Knowledge management Research analytics Data science	Lack of technical skills Poor knowledge management
Technology	Data Automation Human-machine interaction Implications on society Machine learning, robotics, AI and IoT	Data security Data ethics Human-machine interaction Implications on society
Supply Chain	Personalisation of supply chains Automation of supply chains Sophistication and multifaceted	Delays and kinks in supply chain
External Factors	COVID-19 Investment Infrastructure	Societal expectations (gender/age diversity) COVID-19 Investment Infrastructure

The findings of this study clearly indicated that preparedness for Industry 4.0 requires a human-centred and social systems approach. In line with previous research, leading experts and business practitioners

(interviews) believe that to prepare for the future of work, organisations and, more specifically, the leaders of the organisations need to take a proactive approach that considers the needs of the people. Furthermore, the results also indicated that the strategic direction and decisions taken by the organisation not only need to consider the needs of the employees but also the needs of the consumers. This is an important finding that organisations must consider when transitioning to Industry 4.0. For example, when implementing Industry 4.0 relevant processes such as 'end-to-end digitalisation', a practical first step could be to identify the needs of humans involved in each of the steps and phases of that process. Then, implement effective change management strategies that enable organisations to fulfil the needs identified whilst achieving the strategic goal of using end-to-end digitalisation.

This study also indicates the control organisations can have on their operations by focusing on establishing a positive work culture. Keeping workers at the centre of processes and designing systems that support them is an essential characteristic of a positive organisational culture. Going beyond the human-centred approach, the results from this study also clearly indicated the types of business practices organisations could employ, the kind of knowledge and skills they require and the considerations they need to make when implementing new technologies and supply chains to successfully prepare for the future of work. Supporting previous research by Martínez-Caro et al. (2020) and Chung et al. (2012), the findings of this study indicate that positive organisational culture exerts its influence on enabling a better preparedness for Industry 4.0 with its trickle effect and positive correlations with positive business practices, higher levels of skills and knowledge conducive to Industry 4.0, better technological advancements, better supply chains and lastly a more remarkable ability to weather and deal with external factors outside the control of organisations (see Table 9). As summarised in Table 9, the types of business practices that enable organisations to be prepared for Industry 4.0 and increased digitalisation involve strategic workforce planning, open communication of the benefits of implementing specific technologies and taking measures to create internal policies and practices that are more inclusive and sustainable. Next, the knowledge and skills relevant to improved preparedness for the future of work include a stronger focus on soft skills, technological skills and the ability to cross-communicate information outside one's area of expertise. The results also indicate that it is vital to consider the positive and negative implications of increased technology use when implementing new Industry 4.0 technologies. Finally, the customisation of supply chains is regarded as an important aspect for preparing for the future of work. It is also evident that organisations with positive organisational cultures also discuss the value of innovation more positively. This finding is supported by previous research by Črešnar and Nedelko (2020); it exemplifies the importance of leaders being open to change and, in turn, creating an organisational climate that fosters innovation and creativity. All findings summarised in Table 9 could be used to create a checklist or a screening tool for organisations and practitioners intending to improve their preparedness for Industry 4.0.

To further contextualise this study, it is important to introduce the concept of intersectionality. Intersectionality is a theoretical framework that recognises individuals' multiple social identities and examines how they intersect, interact, and overlap to shape their experiences and perspectives within society(Davis, 2014; DeFelice & Diller, 2019). These social identities can include but are not limited to gender, race, class, sexual orientation, age, and ability, among others. The intersectionality concept underscores that individuals' experiences cannot be understood or adequately addressed by considering one identity in isolation; rather, the interactions between these identities create unique and complex experiences (Ozkazanc-Pan, 2021). In the context of this research, the concept of intersectionality is highly relevant. Data collection for this study focused on women leaders who possess multiple social identities, such as being women, holding leadership positions, and embodying women leadership. While the initial research scope concentrated on examining the experiences of women in Industry 4.0 and women in leadership, it later expanded to encompass a broader focus on leadership in Industry 4.0. Despite this shift, it is vital to acknowledge that the participants' intersectional identities continue to influence their perspectives and experiences within the context of Industry 4.0 and leadership.

By recognising the concept of intersectionality, this research underscores the importance of considering how these multiple social identities intersect and contribute to a more comprehensive understanding of the challenges and opportunities associated with Industry 4.0 preparedness. Moreover, it is recommended future research endeavours to delve deeper into these intersecting identities, particularly the gendered aspect, to gain insights into how they influence the interpretation of Industry 4.0 preparedness.

Despite Industry 4.0 being a positive phenomenon, it is essential to note that the future of work will also give rise to new problems that are imperative to understand and prepare for. Specifically, from a human-centred approach, it is apparent that the future of work will be advantageous and beneficial for many organisations. Nonetheless, there will be negative implications on organisations and society as a whole that will need to be dealt with. For instance, the interviews revealed a fear of loss of work, obsoletion of specific skills, data security issues and moral and ethical issues arising from the increased use of technology. It is critical also to acknowledge that while these issues are expected to be a part of the industrial revolution and might be impossible to avoid, nevertheless, through increasing awareness and understanding surrounding these issues, organisations can better prepare themselves for the progression into the future of work.

In summary, the results of this study support the importance of good organisational cultures with high psychosocial safety, effective leadership, inclusive and growth mindsets and a human-centred approach to business operations as factors to enhance the experience of transitioning to Industry 4.0 whilst increasing profitability, productivity and long-term sustainability of businesses.

5.5.1 Theoretical Implications

This study uses the principles of grounded theory to reaffirm the factors relevant to transitioning to Industry 4.0, as discussed by Xing et al. (2021) in their research. It also adds to the importance and impact of organisational culture on other factors relevant to Industry 4.0. Following 'Study 1', this research looks at Industry 4.0 and the future of work through a 'social systems' lens. In contrast to the first study, the findings of this research go a step further to broadly understand organisational culture using a human-centred approach rather than focusing on psychosocial safety climate alone. This broadens the understanding of the pathway established in Study 1 (Chapter 3), indicating the importance of the 'environment' the leaders can create and provide to enable employees to be better prepared for Industry 4.0 and the future of work in general. Nevertheless, it is also important to note that having a psychologically safe work environment was recognised as one of the major sub-themes emerging within 'organisational culture'.

In addition to the insights gained from a human-centred approach to work design and business practices, it's crucial to consider the theoretical implications of intersectionality within this study. Intersectionality, as introduced earlier, emphasises the complex interplay of multiple social identities, including gender and leadership, in shaping individuals' experiences and perspectives. This lens highlights that the challenges and opportunities associated with Industry 4.0 preparedness are influenced not only by a single identity but by the convergence of these identities. Acknowledging the theoretical significance of intersectionality, this study opens doors for further exploration into how these intersecting identities, particularly the gendered aspect, impact the interpretation of Industry 4.0 preparedness. Future research can build upon this foundation to enrich the theoretical framework surrounding Industry 4.0 and the future of work.

Interestingly, the external factors influencing organisations' preparedness for the future of work were discussed more frequently in a negative context than the internal factors, which were predominantly addressed in a positive context (see Table 8). Using existing literature, this phenomenon can be succinctly explained using the psychological trait theory of the 'Locus of Control' (Ng et al., 2006). In psychology literature, 'Locus of Control' is commonly understood as individuals' perceived level of control over their fate. This control is explained dichotomously, with internality and externality as two key elements. Individuals with an internal locus of control recognise the vital link between their actions and consequences and are therefore more likely to have the confidence to attempt to control their external environments. On the other hand, individuals with an external locus of control tend to attribute personal outcomes to external factors or luck and therefore are perceived to have a more passive role in controlling their environments (Lefcourt, 2013; Ng et al., 2006). This theory can also explain participants' locus of control in an organisational context. Previous literature clearly suggests a link between internal locus of control to positive employee outcomes and external locus of control to adverse employee outcomes (Lefcourt, 2013; Ng et al., 2006; Spector, 1982). Keeping this in mind, it is plausible that the research participants discussed

internal aspects of organisations in a more positive context due to a higher perceived level of control over those factors with a human-centred focus. Likewise, they discussed external factors more negatively due to lower levels of perceived control over the factors external to the organisation. A specific example of external factors outside an organisation's control would be the repercussions of COVID-19 on the day-to-day functioning of organisations. For the current research, this insight could indicate how organisations can better prepare for Industry 4.0 and the future of work by increasing their perceived control over the organisational culture and climate. Based on the results of this study, this perceived control could potentially increase by taking a human-centred approach to work design and business practices.

5.5.2 Practical Implications

There are some specific practical implications of this research, the implementation of which would be beneficial for increasing preparedness for the 'social' side of the digital transformation of organisations. All findings summarised in Table 9 could be used to create a checklist or a screening tool for organisations and practitioners intending to improve their preparedness for Industry 4.0. By adopting a human-centred strategy, leaders can start to change the culture of their organisation. To achieve/improve the focus on workers, organisations can refer to the 'positive context' outlined in Table 9 and avoid the sub-themes mentioned in the negative section. Given the importance of culture highlighted as the most crucial factor for social advancement in Industry 4.0, organisations must learn to create a psychologically and physically safe environment for their workers. Leaders can then focus on their business practices and strategies and ensure that they are aligned with the needs of the workers (through open communication channels) and with the goal of further digital transformation. Furthermore, considering the broadened scope of this study, with a specific focus on leadership within the context of Industry 4.0, organisations have the chance to proactively embrace a more diverse workforce, including women leaders with intersecting social identities. By recognising and addressing these intersecting identities, organisations can tailor leadership development, training, and support programmes to better prepare their teams for the challenges and opportunities of Industry 4.0. This approach not only fosters inclusivity but also empowers organisations to navigate the complexities of the digital age more effectively.

In line with previous research, the findings from this study also support that leaders in Industry 4.0 need to be agile, open to learning, and work cross-culturally and cross-generationally to establish a positive organisational culture (Črešnar & Nedelko, 2020; Klein, 2020). Based on the findings, organisations should also focus on training, supporting and upskilling their staff (practicing effective knowledge management) when introducing new technologies and cyber-physical systems (Potter et al., 2022). The training and upskilling will be more effective if the platforms and delivery method are more user-friendly and inclusive of the diverse digital literacy levels and staff learning styles. This can also be achieved by ensuring that the

platform users co-design the systems. Lastly, they can ensure they have technological platforms and systems compatible with existing technology to avoid 'within organisation' supply chain issues.

5.5.3 Future research directions

The two areas that emerged more frequently in the interviews than expected were gender inequality and the diverse ages of workers as barriers to advancement in Industry 4.0. These sub-themes require further research and analysis. This study focused on progression into the future of work on an organisational level, and these 'external factors' indicated a need for change within the society. While organisations cannot change societal expectations outside the realm of their control, they can undoubtedly create cultural climates that are more inclusive and don't allow societal expectations to become barriers for their workers. For example, many women spoke about societal maternity roles becoming barriers in their work. The society we live in is now constantly changing – challenging gender norms and changing the definition of whom a 'Family' comprises. Keeping this in mind, organisations can create a culture that focuses on and accommodates workers with primary parenting responsibilities over the gender identification of the worker undertaking them. Additionally, exploring the intersectionality of gender, age, and other social identities within the context of Industry 4.0 could offer valuable insights into how these intersecting factors affect workforce dynamics and preparedness. These 'societal' themes require further research exploration and practical deliberation to facilitate the creation of inclusive cultures and establish workplace policies that accommodate different kinds of diversity. Further research could also shed light on how other cyber-physical systems could be designed using a socio-technical approach keeping in mind the internal and external factors uncovered in this study.

The findings of this study highlight the importance of considering the impact of organisational culture on other organisational factors (including external factors) that enable or inhibit advancement in Industry 4.0. The study also sheds light on the direct impact organisational culture may have on an organisation's ability to prepare for the future of work. Therefore, it is recommended that future research on the adoption of Industry 4.0 make a concerted effort to view Industry 4.0 as a socio-technical system and recognise the social impact of technological advancements on organisations and their workers. In addition, this multi-faceted study gave rise to many topics beyond its scope but laid the groundwork for further research. Future research could explore the major themes that emerged as 'external factors' to understand the role of organisational culture in tackling important issues arising from societal expectations, such as gender, age and unprecedented challenges like pandemics and other natural calamities. This exploration will give researchers and practitioners valuable tools to create organisational climates that are more gender-inclusive, age inclusive and adapt efficiently to rapidly changing circumstances.

5.5.4 Limitations

The participants of this research were all female (assigned sex) residing predominantly in South Australia, except for two living in Victoria (both are states in Australia). While this sample provides a unique leadership perspective on readiness for Industry 4.0 and is a meaningful contribution to Industry 4.0 literature, it would be helpful to broaden this perspective and interview a more diverse set of people, including workers on different levels of organisational hierarchies, more individuals identifying with other genders and people with diverse geographical and cultural background. Indeed, there is a clear need for broadening this perspective through further research to enable a future of work that is inclusive of diverse needs and accounts for the social and psychological impacts of the growing digital transformation.

5.6 Conclusion

The rise of Industry 4.0 has both positive and negative implications for work. While Industry 4.0 promises new opportunities for increased profitability, it also poses threats such as job displacements and cyber security breaches. Therefore, understanding and preparing for the multiple factors affecting Industry 4.0 implementation will enable organisations to reap more benefits whilst improving work conditions. The results of this study discussed how the emergence of COVID-19 has accelerated the adoption of Industry 4.0 technologies and has allowed people to further understand what the future of work could look like. From a leadership perspective, this study explains how organisations can be more successful in transitioning to Industry 4.0 by creating positive organisational climates that are more inclusive and sustainable. The key message from the results is that leaders that can successfully create organisational cultures with high psychosocial safety, effective leadership, inclusive and growth mindsets, by placing people at the centre of organisational functions will enable their organisations to be better prepared for Industry 4.0. This study adds to the existing literature by providing a unique perspective on how organisational culture and its social elements can enable the positive and mitigate the negative experiences of integrating technologies and transitioning to Industry 4.0. It is also recommended that future research should continue to evaluate and unpack this perspective and delve deeper to explore the specific enablers and barriers faced by women in leadership positions to ensure improved inclusivity and diversity in the future of work.

CHAPTER 6: General Discussion of the Research Findings

6.1 Introduction

This thesis asked, 'How can organisations employ a social systems approach to better prepare for the future of work, especially with the digital advancements brought on by Industry 4.0?'. To answer this question, three studies were undertaken that each explored different aspects of organisational behaviour and provided unique insights to advance the social systems understanding of Industry 4.0 preparedness. Study 1 examined the effect of three key social systems factors on readiness for Industry 4.0. The findings were able to establish a significant pathway that explained how high PSC is a strong precursor for positive employee attitude towards organisational change and innovation capacity leading to better preparedness for Industry 4.0. The second study was a novel attempt at establishing a relationship between the three social systems factors, readiness for Industry 4.0 and the financial growth of organisations. Using data linkage, financial growth data was extracted and connected to the data from the first study revealing the lack of a direct relationship between the social systems factors, better preparedness and monetary gains. Finally, the third study enabled a deeper understanding of Industry 4.0 through a leadership perspective on the future of work. The results from 16 qualitative interviews with women in senior leadership positions highlighted the importance of creating a positive organisational culture as the most significant factor for better preparedness for implementing Industry 4.0 technologies.

Collectively, the results of this thesis present a range of advances that contribute theoretically and practically to a broader understanding of the influence of social systems factors on preparedness for the future of work. The quantitative methodologies used in this thesis revealed an important previously unestablished pathway whereby despite the lack of a direct financial gain, psychosocial safety climate, innovation capacity and attitudes towards organisational change were all established as crucial factors influencing preparedness for Industry 4.0. The qualitative findings also highlighted the importance of organisational culture, with a particular emphasis on the aspects of the social systems that have been discussed in this thesis. The subsequent sections will discuss the numerous theoretical advances, practical implications of findings, and potential future research directions that could help address preparedness for the future of work.

6.2 Theoretical Advances

Making several advances to theory, this thesis reiterated the importance of social systems factors in preparing for the future of work and alleviated the imbalance of existing knowledge of social vs technical aspects of Industry 4.0. Keeping in mind the Socio-Technical Systems theory and the aims of Society 5.0 (see Section 2.6), this thesis approached Industry 4.0 through a social systems lens to address the theoretical

gaps in literature. The research presented in this thesis evaluated Industry 4.0 preparedness and, more specifically, preparedness for digital transformations due to Industry 4.0. It focused on increasing the social understanding of this preparedness by broadly combining contextual elements, personal elements, financial elements and the social implications of technical elements. As a whole, this body of research integrates and builds on pioneering theoretical models and is the first thesis to examine the social impact of Industry 4.0 through an amalgamation of broad social systems factors like PSC, Innovation Capacity, employee attitudes, financial growth and organisational culture.

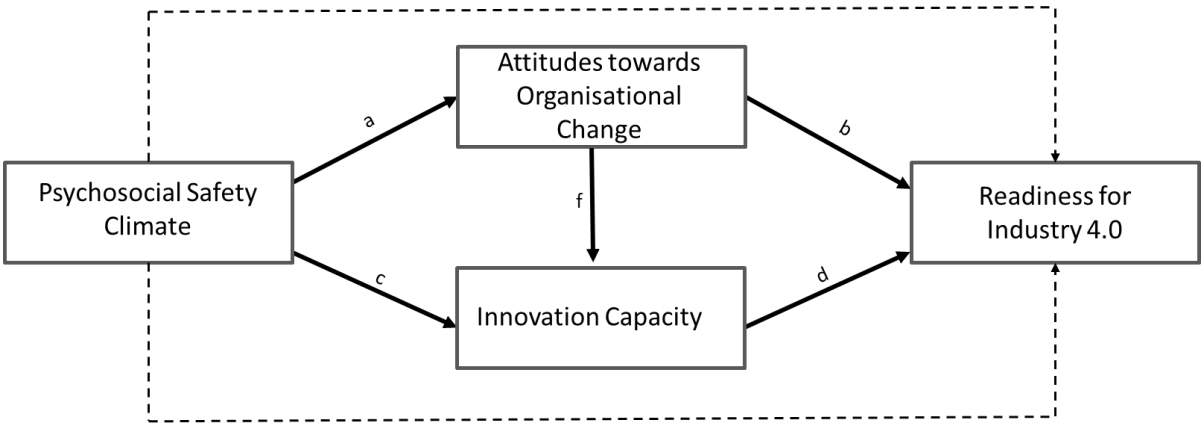
6.2.1 Theoretical Advances of the Studies

The first theoretical advance was made in Study 1. The results from this study enabled a better understanding of how the identified social systems factors interact to facilitate better organisational preparedness for Industry 4.0 and connected the PSC theory to the socio-technical systems theory. As shown in Figure 10, the findings from the first study led to a theoretical pathway/model that explains Industry 4.0 preparedness through a social systems lens. More specifically, the results revealed that psychosocial safety creates a conducive environment for better preparedness for the future of work. Creating this environment will then have a positive trickle effect on employee attitudes to change and innovation capacity, thus creating a better business and skills preparedness for the future of work.

This pathway (see Figure 10) provides further clarity around the 'socio' elements in the 'socio-technical' equation and enables researchers to further understand and explore social readiness for Industry 4.0. The findings from the research also demonstrate that a lack of social focus may be causing resistance and preventing an efficient integration of technological systems. Therefore, organisations can use this lens and shift their focus on incorporating the social systems factors discussed in this thesis instead of continuing to spend resources on improving their digital and technological maturity.

Figure 10

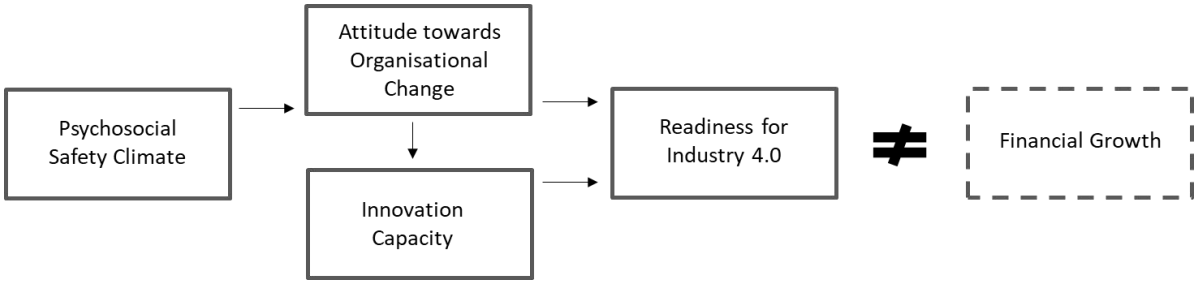
Full Mediation Pathway as Established in Study 1 (Chapter 3)



The second theoretical advance was achieved through a novel attempt at connecting the social systems data from Study 1 to the financial growth of organisations in Study 2 (Chapter 4). This study revealed a lack of a correlation between social systems factors, preparedness for Industry 4.0 and financial performance, suggesting that organisations may not gain immediate monetary benefits by simply focusing on social elements when preparing for the future of work. The lack of a direct link is nevertheless an essential theoretical advancement as it reiterates the presence of other mediating and moderating factors that the current theoretical model is unable to account for. This finding also reaffirms the need to explore and understand what these additional factors are how they could impact the relationship between social systems factors and financial growth. Considering the significance of financial growth as a major strategic objective for most organisations, future research would benefit from exploring this theoretical model further (see Figure 11) by adding other mediating and moderating factors that could impact this relationship.

Figure 11

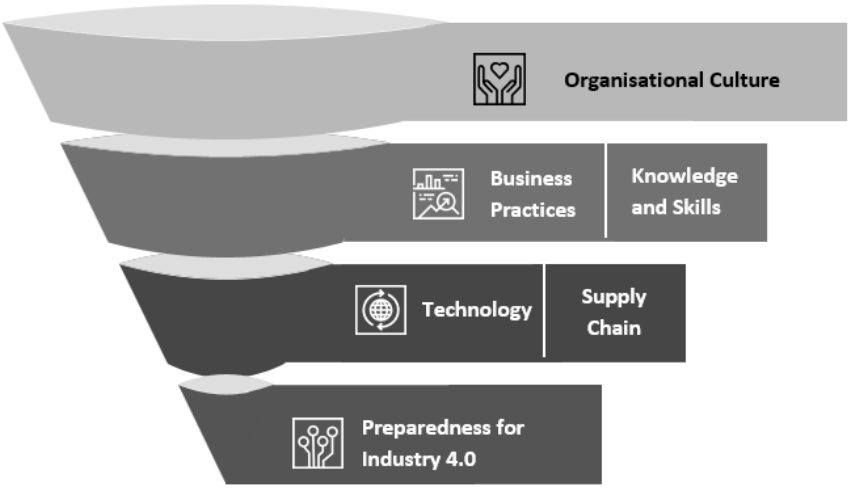
Theoretical Model tested in Study 2 (Chapter 4)



The third theoretical advance was made in Study 3 (Chapter 5). The findings from the study added to the limited research on preparedness for Industry 4.0 through a leadership perspective using a gendered approach. The research provided confirmation of the factors necessary for transitioning to the fourth industrial revolution. Supporting previous research by Martínez-Caro et al. (2020) and Chung et al. (2012), the findings of this study indicate that positive organisational culture exerts its influence on the Industry 4.0 preparedness with a trickle effect on positive business practices, higher levels of skills and knowledge conducive to Industry 4.0, better technological advancements, better supply chains and lastly a more remarkable ability to weather and deal with external factors outside the control of organisations (see Figure 12). This theoretical contribution paved the way to understand social preparedness for the future of work more holistically, accounting for broader concepts from an operations perspective.

Figure 12

Theoretical Model emerging from Study 3 (Chapter 5): The Funnel leading to Better Preparedness for Industry 4.0



In summary, the research presented in this thesis made three key theoretical advancements to literature by focusing on different aspects of organisational behaviour to provide unique insights advancing the social systems understanding of Industry 4.0 preparedness. While these theoretical advances individually offer meaningful contributions to literature, they can provide a distinctive lens to view and understand Industry 4.0 technology adoption when consolidated. The integrated view of the overall results is presented below in Section 6.2.2.

6.2.2 Consolidation of the Theoretical Advances

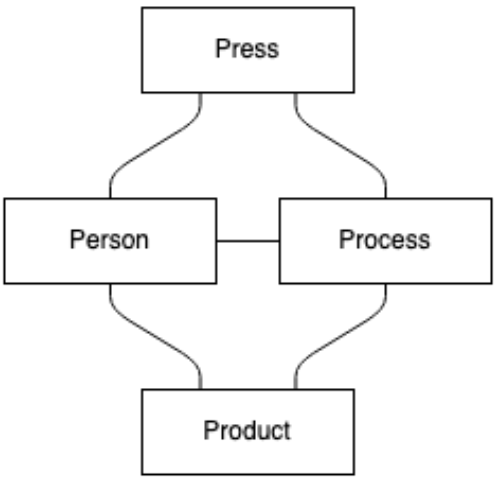
Based on the combined findings of the research undertaken in this thesis, it is evident that to increase preparedness for the future of work, organisations must begin at the top (leadership) by taking a human-centred approach and strategising the creation of an organisational culture that is conducive to organisational growth. Supporting previous research, this thesis reiterates the value of creating an organisational culture that provides a suitable 'climate' for the assimilation of new technologies whilst safeguarding the interests of employees (Martínez-Caro et al., 2020; Rajahonka & Villman, 2019). Adding to a growing body of literature, this research conveys that from a change management perspective, there needs to be a focus on first improving employee attitudes towards change and then creating a social acceptance of the technologies being introduced in order to avoid the failure of technology integration (Del Giudice et al., 2019; Haffke et al., 2017; Martínez-Caro et al., 2020). From there, the desired changes can be integrated through business practices, policies and finally become a part of their operations. This thesis has advanced knowledge and understanding of the social preparedness of Industry 4.0, creating a distinct need for a framework that can capture the essence of amalgamating broad factors like PSC, Innovation Capacity, employee attitudes, financial growth and organisational culture.

As highlighted in Chapter 2 (Section 2.5), previous Industry 4.0 maturity and readiness models assessing factors necessary for Industry 4.0 advancement have often focused more on the technological aspects, failing to effectively account for the 'human' elements necessary for the future of work. This observation, along with the research findings outlined in this thesis, emphasises the need for a framework that can explain the shift to Industry 4.0 whilst also considering the impact of organisational culture and other significant factors such as PSC, Innovation Capacity, and employee attitudes. (Del Giudice et al., 2019; Martínez-Caro et al., 2020; Rajahonka & Villman, 2019). Upon applying a level of abstraction to the collective results, there is a framework often used in creativity research that could potentially capture the socio-technical nature of implementing Industry 4.0 technologies: The Rhodes Four Ps Model of Creativity (Rhodes, 1961).

In the late 1950s, during post-war recovery, organisations faced a comparable paradigm-shifting change requiring creativity to solve problems. This organisational change and the need for creativity occurring as a response to two decades of financial depression and the war was effectively captured and explained by applying Rhodes (1961) four Ps framework. This framework uses the interaction of four factors (or lenses) to explain the phenomenon of creativity: Press, Process, Person, and Product (see Figure 13). Interestingly, during the inception of the four Ps model, Rhodes (1961) also discussed the interdisciplinary appeal of this framework; it was described as a framework used to understand the phenomenon of 'synthesising knowledge' in the context of creativity. Upon reflection, it is evident that this model provides four unique lenses to view human activity and explain a given phenomenon by extracting useful information from the interactions among the four lenses (see Figure 13).

Figure 13

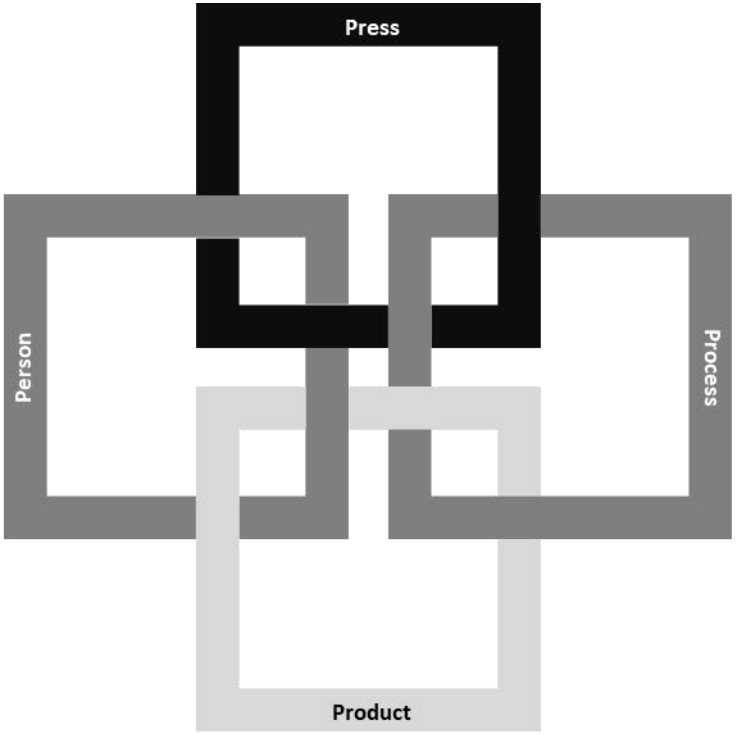
Four P's Framework: Inspired by Rhodes' Four P's Model for Creativity



Following the same principles established by Rhodes (1961) to integrate the 'human elements' to transitioning towards Industry 4.0, this thesis proposes using the four Ps framework more broadly to look at a different phenomenon; the implementation of Industry 4.0 technologies. As illustrated in Figure 14, when Rhodes' four Ps model is applied to improving digital advancement in an organisational context, the 'Person' refers to the employees within the organisation trying to further their digital advancement, including their attitudes and innovation capacity. 'Process' refers to the processes undertaken by the organisation to achieve its goals, including business practices, policies and strategic plans. 'Press' refers to the cultural and social climate the organisation has, which is known to strongly influence an organisation's business practices (Martínez-Caro et al., 2020). In the context of the current research, it would involve important elements of organisational culture (including leadership and Psychosocial Safety Climate). Similar to Rhode's Four Ps, in this framework, the environment or 'Press' exerts its influence on and interacts with the 'Person' and 'Process' to achieve the 'Product', i.e. successfully transitioning to Industry 4.0 and increased profitability. Keeping in mind the research by Cropley and Cropley (2015), it is important to remember that when using a systems approach, the four Ps do not operate in isolation but rather interact to achieve the set outcomes (Product).

Figure 14

Application of the Four P's to understand Industry 4.0 Technology Implementation



Press
Press refers to the cultural and social climate of the organisation. This thesis evidenced this lens to be the most important to consider when increasing organisational preparedness for the future of work. Both organisational culture and Psychosocial Safety Climate would fit under this umbrella. The 'Press' of the organisation will have trickle effects on the other three P's.

Person
Person refers to the employees within the organisation, their skills and knowledge and the workforce capabilities fit for the future of work. As the second most important lens, employee attitudes towards organisational change and the innovation capacity would also fit under this umbrella.

Process
Process refers to the processes undertaken by organisations to achieve their goals; this would include business practices, policies and strategic plans they are trying to pursue/acquire as an organisation. The 'Press' factors, and 'Person' factors would both influence the processes of organisations and our important to consider when trying to improve organisational 'Processes' for better preparedness for the future of work.

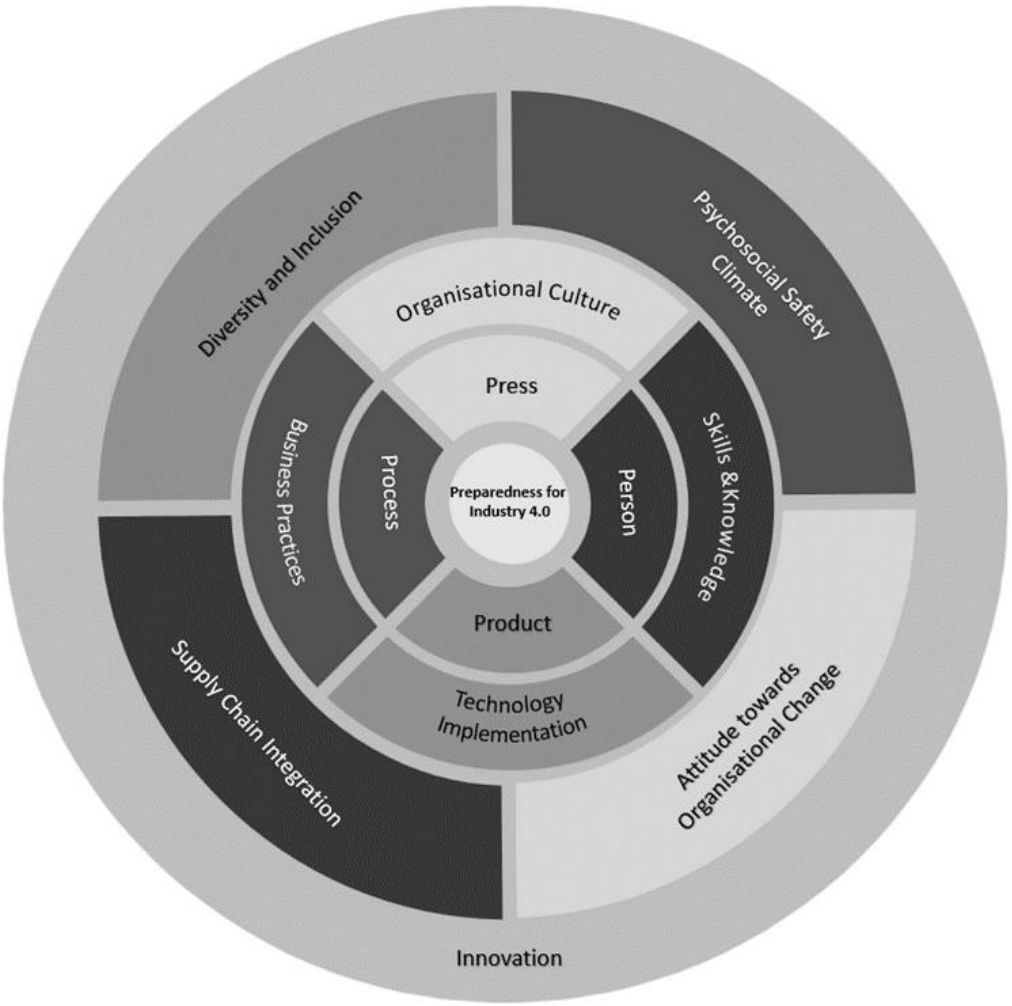
Product
Product would refer to the outcomes of the actions undertaken by the organisations i.e. successful advancement in Industry 4.0 technologies and increased organisational growth as a result. Therefore, when implementing new technologies or designing new cyber-physical systems, organisations will need to take into consideration all the other P's that strongly influence this outcome.

To add to the existing literature on the link between organisational culture and the adoption of new technologies/technological systems, this thesis uses the four Ps framework to understand the collective interaction of all the social systems factors explored that explain the digital advancement and preparedness for Industry 4.0 (see Figure 15) (Büschgens et al., 2013; Ke & Wei, 2008; Martínez-Caro et al., 2020). The broad framework from the four Ps model, along with the understanding of how the social systems factors interact, were amalgamated for the conceptualisation of Figure 15 for this thesis to enable a multi-dimensional and multi-disciplinary understanding of the phenomenon that is Industry 4.0. It is evident that the 'Press' exerts its influence on 'Person' and 'Processes' to successfully integrate technologies and supply chains ('Product') within organisational systems.

Building on the theoretical model based on current literature (see Figure 13), the P's model is layered with the factors relevant to the findings of this thesis, as shown in Figure 15. "Press" is intrinsically linked to "organisational culture," which has an impact on the diversity, inclusion, and psychosocial safety climate of organisations. The "Person" corresponds to the knowledge and skills which the organisation has acquired, resulting in a trickle effect on the psychosocial safety climate and attitudes towards organisational change. Next, business practices are directly related to the "Process" and impact diversity and inclusion as well as supply chain integration related to Industry 4.0 technologies. Finally, the quality of supply chain integration and organisational change attitudes have an impact on the "Product," which is the "technology implementation" relevant to industry 4.0. Lastly, "Innovation," which was also a latent theme in the findings, has a broad impact on the variables in this model and enhances the manner in which the 4Ps interact. This theorisation will give rise to opportunities for future research to quantitively test the new model to advance the 'social systems' understanding of Industry 4.0 and become better prepared for the future of work. Practitioners and researchers can benefit from considering this framework to understand the importance of each factor from a social-systems perspective and apply it to a broader organisational context for better Industry 4.0 preparedness outcomes. Future research could also empirically investigate the presented theoretical framework quantitatively to further the evidence presented in this thesis.

Figure 15

Theoretical Framework using the Four P's; Social Systems Readiness for Industry 4.0



6.3 Practical Advances

The findings from this thesis have clear translatable outcomes that can be implemented within organisations. Firstly, the theoretical pathway established in Study 1 (chapter 3) informs practitioners to go beyond the technological aspects to prepare for Industry 4.0. It also creates logical priorities for managers to follow and increase their social preparedness for the future of work. The research findings iterate that leaders and practitioners can start by understanding their current PSC scores and focus on improving them to create an organisational climate that fosters innovative capacity and a positive attitude towards organisational change. Supporting existing literature, it is evident that higher PSC scores can be achieved by promoting and prioritising employee well-being and healthier leadership practices (Ansah & Mensah, 2020). Ultimately, the findings for Study 1 inform businesses to not just look externally to improve business value but also to start focusing on the inner workings, interpersonal dynamics and competencies of organisations to have the best chance in preparing for and surviving the paradigm shift occurring as a result of Industry 4.0.

The second study informs practitioners of the impact, or the lack thereof, of social preparedness for Industry 4.0 on the financial growth of organisations. This compelling finding can have significant implications for the creation of business practices, work design and strategic foresight within organisations. In order to be better prepared for the future of work and develop a business model that can adapt to the drastic changes brought on by increased digitalisation, leaders are encouraged to look beyond financial gains and use a holistic approach to business success. Again, this holistic level of analysis can be achieved by revisiting the findings from Study 1, prioritising employee wellbeing, and using inclusivity of 'human' needs as a cornerstone of their business practices. Additionally, the conclusions of this study are also important in the context of past research. As reported previously, focusing on employee well-being can lead to enhanced productivity and growth outcomes such as increased productivity, decreased absenteeism and decreased burnout (Bailey et al., 2015). This research provides additional data to indicate that the holistic approach to business growth (above and beyond the bottom line) is an effective way to prepare for and thrive in the future of work.

Based on the findings from the first two studies, it is evident that organisations need to look inwards and focus on employee wellbeing. Leaders need to create an organisational climate and culture conducive to better attitudes towards change and innovation capacity and enable a smoother digital transformation and readiness for the future of work. Study 3 offers valuable insights into how leaders can build this culture, and the results also provide key priority areas to focus on. The key message delivered by the third study highlights the essential nature of organisational culture for the integration of Industry 4.0 technologies. Building on this knowledge, business practices, knowledge and skills, technologies and supply chains were emphasised as pivotal factors for advancement in the future of work. Furthermore, based on the research

findings, it is evident that to create a positive organisational culture, leaders can prioritise taking a human-centred approach, become more inclusive, have a growth/learning mindset, and adopt effective change management practices. Specific steps organisations can take to improve readiness for industry 4.0 are categorised and summarised in the table below (see Table 10).

Table 10

Practical Implications/Steps Practitioners can Take; Categorised by Different Facets of Industry 4.0

Organisational Culture	• Human-centred- Put people at the centre of all processes and decisions. • Leadership - Prioritise employee well-being and maintain open communication channels. • Inclusivity- Create an inclusive culture that recognises the value of diversity. • Growth Mindset- Empower people to continually grow personally and professionally. • Effective Change Management- Manage change effectively by taking people on a journey and addressing their fears and resistance to the future of work.
Business Practices	• Human Resources: Focus on recruitment, training, and upskilling that aligns with strategic goals. • Strong Business Strategies: Develop goals that create the desired culture and meet demands for digitalisation and future work. • Benefit Realisation: Educate stakeholders on the benefits of Industry 4.0 technologies for better preparation. • Effective Policies: Establish inclusive policies that address organisational and employee needs and contemporary issues, such as cybersecurity and psychological health and safety. • Sustainability: Ensure policies and practices are environmentally sustainable and capable of withstanding future work pressures. • Avoid Bureaucracy: Mitigate risks arising from inefficient processes by designing policies and practices with streamlined procedures.
Knowledge and skills	• Soft Skills: Human-centred skills like effective communication, networking, time management, creativity, and innovation are considered essential in the future of work. • Technical Skills: Domain knowledge, research analytics, data literacy, technology literacy, and software learning are highly valued in recruiting future-ready employees. • T-Shaped: Having deep knowledge in a specific area while also having broad knowledge in related areas allows for effective communication and innovation. • Knowledge Management: Adequate knowledge management systems are crucial to prevent duplication of work and silos within organisations. • Data Science: Knowledge in data science is important to enable the successful integration of technologies and prepare for the future of work, as it is a growing domain of knowledge.

Technology	• Data: Understanding and leveraging data, including big data, is important for successful implementation of Industry 4.0 technologies. • Automation: Organisations need to understand and leverage automation to prepare for the future of work. • Human-Machine Interaction: focusing on human-machine interaction as a means of being better prepared for the future of work. • Societal Implications: The increased use of technology not only has positive and negative implications on work but also on society. It is essential to consider these implications when designing work and setting cultural standards. • Machine Learning, Robotics, AI, and IoT: Experts believe that these factors are essential to consider and implement in the future of work. • Security and Ethics: It is important to consider the security, ethical, and moral implications of implementing new technologies in the workplace. Managers need to mitigate risks associated with new technology by vetting and communicating with workers.
Supply Chain	• Personalisation of supply chains - It is recommended that supply chains continue to move towards further customisation and personalisation based on consumer needs. • Automation of supply chains - End-to-end digitisation enables increased automation of systems and supply chains. Managers should create policies that allow further automation of supply chains while utilising surplus human input elsewhere in the business. • Sophistication and Multifaceted - Practitioners need to understand the sophisticated and multifaceted nature of supply chains from a social systems perspective and integrate different facets of supply chains. • Avoid delays - The COVID-19 pandemic caused upheaval to international supply chains, resulting in significant delays. Organisations should have contingencies in place and increase onshore manufacturing to decrease delays caused by unforeseen circumstances.

Given the importance of culture highlighted as the most crucial factor for social advancement in Industry 4.0, organisations must learn to create a psychologically and physically safe environment for their workers. Then, leaders may focus on their business practices and strategies and make sure that they are in line with both the objective of further digital transformation and the needs of the workforce (through open communication channels). The findings from this study support previous research stating that leaders in Industry 4.0 need to be agile, open to learning, and work cross-culturally and cross-generationally to establish a positive organisational culture (Črešnar & Nedelko, 2020; Klein, 2020). It is also recommended that organisations focus on training, supporting and upskilling their staff (practice effective knowledge management) when introducing new technologies and cyber-physical systems (Potter et al., 2022). The

training and upskilling will be more effective if the platforms and delivery methods are more user-friendly and inclusive of workers' diverse digital literacy levels and learning styles. This can also be achieved by ensuring that the platform users co-design the systems. Lastly, they can ensure that technological platforms and systems are compatible with existing technology to avoid internal supply chain issues.

The collective results from each of the studies in this thesis are of great importance to practitioners and leaders, as essential questions are addressed and answered at each step, providing clear guidelines on steps that can be taken to better prepare for the future of work using a social systems approach. These practical questions and their answers are summarised below (see Table 11).

Table 11

Practical Questions Answered in the Thesis

Question	Answered/ addressed in	Answers/Guidelines
What is important to prepare for the future of work?	Background Literature (Chapter 2)	Social systems perspective is crucial for effective digital transformation- without a clear understanding of the social elements, practitioners struggle to employ technological systems effectively. Increased understanding will help organisations and governing bodies create effective designs, policies, and practices for sustainable and profitable digital transformations.
How important is Psychosocial safety?	Study 1 (Chapter 3)	This study explains the importance of psychosocial safety as a precursor to preparing organisations for increased digitalisation. Therefore, managers can begin preparing for Industry 4.0 by showing commitment and prioritisation to employee wellbeing and preparing employees for upcoming and ongoing changes. The increased levels of PSC will, in turn, create a conducive climate that enables workers to be better prepared for Industry 4.0 and, more broadly, the future of work.
Do an increased innovation capacity and better attitudes towards change lead to better preparedness? If so, how?	Study 1 (Chapter 3)	Positive attitudes towards change and increased innovation capacity are both important factors in better preparedness for Industry 4.0. By prioritising psychosocial safety, managers can create a climate that fosters these attitudes and capacities, leading to better preparedness. Additionally, focusing on employee well-being not only benefits employees but also has a significant impact on productivity outcomes.
Does focusing on social systems factors lead to more financial gains?	Study 2 (Chapter 4)	The results indicate that the social systems factors do not directly impact financial organisational growth, highlighting the need to focus not just on external technologies, but also on inner workings and competencies. While prioritising employee health and well-being may not lead to direct monetary growth, it can significantly impact positive non-financial outcomes. This approach enables practitioners to

		make more holistic decisions for organisations in preparation for Industry 4.0.
How can practitioners implement social systems factors to improve organisational culture?	Study 3	Leaders can establish a human-centred approach to their business by prioritising a psychologically and physically safe environment for workers and improving relevant elements of organisational culture. Open communication channels can help align business practices and strategies with the needs of workers, furthering digital transformation. Agile leadership that embraces cross-cultural and cross-generational learning can also foster positive organisational culture. Effective knowledge management through training and upskilling can prepare staff for the introduction of new technologies and cyber-physical systems. Finally, ensuring the compatibility of technological platforms can prevent supply chain issues within organisations.
What steps can be taken to increase human preparedness for increased digitalisation (occurring as a result of Industry 4.0) and smoothly transition into the future of work?	Study 1+2+3 (Overarching message to practitioners)	The key findings of the thesis guide practitioners on specific factors to focus on to improve the social systems and human preparedness for Industry 4.0. Holistically, this thesis encourages organisations to focus on the environmental (or Press) factors when creating effective change management plans for the transition to the future of work and increased digitalisation. The specific environmental factors discussed revolve around creating the 'optimal' organisational culture that enables and empowers the employees to prepare for a journey towards the future of work. This organisational culture will have a firm grounding if it considers specific social systems factors such as Attitudes towards Organisational Change, PSC and innovation capacity, which have all shown to play a pivotal role in enabling better business and skills preparedness for Industry 4.0.

This thesis has taken initial steps in demonstrating the link between focusing on social systems factors and better readiness for the future of work, mainly focusing on integrating Industry 4.0 technologies. These findings benefit all leaders and organisations wanting to increase their digitalisation, integrate new cyber-physical systems, have a business model that survives changes brought on by the future of work and improve organisational outcomes for the business and the employees. As organisations transition to Industry 4.0, this thesis makes a timely and valuable contribution to advocating better preparedness for the future of work whilst remaining equitable, safe, and profitable.

6.4 Overall Contributions of this Thesis

As mentioned in the previous sections, this thesis encompasses three studies that have made novel contributions to literature with various theoretical and practical implications. Study 1 examined the effect of three key social systems factors and established a pathway that explains how high PSC leads to better preparedness for the future of work through improving attitudes towards organisational change and innovation capacity. By examining 192 decision-makers from different organisations, the findings from this Study 1 will be written as a separate journal paper and submitted for publication.

The second study was a novel attempt at establishing a relationship between social systems factors, readiness for Industry 4.0 and the financial growth of organisations. Using data linkage and two databases, financial growth data was connected to the data from the first study. The results indicated a stronger need to view organisational growth more holistically. It also revealed that organisations may need to wait for a considerable period to see the fruition of investment in people-centric activities as noticeable changes in financial growth. This 'lagging' effect can be explored further through future research. This research has contributed to the theoretical assumptions of organisational growth and created avenues for future research.

Finally, Study 3 focused on delving deeper and understanding the 'leadership perspective' of the future of work. The results from 16 qualitative interviews with women in senior leadership positions highlight that focusing on organisational culture and creating an inclusive organisational climate are the most important areas that organisations can focus on to prepare themselves for the future of work. The participants collectively noted that many employees fear their jobs being replaced by sophisticated technological advancements. Therefore, it is becoming increasingly important to have effective change management practices and take the employees 'on the journey' to be ready for the increase in digitalisation. This increase in readiness can be achieved through diminishing generational gaps in 'ways of working' via employee upskilling and making organisations more inclusive of individual needs. The 'generational gap' identified in this research has imminent implications for organisations in the future of work and therefore necessitates further exploration and consideration in future research. The results from this study will be submitted for publication in the International Journal of Qualitative Methods. Furthermore, the data collected on gender disparities and techniques to prevent them in the future of work will also be analysed and written up as a journal article to be published as a contribution to research beyond the PhD.

Additionally, Appendices J and K highlight research conducted in the fields of Industry 4.0 and Future of Work preparedness. The two co-authored book chapters and one co-authored journal article (related to gender disparities) in progress demonstrate dedication to these fields and highlight significant contributions to current literature that go beyond the current PhD.

Collectively, the three studies from this thesis make novel and timely contributions to Industry 4.0 and Future of Work literature. The insightful findings provide clear evidence of why it is important to use a social systems lens when looking at the future of work and demonstrate how to have better social preparedness. In summary, this thesis showcased the trickle effect of high psychosocial safety on readiness for Industry 4.0 in Study 1, demonstrating that organisations could increase their future readiness simply by ensuring the leaders create an excellent psychosocial safety climate through safeguarding and prioritising employee wellbeing. Next, Study 2 demonstrated the importance of focusing on social systems factors for better Industry 4.0 preparedness, even if it may not directly lead to financial gains. Furthermore, Study 3 demonstrated that establishing robust and healthy organisational cultures is of utmost importance for Industry 4.0 readiness as it impacts all other processes, practices, and policies within the workplace. Therefore, researchers and practitioners could be encouraged to consider the impact of organisational culture and use a systems approach to view issues causing resistance to preparedness for Industry 4.0. Finally, the amalgamation of the results can be systematically viewed and understood using the Four P's lenses. This new theorisation brings together the important findings uncovered in this thesis and enables the reader to appreciate the collective impact of this significant body of research.

Overall, the research in this thesis has significantly contributed to the fields of Industry 4.0, Future of Work preparedness, and social systems factors; and has effectively addressed the overarching research question; 'Keeping in mind the digital transformation occurring as a result of Industry 4.0, how can organisations best prepare to sustain themselves in the future of work using human-centred approaches?'. By looking at this question through the Four P's lenses, the answer to this question is simple and straightforward; focus on the environment (Press) of organisations through the creation of an organisational culture and climate that puts employees (Person) at the centre of its processes (Process). This will lead to better integration of the technological systems (Product). Finally, the successful interaction of these four P's will lead to better organisations being equipped to succeed in the future of work (i.e. Product). Previous valuable research by Sony and Naik 2020 uses the socio-technical theory to demonstrate the importance of integrating both 'social' and 'technical' elements when creating cyber-physical systems. This thesis extends and builds on the 'social' side of their pioneering work and sheds light on what kind of social systems factors organisations can focus on improving when designing CPSs and more broadly, when increasing Industry 4.0 readiness and maturity. Additionally, this thesis is the first to conduct a highly detailed examination of social readiness for Industry 4.0 whilst also considering relevant factors like employee attitudes to change, psychosocial safety and innovation. Finally, this thesis offers a contemporary viewpoint that captures the impact of COVID-19 on readiness for Industry 4.0 using a human-centred approach. In the following final chapter, the limitations of this research and valuable directions for future research that could progress knowledge in this area are discussed, followed by concluding remarks.

CHAPTER 7: Final Conclusions

7.1 Introduction

This thesis asked, 'How can organisations employ a social systems approach to better prepare for the future of work, especially with the digital change brought on by Industry 4.0?' To answer this question, three studies were undertaken that each explored different aspects of organisational behaviour and provided unique insights to advance the social systems understanding of Industry 4.0 preparedness. This thesis was successfully able to address three key gaps in the current literature (as identified in Chapter 2)

> Gap 1: The first gap was addressed in Study 1 (Chapter 3) as the findings advanced the limited research determining the impact of social systems factors on preparedness for Industry 4.0.
>
> Gap 2: The second gap was addressed in Study 2 (Chapter 4), providing insights into the impact of social systems factors and readiness for Industry 4.0 on the financial growth of organisations.
>
> Gap 3: The third gap was addressed in Study 3 (Chapter 5) through an exploration of how organisational culture and its social elements can mitigate the negative and enhance the positive experiences of integrating technologies and enable better preparedness for the future of work.

As discussed in Chapter 6, the findings of this thesis represent a number of advancements that contribute, both practically and theoretically, to a broader understanding of the importance of emphasising an organisational culture while preparing for Industry 4.0 and the future of work. The quantitative methodologies used in this thesis revealed an important previously unestablished pathway whereby despite the lack of a direct financial gain, psychosocial safety climate, innovation capacity and attitudes towards organisational change were all established as crucial factors influencing preparedness for Industry 4.0. Similarly, the qualitative methodology also revealed the importance of focusing on organisational culture, emphasising the discussed social systems factors. Collectively, the results of this thesis were looked at through the Four P's lenses (see Figure 15), providing a new theorisation for understanding Industry 4.0 through a social systems lens. Even though this thesis makes numerous important contributions, some limitations should be considered while evaluating the implications of the findings presented in this body of work. Sections 7.2 and 7.3 below discuss the limitations of this thesis and suggest future research directions that could enhance preparedness for the future of work.

7.2 Limitations of the Thesis

While there are many significant contributions in this thesis, there are some limitations that need to be kept in mind when understanding the impact of the conclusions made in this body of research. The background literature presented in Chapter 2 is a 'non-systematic narrative literature review' and is pivotal in providing

context for the research undertaken in this thesis. However, it is essential to note that it is not exhaustive or inclusive of all viewpoints and literature that exist around the topics of Industry 4.0, Industry 4.0 preparedness, social systems factors and the future of work. While the narrative literature presented may not identify the depth and breadth of gaps in literature within these fields, many references have been made to existing systematic reviews that effectively capture the extensive nature of broad and vastly researched topics like Industry 4.0 (Kamble et al., 2018; Liao et al., 2017; Zheng et al., 2021).

Secondly, the research undertaken for Study 3 commenced in late (December) 2021, post the initial aftermath of the pandemic outbreak of COVID-19. As indicated in the previous chapters of this thesis, a key focus of this body of research is on the 'Future of Work' preparedness. Given the turmoil and uncertainty the pandemic caused amongst people, in hindsight, it could have been anxiety provoking and even unethical to conduct interviews during the outbreak and ask participants their thoughts about the future of work. This presented unique limitations causing delays in ethics applications, added administrative tasks relating to health and safety and data collection. This third study was therefore re-planned, and the research was undertaken at a more appropriate time to briefly capture the impact of COVID-19 and understand the future of work, keeping in mind the turbulent changes that society had and is still undergoing. It is important to acknowledge that the pandemic was eye-opening for many organisations causing various changes in how people operate and understand work (Antova, 2020; McMahon, 2020; Sarfraz et al., 2021). The repercussions of this phenomenon are still being felt to date and are predicted to have long-lasting effects on society's overall functioning.

Another limitation of this thesis relates to the participants from Study 1 and Study 2. Not capturing the gender, age and other biodata elements ensured the participants' anonymity. However, it also led to a missed opportunity to account for these factors in the research and gather valuable insights into how different groups of people think differently.

Furthermore, the data collected for Study 2 (using participant responses and financial databases) was cross-sectional and correlated leading and lagging measures simultaneously. Consequently, the correlations may be inaccurate and unable to effectively capture the causal effect of investment in social systems factors. Additionally, the participants were only rewarded if they 'passed' the screening questions, which included their organisation's name. It is plausible that some participants had anonymity concerns and answered deceitfully to get the rewards associated with completing surveys. Future research may benefit from sending screening questions separately, using an open-ended question to ask the name of the organisation and only sending the complete survey to the participants who meet the selection criteria.

A limitation of Study 3 (Chapter 5) was that the assigned sex of the participants was limited to 'female', and all participants came from a narrow geographical background in Australia. While this provides a unique perspective and 'voice' to existing literature, the applicability of the results to a broader population may be

limited. The sample used in this study also provides a unique leadership perspective on readiness for Industry 4.0. However, it would be helpful to broaden this perspective and interview a more diverse set of people, including workers on different levels of organisational hierarchies, individuals identifying with other genders and employees with diverse geographical and cultural backgrounds. Future research would indeed benefit from replicating this study with a larger sample size.

Collectively, while the results from this thesis have made valuable contributions to literature, the data collected is cross-sectional, which may affect the generalisability and applicability of the findings. Future research would benefit from longitudinally testing the theoretical models discussed in this thesis to improve the generalisability of the results along with furthering a deeper social systems understanding of preparedness for Industry 4.0 and the future of work. Finally, when understanding the conclusion of this thesis and the generalisability of the results, the ramifications of COVID-19 and the time and funds allocated to the completion of this thesis must all be considered.

7.3 Future Directions for Research

This thesis has been a novel attempt at addressing the 'social systems' gaps in Future of Work literature and reiterated the importance of putting humans at the centre of cyber-physical systems. It highlights the importance of organisational culture and how a conducive organisational 'environment' (or Press) can be a key enabler in increasing organisations' preparedness for the future of work. Building on the concept of Society 5.0, future research could use the findings from this research to increase the knowledge and understanding of viewing Industry 4.0 more holistically on a systems level. As mentioned in Chapters 5 and 6, increasing organisational inclusivity, specifically from a gender and generational perspective, is an important step towards preparing for the future of work. While this exploration was beyond the scope of this thesis, further research could delve deeper and understand the impact of non-inclusive cultures on organisational preparedness and how to overcome inequalities through effective workforce planning, work design and change management. Furthermore, future research could also view COVID-19 as a case study for crisis management and explore the connection between Industry 4.0 preparedness/maturity and adaptability to unforeseen and unprecedented changes.

These suggestions for future research are clear roadmaps resulting from the findings of this thesis. However, it is essential to note that preparing for the future and the future of work does not stop at an organisational level. While this increased understanding will be helpful on an organisational level, it is also important to acknowledge and account for the broader societal and political impacts of Industry 4.0 on a systematic level. Given that the findings of this body of research were presented on a micro-level (organisational) and the macro-level factors were outside its scope, future research could use these

foundational results and apply them to a broader systems approach. Some of these preliminary ideas that need further exploration and empirical analysis are presented below:

7.3.1 The Role of Society 5.0

It is well understood that Industry 4.0 broadly focuses on transforming and elevating 'industrial' processes using digital uplift and interconnection of systems (Nair et al., 2021). This thesis has played a pivotal role in contributing to the literature and shedding light on the importance of focusing on organisational culture to improve social preparedness for Industry 4.0. Keeping these findings in mind, future research could delve deeper into exploring the role of organisational culture (including aspects like psychosocial safety and attitudes towards organisational change) in enabling the creation of Society 5.0. As explained in Chapter 2 and in line with the findings of this thesis, Society 5.0 endorses the use of human-centric principles to create Cyber-Physical systems for the future of work (Gladden, 2019). In their study, Nair et al. (2021) explain how the human-centric community in Society 5.0 can balance economic proliferation with resolving societal disparities occurring because of increased digitalisation and Industry 4.0. Holding on to the goal of increasing organisational inclusivity from this thesis, the use of Society 5.0 principles for designing cyber-physical systems and future work is imminent. Future research will also need to look beyond the organisational level and focus on 'culture' in general to understand its impact on larger communities or groups. This continued research using Society 5.0 principles has the potential to encourage society as a whole to focus on the role of 'Press' or the cultural environment that is being created around them and find ways to strive towards the creation of an 'exuberant, intelligent and smart society'- which is the ultimate goal of Society 5.0.

Interestingly, there is also emerging literature on the concept of 'Industry 5.0' emphasising sustainability, resilience, and human-centric values in the manufacturing sector (Breque et al., 2021; Fazal et al., 2022; Huang et al., 2022; Tiwari et al., 2022; Xu et al., 2021). The proposal of Industry 5.0 by the European Commission is viewed as a corrective measure for the perceived limitations of Industry 4.0, specifically its concentration on efficiency and technology (Breque et al., 2021). This proposition of Industry 5.0 may signify the Commission's acknowledgment of the necessity for a shift in paradigm towards a more sustainable and human-centric approach to manufacturing, aligning with the principles of Society 5.0. Industry 5.0 builds upon the literature on Industry 4.0, which focuses on optimising manufacturing processes through the integration of digital and physical technologies. Although Industry 5.0 has not been extensively researched and was beyond the scope of this thesis, it presents an exciting avenue for future exploration. However, the insights and findings from this thesis may have implications for future research in the domain of Industry 5.0. It is worth examining the potential connections and intersections between Industry 5.0 and Society 5.0, as both paradigms aim to integrate technology with human-centered values to benefit society as a whole. Future research may investigate how Industry 5.0 can promote sustainability,

resilience, and human-centric values in the manufacturing sector, and how these factors may influence social systems preparedness for the future of work.

7.3.2 The dark side of Industry 4.0

Another research area not included in this thesis is the 'dark side' of Industry 4.0. As echoed by Kovacs (2018) in their research, it is imminent that the capability, capacity and preparedness for Industry 4.0 will differ for different individuals, organisations and governments. It is therefore essential to view advancement in Industry 4.0 as a change in the whole ecosystem requiring interacting considerations between various social, technical and environmental factors (Kovacs, 2018). It is quite peculiar that most of the literature solely focuses on the positive aspects of transitioning to Industry 4.0, emphasising the promise of increased profitability while ignoring the dark corners, i.e. the unintended negative consequences of the technological advancements and innovations (Kovacs, 2018). While some of these unprecedented consequences have been briefly addressed in Chapter 5 of this thesis, there is a clear need for future research to explore these further and advance the understanding of Industry 4.0 as an ecosystem with both positive and negative effects on people, organisations, governments and society as a whole.

Interestingly in their recent book, Cropley and Cropley (2021) discuss how Industry 4.0 will inevitably have negative consequences that organisations will have to face. While it is unreasonable to think that any organisation will be able to avoid the negative consequences, it is plausible to identify and understand them through further research and be better prepared to deal with them in the future of work (Cropley & Cropley, 2021). With governments worldwide trying to design interventions to promote Industry 4.0, it is important to consider whether there is enough capacity within countries and individual organisations to offset those who are not equipped to deal with Industry 4.0 (Kovacs, 2018; Mazzucato, 2021). This process of transitioning entire countries and ecosystems requires critical deliberation and exploration of prevalent consequences of Industry 4.0 on factors such as employability, occupational health and safety, cybersecurity, legislation, ethics, work design and socioeconomic disparities (Kovacs, 2018; Szabó-Szentgróti et al., 2021). Some of these factors and ideas for future research are briefly described in the subsequent final section of this chapter.

7.3.2.1 Employability- Workforce Planning. It is increasingly crucial to comprehend and not undervalue the influence of Industry 4.0 on employability given that, despite a sixty-fold increase in global GDP, there has been no discernible increase in industrial employment over the past three decades (Kovacs, 2018; Szabó-Szentgróti et al., 2021). It is estimated that roughly 50% of all jobs can be displaced by automation using the technologies currently available (Kovacs, 2018; Szabó-Szentgróti et al., 2021). This phenomenon can leave large portions of the population vulnerable and susceptible to job loss. As highlighted in this thesis, Industry 4.0 is growing continually, and further digitalisation will only worsen

unless displaced workers are absorbed elsewhere. Therefore, workforce preparedness, training and upskilling will become central strategic goals for organisations and governments and is an area that requires more research (Hajkowicz et al., 2016; Kovacs, 2018). Future research can explore how organisations can avoid more significant displacements of the workforce through effective training, upskilling and preparedness. Interestingly, a study by Kovacs (2018) confirms the findings of this research and agrees that a sustained transition to Industry 4.0 as a society is only possible if the growth is inclusive and socially just.

7.3.2.2 Health and Safety. The current literature shows that the increase in digitalisation and automation will have detrimental effects on people's physical and mental health (Oppert et al., 2022). This thesis has repeatedly explained the importance of the psychosocial safety climate of organisations as a precursor for increased preparedness for the future of work. Keeping the increasing digitalisation in mind, and in line with the findings of this thesis, it is likely that Industry 4.0 could damage the cultures of organisations that are unprepared, leading to worker isolation, higher stress, lower support and reduced staff contact due to the promotion of more independent work through technologies (Hawkins & McDermid, 2019). This increased threat to psychosocial safety requires further exploration of occupational health and safety implications of preparing for Industry 4.0. A recent study by Potter et al. (2022) further reiterates the importance of understanding the impacts of digitalisation on psychological health and the future of work through their research.

Another critical health implication requiring further research is the impact of COVID-19 on the future of work. Since COVID has set the trend and enabled workers to work from home, it has also given rise to a heightened need for organisations to monitor work and new risks to health associated with the home environment (Kovacs, 2018). Therefore, future research must understand how organisations can continue to support employees and provide them with the necessary resources to cope with Industry 4.0 demands and offset the increasing health and safety concerns.

7.3.2.3 Cybersecurity. While concerns around cybersecurity are not new, they are increasingly being recognised as a significant issue related to transitioning to Industry 4.0 (Kovacs, 2018). Cybersecurity has the potential to induce severe uncertainties in the innovation ecosystem. Systematic intrusions into this ecosystem increase the vulnerability of the complex, interconnected systems built for improving technological processes. This could potentially result in significant damage, data leakage, and partial or even complete downtime in the event of a cyber-attack (Kovacs, 2018; Nair et al., 2021; Szabó-Szentgróti et al., 2021). As highlighted in Chapter 5, security, privacy, and data sovereignty are significant, constantly evolving challenges in the future of work that call for critical thought and more precise answers from the research and scientific community. Therefore, organisations will need to find ways to ensure the consistency, confidentiality, defence, ownership and integrity of big data through long and complex supply chains

(Cropley & Cropley, 2021; Kamble et al., 2018; Kovacs, 2018). As the need for appropriate infrastructure and personnel that can combat data security issues continues to rise, future research can assist organisations in understanding what measures can best prepare them for cybersecurity threats and cyber-attacks.

7.3.2.4 Socio-economic disparities. Industry 4.0 has transformed socioeconomic and environmental systems (Potočan et al., 2020). Reiterating the findings from Study 3, Industry 4.0 has intensified the social, cultural, ethnic and other conflicts between countries and organisations, leading to increasing inequality (Bashtannyk et al., 2020; Potočan et al., 2020). It is also important to note that more well-developed countries can invest more in the future of work and digitalisation, furthering the global socio-economic divide. Therefore, establishing a clear link between digitalisation and financial growth may provide insights into how policymakers can influence future legislation to address this challenge (Alekseev et al., 2018; Bashtannyk et al., 2020). Future research also needs to address how organisations can ensure better inclusivity and at least reduce the socioeconomic divide at work.

7.4 Conclusion

This thesis is an essential contribution to Industry 4.0 and the future of work paradigm shift. This body of research provides several significant theoretical and practical contributions to address the gaps in current knowledge of preparedness for the future of work through a social systems lens. Echoing the message in recent literature, this thesis exemplifies that despite the rapid growth of technologies, it is clear that humans are unlikely to get 'replaced' and that it is still necessary to keep humans at the centre of work to solve the problems of the future (Cropley & Cropley, 2021; Mazzucato, 2021; Nair et al., 2021; Potočan et al., 2020). The theoretical contributions have highlighted several pathways through increased psychosocial safety, positive attitudes, innovation and a focus on inclusivity that enable a better understanding of the role of organisational culture in increasing preparedness for the digitalisation of work. The results from this thesis also draw on the Rhodes' Four P's Model of Creativity and use the four P's lenses to better understand social readiness for Industry 4.0 (Rhodes, 1961). This research has various theoretical implications that pave the way for future research in the fields of Future of Work, gender inclusivity, generational inclusivity and occupational health and safety. On a broader level, this research highlights the gaps in knowledge in addressing the dark side of Industry 4.0 that, if neglected, can have damaging consequences for the future of work.

This thesis also offers practitioners specific objectives they can set, including adopting a human-centred approach to business strategies and work design, using efficient change management and workforce planning, and encouraging growth mindsets among staff members to support lifelong learning and improve their readiness for Industry 4.0 digitalisation. Specifically, this thesis encourages practitioners and policymakers to target improvement in the 'press' or environmental factors to plan for the changes that the future of work will inevitably bring about in organisations. Overall, the outcome of this thesis is an increased understanding of the social systems factors that enable a smoother transition into Industry 4.0. Finally, the fundamental ideas from this thesis can also be used to develop future-ready cyber-physical systems that put people first and, most importantly, with the increased social systems understanding are able to consider both technical and social systems.

CHAPTER 8: References

Acs, Z. J., & Sany, J. (2009). Measuring the Social Value of Innovation: The Cases of Muhammad Yunus, Grameen Bank and Bill Gates, Microsoft. In G. D. Libecap (Ed.), *Measuring the Social Value of Innovation: A Link in the University Technology Transfer and Entrepreneurship Equation* (pp. 143-170). Emerald Group Publishing Limited.

Adams, R., Bessant, J., & Phelps, R. (2006). Innovation management measurement: A review. *International Journal of Management Reviews, 8*(1), 21-47. https://doi.org/10.1111/j.1468-2370.2006.00119.x

Ahmad, A., Mehra, S., & Pletcher, M. (2004). The perceived impact of JIT implementation on firms' financial/growth performance. *Journal of Manufacturing Technology Management*, *15*(2), 118-130. https://doi.org/10.1108/09576060410513715

Ainsworth, S., & Knox, A. (2022). "A bridge too far?" Ideas, employment relations and policy-making about the future of work. *Industrial Relations: A Journal of Economy and Society*, *61*(1), 68-89. https://doi.org/10.1111/irel.12295

Akins, R. B., Tolson, H., & Cole, B. R. (2005). Stability of response characteristics of a Delphi panel: application of bootstrap data expansion. *BMC medical research methodology, 5*(1), 1-12.

Alekseev, A. N., Evdokimov, S. Y., Tarasova, A. Y., Khachaturyan, K. S., & Khachaturyan, A. A. (2018). Financial strategy of development of industry 4.0 in the countries with developing economy. *Revista Espacios*, *39*(12).

Ansah, E. W., & Mensah, J. K. O. (2020). Mediating Effect of Psychosocial Safety Climate and Job Resources in the Job Demands-Health Relation: Implications for Contemporary Business Management. *American International Journal of Business Management*, *3*(8), 74-83.

Antova, G. (2020, May 4). *COVID-19 set to accelerate Industry 4.0*. Australian Manufacturing. https://www.australianmanufacturing.com.au/119036/covid-19-set-to-accelerate-industry-4-0

Appelbaum, S. H. (1997). Socio-technical systems theory: an intervention strategy for organizational development. *Management Decision*, *35*(6), 452-463. https://doi.org/10.1108/00251749710173823

Appelbaum, S. H., Degbe, M. C., MacDonald, O., & Nguyen-Quang, T.-S. (2015). Organizational outcomes of leadership style and resistance to change (Part Two). *Industrial and Commercial Training*, *47*(3), 135-144. https://doi.org/10.1108/ICT-07-2013-0045

Asiimwe, M. M., & De Kock, I. H. (2019). An analysis of the extent to which Industry 4.0 has been considered in sustainability or socio-technical transitions. *South African Journal of Industrial Engineering*, *30*(3), 41-51.

Audretsch, D. B., Coad, A., & Segarra, A. (2014). Firm growth and innovation. *Small Business Economics*, *43*(4), 743-749. https://doi.org/10.1007/s11187-014-9560-x

Badri, A., Boudreau-Trudel, B., & Souissi, A. S. (2018). Occupational health and safety in the industry 4.0 era: A cause for major concern? *Safety Science*, *109*, 403-411. https://doi.org/10.1016/j.ssci.2018.06.012

Bag, S., Yadav, G., Dhamija, P., & Kataria, K. K. (2021). Key resources for industry 4.0 adoption and its effect on sustainable production and circular economy: An empirical study. *Journal of Cleaner Production, 281*, 125233.

Bailey, T. S., Dollard, M. F., & Richards, P. A. (2015). Programmes and Interventions for Psychosocial Risk and Worker Well-being: the Psychosocial Safety Climate (PSC) Framework. In R. J. Burke, & A. M. Richardsen (eds), *Corporate Wellness Programs: Linking Employee and Organizational Health* (pp. 101-119). Edward Elgar Publishing Limited. https://doi.org/10.4337/9781783471706

Bailey, T. S., Dollard, M. F., Richards, P. A. M., & Hurrell, J. J. (2015). A National Standard for Psychosocial Safety Climate (PSC): PSC 41 as the Benchmark for Low Risk of Job Strain and Depressive Symptoms. *Journal of Occupational Health Psychology*, *20*(1), 15-26. https://doi.org/10.1037/a0038166

Bakker, A. B., & Demerouti, E. (2007). The job demands-resources model: State of the art. *Journal of Managerial Psychology*, *22*(3), 309-328.

Baldassari, P., & Roux, J. D. (2017). Industry 4.0: Preparing for the future of work. *People & Strategy*, *40*(3), 20-24.

Baldassarre, F., Ricciardi, F., & Campo, R. (2017). The Advent of Industry 4.0 in Manufacturing Industry: Literature Review and Growth Opportunities. *DIEM: Dubrovnik International Economic Meeting*, *3*(1), 632-643.

Bartodziej, C. J. (2017). The concept industry 4.0. In C. J. Bartodziej (Ed), *The concept industry 4.0* (pp. 27-50). Springer.

Bartsch, S., Weber, E., Büttgen, M., & Huber, A. (2020). Leadership matters in crisis-induced digital transformation: how to lead service employees effectively during the COVID-19 pandemic. *International Journal of Service Industry Management*, *32*(1), 71-85. https://doi.org/10.1108/JOSM-05-2020-0160

Bashtannyk, V., Buryk, Z., Kokhan, M., Vlasenko, T., & Skryl, V. (2020). Financial, economic and sustainable development of states within the conditions of industry 4.0. *International journal of management, 11*(4), 406-413.

Beaudan, E. (2006). Making change last: How to get beyond change fatigue. *Ivey Business Journal, 70*(3), 1-7.

Bednar, P. M., & Welch, C. (2020). Socio-technical perspectives on smart working: Creating meaningful and sustainable systems. *Information Systems Frontiers*, *22*(2), 281-298.

Belazreg, W., & Mtar, K. (2020). Modelling the causal linkages between trade openness, innovation, financial development and economic growth in OECD Countries. *Applied Economics Letters*, *27*(1), 5-8. https://doi.org/10.1080/13504851.2019.1605581

Belias, D., & Koustelios, A. (2014). The impact of leadership and change management strategy on organizational culture. *European Scientific Journal*, *10*(7), 451-470.

Berg, J., Furrer, M., Harmon, E., Rani, U., & Silberman, M. S. (2018). *Digital labour platforms and the future of work: Towards decent work in the online world*. International Labor Organization. http://wtf.tw/text/digital_labour_platforms_and_the_future_of_work.pdf

Bernerth, J. B., Walker, H. J., & Harris, S. G. (2011). Change fatigue: Development and initial validation of a new measure. *Work & Stress, 25*(4), 321-337.

Bhattacharya, A., Reeves, M., Lang, N., & Augustinraj, R. (2017, November 14). *New business models for a new global landscape*. BCG Henderson Institute. https://www.bcg.com/publications/2017/globalization-new-business-models-global-landscape

Bonate, P. L. (2017). Effect of correlation on covariate selection in linear and nonlinear mixed effect models. *Pharmaceutical statistics, 16*(1), 45-54.

Bonekamp, L., & Sure, M. (2015). Consequences of Industry 4.0 on human labour and work organisation. *Journal of Business and Media Psychology*, *6*(1), 33-40.

Bordeleau, F.-È., & Felden, C. (2019). Digitally transforming organisations: a review of change models of industry 4.0. *Proceedings of the 27th European Conference on Information Systems (ECIS)*. https://core.ac.uk/download/pdf/301379432.pdf

Bouckenooghe, D., Devos, G., & Van Den Broeck, H. (2009). Organizational Change Questionnaire–Climate of Change, Processes, and Readiness: Development of a New Instrument. *The Journal of Psychology*, *143*(6), 559-599. https://doi.org/10.1080/00223980903218216

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 Information and Communication Engineering, 8*(1), 37-44.

Brockman, J. B. (2009). *Introduction to engineering: modeling and problem solving*. John Wiley & Sons Inc.

Brown, J., Gosling, T., Sethi, B., Sheppard, B., Stubbings, C., Sviokla, J., Williams, J., & Zarubina, D. (2017). *Workforce of the future, The competing forces shaping 2030.* PricewaterhouseCoopers. https://www.pwc.com/gx/en/services/people-organisation/workforce-of-the-future/workforce-of-the-future-the-competing-forces-shaping-2030-pwc.pdf

Browne, M. W., & Cudeck, R. (2016). Alternative Ways of Assessing Model Fit. *Sociological methods & research*, *21*(2), 230-258. https://doi.org/10.1177/0049124192021002005

Büchi, G., Cugno, M., & Castagnoli, R. (2020). Smart factory performance and Industry 4.0. *Technological Forecasting & Social Change*, *150*. https://doi.org/10.1016/j.techfore.2019.119790

Buhl, H. R. (1960). *Creative engineering design*. Iowa State University Press.

Bujang, M. A., & Baharum, N. (2016). Sample size guideline for correlation analysis. *World, 3*(1), 37-46.

Burghardt, M. D. (1995). *Introduction to the Engineering Profession*. (2nd ed.). HarperCollins College Publishers.

Büschgens, T., Bausch, A., & Balkin, D. B. (2013). Organizational culture and innovation: A meta-analytic review. *Journal of Product Innovation Management*, *30*(4), 763-781.

Bustinza, O. F., Bigdeli, A. Z., Baines, T., & Elliot, C. (2015). Servitization and Competitive Advantage: The Importance of Organizational Structure and Value Chain Position. *Research-Technology Management*, *58*(5), 53-60. https://doi.org/10.5437/08956308X5805354

Cameron, E., & Green, M. (2009). *Making Sense of Change Management: A Complete Guide to the Models, Tools & Techniques of Organizational Change* (2nd ed). Kogan Page. http://search.ebscohost.com.access.library.unisa.edu.au/login.aspx?direct=true&db=nlebk&AN=265362&site=ehost-live

Cattivelli, V., & Rusciano, V. (2020). Social innovation and food provisioning during COVID-19: The case of urban–rural initiatives in the province of Naples. *Sustainability (Basel, Switzerland)*, *12*(11), 4444.

Chadwick, J. (2022, May 3). *Inside Ocado's giant 'Hive' warehouse in south-east London where an army of 2,000 robots pick up to 2 MILLION food items per day – five times faster than a trained human*

worker. Daily Mail Australia. https://www.dailymail.co.uk/sciencetech/article-10774949/Ocado-using-army-2-000-robots-East-London-fulfilment-centre.html

Chang, W., Ellinger, A. E., Kim, K., & Franke, G. R. (2016). Supply chain integration and firm financial performance: A meta-analysis of positional advantage mediation and moderating factors. *European Management Journal*, *34*(3), 282-295. https://doi.org/10.1016/j.emj.2015.11.008

Chui, M., Manyika, J., & Miremadi, M. (2016). Where machines could replace humans - and where they can't (yet). *The McKinsey Quarterly*, *3*, 58-69.

Chung, Y., Hsu, Y., Tsai, S., Huang, H., & Tsai, C. (2012). The correlation between business strategy, information technology, organisational culture, implementation of CRM, and business performance in a high-tech industry. *South African Journal of Industrial Engineering*, *23*(2), 1-15.

Cifuentes-Faura, J., & Faura-Martínez, U. (2023). Measuring Spanish airport performance: A bootstrap data envelopment analysis of efficiency. *Utilities Policy, 80*, 101457.

Cimini, C., Boffelli, A., Lagorio, A., Kalchschmidt, M., & Pinto, R. (2020). How do industry 4.0 technologies influence organisational change? An empirical analysis of Italian SMEs. *Journal of Manufacturing Technology Management*, *32*(3), 695-721. https://doi.org/10.1108/JMTM-04-2019-0135

Clarke, V., & Braun, V. (2013). Successful qualitative research: A practical guide for beginners. *Successful qualitative research*, SAGE Publications.

Cooper, J., & James, A. (2009). Challenges for database management in the internet of things. *IETE Technical Review*, *26*(5), 320-329.

Črešnar, R., & Nedelko, Z. (2020). Understanding Future Leaders: How Are Personal Values of Generations Y and Z Tailored to Leadership in Industry 4.0? *Sustainability (Basel, Switzerland)*, *12*(11), 4417. https://doi.org/10.3390/su12114417

Cropley, A. J. (1999). Creativity and cognition: Producing effective novelty. *Roeper Review*, *21*(4), 253-260.

Cropley, A. J. (2019). *Introduction to qualitative research methods: A practice-oriented introduction.* Editura Intaglio Publishing House.

Cropley, D. H., & Cropley, A. J. (2012). A psychological taxonomy of organizational innovation: Resolving the paradoxes. *Creativity Research Journal*, *24*(1), 29-40.

Cropley, D. H., & Cropley, A. J. (2017). Innovation capacity, organisational culture and gender. *European journal of innovation management*, *20*(3), 493-510. https://doi.org/10.1108/ejim-12-2016-0120

Cropley, D. H., & Cropley, A. J. (2021). *Core Capabilities for Industry 4.0: Foundations of the Cyber-Psychology of 21st Century Engineering Education*. wbv Media GmbH & Company KG.

Cropley, D. H. (2015). *Creativity in engineering: Novel solutions to complex problems*. Academic Press.

Cropley, D. H. (2019). *Homo Problematis Solvendis - Problem-solving Man: A History of Human Creativity*. Springer Nature.

Cropley, D. H., & Cropley, A. J. (2015). *The psychology of innovation in organizations. Cambridge University Press*. https://doi.org/10.1017/cbo9781316104811

Cropley, D. H., & Cropley, A. J. (2021). *Core Capabilities for Industry 4.0 - Foundation of the Cyber-Psychology of Engineering*. Wbv Media.

Cropley, D. H., Cropley, A. J., Chiera, B. A., & Kaufman, J. C. (2013). Diagnosing Organizational Innovation: Measuring the Capacity for Innovation. *Creativity Research Journal*, *25*(4), 388-396. https://doi.org/10.1080/10400419.2013.843330

Cropley, D. H., Cropley, A. J., & Sandwith, B. L. (2017). Creativity in the Engineering Domain. In J. C. Kaufman, V. P. Glăveanu, & J. Baer (Eds.), *The Cambridge Handbook of Creativity Across Domains* (2nd ed., pp. 261-275). Cambridge University Press.

Cruz-Cárdenas, J., Zabelina, E., Guadalupe-Lanas, J., Palacio-Fierro, A., & Ramos-Galarza, C. (2021) COVID-19, consumer behavior, technology, and society: A literature review and bibliometric analysis. *Technological Forecasting and Social Change*, *173*, 121179. https://doi.org/10.1016/j.techfore.2021.121179

Cugno, M., Castagnoli, R., & Büchi, G. (2021). Openness to Industry 4.0 and performance: The impact of barriers and incentives. *Technological Forecasting and Social Change*, *168*, 120756. https://doi.org/10.1016/j.techfore.2021.120756

Dalenogare, L. S., Benitez, G. B., Ayala, N. F., & Frank, A. G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics*, *204*, 383-394. https://doi.org/10.1016/j.ijpe.2018.08.019

Dalmarco, G., Ramalho, F. R., Barros, A. C., & Soares, A. L. (2019). Providing industry 4.0 technologies: The case of a production technology cluster. *The Journal of High Technology Management Research*, *30*(2), 100355. https://doi.org/10.1016/j.hitech.2019.100355

Daovisan, H., & Chamaratana, T. (2020). Resistance to change in the financial management of small family-owned firms: a grounded theory of family firms in Laos. *Journal of Accounting & Organizational Change*, *16*(3), 497-514. https://doi.org/10.1108/JAOC-05-2020-0063

Davies, R., Coole, T., & Smith, A. (2017). Review of socio-technical considerations to ensure successful implementation of Industry 4.0. *Procedia Manufacturing*, *11*, 1288-1295.

Davis, K. (2014). Intersectionality as critical methodology. In N. Lykke (Ed.), *Writing academic texts differently: Intersectional feminist methodologies and the playful art of writing* (pp. 17-29). Routledge.

Dawadi, S., Shrestha, S., & Giri, R. A. (2021). Mixed-methods research: A discussion on its types, challenges, and criticisms. *Journal of Practical Studies in Education, 2*(2), 25-36.

DeFelice, K. A., & Diller, J. W. (2019). Intersectional feminism and behavior analysis. *Behavior Analysis in Practice, 12*, 831-838.

Deguchi, A., Hirai, C., Matsuoka, H., Nakano, T., Oshima, K., Tai, M., & Tani, S. (2020). What is society 5.0. *Society*, *5*, 1-23.

Del Giudice, M., Scuotto, V., Garcia-Perez, A., & Petruzzelli, A. M. (2019). Shifting Wealth II in Chinese economy. The effect of the horizontal technology spillover for SMEs for international growth. *Technological Forecasting and Social Change*, *145*, 307-316.

Demirel, P., & Mazzucato, M. (2012). Innovation and Firm Growth: Is R&D Worth It? *Industry and Innovation*, *19*(1), 45-62. https://doi.org/10.1080/13662716.2012.649057

Dhondt, S., Van der Zee, F., Preenen, P., Kraan, K., & Oeij, P. R. (2022). Dominant Technology and Organization: Impact of Digital Technology on Skills. *Digital Innovation and the Future of Work* (pp. 259-283). River Publishers.

Diaz, I., Chiaburu, D. S., Zimmerman, R. D., & Boswell, W. R. (2012). Communication technology: Pros and cons of constant connection to work. *Journal of Vocational Behavior*, *80*(2), 500-508.

Dieter, G. E., & Schmidt, L. C. (2012). *Engineering design* (5th ed.). McGraw-Hill Higher Education.

Dollard, M. F., & Bakker, A. B. (2010). Psychosocial safety climate as a precursor to conducive work environments, psychological health problems, and employee engagement. *Journal of Occupational and Organizational Psychology*, *83*(3), 579-599. https://doi.org/10.1348/096317909x470690

Dollard, M. F., & Karasek, R. A. (2010). Building psychosocial safety climate: evaluation of a socially constructed PAR risk management stress prevention study. In S. Leka, & R. R. Sinclair (Eds.),

Contemporary occupational health psychology: global perspectives on research practice (pp. 208-233). Wiley-Blackwell & Sons.

Dollard, M. F., & McTernan, W. P. (2011). Psychosocial safety climate: a multilevel theory of work stress in the health and community service sector. *Epidemiology and psychiatric sciences*, *20*(4), 287-293. https://doi.org/10.1017/s2045796011000588

Dollard, M. F., Opie, T., Lenthall, S., Wakerman, J., Knight, S., Dunn, S., Rickard, G., & Macleod, M. (2012). Psychosocial safety climate as an antecedent of work characteristics and psychological strain: A multilevel model. *Work & Stress*, *26*(4), 385-404. https://doi.org/10.1080/02678373.2012.734154

Durana, P., Kral, P., Stehel, V., Lazaroiu, G., & Sroka, W. (2019). Quality Culture of Manufacturing Enterprises: A possible way to adaptation to Industry 4.0. *Social Sciences*, *8*(4), 124.

Eslami, M. H., Jafari, H., Achtenhagen, L., Carlbäck, J., & Wong, A. (2021). Financial performance and supply chain dynamic capabilities: the Moderating Role of Industry 4.0 technologies. *International Journal of Production Research*, 1-18.

Farzad, F. S., Salamzadeh, Y., Amran, A. B., & Hafezalkotob, A. (2020). Social innovation: Towards a better life after COVID-19 crisis: What to concentrate on. *Journal of Entrepreneurship, Business and Economics*, *8*(1), 89-120.

Fatorachian, H., & Kazemi, H. (2021). Impact of Industry 4.0 on supply chain performance. *Production Planning & Control, 32*(1), 63-81.

Fernández-Macías, E. (2018). *Automation, digitalisation and platforms: Implications for work and employment*. Eurofound. https://ecommons.cornell.edu/bitstream/handle/1813/87388/EF_Automation_digitisation_and_platforms.pdf

Finsterwalder, J., & Kuppelwieser, V. G. (2020). Equilibrating resources and challenges during crises: a framework for service ecosystem well-being. *Journal of Service Management*, *31*(6), 1107-1129. https://doi.org/10.1108/JOSM-06-2020-0201

Fleetwood, S. (2005). Ontology in organization and management studies: A critical realist perspective. *Organization, 12*(2), 197-222.

Forbes Technology Council. (2020, July 10). *The 16 most influential (and inspirational) modern tech leaders, according to industry experts*. Forbes. https://www.forbes.com/sites/forbestechcouncil/2020/07/10/the-16-most-influential-and-inspirational-modern-tech-leaders-according-to-industry-experts/?sh=cb177e279c30

Frank, A. G., Dalenogare, L. S., & Ayala, N. F. (2019). Industry 4.0 technologies: Implementation patterns in manufacturing companies. *International Journal of Production Economics, 210*, 15-26.

Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change, 114*(C), 254-280. https://EconPapers.repec.org/RePEc:eee:tefoso:v:114:y:2017:i:c:p:254-280

Friedman, Y., & Carmeli, A. (2022). CEOs Driving Decision Making Toward Higher Performance: Strategic Micro-foundations of Small-Sized Family Firms. *The Journal of Applied Behavioral Science, 58*(2), 256-280.

Frunzaru, V., & Corbu, N. (2020). Students' attitudes towards knowledge and the future of work. *Kybernetes, 49*(7), 1987-2002.

Fukuda, K. (2020). Science, technology and innovation ecosystem transformation toward society 5.0. *International Journal of Production Economics*, *220*, 107460.

Gallo, C. (2011). *Innovation Secrets of Steve Jobs: Insanely Different Principles for Breakthrough Success* (1st ed). McGraw-Hill Education.

Garrick, A., Mak, A. S., Cathcart, S., Winwood, P. C., Bakker, A. B., & Lushington, K. (2014). Psychosocial safety climate moderating the effects of daily job demands and recovery on fatigue and work engagement. *Journal of Occupational and Organizational Psychology, 87*(4), 694-714.

Ghadge, A., Kara, M. E., Moradlou, H., & Goswami, M. (2020). The impact of Industry 4.0 implementation on supply chains. *Journal of Manufacturing Technology Management*, *31*(4), 669-686.

Gianecchini, M., Dotto, S., & Gubitta, P. (2022). Shaping the Future of Work. In L. Solari, M. Martinez, A. M. Braccini, & A. Lazazzara (Eds.), *Do Machines Dream of Electric Workers?* (pp. 67-83). Springer.

Gilchrist, A. (2016). *Industry 4.0: the industrial internet of things*. Apress.

Gilley, A., Dixon, P., & Gilley, J. W. (2008). Characteristics of leadership effectiveness: Implementing change and driving innovation in organizations. *Human Resource Development Quarterly*, *19*(2), 153-169.

Gladden, M. E. (2019). Who will be the members of Society 5.0? Towards an anthropology of technologically posthumanized future societies. *Social Sciences*, *8*(5), 148.

Glasscock, D. J., Rasmussen, K., Carstensen, O., & Hansen, O. N. (2006). Psychosocial factors and safety behaviour as predictors of accidental work injuries in farming. *Work & Stress*, *20*(2), 173-189. https://doi.org/10.1080/02678370600879724

Görmüş, A. (2019). Future of work with the industry 4.0. *International Congress on Social Sciences (INCSOS 2019) proceeding book*, *1*(32), 317-323.

Goswami, M., & Daultani, Y. (2021). Make-in-India and Industry 4.0: technology readiness of select firms, barriers and socio-technical implications. *The TQM Journal*, *34*(6), 1485-1505. https://doi.org/10.1108/TQM-06-2021-0179

Gradinaru, C., Toma, S.-G., Catana, S., & Andrisán, G. (2020). A view on transformational leadership: The case of Jeff Bezos. *Manager*, (31), 93-100.

Gray, C. (2002). Entrepreneurship, resistance to change and growth in small firms. *Journal of small business and enterprise development*, *9*(1), 61-72. https://doi.org/10.1108/14626000210419491

Grayling, A. (2022*). For the Good of the World: Why Our Planet's Crises Need Global Agreement Now*. Simon and Schuster.

Grewatsch, S., & Kleindienst, I. (2017). When Does It Pay to be Good? Moderators and Mediators in the Corporate Sustainability–Corporate Financial Performance Relationship: A Critical Review. *Journal of Business Ethics*, *145*(2), 383-416. https://doi.org/10.1007/s10551-015-2852-5

Guckelsberger, C., Salge, C., & Colton, S. (2017). Addressing the" why?" in computational creativity: A non-anthropocentric, minimal model of intentional creative agency. *8th International Conference on Computational Creativity*. https://research.gold.ac.uk/id/eprint/21743/1/iccc2017_guckelsberger.pdf

Guest, G., Namey, E., & Chen, M. (2020). A simple method to assess and report thematic saturation in qualitative research. *PloS one, 15*(5), e0232076.

Guilford, J. P. (1950). *Creativity*. American Psychologist.

Guilford, J. P. (1959). Traits of creativity. In H. H. Anderson (Ed.), *Creativity and its cultivation* (pp. 142-161). Harper.

Gupta, S., Drave, V. A., Bag, S., & Luo, Z. (2019). Leveraging smart supply chain and information system agility for supply chain flexibility. *Information Systems Frontiers, 21*(3), 547-564.

Haffke, I., Kalgovas, B., & Benlian, A. (2017). The transformative role of bimodal IT in an era of digital business. *Proceedings of the 50th Hawaii International Conference on System Sciences,* 5460-5469.

Hahn, G. J. (2020). Industry 4.0: a supply chain innovation perspective. *International Journal of Production Research, 58*(5), 1425-1441.

Hajkowicz, S., Reeson, A., Rudd, L., Bratanova, A., Hodgers, L., Mason, C., & Boughen, N. (2016). Tomorrow's digitally enabled workforce: Megatrends and scenarios for jobs and employment in Australia over the coming twenty years. *Brisbane, QLD, Australia: CSIRO*

Hall, G. B., Dollard, M. F., Coward, J., & Vandenbos, G. (2010). Psychosocial Safety Climate: Development of the PSC-12. *International Journal of Stress Management*, *17*(4), 353-383. https://doi.org/10.1037/a0021320

Hall, G. E., & Hord, S. M. (2006). *Implementing change : patterns, principles, and potholes* (2nd ed.). Pearson/Allyn & Bacon.

Hall, J. L., & Howell-Moroney, M. E. (2012). Poverty, innovation capacity, and state economic development in the knowledge economy: Evidence from the US. *Growth and Change*, *43*(2), 228-251.

Hamada, T. (2019). Determinants of Decision-Makers' Attitudes toward Industry 4.0 Adaptation. *Social Sciences*, *8*(5), 140. https://doi.org/10.3390/socsci8050140

Harrison, R. L., Reilly, T. M., & Creswell, J. W. (2020). Methodological rigor in mixed methods: An application in management studies. *Journal of Mixed Methods Research, 14*(4), 473-495.

Haseeb, M., Hussain, H. I., Ślusarczyk, B., & Jermsittiparsert, K. (2019). Industry 4.0: A solution towards technology challenges of sustainable business performance. *Social Sciences*, *8*(5), 154.

Hawkins, R., & McDermid, J. (2019). *Safety assurance of autonomy to support the Fourth Industrial Revolution.* Global Manufacturing & Industrialisation Summit. https://www.ciip-group.org/reports-and-articles/safety-assurance-autonomy-support-fourth-industria/download/Briefing_Assurance_of_AM.pdf

Hecklau, F., Galeitzke, M., Flachs, S., & Kohl, H. (2016). Holistic Approach for Human Resource Management in Industry 4.0. *Procedia CIRP*, *54*, 1-6. https://doi.org/10.1016/j.procir.2016.05.102

Hennink, M., & Kaiser, B. N. (2022) Sample sizes for saturation in qualitative research: A systematic review of empirical tests. *Social Science & Medicine, 292*, 114523. https://doi.org/https://doi.org/10.1016/j.socscimed.2021.114523

Herold, D. M., Fedor, D. B., Caldwell, S. D., & Zedeck, S. (2007). Beyond Change Management: A Multilevel Investigation of Contextual and Personal Influences on Employees' Commitment to Change. *Journal of Applied Psychology*, *92*(4), 942-951. https://doi.org/10.1037/0021-9010.92.4.942

Hess, T., Matt, C., Benlian, A., & Wiesböck, F. (2016). Options for formulating a digital transformation strategy. *MIS Quarterly Executive*, *15*(2), 123-139.

Higgins, J. M. (1994). *101 creative problem solving techniques: The handbook of new ideas for business.* The New Management Publishing Company.

Hiller, J. (2016). Epistemological foundations of objectivist and interpretivist research. In B. L. Wheeler and K. M. Murphy (Ed.), *Music Therapy Research* (3rd ed.). Barcelona Publishers.

Horenstein, M. N. (2002). *Design concepts for engineers* (2nd ed.). Prentice-Hall, Inc.

Horton, J., Cameron, A., Devaraj, D., Hanson, R., & Hajkowicz, S. (2018). Workplace safety futures: the impact of emerging technologies and platforms on work health and safety and workers' compensation over the next 20 years. *Canberra, ACT, Australia: CSIRO.*

Huang, D. T., Clermont, G., Sexton, B. J., Karlo, C. A., Miller, R. G., Weissfeld, L. A., Rowan, K. M., & Angus, D. C. (2007). Perceptions of safety culture vary across the intensive care units of a single institution. *Critical care medicine, 35*(1), 165-176.

Hurley, R. F., Hult, G. T. M., & Knight, G. A. (2005). Innovativeness and capacity to innovate in a complexity of firm-level relationships: A response to Woodside (2004). *Industrial marketing management*, *34*(3), 281-283. https://doi.org/10.1016/j.indmarman.2004.07.006

Ibarra, D., Ganzarain, J., & Igartua, J. I. (2018). Business model innovation through Industry 4.0: A review. *Procedia Manufacturing*, *22*, 4-10. https://doi.org/10.1016/j.promfg.2018.03.002

Idris, M. A., Dollard, M. F., Coward, J., & Dormann, C. (2012). Psychosocial safety climate: Conceptual distinctiveness and effect on job demands and worker psychological health. *Safety Science*, *50*(1), 19-28. https://doi.org/10.1016/j.ssci.2011.06.005

Idris, M. A., Dollard, M. F., & Glazer, S. (2011). Psychosocial Safety Climate, Work Conditions, and Emotions in the Workplace: A Malaysian Population-Based Work Stress Study. *International Journal of Stress Management*, *18*(4), 324-347. https://doi.org/10.1037/a0024849

Idris, M. A., Dollard, M. F., Yulita, M. F., & Hurrell, J. J. (2014). Psychosocial Safety Climate, Emotional Demands, Burnout, and Depression: A Longitudinal Multilevel Study in the Malaysian Private Sector. *Journal of Occupational Health Psychology*, *19*(3), 291-302. https://doi.org/10.1037/a0036599

ILO, & IEA. (2021). *Principles and guidelines for human factors/ergonomics (HFE) design and management of work systems*. International Labor Organization. https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---lab_admin/documents/publication/wcms_826596.pdf

Imran, F., & Kantola, J. (2018). Review of industry 4.0 in the light of sociotechnical system theory and competence-based view: A future research agenda for the evolute approach. In *International Conference on Applied Human Factors and Ergonomics* (pp. 118-128). Springer, Cham.

Izadi Z.D, J., Ziyadin, S., Palazzo, M., & Sidhu, M. (2020). The evaluation of the impact of innovation management capability to organisational performance. *Qualitative market research*, *23*(4), 697-723. https://doi.org/10.1108/QMR-04-2020-0052

James, T. (2012). Smart factories. *Engineering & technology*, *7*(6), 64-67.

Jantunen, A., Puumalainen, K., Saarenketo, S., & Kyläheiko, K. (2005). Entrepreneurial orientation, dynamic capabilities and international performance. *Journal of International Entrepreneurship, 3*(3), 223-243.

Javaid, M., Haleem, A., Vaishya, R., Bahl, S., Suman, R., & Vaish, A. (2020). Industry 4.0 technologies and their applications in fighting COVID-19 pandemic. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(4), 419-422. https://doi.org/https://doi.org/10.1016/j.dsx.2020.04.032

Jensen, J. N. (2006). *A User's Guide to Engineering*. Pearson: Prentice Hall.

Jiménez-Zarco, A. I., Rospigliosi, A., Martínez-Ruiz, M. P., & Izquierdo-Yusta, A. (2019). Marketing 4.0: Enhancing consumer-brand engagement through big data analysis. In Information Resources Management Association (Ed.), *Web Services: Concepts, Methodologies, Tools, and Applications* (pp. 2172-2195). IGI Global.

Kadir, B. A., & Broberg, O. (2021). Human-centered design of work systems in the transition to industry 4.0. *Applied Ergonomics*, *92*, 103334.

Kamble, S. S., Gunasekaran, A., & Gawankar, S. A. (2018). Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection*, *117,* 408-425. https://doi.org/https://doi.org/10.1016/j.psep.2018.05.009

Kaminski, J. J. (2019). Rethinking Realism and Constructivism Through the Lenses of Themes and Ontological Primacy. *Croatian International Relations Review, 25*(85), 6-29.

Kashif, M., Zarkada, A., & Ramayah, T. (2018). The impact of attitude, subjective norms, and perceived behavioural control on managers' intentions to behave ethically. *Total Quality Management & Business Excellence, 29*(5-6), 481-501.

Kazim, F. A. (2019). Digital Transformation and Leadership Style: A Multiple Case Study. *ISM Journal of International business*, *3*(1), 24-33.

Ke, W., & Wei, K. K. (2008). Organizational culture and leadership in ERP implementation. *Decision support systems, 45*(2), 208-218.

Kelly, L. M., & Cordeiro, M. (2020). Three principles of pragmatism for research on organizational processes. *Methodological innovations, 13*(2), 2059799120937242.

Kessler, S. (2018). *Gigged: The gig economy, the end of the job and the future of work*. Random House.

Khallash, S., & Kruse, M. (2012). The future of work and work-life balance 2025. *Futures, 44*(7), 678-686. https://doi.org/https://doi.org/10.1016/j.futures.2012.04.007

Kirby, E. L., & Harter, L. M. (2003). Speaking the Language of the Bottom-Line: The Metaphor of "Managing Diversity". *The Journal of Business Communication (1973), 40*(1), 28-49. https://doi.org/10.1177/002194360304000103

Kirk, C. P., & Rifkin, L. S. (2020). I'll trade you diamonds for toilet paper: Consumer reacting, coping and adapting behaviors in the COVID-19 pandemic. *Journal of business research, 117*, 124-131.

Klein, M. (2020). Leadership characteristics in the era of digital transformation.

Koh, L., Orzes, G., & Jia, F. J. (2019). The fourth industrial revolution (Industry 4.0): technologies disruption on operations and supply chain management. *International Journal of Operations & Production Management*, *39*(6/7/8), 817-828.

Kopp, R., Dhondt, S., Hirsch-Kreinsen, H., Kohlgrüber, M., & Preenen, P. (2019). Sociotechnical perspectives on digitalisation and Industry 4.0. *International Journal of Technology Transfer and Commercialisation*, 16(3), 290-309.

Kovacs, O. (2018). The dark corners of industry 4.0–Grounding economic governance 2.0. Technology in Society, *55*, 140-145.

Kruglanski, A. W., Fishbach, A., Woolley, K., Bélanger, J. J., Chernikova, M., Molinario, E., & Pierro, A. (2018). A structural model of intrinsic motivation: On the psychology of means-ends fusion. *Psychological Review, 125*(2), 165.

Kursunoglu, A., & Tanrıogen, A. (2009). The relationship between teachers' perceptions towards instructional leadership behaviors of their principals and teachers' attitudes towards change. Procedia - Social and Behavioral Sciences, *1*(1), 252-258. https://doi.org/10.1016/j.sbspro.2009.01.046

Kusiak, A. (2022). Universal manufacturing: Enablers, properties, and models. International Journal of Production Research, *60*(8), 2497-2513.

Kwan, S. S. M., Tuckey, M. R., & Dollard, M. F. (2020). The Malaysian Workplace Bullying Index (MWBI): A new measure of workplace bullying in Eastern countries. PLoS One, *15*(1), e0223235. https://doi.org/10.1371/journal.pone.0223235

Kyläheiko, K., Puumalainen, K., Pätäri, S., & Jantunen, A. (2017). How do firm-and industry-specific factors affect innovation and financial performance*? International Journal of Technology Intelligence and Planning*, *11*(3), 230-251.

Kyriacou, N. (2020, June 10). *Designing humanity: Human-centred principles to put people first.* PricewaterhouseCoopers. https://www.pwc.com.au/digitalpulse/human-centred-principles-future.html#:~:text=As%20a%20starting%20point%2C%20human,can%20reach%20their%20full%20potential

Lee, J., Davari, H., Singh, J., & Pandhare, V. (2018). Industrial Artificial Intelligence for industry 4.0-based manufacturing systems. *Manufacturing Letters*, *18*, 20-23. https://doi.org/10.1016/j.mfglet.2018.09.002

Lee, M. C. C., & Idris, M. A. (2017). Psychosocial safety climate versus team climate. *Personnel Review*, *46*(5), 988-1003. https://doi.org/10.1108/PR-01-2016-0003

Lee, Y., & Kim, J. (2021). Cultivating employee creativity through strategic internal communication: The role of leadership, symmetry, and feedback seeking behaviors. *Public Relations Review, 47*(1), 101998.

Lefcourt, H. M. (2013). *Research with the locus of control construct: extensions and limitations*. Elsevier.

Lepore, D., Micozzi, A., & Spigarelli, F. (2021). Industry 4.0 accelerating sustainable manufacturing in the Covid-19 era: Assessing the readiness and responsiveness of Italian regions. *Sustainability, 13*(5), 2670.

Leso, V., Fontana, L., & Iavicoli, I. (2018). The occupational health and safety dimension of Industry 4.0. *La Medicina del lavoro*, *109*(5), 327.

Levasseur, R. E. (2010). People Skills: Ensuring Project Success-A Change Management Perspective. *Interfaces*, *40*(2), 159-162. https://doi.org/10.1287/inte.1090.0473

Leybourne, S. A. (2006). Managing improvisation within change management: Lessons from UK financial services. *The Service Industries Journal*, *26*(1), 73-95. https://doi.org/10.1080/02642060500358886

Liao, Y., Deschamps, F., Loures, E. D. F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0 - a systematic literature review and research agenda proposal. *International Journal of Production Research, 55*(12), 3609-3629. https://doi.org/10.1080/00207543.2017.1308576

Loh, M. Y., Idris, M. A., Dormann, C., & Muhamad, H. (2019). Organisational climate and employee health outcomes: A systematic review. *Safety Science, 118*, 442-452.

Loh, M. Y., Zadow, A., & Dollard, M. (2020). Psychosocial Safety Climate and Occupational Health. In T. Theorell (Ed.), *Handbook of Socioeconomic Determinants of Occupational Health: From Macro-level to Micro-level Evidence* (pp. 1-27). Springer International Publishing. https://doi.org/10.1007/978-3-030-05031-3_17-1

Loh, M. Y., Dollard, M. F., McLinton, S. S., & Tuckey, M. R. (2021). How psychosocial safety climate (PSC) gets stronger over time: A first look at leadership and climate strength. *Journal of Occupational Health Psychology, 26*(6), 522.

Lorenzo-Seva, U. (2013). *How to report the percentage of explained common variance in exploratory factor analysis. Technical Report.* Department of Psychology, Universitat Rovira i Virgili, Tarragona. https://www.psicologia.urv.cat/media/upload/domain_2082/arxius/Utilitats/factor/documentation/Percentage_of_explained_common_variance.pdf

Ludwig, T., Kotthaus, C., Stein, M., Pipek, V., & Wulf, V. (2018). Revive old discussions! Socio-technical challenges for small and medium enterprises within industry 4.0. *Proceedings of 16th European Conference on Computer-Supported Cooperative Work-Exploratory Papers, Reports of the European Society for Socially Embedded Technologies, 2*(1).

Manski, C. F., & Molinari, F. (2008). Skip sequencing: A decision problem in questionnaire design. *The annals of applied statistics, 2*(1), 264.

Manyika, J. (2017). *Technology, jobs and the future of work*. McKinsey Global Institute. dln.jaipuria.ac.in:8080/jspui/bitstream/123456789/1891/1/MGI-Future-of-Work-Briefing-note-May-2017.pdf

Margherita, E. G., & Braccini, A. M. (2021). Exploring the socio-technical interplay of Industry 4.0: a single case study of an Italian manufacturing organisation. *CEUR Workshop Proceedings*, *2789*, 121-126.

Martínez-Caro, E., Cegarra-Navarro, J. G., & Alfonso-Ruiz, F. J. (2020). Digital technologies and firm performance: The role of digital organisational culture. *Technological Forecasting and Social Change*, *154*, 119962. https://doi.org/10.1016/j.techfore.2020.119962

Mason, C. M., Ayre, M., & Burns, S. M. (2022). Implementing Industry 4.0 in Australia: Insights from Advanced Australian Manufacturers. *Journal of Open Innovation: Technology, Market, and Complexity,* 8(1), 53. https://doi.org/https://doi.org/10.3390/joitmc8010053

Mathekga, H. L., & Sekudu, J. (2019). Employee wellness: Preparation for the fourth industrial revolution. *International Journal of Innovative Studies in Sociology and Humanities, 4*(5), 31-39.

Mazzucato, M. (2021). *Mission economy: A moonshot guide to changing capitalism*. Penguin UK.

McCormack, L., Thomas, V., Lewis, M. A., & Rudd, R. (2017). Improving low health literacy and patient engagement: A social ecological approach. *Patient education and counseling, 100*(1), 8-13.

McMahon, C. (2020, May 20). *Examining COVID-19's Impact on Industry 4.0. Is Coronavirus Triggering Industry 5.0*. Keypoint Intelligence. https://beta3.infotrends.com/news/editors-desk/2020/april/examining-covid-19-s-impact-on-industry-40/

Mertens, D. M., Bazeley, P., Bowleg, L., Fielding, N., Maxwell, J., Molina-Azorin, J. F., & Niglas, K. (2016). Expanding thinking through a kaleidoscopic look into the future: Implications of the mixed methods international research association's task force report on the future of mixed methods. *Journal of Mixed Methods Research, 10*(3), 221-227.

Metallo, C., Agrifoglio, R., Schiavone, F., & Mueller, J. (2018). Understanding business model in the Internet of Things industry. *Technological Forecasting & Social Change*, *136*, 298-306. https://doi.org/10.1016/j.techfore.2018.01.020

Mollaahmetoğlu, E., & Akçalı, B. Y. (2019). The Missing-Link between Financial Development and Economic Growth: Financial Innovation. *Procedia Computer Science*, *158*, 696-704. https://doi.org/10.1016/j.procs.2019.09.105

Molino, M., Cortese, C. G., & Ghislieri, C. (2020). The promotion of technology acceptance and work engagement in industry 4.0: From personal resources to information and training. *International Journal of Environmental Research and Public Health, 17*(7), 2438.

Moore, P. V. (2019). OSH and the future of work: benefits and risks of artificial intelligence tools in workplaces. In V. G. Duffy (Ed.), *Digital Human Modeling and Applications in Health, Safety, Ergonomics and Risk Management. Human Body and Motion* (pp. 292-315). Springer, Cham.

Morrar, R., Arman, H., & Mousa, S. (2017). The Fourth Industrial Revolution (Industry 4.0): A Social Innovation Perspective. *Technology Innovation Management Review*, *7*(11), 12-20. https://doi.org/10.22215/timreview/1117

Nadkarni, S., & Prügl, R. (2021). Digital transformation: a review, synthesis and opportunities for future research. *Management Review Quarterly*, *71*(2), 233-341.

Nair, M. M., Tyagi, A. K., & Sreenath, N. (2021). The future with industry 4.0 at the core of society 5.0: open issues, future opportunities and challenges. *2021 International Conference on Computer Communication and Informatics (ICCCI)*. https://ieeexplore.ieee.org/abstract/document/9402498

Napoleone, A., Macchi, M., & Pozzetti, A. (2020). A review on the characteristics of cyber-physical systems for the future smart factories. *Journal of manufacturing systems*, *54*, 305-335.

Neumann, W. P., Winkelhaus, S., Grosse, E. H., & Glock, C. H. (2021). Industry 4.0 and the human factor–A systems framework and analysis methodology for successful development. *International Journal of Production Economics, 233*, 107992.

Ng, T. W., Sorensen, K. L., & Eby, L. T. (2006). Locus of control at work: a meta-analysis. *Journal of Organizational Behavior*, *27*(8), 1057-1087.

Nosek, B. A., Smyth, F. L., Sriram, N., Lindner, N. M., Devos, T., Ayala, A., Bar-Anan, Y., Bergh, R., Cai, H., Gonsalkorale, K., Kesebir, S., Maliszewski, N., Neto, F., Olli, E., Park, J., Schnabel, K., Shiomura, K., Tulbure, B. T., Wiers, R. W., Somogyi, M., Akrami, N., Ekehammar, B., Vianello, M., Banaji, M. R., & Greenwald, A. G. (2009). National differences in gender–science stereotypes predict national sex differences in science and math achievement. *Proceedings of the National Academy of Sciences of the United States of America*, *106*(26), 10593-10597. https://doi.org/10.1073/pnas.0809921106

Odor, H. O. (2018). Organisational culture and dynamics. *Global Journal of Management and Business Research*, *18*(1), 23-29.

Oesterreich, T. D., & Teuteberg, F. (2016). Understanding the implications of digitisation and automation in the context of Industry 4.0: A triangulation approach and elements of a research agenda for the construction industry. *Computers in Industry, 83*, 121-139. https://doi.org/10.1016/j.compind.2016.09.006

Oppert, M. L., Dollard, M. F., Murugavel, V. R., Reiter-Palmon, R., Reardon, A., Cropley, D. H., & O'Keeffe, V. (2022). A Mixed-Methods Study of Creative Problem Solving and Psychosocial Safety Climate: Preparing Engineers for the Future of Work. *Frontiers in Psychology*, *12*, 759226.

Oreg, S. (2006). Personality, context, and resistance to organizational change. *European Journal of Work and Organizational Psychology*, *15*(1), 73-101. https://doi.org/10.1080/13594320500451247

Oskam, I. (2009). T-shaped engineers for interdisciplinary innovation: an attractive perspective for young people as well as a must for innovative organisations. *37th Annual Conference–Attracting students in Engineering.*

Ozkazanc-Pan, B. (2021). Diversity and future of work: inequality abound or opportunities for all? *Management Decision, 59*(11), 2645-2659.

Pacaux-Lemoine, M.-P., Trentesaux, D., Rey, G. Z., & Millot, P. (2017). Designing intelligent manufacturing systems through Human-Machine Cooperation principles: A human-centered approach. *Computers & Industrial Engineering*, *111*, 581-595.

Patriarca, R., Falegnami, A., Costantino, F., Di Gravio, G., De Nicola, A., & Villani, M. L. (2021). WAx: An integrated conceptual framework for the analysis of cyber-socio-technical systems. *Safety Science*, *136*, 105142.

Peters, M. A., Jandrić, P., & Hayes, S. (2019). The curious promise of educationalising technological unemployment: What can places of learning really do about the future of work? *Educational Philosophy and Theory, 51*(3), 242-254.

Pham, N. T., Tučková, Z., & Jabbour, C. J. C. (2019). Greening the hospitality industry: How do green human resource management practices influence organizational citizenship behavior in hotels? A mixed-methods study. *Tourism Management, 72*, 386-399.

Potter, R. E., Zadow, A., Dollard, M., Pignata, S., & Lushington, K. (2022). Digital communication, health & wellbeing in universities: a double-edged sword. *Journal of Higher Education Policy and Management*, *44*(1), 72-89.

Pozzi, R., Rossi, T., & Secchi, R. (2021). Industry 4.0 technologies: critical success factors for implementation and improvements in manufacturing companies. *Production Planning & Control*, 1-21.

Prindle, E. J. (1906). The art of inventing. *Transactions of the American Institute for Engineering Education*, *25*, 519-547.

Puccio, G. J., & Cabra, J. F. (2010). Organizational Creativity: A Systems Approach. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge handbook of creativity* (pp. 145-173). Cambridge University Press.

Pugh, S. (1991). *Total design: integrated methods for successful product engineering*. Addison-Wesley.

Qamruzzaman, M., & Jianguo, W. (2017). Financial innovation and economic growth in Bangladesh. *Financial Innovation*, *3*(1), 19.

Rajahonka, M., & Villman, K. (2019). Women managers and entrepreneurs and digitalization: on the verge of a new era or a nervous breakdown? *Technology Innovation Management Review*, *9*(6), 14-24.

Rajapathirana, R. J., & Hui, Y. (2018). Relationship between innovation capability, innovation type, and firm performance. *Journal of Innovation & Knowledge*, *3*(1), 44-55.

Rajnai, Z., & Kocsis, I. (2018). Assessing industry 4.0 readiness of enterprises. *2018 IEEE 16th world symposium on applied machine intelligence and informatics (SAMI)*.

Ramanathan, K., & Samaranayake, P. (2021). Assessing Industry 4.0 readiness in manufacturing: a self-diagnostic framework and an illustrative case study. *Journal of Manufacturing Technology Management*, *33*(3), 468-488.

Rattray, J., & Jones, M. C. (2007). Essential elements of questionnaire design and development. *Journal of clinical nursing, 16*(2), 234-243.

Rhodes, M. (1961). An analysis of creativity. *Phi Delta Kappan*, *42*(7), 305-310.

Rimmer, M. (2018). Elon Musk's open innovation: Tesla, intellectual property, and climate change. In M. Rimmer (Ed.), *Intellectual Property and Clean Energy* (pp. 515-551). Springer.

Rugulies, R., Ando, E., Ayuso-Mateos, J. L., Bonafede, M., Cabello, M., Di Tecco, C., Dragano, N., Durand-Moreau, Q., Eguchi, H., Gao, J., Garde, A. H., Iavicoli, S., Ivanov, I. D., Leppink, N., Madsen, I. E. H., Pega, F., Prüss-Üstün, A. M., Rondinone, B. M., Sørensen, K., Tsuno, K., Ujita, Y., & Zadow, A. (2019). WHO/ILO work-related burden of disease and injury: Protocol for systematic reviews of exposure to long working hours and of the effect of exposure to long working hours on depression. *Environment International*, *125*, 515-528. https://doi.org/10.1016/j.envint.2018.11.011

Ryan, A. B. (2006). Post-positivist approaches to research. *Researching and Writing your Thesis: a guide for postgraduate students*, 12-26.

Salter, A., & Alexy, O. (2014). The Nature of Innovation. In M. Dodgson, D. M. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (pp. 26-49). Oxford University Press.

Sampat, B. N., & Shadlen, K. C. (2021). The COVID-19 Innovation System: Article describes innovations that emerged during the COVID-19 pandemic. *Health Affairs*, *40*(3), 400-409.

Sarfraz, Z., Sarfraz, A., Iftikar, H. M., & Akhund, R. (2021). Is COVID-19 pushing us to the Fifth Industrial Revolution (Society 5.0)? *Pakistan journal of medical sciences*, *37*(2), 591-594. https://doi.org/10.12669/pjms.37.2.3387

Schiuma, G., Andreeva, T., & Kianto, A. (2012). Does knowledge management really matter? Linking knowledge management practices, competitiveness and economic performance. *Journal of knowledge management*, *16*(4), 617-636.

Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological Review*, *115*(2), 336-356. https://doi.org/10.1037/0033-295x.115.2.336

Schulte, P. A. (2020). A global perspective on addressing occupational safety and health hazards in the future of work. *La Medicina del lavoro*, *111*(3), 163.

Schulte, P. A., Iavicoli, I., Fontana, L., Leka, S., Dollard, M. F., Salmen-Navarro, A., Salles, F. J., Olympio, K. P., Lucchini, R., & Fingerhut, M. (2022). Occupational safety and health staging framework for decent work. *International Journal of Environmental Research and Public Health, 19*(17), 10842.

Schumacher, A., Erol, S., & Sihn, W. (2016) A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises. *Procedia CIRP*, *52*, 161-166. https://doi.org/https://doi.org/10.1016/j.procir.2016.07.040

Schwab, K., & Malleret, T. (2020). *The Great Reset.* Forum Publishing.

Schwartz, J., Hatfield, S., Jones, R., & Anderson, S. (2019, April 1). *What is the future of work. Redefining work, workforces, and workplaces*. Deloitte. https://www2.deloitte.com/us/en/insights/focus/technology-and-the-future-of-work/redefining-work-workforces-workplaces.html

Schwarzmüller, T., Brosi, P., Duman, D., & Welpe, I. M. (2018). How does the digital transformation affect organizations? Key themes of change in work design and leadership. *Management Revue, 29*(2), 114-138.

Sgarbossa, F., Grosse, E. H., Neumann, W. P., Battini, D., & Glock, C. H. (2020). Human factors in production and logistics systems of the future. *Annual Reviews in Control*, *49*, 295-305.

Simpson, A. (2017). *The Innovation-Friendly Organization: How to cultivate new ideas and embrace the change they bring*. Palgrave Macmillan. https://doi.org/10.1057/978-1-137-48302-7

Singh, A., & Hess, T. (2020). How chief digital officers promote the digital transformation of their companies. In *Strategic Information Management* (pp. 202-220). Routledge.

Singhal, N. (2021). An Empirical Investigation of Industry 4.0 Preparedness in India. *Vision*, *25*(3), 300-311. https://doi.org/10.1177/0972262920950066

Sommer, L. (2015). Industrial revolution-industry 4.0: Are German manufacturing SMEs the first victims of this revolution? *Journal of Industrial Engineering and Management, 8*(5), 1512-1532.

Sony, M., & Naik, S. (2019). Key ingredients for evaluating Industry 4.0 readiness for organizations: a literature review. *Benchmarking: An International Journal*, *27*(7), 2213-2232.

Sony, M., & Naik, S. (2020). Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model. *Technology in Society*, *61*, 101248.

Spector, P. E. (1982). Behavior in organizations as a function of employee's locus of control. *Psychological bulletin*, *91*(3), 482.

Steen, L. (2012). *Mathematics tomorrow*. Springer Science & Business Media.

Stentoft, J., Adsbøll Wickstrøm, K., Philipsen, K., & Haug, A. (2021). Drivers and barriers for Industry 4.0 readiness and practice: empirical evidence from small and medium-sized manufacturers. *Production Planning & Control, 32*(10), 811-828.

Szabó-Szentgróti, G., Végvári, B., & Varga, J. (2021). Impact of Industry 4.0 and digitization on labor market for 2030-verification of Keynes' prediction. *Sustainability (Basel, Switzerland)*, *13*(14), 7703.

Tashakkori, A., & Teddlie, C. (2021). *SAGE Handbook of Mixed Methods in Social & Behavioral Research* (2nd ed.). SAGE Publications.

Tcytcarev, A., Bazhenov, R., Amineva, E., & Pronin, A. (2019). Constructive realism: advantages of ontology and methodology. *SHS Web of Conferences*, *72*, 4009.

Todnem, R. (2005). Organisational change management: A critical review. *Journal of Change Management*, *5*(4), 369-380. https://doi.org/10.1080/14697010500359250

Tzelgov, J., & Henik, A. (1991). Suppression situations in psychological research: Definitions, implications, and applications. *Psychological bulletin, 109*(3), 524.

Villar, L. M., Oliva-Lopez, E., Luis-Pineda, O., Benešová, A., Tupa, J., & Garza-Reyes, J. A. (2020) Fostering economic growth, social inclusion & sustainability in Industry 4.0: a systemic approach. *Procedia Manufacturing*, *51*, 1755-1762. https://doi.org/10.1016/j.promfg.2020.10.244

Voland, G. (2004). *Engineering by Design* (2nd ed.). Pearson Prentice Hall.

Vrchota, J., Mařiková, M., Řehoř, P., Rolínek, L., & Toušek, R. (2019a). Human Resources Readiness for Industry 4.0. *Journal of Open Innovation*, *6*(1), 3.

Walker, G. H., Stanton, N. A., Salmon, P. M., & Jenkins, D. P. (2008). A review of sociotechnical systems theory: a classic concept for new command and control paradigms. *Theoretical issues in ergonomics science*, *9*(6), 479-499.

Wallach, M. A., & Kogan, N. (1965). *Modes of thinking in young children*. Rinehart and Winston.

Wallas, G. (1926). *The art of thought*. Harcourt Brace.

Wang, W., & Siau, K. (2019). Artificial intelligence, machine learning, automation, robotics, future of work and future of humanity: A review and research agenda. *Journal of Database Management (JDM), 30*(1), 61-79.

Waschneck, B., Altenmüller, T., Bauernhansl, T., & Kyek, A. (2016). Production Scheduling in Complex Job Shops from an Industry 4.0 Perspective: A Review and Challenges in the Semiconductor Industry. *1st International Workshop on Science, Application and Methods in Industry 4.0*. https://ceur-ws.org/Vol-1793/paper3.pdf

Weber, E. (2016). *Industry 4.0: Job-producer or employment-destroyer?* Institute for Employment Research. https://www.econstor.eu/bitstream/10419/161710/1/aktueller_bericht_1602.pdf

Wiltshire, G., & Ronkainen, N. (2021). A realist approach to thematic analysis: making sense of qualitative data through experiential, inferential and dispositional themes. *Journal of Critical Realism, 20*(2), 159-180.

Woolliscroft, J. O. (2020). Innovation in response to the COVID-19 pandemic crisis. *Academic medicine*, *95*(8), 1140-1142.

Xing, K., Cropley, D. H., Oppert, M. L., & Singh, C. (2021). Readiness for digital innovation and industry 4.0 transformation: studies on manufacturing industries in the city of Salisbury. In M. Kosaka, J. Wu, K. Xing, & S. Zhang, *Business Innovation with New ICT in the Asia-Pacific: Case Studies* (pp. 155-176). Springer.

Yilmaz, A., Dora, M., Hezarkhani, B., & Kumar, M. (2021). Lean and industry 4.0: Mapping determinants and barriers from a social, environmental, and operational perspective. *Technological Forecasting and Social Change*, *121320*. https://doi.org/10.1016/j.techfore.2021.121320

Zaoui, F., & Souissi, N. (2020). Roadmap for digital transformation: A literature review. *Procedia Computer Science*, *175*, 621-628.

Zheng, T., Ardolino, M., Bacchetti, A., & Perona, M. (2021). The applications of Industry 4.0 technologies in manufacturing context: a systematic literature review. *International Journal of Production Research, 59*(6), 1922-1954.

Zhu, X., Asimakopoulos, S., & Kim, J. (2020). Financial development and innovation-led growth: Is too much finance better? *Journal of International Money and Finance*, *100*, 102083.

Zwanka, R. J., & Buff, C. (2021). COVID-19 generation: A conceptual framework of the consumer behavioral shifts to be caused by the COVID-19 pandemic. *Journal of International Consumer Marketing, 33*(1), 58-67.

Appendix A: Study 1 – Measurement of Psychosocial Safety Climate

This Appendix contains the questionnaire provided to the participants from Studies 1 and 2 to measure the Psychosocial Safety Climate (PSC) of their organisations. This Appendix in referenced in Sections 3.3.2 and 4.3.2.

The following statements concern the Psychosocial Health and Safety in your workplace. Please answer with the best option provided. (Strongly Disagree, Disagree, Neither agree nor disagree, Agree, strongly agree)

Original Questions

1. In my workplace senior management acts quickly to correct problems that affect employees' psychological health.
2. Senior management acts decisively when a concern of an employees' psychological status is raised.
3. Senior management show support for stress prevention through involvement and commitment.
4. Psychological wellbeing of staff is a priority for this organization.
5. Senior management clearly considers the psychological health of employees to be of great importance.
6. Senior management considers employee psychological health to be as important as productivity.
7. There is good communication here about psychological safety issues which affect me.
8. Information about workplace psychological wellbeing is always brought to my attention by my manager/supervisor.
9. My contributions to resolving psychological health and safety concerns in the organization are listened to.
10. Participation and consultation in psychological health and safety occurs with employees', unions and health and safety representatives in my workplace.
11. Employees are encouraged to become involved in psychological safety and health matters.
12. In my organization, the prevention of stress involves all levels of the organization.

Chanvi's Questions – One person representing/ answering on behalf of the organisation.

1. In our organisation, senior management acts quickly to correct problems that affect employees' psychological health.
2. In our organisation, senior management acts decisively when a concern of an employees' psychological status is raised.
3. In our organisation, senior management show support for stress prevention through involvement and commitment.
4. Psychological wellbeing of staff is a priority for this organisation.
5. In our organisation, senior management clearly considers the psychological health of employees to be of great importance.
6. In our organisation, senior management considers employee psychological health to be as important as productivity

7. There is good communication in our organisation about psychological safety issues which affect employees.
8. Information about workplace psychological wellbeing is always brought to employees' attention through managers/supervisors.
9. Employees' contributions to resolving psychological health and safety concerns in the organisation are listened to.
10. Participation and consultation in psychological health and safety occurs with employees', unions and health and safety representatives in our organisation.
11. Employees are encouraged to become involved in psychological safety and health matters.
12. In our organisation, the prevention of stress involves all levels of the organisation.

Appendix B: Study 1 – Measurement of Innovation Capacity (Environment, Attitudes and Processes)

This Appendix contains the questionnaire provided to the participants from Studies 1 and 2 to measure the Innovation Capacity of their organisations. This Appendix in referenced in Sections 3.3.2 and 4.3.2.

The following statements measure your organisation's innovative capacity. Please keep your organisation in mind when responding to the following statements. Please answer with the best option provided. (Strongly Disagree, Disagree, Neither agree nor disagree, Agree, strongly agree)

Environments for Innovation

1. Employees in this organisation cannot openly discuss misgivings about what they are working on. ActPre3
2. Managers welcome discussion of the worth of what we do.
3. Employees in this organisation are given time to mull over problems.
4. Employees in this organisation are encouraged to look everywhere for ideas.
5. Wild ideas are supported if they solve the problem.
6. Good ideas are not rewarded.
7. Ideas that disturb the status quo are resisted.
8. "Free spirits" are accepted.
9. Managers look at mistakes as opportunities to learn and improve
10. Managers provide minimal feedback to help employees improve.

Attitudes to innovation

11. Employees in this organisation get a feeling of satisfaction out of "dissecting" what they do.
12. Employees in this organisation have no desire to change the way things are currently done.
13. Employees in this organisation place high value on looking at things from different perspectives.
14. Employees in this organisation seek broad approaches to problems.
15. Employees in this organisation feel under attack when others judge their work.
16. Employees in this organisation try to avoid any criticism of their own ideas.

17. Employees in this organisation feel comfortable when asked to choose among alternatives.
18. Employees in this organisation feel no drive to identify promising solutions.
19. Employees in this organisation feel under personal attack if their ideas are questioned.
20. Employees in this organisation want to find the best answer.

Processes for Innovation

21. Employees in this organisation help to define the goals of their work.
22. Employees in this organisation do not analyse (dissect) their own work.
23. Employees in this organisation like to link disparate ideas.
24. Employees in this organisation build broad networks of information.
25. Employees in this organisation protect their ideas from external scrutiny.
26. Employees in this organisation derive ideas for improving products from interactions with the external world.
27. Employees in this organisation are attracted to promising solutions that are original.
28. Employees in this organisation ignore promising solutions if they are surprising.
29. Employees in this organisation recognise promising solutions when they see them.
30. Employees in this organisation support candidate solutions that offer new approaches.

Appendix C: Study 1 – Measurement of Attitudes towards Organisational Change

This Appendix contains the questionnaire provided to the participants from Studies 1 and 2 to measure their Attitude towards Organisational Change. This Appendix in referenced in Sections 3.3.2 and 4.3.2.

The following statements explore your organisation's attitude towards change. Please keep your organisation in mind when responding to the following statements. Please answer with the best option provided. (Strongly Disagree, Disagree, Neither agree nor disagree, Agree, strongly agree)

1. Employees in my organisation are regularly informed on how the change is going.
2. There is good communication between project leaders and staff members about the organisation's policy toward changes.
3. Information provided on change is clear.
4. Employees in my organisation are sufficiently informed of the progress of change.
5. Departments are consulted about change sufficiently.
6. Employees in my organisation are consulted about the reasons for change.
7. Corporate management team has a positive vision of the future.
8. Corporate management team is actively involved with the changes.
9. Corporate management team supports the change process unconditionally.
10. Employees in my organisation want to devote myself to the process of change.
11. Employees in my organisation are willing to make a significant contribution to the change.
12. Employees in my organisation are willing to put energy into the process of change.
13. Employees in my organisation are somewhat resistant to change.
14. Employees in my organisation think that most changes will have a negative effect on the clients we serve.
15. Most change projects that are supposed to solve problems around here will not do much good.
16. Employees in my organisation have a good feeling about the upcoming changes.
17. Employees in my organisation experience change as a positive process.
18. Employees in my organisation find the change refreshing.
19. Decisions concerning work are taken in consultation with the employees who are affected.
20. Changes are always discussed with all people concerned.
21. Front line employees can raise topics for discussion.

Appendix D: Study 1 – Measurement of Preparedness of Industry 4.0 (Business and Skills)

This Appendix contains the questionnaire provided to the participants from Studies 1 and 2 to measure the Business and Skills preparedness of their organisations. This Appendix in referenced in Sections 3.3.2 and 4.3.2.

What is Industry 4.0?

Industry 4.0 is a strategic initiative that was launched by the German government in 2011. The fundamental objective of this initiative is to support the integration of cyberphysical systems, the Internet of Things (IoT), cloud computing, automation and artificial intelligence (AI), leading to the creation of smart factories. It also aims to support research, the networking of industry partners and standardisation.

As the initiative has matured and spread throughout the developed world, it has become a foundation of digital innovation for the transformation of business models and product/service delivery, not only in the manufacturing sector but also in the wider economic system. Known also as the Industry Renaissance in some countries, the digital transformation of the industry is now an accepted prerequisite for improved productivity, improved efficiency, flexibility, agility, improved customer satisfaction, cost reductions, and improved innovation. The following statements are concerned with your organisation's readiness to adopt Industry 4.0. Please keep your organisation in mind when answering the following questions.

The following statements measure your organisation’s business and skills preparedness for Industry 4.0 . Please keep your organisation in mind when responding to the following statements. Please answer with the best option provided. (Strongly Disagree, Disagree, Neither agree nor disagree, Agree, strongly agree)

1. Our organisation’s vision aligns with the potential offered by digital transformation/Industry 4.0.
2. Our organisation has the drive to engage in digital transformation.
3. We take initiatives and actions to embrace Industry 4.0 within our business strategy.
4. Our organisation recognises digital features, digital products and digital services as critical to our business value creation model.
5. We do not consider or implement products and services customised to our client needs.
6. We use multiple channels to collect data from our customers, manage complaints, and to regulate and improve our products and services.

7. Our organisation has no cybersecurity systems and policies in place to meet the needs of digital transformation and Industry 4.0.
8. We have a digital compliance policy in place to protect critical data and information.
9. Our organisation has policies and mechanisms in place to protect our intellectual property.
10. We believe there is a "digital" risk to our business functions.
11. We trust storing sensitive data and IP to cloud services.
12. Our organisation pursues social responsibility through employment security and job creation.
13. Our organisation recognises the importance of "sustainability" in our operations and technologies.
14. Digital transformation and the move to Industry 4.0 is not creating jobs and/or internships in our organisation.
15. Our organisation's values and culture are aligned with embracing digital transformation and Industry 4.0.
16. Our organisation has open vertical and horizontal channels of communication for employees, internal and external stakeholders.
17. Our organisation does not encourage feedback from employees.
18. Our leadership model supports and guides employees, enabling them to grow with the business.
19. The leaders in our organisation are reluctant to embrace the changes related to Industry 4.0 and digital transformation.
20. Our organisation invests in, and supports, employees in developing technical skills related to Industry 4.0 (e.g. data analytics, software, AI).
21. Our organisation has a thorough understanding of the skills required to implement Industry 4.0 and digital transformation.
22. Our organisation does not consider the professional, "skills" aspirations of employees.
23. Our organisation does not take initiatives to ensure retention of our employees
24. Our organisation is good at retaining employees.
25. The new workforce (e.g. university graduates) has underdeveloped skills required for Industry 4.0 and digital transformation.

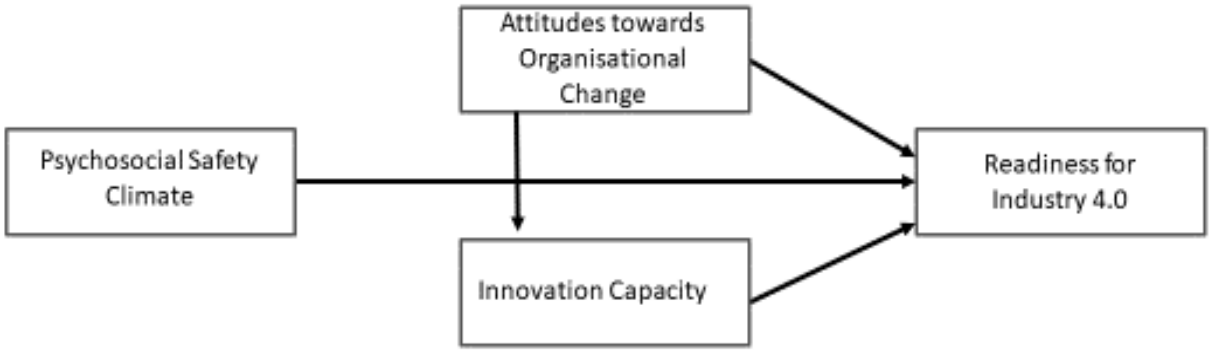
26. Our organisation actively seeks out professional development training related to Industry 4.0 (e.g. information sessions, workshops).
27. We have difficulty recruiting the data analysts/scientists needed to support digital transformation.
28. People in our organisation have a positive attitude to the changes related to digital transformation and Industry 4.0 (e.g. increased automation).

Appendix E: Study 1- Path Analysis Alternate Models

This Appendix is relevant to the pathway analysis conducted in Study 1. It contains the two pathways that were not a good fit for the data and were utilised for comparison with the best fitting model. This Appendix in referenced in Sections 3.3.4 and 3.4.1.



Partial mediation model (Model 2- modified).



Direct effect model (Model 3)

Appendix F: Data Linkage Examples

This Appendix contains the examples of reports generated from the databases 'DatAnalysis Premium' and 'Company 365' for Study 2. The financial information was sourced and extracted from reports generated from these databases and entered into the data set for analysis. The screenshots of reports attached to this Appendix are examples only – the participants of Study 1 and 2 did not belong to either of the organisations presented below. This Appendix is referenced in Section 4.3.2.

Example- front page from financial report (Dat Analysis Premium)

MORNINGSTAR DatAnalysis **Premium**

Print Download

Note: Some sections of this report provide current data only. Please refer to the on-line version of DatAnalysis for a full history of all sections within a Company Report.

Woolworths Group Limited

WOW

Trading Status: Trading
Listing Date: 12/07/1993

Market Cap	Total Shares Quoted	Last Close
$41,068m	1,216.5m	$33.76

GICS Sector	GICS Industry Group	GICS Industry
Consumer Staples	Food & Staples Retailing	Food & Staples Retailing

Share market data: as at 14/10/2022

Corporate Details

Show Data Definitions

Former Names
Woolworths Limited (WOW), 08/12/2017

Principal Activity
Retail operations including Australian food, Australian B2B, New Zealand food, and BIG W.

Head and Registered Office

Address:	1 Woolworths Way
	Bella Vista, NSW 2153
Telephone:	+61 2 88850000
Fax:	+61 2 88880001
Internet:	www.woolworthsgroup.com.au
Email:	woolworths@linkmarketservices.com.au
ACN:	000 014 675
ABN:	88 000 014 675

Head and Registered Office Postal Address

Address:	Baulkham Hills, NSW 2153

ASX Home Exchange	Sydney
Overseas Exchange	n/a
Report Currency	AUD
Number of Employees	210,067 as at 30/06/2021
Auditors	Deloitte Touche Tohmatsu
Auditors Sign-Off Partner	Tom [redacted]
Banker	n/a
Solicitor	n/a

Dividends

Dividends Rein.Plan:	Active
Dividends Rein. Plan Features:	No discount

Share Registry

Postal Address:	Link Market Service Limited
	Level 12, 680 George St
	Sydney, NSW 2000
PO Box Address:	
Telephone:	+61 2 8280 7100
Fax:	+61 2 9287 0303
Internet:	www.linkmarketservices.com.au
Email:	registrars@linkmarketservices.com.au

Important Dates

Event	Date
AGM:	26/10/2022
Annual Report:	25/08/2022
Prelim Report:	25/08/2022
Interim Report:	23/02/2022
Account Close:	26 June

Example- front page from financial report (Company 365)

Company 360™

360 View

Summary

Hungry Jack's Pty Ltd holds the exclusive franchise rights for the Burger King Corporation in Australia. The company is a wholly-owned subsidiary of COMPETITIVE FOODS AUSTRALIA PTY LTD. It owns and operates or sub-licenses all Hungry Jack's restaurants in Australia. As the master franchiser of the Burger King brand in Australia, the company is responsible for opening stores and licensing new operators. Hungry Jack's is headquartered in the Sydney suburb of Woolloomooloo, New South Wales.

Key Information

Address	L 6 100 William St Woolloomooloo NSW 2011 Australia
Phone	02 93560900
Web	hungryjacks.com.au
DUNS Number	757555719
ACN	008747073
Company Type	Private
Revenue ($000s)	$654,720 Sourced directly from company
Number of Employees	17900(G)

Key Statistics

Revenue from continuing operations (as of 2011)	$654,720
Growth	2.93%
EBIT	$23,352
EBIT Growth	(8.63%)
EBIT Margin	-
Profit from continuing op's after tax	$17,447
Growth	(6.09%

Financials example

Company 360™

Financials

P & L / Income Statement

Note: *all monetary values are expressed in ($000s) of AUD (except earnings per share).*

D&B obtains its financial data from a number of sources not controlled by D&B. Whilst D&B has processes in place for updating the information contained in this product, D&B makes no warranty that the information provided is correct or free from error and will not accept any liability for, or be responsible for, any errors that are contained therein.

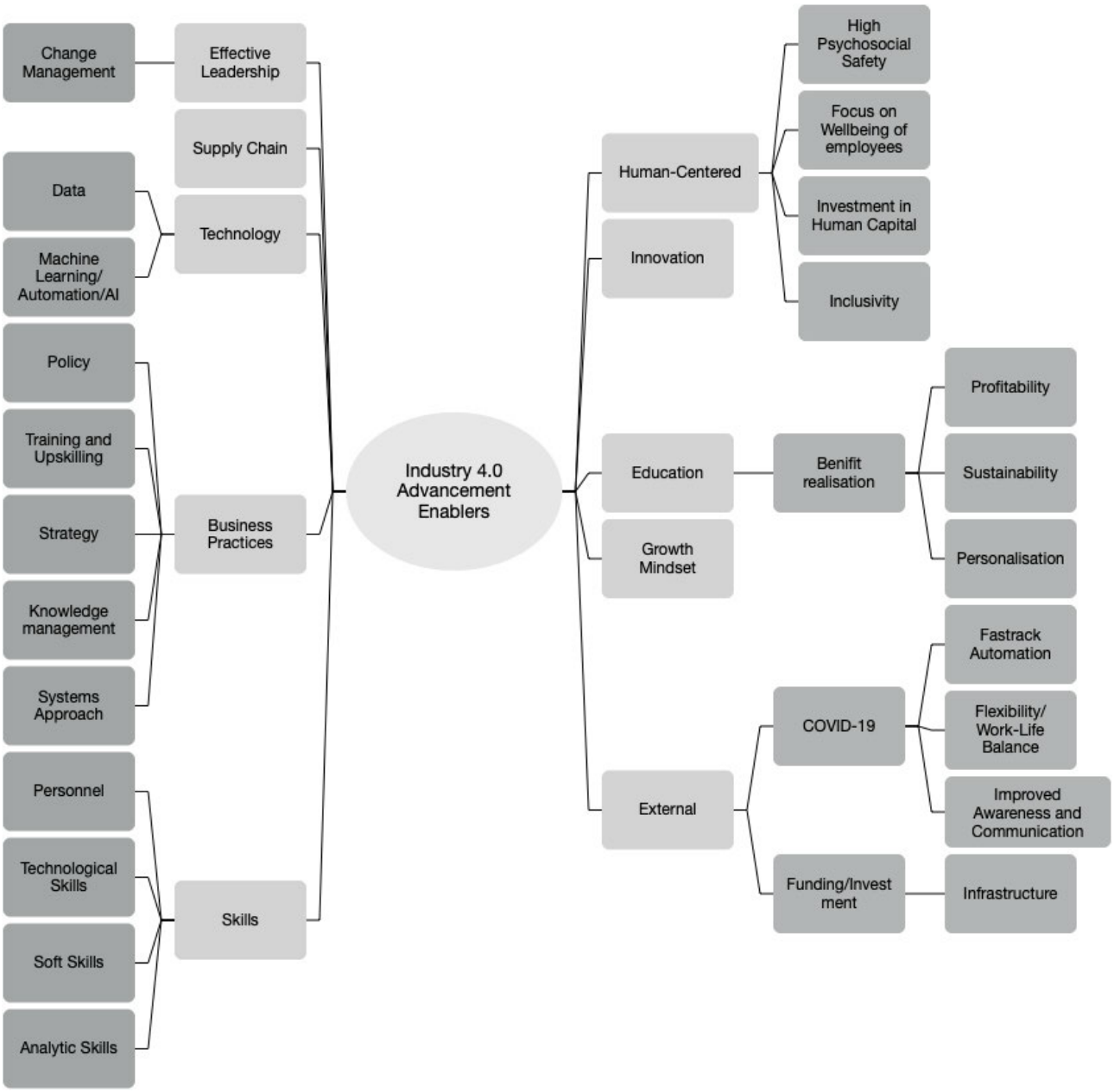
	2011 AUD	2010 AUD	2009 AUD	2008 AUD	2007 AUD
Income Statement	-	-	-	-	-
Revenue from continuing operations ($000s)	$654,720	$636,059	$593,948	$556,894	$470,904
Growth	*2.93%*	*7.09%*	*6.65%*	*18.26%*	-
Cost of sales ($000s)	($210,348)	($205,230)	($198,434)	($186,901)	($156,929)
Gross profit ($000s)	$444,372	$430,829	$395,514	$369,993	$313,975
Growth	*3.14%*	*8.93%*	*6.90%*	*17.84%*	-
Other income ($000s)	$6,392	$5,801	$5,055	-	-
Administrative expenses ($000s)	($107,554)	($99,141)	($91,773)	($84,676)	($69,230)
Finance costs ($000s)	($54)	($46)	($324)	($890)	($1,271)
Share of associate profits/(losses) ($000s)	-	-	-	-	-
Profit/(loss) from continuing operations before income tax ($000s)	$23,298	$25,511	$11,323	$7,673	$4,166
Growth	*(8.67%)*	*125.30%*	*47.57%*	*84.18%*	-
Income tax expense ($000s)	($5,850)	($6,933)	($3,412)	($2,211)	($1,121)
Profit from continuing operations after income tax ($000s)	$17,447	$18,578	$7,911	$5,463	$3,045
Growth	*(6.09%)*	*134.84%*	*44.81%*	*79.41%*	-
Profit/(loss) from discontinued	-	-	-	-	-

Appendix G: Inductive and Deductive Approaches to Thematic Analysis (Study 3)

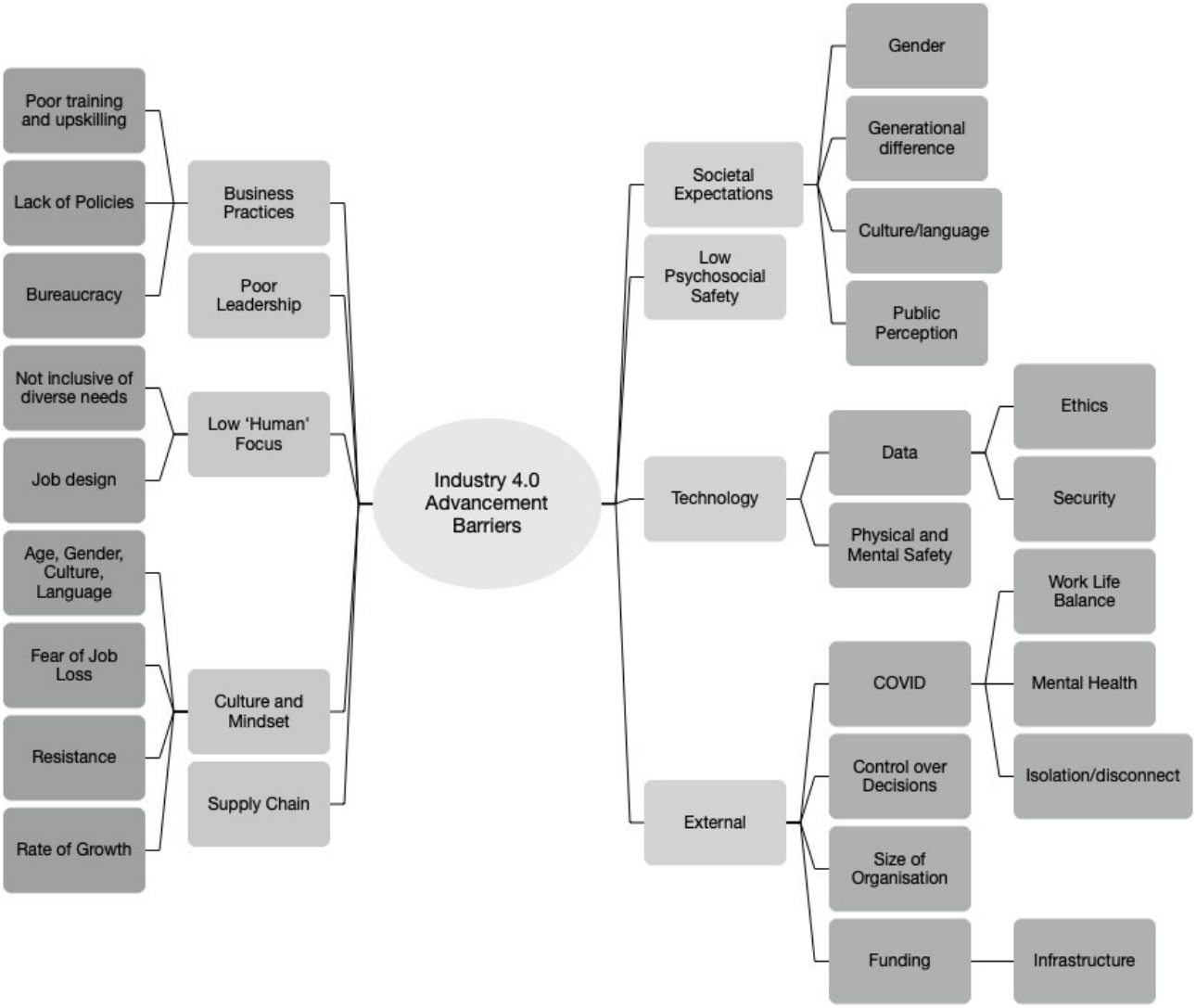
This appendix contains the mind maps and tables created using the data collected in the semi- structured interviews for Study 3 showcasing both Inductive and deductive approaches to qualitative data analysis. This Appendix is referenced in Section 5.3.3.

Using an inductive approach, the categorization of Enablers and Barriers (of Industry 4.0 technology implementation respectively, are presented in the mind maps below.

Enablers of Industry 4.0 implementation- Inductive Mind Map

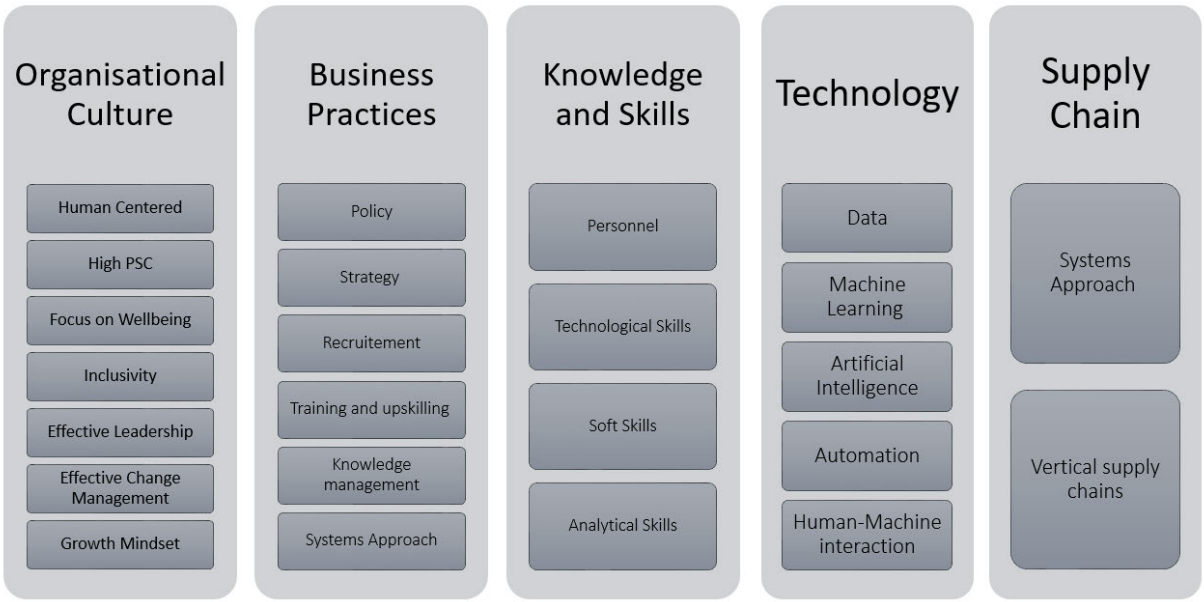


Barriers to Industry 4.0 implementation- Inductive Mind Map

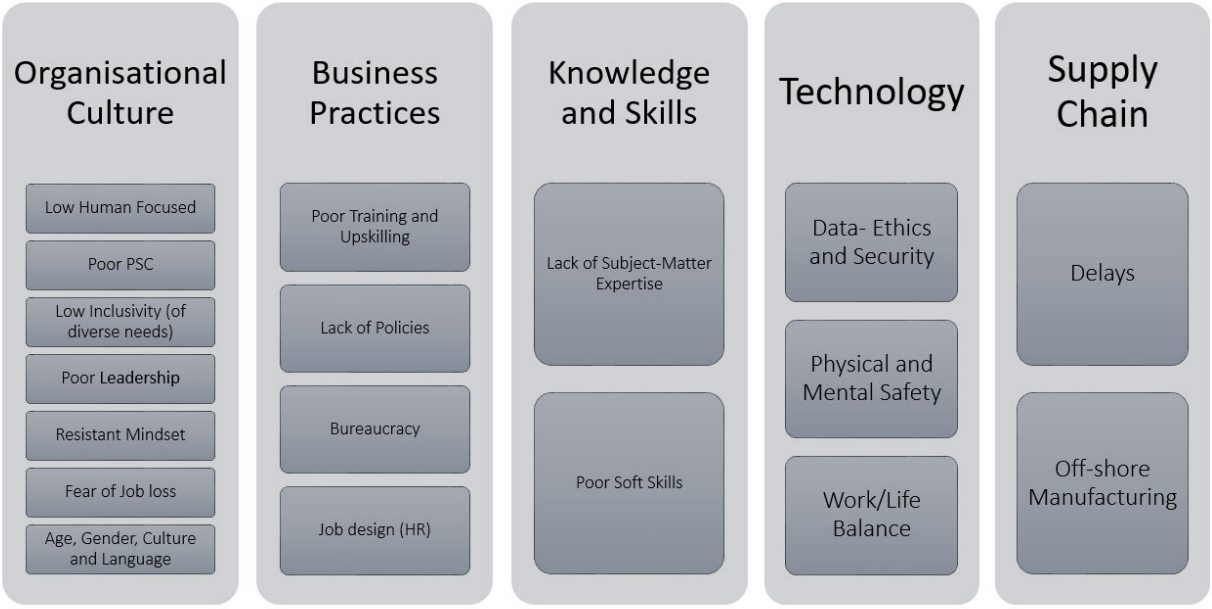


Presented below is categorisation of themes using a grounded theory approach for Study 3. Using a deductive approach, the categorisation of Enablers and Barriers (of Industry 4.0 technology implementation respectively, are presented.

Enablers of Industry 4.0 implementation- Grounded Theory (deductive)



Barriers to Industry 4.0 implementation- Grounded Theory (deductive)



Appendix H: Interview Protocol

This appendix contains the interview protocol and guidelines used for the semi-structured interviews conducted for Study 3. This Appendix is referenced in Sections 1.8.4 and 5.3.1.

Interview Protocol for Study 3

First I would introduce myself, provide an overview of the study, ask if they have questions and then get then to sign the consent form. They should have all read a participant information sheet and so hopefully familiar with the study.

1. **It would be great to start with exploring your understanding of Industry 4.0. Could you tell me what you know about Industry 4.0?** *(Please be assured that it's okay if you don't know. I am just trying to understand your perception of Industry 4.0.)*

Provide the participant with the definition of Industry 4.0 in the context it is being used in this study.

> *Industry 4.0 can be generally defined as the advancement of internet-connected technologies which have pushed industries to full automation, digitization processes and the use of information technologies in manufacturing and services (Roblek et al. 2016). The concept is now used in a broader context outside of manufacturing as well. For this study we use the term Industry 4.0 more broadly as a system of applying digitalisation and automation in the workplace – creating more autonomous systems and SMART factories. More simply put it is an increase of automation of systems in the workplace.*

Follow up question:

i. *Thinking about workplaces in general (Not thinking about your organisation specifically) what do organisations in general need to focus on in order to prepare themselves/advance themselves in Industry 4.0?*

> **Now lets turn our attention to your organisation specifically. For the next few questions I would like you to keep your organisation in mind and remember that there are no right or wrong answers. I am just trying to capture your thoughts here.**

2. **What does advancing and transitioning into Industry 4.0 look like for you? (what do you need to do)?**

Follow up questions:

i. *What factors in your workplace will enable you to successfully transition and be future-ready? (enablers)?*

ii. *Barriers are something that block growth. Challenges on the other hand can be overcome. Can you tell me about the potential challenges you may encounter in being future-ready?*

iii. *Follow-up: How do you think they can be overcome?*

iv. *What barriers can you identify that you know are stopping your organisation from progressing in I4.0?*

COVID -19

3. We know the pandemic has changed the way people and organisations work. How has it changed your perspective on the future of work (with automated systems).

SOCIAL FACTORS AFFECTING INDUSTRY 4.0

4. It is perceived in Industry 4.0, people will need to have specific skills to advance. Can you talk about the skills your organisation has or will need in order to successfully advance in Industry 4.0?
5. Thinking about your current business strategies, how do you foresee needing to change your approach in line with the needs of Industry 4.0. *(What changes do you need or expect to see)*
6. Does getting ready for Industry 4.0 drive your organisation towards innovation?
Follow up questions:

i. *If yes, could you give me an example?*
ii. *If not, why do you think that might be?*

7. Could you describe the mindset/attitudes towards organisational change your organisation has and would need in order to advance in Industry 4.0?
8. I understand that there would be clear laws and procedures about work health & safety, particularly regarding physical safety. The advancement into the future of work may lead to the introduction of new guidelines. From your perspective, how do you think you could protect workers psychological health in the workplace (*keeping in mind the automation of systems***)?**

Follow up questions:

i. *How could you ensure prioritising and showing commitment to employee health and wellbeing? Could you give a few examples?*
ii. *Do you think having a bigger focus on employee health and wellbeing will enable you to be better prepared for the future of work ? If yes, how? And if not, why do you think that might be?*

9. Lastly, how do you think your job we will change the more your organisation advances/transitions towards Industry 4.0?

WOMEN IN INDUSTRY 4.0

10. In light of the conversation we've been having about I 4.0, what do you think women excel in that will make them future-ready?

Follow up questions:

i. *What do think is a general barrier for women that you may have noticed?*
ii. *What skills do you think women could learn/develop in order to prepare for the future of work.*

11. That's everything I wanted to ask. Have you got anything else you would like to say or any kind of final thoughts you would like to follow up with that I haven't already asked you?

Appendix I: Complete Interview Transcripts – Samples

This appendix contains two complete interviews from the participants from Study 3. These transcripts will enable the reader to understand the patterns of the 16 interviews conducted and the similarities and differences within each of the interview. It is interesting to note that approximately 160,000 words were analysed and thematically coded for this study. Any identifiers and/or personal information including personal stories, software names and references to their organisations have been omitted. This Appendix is referenced in Section 5.3.1.

Participant x

Tue, 12/21 11:09AM • 1:03:34

SUMMARY KEYWORDS

people, work, industry, organization, business, clients, question, barrier, digital, terms, tools, important, area, robotic process automation, understand, systems, technology, deal, understanding, hiring

SPEAKERS

Participant X, Chanvi Singh

Chanvi Singh 00:01

All right, excellent. Thank you so much for agreeing to do this, I understand that we've gone through the consent, and you're happy to start the interview.

Participant X 00:16

Yes

Chanvi Singh 00:22

Why don't we begin with you telling me a little bit about your role and the organization you work for?

Participant X 00:29

Yep. So I'm a (Omitted). So essentially, we have approximately between (Omitted) at the moment, at any one time, I lead the (Omitted) in (Omitted). I'm also a (Omitted) in our national (Omitted), where we identify (Omitted) scale ups. And our aim is to get them to (Omitted) turnover in

(Omitted) years. And they need to be tech enabled scale ups. The (Omitted) position, sorry, just taking a step back. I essentially look after a team that does various different things. So (Omitted) and some incentives for like (Omitted) grants or (Omitted) incentives for innovative businesses.

Chanvi Singh 01:34

Yeah, excellent. I'm sure it keeps you more than busy.

Participant X 01:37

Yeah. The other role that I have is I lead our (Omitted) at the firm, as well. And I also in the Australian point of contact for our (Omitted) at (Omitted).

Chanvi Singh 01:53

Thank you for that. And now we'll start with the questions as long as you're happy.

Yeah, go for it.

Perfect. It'll be great to start with exploring your understanding of Industry 4.0. Could you please tell me what you know about and how you understand the term ‘Industry 4.0’. Please be assured that this is not a knowledge test and I'm just trying to understand your perception of Industry 4.0

Participant X 02:13

sure. So my perceptions, probably based on kind of just my experience in terms of dealing with a lot of, you know, companies that I work with, and being kind of in the industry. And so my understanding is, you know, obviously, we've had different things happen over time. And then we've got the Industrial Revolution, the first industrial revolution, all that sort of thing. And industry 4.0, from my point of view, and my understanding, and I could be wrong is, is it's really about kind of that that next step of data and connectivity, and, you know, kind of having everything accessible in real time, and advanced manufacturing, automation, all those things, is kind of my understanding if I can kind of simplify it.

Chanvi Singh 03:13

Yeah, that's fine. That's perfect. Thank you for that. And before we move on to the next question, I would just like to quickly go through the definition of Industry 4.0 that we would be using for this study. And then all the other questions will make sense in the context as well.

Participant X 03:30

Yeah, awesome. No worries.

Chanvi Singh 03:33

Alrighty, so Industry 4.0 can generally be defined as the advancement of internet connected technologies, which have pushed to full automation, digitalization processes, and the use of information technology, artificial intelligence, big data, robotics, especially in the manufacturing services. The concept is now used in a broader context, outside of manufacturing as well. So for this study, the term Industry 4.0 is more broadly understood as a system of applying digitalization and automation in the workplace. And that includes the use of artificial intelligence, big data, robotics, everything you mentioned before as well, creating more autonomous systems and smart factories. So More simply put, it is an increase of automation of systems within the workplace. Does that make sense? Is there anything you'd like to clarify?

Participant X 04:38

that's a much better definition! Yeah, but yeah, I was like, I was close. I was close (laughs).

Chanvi Singh 04:50

you mentioned pretty much mention all the concepts anyway. So yes absolutely! And it's just that different people perceive it differently depending on the industry they're in. And so it's just interesting to know how people perceive it anyway.

Participant X 05:03

Yeah, no, no problem. cool.

Chanvi Singh 05:08

Okay so the first question I have around your perceptions is that thinking about work places in general and not just your organization, specifically, what do you think organizations in general need to focus on in order to advance themselves in Industry 4.0?

Participant X 05:28

So I think they definitely need to. And I think COVID was a really good example of this is, you know, the embracing of technology. And just in general, like, I think, if you look at, and look, it's gonna depend on. So in the context of my workplace, we have embraced technology very early, which then meant that we were able to, do things be very agile when COVID hit, for example, and but there was, a lot of clients that I work with, that weren't necessarily as progressed in terms of their uptake of technology. That's probably changed a little bit now. But I think, yeah, embracing technology and being curious about the sorts of, I think, benefits of, you know, new systems, and sometimes it's not about so I think there's obviously an upfront investment, but then actually understanding the our, return on investment over time, and all of the other benefits of it, you know, increased productivity efficiency, happier staff, like there's always things that are, I think, play a role

that sometimes businesses just look at the look at workplaces look at the actual upfront costs, but they don't look at the longer term kind of return on investment.

Chanvi Singh 06:51

Yeah, that makes complete sense. And so having more systems, looking at multiple factors that are going to get influenced is probably really important. So curiosity and awareness is important to embrace the technology and realize what benefits it can provide us from an investment point of view, but also the benefits from a people point of view. Have I captured that correctly?

Participant X 07:10

Yeah. So I think having a look at it, probably a good way of putting is having a look at it more holistically. Yeah. Rather than kind of just are this part of my business in this part of the business? I think what I've also seen, just from experience with ‘customers’ is sometimes they focus on one part of the business. And, you know, because they have to look at prioritizing, and they go, Oh, well just look at that. But sometimes, if you have a better kind of broader, view to begin with, sometimes it saves you down the track, you know, like sometimes people go, oh, I'll just invest in this area. And then actually realise it's probably not the right solution if they had thought about the broader business. So yeah. I think having a full integrated kind of thing is, really helpful. Yeah,

Chanvi Singh 08:03

Basically understanding it, and also managing it as a multifactorial and holistic thing?

Participant X 08:10

Yeah, yeah.

Chanvi Singh 08:14

Great. So now, let's turn our attention to your organization's specifically. So, for this section of questions- the next few questions, I would like to keep your organization in mind. Once again, there are no right or wrong answers. And I'm just trying to capture your thoughts.

Participant X 08:32

Yeah, sure.

Chanvi Singh 08:39

Alright, so what does advancing in Industry 4.0 look like for your organization or what do you think you need to do?

Participant X 08:49

So I think we've started doing this. But you know, I think it's kind of a work in progress. So we so I think, so for example, we have put in place, what we call a (Omitted), and it's essentially upskilling all of our staff. So everyone in the (Omitted), or (Omitted) have to do it. And it's actually just having a basic, but at the very kind of start of it, they the firm has developed a digital fitness (Omitted). And we also then market this to our (Omitted), but we used it internally, to really get our people to understand basic digitization industry 4.0 What's happening in the world. So that was really awesome, because the (Omitted) said, you know, it needs to kind of start at the top. So as (Omitted), we need to actually understand, you know, in particularly if we're talking to our (Omitted) about technology, we need to at least have a basic understanding even if it's something that we don't normally do (Omitted) but you know, it's really important for us so, they had this digital future just happened, the goal was to get everyone to a score of (Omitted) within a certain amount of time. And so we're very competitive So we did that. And then the, then the second thing they did was they actually did a (Omitted) where they got all of our staff has been through the (Omitted), and it's to really understand things like certain tools like Power BI and old tricks and things that can actually help with creating efficiencies in terms of how we do our work. Which so what I think, you know, has happened over time is, again, like I said, happier staff, because, there's a lot of manual processes that we do that are not necessarily fun. We don't enjoy doing so how do we get how do we get people to, to learn new tools and skills, and systems to be able then to apply that to everyday stuff. So that's one thing. And then we also, did this for our (Omitted). So, and we've implemented tools now. And we've actually, so you know, the company has got software developers, and we build software that has uses machine learning and AI to actually be more accurate, help solve our clients problems, we've built tools in terms of robotic process automation, we've built tools, for example, in terms of automation associated with being able to analyze, you know, like, 1000s, of, you know, (Omitted) and (Omitted) to then be able to find anomalies or whatever it might be, but it just does everything quicker, faster. It's simpler. And then, it reduces human error as well.

Participant X 12:12

Does that make sense? Yeah. Okay.

Chanvi Singh 12:14

yes, So I think just just to clarify, from what I understand, the company is already progressing quite well. You’re engaged in doing lots and lots of different things, including the elements of Industry 4.0 -including machine learning, robotics, data analytics, and through the (Omitted), you're trying to ensure that the staff are continuously getting trained and skilled. And in your education and awareness to that.

Participant X 12:42

Yeah, yes, yes. And then probably the only other thing I would add is that we also, we also identified what we would call (Omitted). So people who are either really interested in digitization

and improvements, you know, and efficiencies, or people that had a knack for it, you know, some people were already software developers, or they love gaming, and you know, so this thing's right up their alley. And we, we made sure there was a (Omitted) in kind of every meaningful tech, or there abouts or every office, so that then they could, they did more work. So they did a lot more kind of projects and training that they could then take back and, you know, disseminate to the rest of their teams in areas so and they could Yeah, and then we also hold competitions in global things around ideas. So hubs that you can, if you found a better way, using rpa, (robotic process automation), or data analytics or tool to do something, you could upload it for points, but also share it with everyone else. So they could take that that particular algorithm or whatever it is, and then apply it to their own. I think that knowledge sharing as well, that was really important, so that no one's reinventing the wheel.

Chanvi Singh 14:04

That's super interesting! And you've touched on lots of things that I'll be asking you about in specific. So that's great., it's a great start. So we only started a bit broad and now we're going to start going into specifics. I'll ask you a few questions around the enablers, the barriers and challenges that your organization may encounter when advancing in Industry 4.0. So the first question about those specifics is - what factors in your workplace will enable you to successfully advance Industry 4.0 and be future ready?

Participant X 14:36

So I think one of the big enablers for us was having capacity and time so we were given time to do (Omitted) and the sessions and there was a lot of, online training, but the staff was given the time to do it. So I think the firm understood that we needed to invest in that. I think that's really important. I think if you don't give yourself the time to do those things, you're not gonna go very far even if you have good intentions. Another enabler is probably just the tools and, subject matter experts to enable us to, to kind of, I guess, teach us what we don't know. And then the other tools, obviously, you know, (Omitted) So I think having tools like iPhone, everything uploaded in easy to access type is is also helpful.

Chanvi Singh 15:34

Yeah, so the big ones are having the correct people, the subject matter experts, and having the tools and technology to actually perform those. Investing in time wise, and money wise, being able to invest has been also been a great enabler. Yeah. Yep. Excellent. The next question is around barriers. So barriers are something that we know block growth, what barriers can you identify that, you know, are stopping your organization from advancing Industry 4.0?

Participant X 16:08

I don't know. I don’t want to say nothing. I want to be critical. So I think that because I think we are doing the best that we can. Yeah, I think I think it can be an enabler, but I think it can also be a barrier at times. So like, you know, we're so busy trying to help (Omitted) that sometimes. And so I

think that's why we're, we're trying to, you know, identify people and say, we'll give you, you know, you can take 20% of your time to do stuff so that they get that permission, they know that they can allocate that time. So I think time is going to enable it, but it can also be a massive barrier, I think to Yeah, we are a really (Omitted) organization. And so like, you know, (Omitted) people (Omitted), we've got (Omitted) people in (Omitted). So I think it's just the sheer volume of, you know, like, how do you get the whole like whole organization, and, you know, so that takes time, and it took, , a couple of years to get everyone through (Omitted). So I think sometimes the barriers can be the size and the complexity of the organization. So we are split into (Omitted) different kind of business units. So every business unit, and we're very business unit LED. So, you know, whilst we're doing (Omitted), all across the business units, there's certain things that each business unit will be doing differently. So then, you know, you need to be able to come together and make sure we're not reinventing the wheel. So I think there's a lot of things that Yeah, I think complex like and how (Omitted) the organization and how complex this structure can be, can be a barrier.

Chanvi Singh 17:50

Yeah, that makes sense, as well. Um, are there any other red tapes that you can think of, in terms of the constraints you work within? Perhaps?

Participant X 18:00

Probably not red tape. But I think just, there might be the other barrier, which I think is, you know, we've, we've been on the journey for a while, but probably right at the start, there would have been just that resistance to change potentially, in certain mindsets of probably people who are a bit more traditional, in their ways of working and, you know, not as agile.

Chanvi Singh 18:25

Yeah, so this has already started going into the next question, which is challenges. So challenges are something that, can we overcome them? So could you talk a little bit about potential challenges? And you've already mentioned as to you probably saw that inertia, initially and then you were able to overcome it as a challenge.

Participant X 18:45

Yeah. Yeah. But I think getting people from the top on board to begin with, and doing the (Omitted) and, you know, we were, that was a KPI for us. Like, as leadership, we were kind of expected to get to a certain number by a certain time, otherwise, we wouldn't get a good outcome. Like so. And I think in the end, I'm pretty sure not everyone can embrace I don't think, but it's still that was kind of, how we dealt with that. Other challenges? I don't know. I think, um, yeah, probably kind of similar to barriers – there is a little bit overlap as well.

Chanvi Singh 19:40

Great! Yeah. If you think of another one that you can always come back to that. Yeah. And then and then the next question was, how do you think that can be overcome?

Participant X 19:51

So yeah, I think putting, being willing to obviously allocate time. One of the things we did was trying to kind of identify the (Omitted), like people who are already kind of on the way to doing it so that then they could influence others. So I think kind of potential identifying potential influences that can then create kind of impact in within teams is really helpful. And then I think, you know, providing, the other thing that's really helpful is providing real kind of case studies and examples of why, it's the right thing to do, or it's good for our clients, it's good for our people. It's good for us. And you know, the importance of it. I think, if everyone understands the why, -when I asked you before, I was like, Oh, why do you need the video that gets it? You know, it's it's much easier to then get them on board. If you just kind of telling people they've got to do something. It's does not have as much impact. Yeah.

Chanvi Singh 21:06

Yeah! Makes sense. So, to summarise, like overarching having a good change management plan.

Participant-Yeah, definitely.

Having those champions, -people who can champion the changes, and

yeah, exactly, yeah.

Chanvi- Excellent. So we will now move on to our attention to the impact of COVID-19 on the future of work. You already touched on this at the beginning of the interview, so this is great. It's flowing perfectly. So we know that the pandemic has changed the way people and organizations work? How has it changed your perspective on the future, keeping in mind, like the automation of systems and big data, etc?

Participant X 21:49

Yeah, so I think, yeah, I'm just, I'm just trying to make sure it's in the context of that. Because I think everyone just automatically thinks to being able to work flexibly, because I think that's definitely one. Yeah, I think it's really, really impacted, you know, people's mindset around what it means to work flexibly, and that you don't need to be in the office all the time to be able to work and that, you know, that there are better ways, potentially of doing something. So, you know, like, this is very basic, but you know, why spend however many hours commuting in the car every day of the week, if you don't need to be and all that sort of stuff. So and you could be using that time, in more productive ways. So there's that sort of thing that I think it's really and, you know, being

digitally enabled, and having, you know, systems in place that allow you to do that is really important. Yeah. I think some of the tools that you get around real time data, you know, really, so if you think, you know, if I think about all my clients, those that are already kind of working in industry 4.0. So like, I have clients that are basically Internet of Things, (Omitted). And that's why I have, I think I have a decent understanding. Like they, you know, they didn't slow down at all with COVID. Because they are really forward thinking they've got all of those sorts of things in place, you know. Yeah. So I think, I think that's really important. And then I think, you know, if you think about from a manufacturing point of view, I'm sure there's, and I know that, you know, businesses, I think now are looking to more advanced manufacturing processes and opportunities, because there's a lack of lack of supply, right? So they have to build sovereign capability. So they need to be able to either manufacture whatever they do on shore, or symbol or whatever it is. And so they're looking to alternative methods- whether it's 3d printing, or, you know. It's because they're kind of forced to, I think, whereas previously you know, it was cheap came from China and we'll just do that.x

Chanvi Singh 24:37

So you think COVID brought like, a few problems and good things to the forefront?

Participant X 24:46

Yeah, I think yeah, look, I think I think it's definitely accelerated the need to like really Look at what technological advances you can make within your business to kind of deal with the fact that you can always have people at site or you can always on site or, you know, there could potentially disruptions to like shipping or freight or whatever it might be, or there's disruption, I think it's, you know, ways of kind of getting an understanding of where you are, at any point in time in terms of your business. And this could be financial, or it could be, you know, logistical, whatever it might be real can you can, if you can get real time data, I think that that makes a big difference. And so I think that that, yeah, I think so that's a positive, where I think it's kind of accelerated that I think people were aware of it, and they're like, Oh, we don't need to do it now. So I think it's accelerated in terms of negative impacts. I don't know if this is because of COVID. But I think we've the increase the use of technology, although, there's also the increase of risk associated with like cyber, and that sort of thing.

Chanvi Singh 26:23

It goes hand in hand, for sure. Yeah, this could probably also feed into the challenges we were talking about before as well.

Participant X 26:34

yeah. Yeah. So I think there's always Once you're connected in any way to any third party or outside, you know, I think there's always a risk around cybersecurity, and all those sorts of things. So I think, and that's where a lot of businesses are not advanced enough. and that's why people are getting hacked.

Chanvi Singh 26:57

Yes cybersecurity as an industry is certainly growing hugely at the moment. Yeah, yeah. Excellent. So now, I would like to ask you a few questions regarding the business strategy of the organization, the skills and mindset of the people. And also touch a little bit on work health and safety practices of the organization. The first question I have is that it is perceived that in Industry 4.0 people need to have specific skills to advance, can you talk about the skills of the people in your organization that they have, or will need in order to successfully advance in Industry 4.0?

Participant X 27:40

Yeah, so I think they need to have a basic understanding of kind of the, you know, what, the different systems and tools and, I guess just understand industry 4.0 And the opportunities, I think they need to understand for us, we absolutely need to understand what, how that impacts from an industry perspective, depending on the industries we work with, and particularly the types of work that we do so for example. And we're super broad, right? So I work in (Omitted) and (Omitted) and helping scale ups and startups who are doing some of these things to grow really quickly. Yet, you know, there's people in my organization that are cybersecurity experts, with people that are experts in terms of Economics and Policy, there's people that are (Omitted) that experts in (Omitted), but that's where you know, that we were doing a lot of robotic process automation in that area. We're doing a lot of automation in (Omitted) So there's Yeah, so I think back to your question- What was it?

Chanvi Singh 29:01

Skills that you think other people..

Participant X 29:04

yeah, there's that. But then we are, like I said, we've moved our hiring in house. So generally, and we still do this, we will use third party tools. But what we've worked out is in our because we're, you know, we would see ourselves as subject matter experts in terms of (Omitted) for example. So we've hired and have now had for the last (Omitted) years, our own (Omitted), where we hire a bunch of software developers, and all they do is develop (Omitted) automation tools. So we're hiring people that have software development skills that can build AI that can build robotic process automation. And we've done that in our (Omitted) business as well. So yeah, so.

Chanvi Singh 29:55

So, overarching, you think that there needs to be a focus on the technical skills. So you are able to do the things properly and efficiently?

Participant X 30:06

I think that's where, yeah, I think for us if because we're servicing (Omitted), we find that to kind up with making sure that our expertise is being deployed in a way that will actually benefit through industry 4.0, cut type tools and concepts. We have done that. But I think then, if you think about everyone else in the organization, who's not necessarily a software developer, its still important to understand the potential implications of things. So for example, how do you treat again, I'm going back to the (Omitted), we're a (Omitted) expert, for example, or an (Omitted) expert, you need to understand how to treat industry 4.0 assets, so I think having an understanding of what it is, is kind of a basic skill that you need. And then how do we apply it, in what we provide?

Chanvi Singh 31:12

yeah, that makes Yeah, yeah. Um, so the next question is around the business strategies. So thinking about your organization's current business strategies? How do you foresee needing to change or in line with the needs of Industry 4.0, what changes do you think you need or expect to see?

Participant X 31:39

I actually think we'll be hiring more technical people. So I think the types of jobs that we hire for will be or continue to evolve to being more technical. Or more like engineers, and that sort of thing versus accountants, if that makes sense. So the types of roles will change? Can you please ask the question again?

Chanvi Singh 32:18

Yes, in terms of the business strategy of the organization? What changes do you expect to see? Or do you think that the organization needs in order to keep in line with the needs of the Industry 4.0?

Participant X 32:33

Yeah, I think we're hiring people who have that subject matter expertise in the industry. 4.0 area, so like, actually, people who've lived, breathed that sort of thing, and then upskilling ourselves in particular areas? We've already kind of done a lot of it as well, , we take industry experts, and we hire them, as well. And we do that not just across industry. 4.0, but others. looking at ways that we can apply it to our clients, you know, how can if we're looking after we've got, you know, a business dedicated to aged care, how do we, how do we help, you know, because they're traditionary traditional businesses, how do we help them with implementing industry? 4.0 to improve? Yeah, for their clients and stuff,

Chanvi Singh 33:29

Do you think that there's a generational effect that you need to cater to their needs differently from your other clients?

Participant X 33:49

I don't know if it's a generational effect, because like, the actual aged care, you know, let the residents aren't using our, you know, it's more the the people who are running the aged care facilities, but they are, but they are very traditional. So I think yes, how do we, we need to be across all of the new technologies to be able to (Omitted) because, you know, they might be looking for process improvements in, in the aged care facility, for example, and we would potentially recommend, or have you thought about, you know, wearable technology that might be able to give you real time data are across the residences? Well, well being, you know, so there's a, there's a bunch of things like that. I think we're also implementing applications and technology that are applied to the well being of our people as well. So you know, applications and things that can help them feel safe, as well. Yeah. Perfect.

Chanvi Singh 35:00

Perfect! Could you tell me a little bit about how you think Industry 4.0 might help your organization be innovative? Now, once again, I think you've touched on this quite a bit throughout. So if there's anything Yeah, I don't know, something specific that you want to talk about?

Participant X 35:14

Um, yeah, I think being across what the different opportunities are, and then looking at how we can apply that to our organization, I think is really important. Being really open and curious and not thinking we know it all. And yeah, so I think continuing to, which I think is what we do, but continuing to keep abreast of how things are evolving, and all of the improvements and updates is always something different.

Chanvi Singh 35:55

Like, coming back to the continuing upskilling and training and recruitment?

Yes.

Chanvi Singh 36:18

All right. So now keeping in mind the current employees of your organization, could you describe the mindset or attitudes towards change that your organization has or will need in order to implement Industry 4.0 technologies?

Participant X 36:35

Yeah, again, need to be agile, open minded, curious. I think need to be Not resistant. Yeah. Yeah, all of those things. But I think also then, and then willing to try new things. So giving it a go, and that sort of thing. So yeah, I think that's really important. kind of part of our values, like one of our

values is to like, have a go and the other ones, (Omitted). So yeah, it's kind of ingrained in everything.

Chanvi Singh 37:35

So yeah. Now that makes it make sense, even based on the other answers that you've given, you talked about agility and keeping an open mind, it makes sense that you know, you want to have an organization, like the people in the organization need to have that growth mindset and that open mindset where they can continually learn and improve themselves. That's perfect. So thank you for that. Now, we're going to touch on a little bit on the health and safety side of things. So I understand that there would be clear laws and procedures about work health and safety, particularly regarding physical safety. The advancement into the future of work may lead to the introduction of new guidelines, policies and practices. So from your perspective, as a manager, how do you think you can protect workers psychological health in the workplace, keeping in mind what Industry 4.0 is going to bring? Yeah.

Participant X 38:36

So I think, making sure that our people feel safe, have the ability to seek help when they need it, for whatever it might be. And I think prevention is better than having to deal when someone is in an in a spot of either being mentally feeling unwell or burnt out or unsafe. And so yeah, so we've actually, and I've been closely involved in this because it's (Omitted) have just deployed a new safety and wellbeing (Omitted) to all of our stuff. And this is a third party. (Omitted). So we didn't build this. And it's called (Omitted) you should check it out. It's awesome. I used it when I walked home from work yesterday. And essentially, it's (Omitted) that and we just deployed it to (Omitted) people. So we just started with one business unit. And then we're hopefully going to take it, to the rest of the firm in (Omitted). It has kind of three main or four main areas. So one is notifications. So it will tell you when or things that you might need to know with helpful information. So for there's like COVID, COVID outbreak, or I often get notifications to say there's a protest happening on this particular street don't go down that area, or there's been a bushfire or you know, so useful. Yeah, that's really helpful. The other thing, so then the second thing that it does is it has a chat function. And now this is actually, the stats are showing that this is having quite a big impact, because with your normal, so we've got one and most organizations have one now, but an EAP. and you know, that's the traditional EAP is, I think, very kind of old school, and probably not catering to the needs of our current workforce, who are generally a lot younger, a lot, a lot more savvy with technology. And, you know, I feel like ringing a 1800 number and then trying to find a time for an appointment, and during work hours, is actually a barrier for a lot of people. So what (Omitted) does is it has a bunch of different tiles, and so you can choose them. (description of app functions omitted) But essentially, people are using it mostly between, like (Omitted) in the (Omitted), so it's generally after hours when they're alone home at night, you know, and often what they're finding is that it's more severe. And I'm not talking about our organization now. But like, just in general, the steps of what they've found is that, sometimes the issue that they want to chat about is just the surface issue. And then there's more things underneath. But what it does is it helps and the steps of sharing that people have said, they will not have sought help if they didn't have that. So that's really helpful. So

Participant X 42:29

And then the two other things that it has. So one is (Omitted), which is what I used to (Omitted) because it's (Omitted) is it basically you enter where your it knows where you are deactivated, you enter where you're going. So I just entered my (Omitted), and it basically (Omitted) to make sure that you (Omitted) and are safe. And the other function is (Omitted). So a lot of mobile lenders or nurses that have to go into homes use this, where you can set a timer, and you can say where you are and says please (Omitted) so that if something happens, they know where you are. So if you're at a (Omitted), or whatever it may be. But essentially, if you just hit a button, you can get help by asside within 20 minutes anywhere in Australia, obviously very few areas that they have. And so it's such an amazing thing, and that's the sort of thing we're starting to do, to really kind of Yeah, challenge the fact that, you know, I think people just go EAP is kind of what we've done all the time over time. But I think this is a much more advanced tool. We call it like the next generation EAP provider.

Chanvi Singh 43:56

Yeah, that makes complete sense. And that's, it's fantastic. I think there's so many elements in there that will be useful and EAP's. I think the reason why they're ineffective is because they are updated, and people really are not in that mindset anymore, where if they want help, they're going to call the number two. Yeah, exactly. Yeah, that makes sense. And just following up with from that question, as a manager, how do you ensure prioritizing and showing commitment to employee health and well being?

Participant X 44:28

So we're hold wellbeing sessions with my team. We talk about kind of tools that we can use, like meditation and exercise, we talk about how to get balance. If I identify that someone doesn't seem well, I will go and talk to them and tell them do you need to take a day off? Or, you know, like, what's happening? I think really being so I think communication is really key and being an awareness. So I think, you know, constantly talking to your people in At (Omitted) we have, we have obviously kind of (Omitted) but then every (Omitted) is a team leader. So we have like a (Omitted) system so that there's always someone that you've got that you can go to, for whatever you might need. We've obviously got (Omitted) we've got in house psychologists, so we've got all those support mechanisms. But I think as a manager myself, the best thing that I can do is just have an awareness of how my people may be feeling and making sure and checking in with them, I think is really important. But then helping them to ensure because we're very high performing busy, you know, culture. So how do we ensure that they have the tools to deal with deadlines and stress? Like, you know, sometimes we have staff that have young families, you know, so it's hard on them not to kind of deal with both, or we have others that study and work. And so I think just if you're aware of someone's potential like situation, then you could be attuned to the potential issues that might pop up.

Chanvi Singh 46:15

so enable them by giving them resources that are at their disposal, including Yeah, you access through psychologist and making them feel heard and supported?

Participant X 46:27

Yeah we did a whole session on how to write a wellness plan, like, can we, you know, encourage people to do a wellness plan for the year. So you know, what, what are the three things you're going to do to improve, you know, your health and your well being? Yeah, and it not just from a physical perspective, but just a mental perspective as well. So,

Chanvi Singh 46:51

yeah. And do you think having a bigger focus on employee health and well being, including psychological health will enable you to be better prepared for future of work? Yeah. How do you think that might be?

Participant X 47:05

Because I think I think our people are our biggest asset. And, like, I don't think you can underestimate how someone's mental and physical well being, can impact their, how they show up at work, how they, how they conduct their work, and how they can influence others, I think, from my experience, and I have dealt with, you know, people at very senior levels. So other (Omitted) who, as well as staff who have had mental health issues, and, you know, like, an often it's stuff that starts, you know, at home, and then what works just kind of like on top of that, and it's and, you know, you can have this kind of downward spiral, and it becomes very hard to get out of, so I think being able to kind of support people in being aware of that's really important. But the other thing is, if those people are not feeling well, they can often then become toxic, like toxic to others and influence the broader team. So it's just like, to me, it's kind of like a non negotiable around having happy, healthy staff, because then it just, you know, like going forward. And I think, I think part of that as well, which is was a challenge with COVID Was that when people were working at home too much, and they weren't getting that interaction with the team. And that was then also having a negative effect because some people, and most people, even if it was just a day or two to come back to the office made a massive difference to their mental health and having that interaction with others,

Chanvi Singh 48:54

I think its really good that you're so aware of all the factors. Great to see organizations that care. So what youre saying is that, like you mentioned before as well, having that holistic approach is, perhaps most important. So the last question to this section, which is one of my favorites. How do you think your job role will change the more your organization advances in Industry 4.0

Participant X 49:24

That is a good question, I think, my job will, hopefully so I think there's things like timesheets, and I know that they're really looking at this and they're looking for ways to do things a lot better. And we've got a system that it can automatically deduct from your diary, it can pull the time that you've spent but but so you have to set up the meeting with the right information for it to be effective. So you know, it's only as good as the data you put in there. So So I think things like that will give would mean more time to spend on value adding, like tasks and activities and spending more time with my (Omitted) versus doing that sort of stuff would be awesome. And I think that, yeah, so I think that's absolutely positive. I don't really see any negatives. You know, a lot of what I do is kind of, you know, kind of, like, it's not necessarily manual work, you know what I mean? Like, it's more kind of the way information, I guess, and knowledge sharing and applying, we have no (Omitted) and stuff like that, but and business (Omitted), but I think it will impact a lot of our customer base. But I think also my clients who are doing really awesome things. In terms of Industry 4.0 I thing it will have a broader impact on more traditional client base.

Chanvi Singh 50:59

yeah, it's cool to imagine yourself and envision yourself in the future and try and see what that feels like isn't it? Yeah!.

So we've now come to the last section of this question. So this is specifically looking at women in Industry 4.0 so in light of the conversation that we've been having about Industry 4.0 what do you think women excel in, in general? That would make them future ready?

Participant X 51:37

Um, I think I think women think differently, like, in my view, and I think we are often a little bit more of its like, analytics, maybe not the right word. But I think we think a bit more about the broader implications of things or, you know, it's almost like that very simple kind of way of putting it. Yeah, we think before we speak a bit more than and so I think that we have a bit more maybe good way of putting it into a bit more considered in a way that we and so. Yeah, so I think that that is actually a good thing, particularly as Yeah, you know, industry 4.0 Will, can have such a massive impact in a number of different ways. And so, I think, yeah, is that kind of answer your question?

Chanvi Singh 52:34

Yeah. So in terms of what the accelerant that will make them more future ready. So they think differently, they have like, almost like a systems thinking approach, where they can broadly look at the implications of particular action on different things, different people.

Exactly. So

Participant X 52:52

I think definitely a lot more inclusive, you know, more, I think, sometimes I think we're a bit more better than, look, it depends. But I think, the way we communicate, and also, if you think about kind of imparting knowledge, I think women can play a really big role as role models, get future, female, potential 4.0, you know, work ready stuff up and running.

Chanvi Singh 53:32

And what do you think would be a general barrier for women that you have noticed around you, and hopefully won't continue to exist in the future?

Participant X 53:42

Yeah, I think it's, again, it's just the unconscious bias that we deal with at the firm, about, you know, I did it maybe seven years ago, we did unconscious bias training for all of (Omitted) to ensure that we weren't, and it was all around gender bias to make sure that whenever we were making decisions on jobs and projects and that sort of thing, that we weren't making decisions unconsciously thinking that men are better than women, or would be better for the job. So yeah, so I've done a lot of kind of, every time I think about how to make sure that I'm not being unconsciously biased. So yeah, I really challenged myself on why did I consider that person versus this person? etcetera. So I think that's important. And then I think just having again, good role models, and then I think, yeah, so a barrier will be not set. I think you can't be what you can't see. You know, I think that's an issue for women. And then

Chanvi Singh 54:56

like when you're growing up, and if you don't see a lot of scientists and engineer So,

Participant X 55:00

yeah, women that are doing those sorts of things. Yeah, I think it's really can be a barrier. And I think to them. I think women sometimes think that the, I think it's as a confidence thing ingrained in us that we tend to pull ourselves out, I still do it. And I don't even realize I'm doing it sometimes. And, you know, so I think, for example, you know, when we're going for roles and that sort of thing, you know, it's all in all of the studies and stuff. if there's 10 kind of criteria, we'll say, We've got to have all 10 and to be able to apply for the job, whereas men would have to read in like, I'm going to go for it, get it, you know, like so, I think I think all of those kind of, you know, known

Chanvi Singh 55:49

the perception where perhaps having the same characteristics, women are perceived differently.

Participant X 55:56

Yes, exactly. You know, instead of being assertive, we're told, called bossy or that sort of thing. So yeah, I think that's definitely a potential challenge. But I think that we're getting so much better with that. And again, it starts with being the awareness of it.

Chanvi Singh 59:46

Alright, so we've come to the last question of the interview, which is what skills do you think women could learn or develop in order to prepare themselves better for the future of work? So you have we've already mentioned confidence, for example, like any others that you can think of?

Participant X 1:00:05

Um do you mean technical or could be anything?

Chanvi Singh 1:00:13

Whatever you think that women could benefit?

Participant X 1:00:17

I just think, again, if you're not exposed to it, you're not going to have an interest in it. If you don't know what you don't know. So I think from a younger age, like, having exposure to, you know, that there's a space industry that there's an Internet of that, you know, there's things, there's a, like thing called Internet of Things. And, you know, understanding, I think, more that engineering and science rather than kind of the traditional things that we kind of, you know, think that females should be doing more of so I think, just having exposure to everything so that they have a better understanding of it, and then potentially can choose to be in that field, they might still not want to do it like I, you know, you don't I just don't think people should be doing it for the sake of it either. Like, you need to

Chanvi Singh 1:01:09

just need numbers, like it doesn't need to be a heck of it

Participant X 1:01:17

I think, I think that's really important for the future of work, I think, communicate, I think communication look, and this is for any gender, but I think for females, you know, communication is such a massive opportunity to really tap into because I think often it can make the difference between, you know, I think, opportunity, the opportunities that we get, so if you're able to communicate with someone be articulate, all those sorts of things that you you want, or Yeah, I don't know if that's a find that answered your question. No, that's, that's perfect.

Chanvi Singh 1:02:00

Well, that's everything I wanted to ask, Have you got anything else you would like to see or any final thoughts that you would like to follow up with that? I haven't already asked you.

Participant X 1:02:09

I think just Yeah, as long as it's clear, these are my opinions, my personal views. But I think I'm really lucky that I actually have people around me that work in this field, but I also sit across a lot of different aspects of (Omitted). So I know a lot of what we're doing, to try and improve things for our people in the way we work. And the future of work is so important to us. And, you know, we're even implementing things at the moment- We're always looking at ways to kind of improve the experience for our people. So yeah. Yeah, that's why I've been here for so long. I mean, I'm, I'm, yeah, (Omitted) years I've been with (Omitted). So and I've worked in (Omitted) different offices, so but yeah, and I was just gonna ask as well a bit more about your research - like how many people are you interviewing and how its all going? I'm just interested.

Chanvi Singh 1:03:31n

Yes of course! I'm happy to talk about that – do you mind if I stop the recording?

Participant X 1:03:31

Yeah, that's fine.

Thank you so much for your time today- I really appreciate it.

participant Y

Thu, 11/25 10:50AM • 1:03:32

SUMMARY KEYWORDS

people, technology, industry, organisation, work, barrier, challenges, big, role, talking, shift, engineers, manager, understand, push, skills, excellent, workplace, question, business

SPEAKERS

Chanvi Singh, PARTICIPANT Y

Chanvi Singh 00:00

Thank you very much, (Omitted) for agreeing to participate. We have signed the consent form and are going to now start the interview. Are you happy with everything? Good? Excellent. So why don't we begin with you just talking a little bit about your role within the organisation. And then we'll go from there.

PARTICIPANT Y 00:21

So I had two roles at (Omitted). My first one was (Omitted) assets. So I lead the team responsible for planning, and asset management planning for all the (Omitted) in (Omitted). (Omitted). My second role was (Omitted). And I had three elements to that role. One was (Omitted), one was the (Omitted) quality system. And the last was, we called it the (Omitted) team. But it was a team responsible for bringing advanced analytics into (Omitted). So looking at machine learning and AI, to predict failures, and understand what was happening in the network and to also drive research and innovation in (Omitted).

Chanvi Singh 01:35

That's very interesting! I'm sure it kept you busy. So it would be great to start with exploring your understanding of Industry 4.0. So could you tell me a little bit about what you know about Industry 4.0, I know you've just described your role. But please be assured that this is not me testing your knowledge. I just want to understand what your perception of Industry 4.0 is.

PARTICIPANT Y 02:03

So the most generic version is it's the next form of industrial revolution. Yeah. So yeah, everything moving forward. So for me the most relevant bits as an (Omitted), working in (Omitted), or work that will move away from people on the ground, doing work, to use some technology to help people make smarter decisions, make faster decisions, and make better informed decisions, moving from reacting to predicting, and proactively managing stuff and using technology to do that. So using machine learning, teaching machines, what to look for, so that they can alert people to what's happening, starting to try and bring in, ai as well, yeah, to that. So there are probably the most best for me, it was just that shift technology to support what people were doing.

Chanvi Singh 02:59

That's excellent. That's pretty spot on. So thank you for that. Before we move on to the next question, what I'll do is I'll quickly go through the definition of Industry 4.0 that we're using for this study, so that everything else makes sense in context, I'm sure that this is not required, but we're going to do it because it's standard procedure. So Industry 4.0 can generally be defined as the advancement of interconnected technologies, which have pushed industries to full automation, digitalization. And with the use of information technology, artificial intelligence, robotics, AI, and mostly in the manufacturing sector. And of course, the concept is now used in a broader context outside of manufacturing as well. And for this study, we're using the term Industry 4.0 more broadly as a system of applying digitalization and automation to systems in the workplace. And with, of course, the use of artificial intelligence, data analytics, robotics, etc. Creating more autonomous systems and smart factories. And more simply, it is increasing automation of systems in the workplace. Does that make sense? Yep. Yeah.

So I'd like to follow up with your opinions on Industry 4.0 now. So thinking about workplaces in general, not specifically your organisation, what do organisations in general need to focus on in order to advance themselves in Industry 4.0?

PARTICIPANT Y 05:57

So the biggest thing for me and I have seen this organisations I have worked for is really changing their thinking about workforce. So moving away from people having do certain things and certain roles to people who have the aptitude to learn new things and apply those in lots of different ways and also the capacity to move between roles as work levels have different ups and downs in different situations so having more flexible, more adaptable workforce on the tools side of experience and have the ability to understand technology, utilize technology- more problem solving. Rather than actually bringing in the data- adding value to that data to make decisions is probably the biggest thing for me. So for example, the data scientist I have at (Omitted) is an engineer who can code. So they can understand and teach how to use the machine rather than just being able to analyse.

CS- so learning how to utilize data?

PARTICIPANT Y- It's like setting a value add on the data. For too long organisations have just been about collecting it. Yeah. Now it's about collecting the right information, and then add that value out being able to actually use it.

Chanvi Singh 06:09

it. Yeah. Excellent. Now let's turn our attention to your organisation specifically. So for the next few questions, I would like to keep your organisation in mind. And once again, there are no right or wrong answers. I'm just trying to capture your thoughts and opinions on things. So what is advancing in industry will look like for your organisation. So what do you need to do?

PARTICIPANT Y 06:32

Few things. The biggest challenge is actually against that people pieces, that cultural shift. And taking people on the journey. This probably big is a big thing for me. Is that seen so many things fail? Yeah. Because it's like, we've always done it this way. It works. Why would we change? So it's taking them on that journey and showing them the benefit of making that shift? I Should say the technology piece is pretty simple. Yes. The technology is there. Yeah. The analytics is there. Yeah. It's it's getting people to use it and trust it.

Chanvi Singh 07:20

Yeah. Getting over that initial inertia. Yeah. Resistance. Yeah.

PARTICIPANT Y 07:27

I know. That's what it says. But I don't believe it. Yeah. Okay. We'll go and dig the hole and prove it, shall we? Yeah. Yeah. So we dug the hole proved it. The next few next few times, we've dug the hole and proved it. And then it was okay. Yeah, I guess Yeah. Yeah. Fine. If it says that. Nine times out of 10 is right. Yeah. We'll do it. Without doing the investigations and everything else. We'll just we'll trust it and do it. It was that thing as well of. And this is still a big thing is automating control of things like (Omitted). It's still a big not going there. So it's, it's selling it as its decision support, it's going to present you some more information yet, you can then make a decision more quickly. So you can make a faster decision. Almost from a BD perspective. Yeah, yeah. It's, but it's not going to just do it, you're still going to have to push the button. Yeah. But it will present you with some options that you can choose from, you don't have to do all the processing and thinking yourself

Chanvi Singh 08:38

Makes sense. Excellent. So we started broad. And now we're going to start going into specifics. And I know you've already touched on some of them already, but we'll just go into detail. So I'll ask you a little bit about the enablers, the barriers and the challenges that your organisation may encounter when in entering or advancing Industry 4.0 in that context. So what factors in your workplace would enable you to successfully advance in Industry 4.0 and be future ready?

PARTICIPANT Y 09:08

keeps coming back to people Yeah, it's it's the right people with the right mindset. Recently, I heard somebody describe there being too many people in (Omitted) who come from the old school blazer with the elbow pads, like old school will also that they actually just need to shift their thinking it's, it caught all of this weirdly, it's people it's not technology is the people who are willing to to adapt it, trust it and use it and go on the journey. So when I was doing smart networks in (Omitted), I was told that IT department would get in my way of being resistant because all the projects that follow because IT werent on board and I wouldn't get (Omitted) on board. They weren't adopted. I took them on the journey. Yeah. I bought them in, I showed them the shiny thing we were aiming for. It kept the focus on the shiny thing we were aiming for and we achieved it.

Chanvi Singh 10:09

Yeah, that's excellent.

PARTICIPANT Y 10:10

But it was it was people it was spending the time having the conversations listening to the concerns.

Chanvi Singh 10:16

So the biggest enabler in your opinion is having the right people doing the right thing.

PARTICIPANT Y 10:21

The right people is having good change management support, it's having the right people in the team in the first place, it's having the champions within the departments

Chanvi Singh 10:31

and then technology is secondary, secondary excellent, are there any other enablers that you can think of? Alright, now we move on to barriers

So barriers are something that block growth. what barriers can you identify that you know are stopping your organisation from advancing and Industry 4.0

PARTICIPANT Y- so 2 things- one is people and attitude, bit of organisational culture- it is a very defensive culture in the organisation- both passive and defensive and there needs to be a bit cultural shift towards being more collaborative in the work. The other piece is actually the technology barriers- the kind of sensors that are used in the network were not compatible with (Omitted). It was weird they only worked with (Omitted) we had trouble getting anything that was (Omitted) most of the technology or (Omitted) and of course we are turning off (Omitted) here. So there are technology barriers and issues

Chanvi Singh 11:59

Do you think it was almost like a supply chain issue? that there's technology there. But with a supply chain that you have, it's not working.

PARTICIPANT Y- yes, some of it was supply chain issue some of it was we were trying to push what the technology does. So we were relying on what other countries had been doing and bringing in technology from overseas so that was some of that there was nothing local and there were oddities about having local things- (Omitted) and things like that so some of the technology has taken awhile to develop.

Chanvi Singh 12:36

Makes sense

PARTICIPANT Y 12:39

But yes, disconnect between, across that technology value chain, there's disconnects between pieces of it.

Chanvi Singh 12:47

Yeah. So as longas you can't run something smoothly from one piece to another, it wont work. You need it to talk to each other.

PARTICIPANT Y- yeah and if there are issues with the comms (Omitted) then there's not much we can do.

Chanvi Singh 13:00

And now what about challenges? Challenges are something of course, you can overcome. So can you tell me a little bit about the potential challenges that you may encounter or already have encountered in being future ready?

PARTICIPANT Y 13:17

Challenges? Some of it was people skill. Yeah. And we fix that look to fix in two ways, I think there's still got an ongoing exercise. One was we recruited different skill sets in and the other was training. Yeah. Just training people, and upskilling. And then the other bit was some of the technology. But in some ways that excited the guys in the team, yes, they'd like that problem solving, and trying to make it work. And it was a fun challenge. It was a fun challenge. It was there. So while there was a barrier with some of that technology, the challenge was, can we make it still make it work? Is there a work around is something different we can do. And we. And even just weird things like, this stuff's got an antenna on it. Great. So then working to just like, well, can we work with the workshop to like, drill the hole to get this thing to this? All that kind of stuff was just the physical on the ground challenge, just problem solving. Yeah, which the team just thrives on. Because the kind of people are recruited to do it.

Chanvi Singh 14:28

That's excellent. So you've already mentioned that when it comes to people skills, they can be overcome through training, and then with technology challenges, having the right people will enable you to have that problem solving skill?

PARTICIPANT Y 14:47

Yeah. And it's that thing of you sort of somebody who said in an organisation where you hit that challenges, you change the people or you change the people. Yeah, so you train them or you replace them.

Chanvi Singh 14:56

Yeah. Yeah. And are there any other challenges that you can think of?

PARTICIPANT Y 15:10

Yea the other one had was a unrealistic deadline that was set. we had a very ambitious (Omitted) at the time. who we'd said it would take us a year, a year to put this thing in and get it working properly. So (Omitted) told us, we had six months, right? It took us a year. But at the end of six months, we could say it's in. And at the end, at the end of the year, we now it's working. (Omitted) . And so we've got a smart network. Yeah. There anything Yes. Well, we spent the next six months learning and teaching and all that stuff actually making us actually making it work. making it usable, but yeah. Excellent.

Chanvi Singh 15:53

So now we'll move on, move our attention to the impact that COVID-19 has had on the future of work. So we know that the pandemic has changed the way people and organisations work. How has it changed your perception on the future of work? If it has?

PARTICIPANT Y 16:10

I don't think it has. I think it's just forced acceleration of some things that were already coming. Yeah. But people were resistant to. So I've always worked in very traditional industries. They don't trust people who work remotely, don't just don't trust people. But that a leadership thing. That's, yeah, that's a people thing. Yeah. I think this is just forced the issue and made those people have to accept it. I think it's tested some people as well in their preferences. I discovered that this confirmed to me that I actually hate being in the office. But all my work at the moment is done remotely.

Chanvi Singh 17:00

So a lot of people talk about how remote working was a possibility before COVID. Now it's just become such a more normal option.

PARTICIPANT Y 17:10

And I think it's shifted that thing. And I think it's a good thing. But so the more hybrid ways of working, and you use face to face for collaboration and innovation, and that stuff, where you really you need that human contact to do it. The day to day stuff, you don't need to be around other people.

Chanvi Singh 17:34

Like an update meeting? Yea

PARTICIPANT Y- so the project I'm working on at the moment my clients are in (Omitted) the rest of the team is in (Omitted). I'm working on another project where the team is in (Omitted) and the rest in (Omitted) and I can do all of this completely remotely. So it's not a barrier any more I don't think it was ever a barrier. I think it's just forced organisations to move and accept.

Chanvi Singh 18:07

So perhaps people who were resistant are now being forced to question their views on remote working.

PARTICIPANT Y 18:15

For some of us the work was some people who are very much like if I can't see you then. And yet, I work with groups, so just completely accepting of it. Again, it's that old school thing and utilities, a lot of them prefer being in the office prefer that structure to their day, and seem incapable of structuring their day, not in the office. As people thing, again, I think it forced it for some companies who are being slow with technology to actually get in place.

Chanvi Singh 18:54

Yeah, well, because they didn't have a choice.

PARTICIPANT Y 18:58

Yea there was no choice. So for me some of the document sharing things. Some of them are really old school where only one person can work on a document at a time and you have to check it out and work on it and then check it back in where I work at the moment. The software suite we use now is completely collaborative, and 10 of us can be in a document all at once working.

PARTICIPANT Y 19:25

It does get messed up if two of you tried to move the same thing at the same time, it gets a bit confused. Which point you've tracked each other and go we'll get there. But that that's the way forward is you producing a report and 10 authoring it? Why cant the content you write be in 10 different sections.

Chanvi Singh 20:11

Yeah, it's interesting,

PARTICIPANT Y 20:34

And I think it's that balance. And I was lucky when I did my (Omitted), because I was doing physical stuff. And everybody else who's doing a (Omitted) in the same area were also doing stuff in the lab. We all had our own setups on our own things. But it was real old school, there was still a staff room, where everyone went and have morning tea at the same time. Yeah, even with the lady making the tea, and biscuits and stuff. So it was that even through the day, you knew three times a day, you were gonna see to have a chat. And working with people who were doing similar but different (Omitted). We could problem solve

Chanvi Singh 21:14

yeah, that's so important!

PARTICIPANT Y 21:17

Or just, how do I connect this thing? Just but also working with technicians who built stuff? Again, we worked together to design what it was going to do they go away and go, I've been researching. We've never tried this before, but we'll give it a go.

Chanvi Singh 21:35

Sure, yeah. Excellent. So now, I would like to ask you a few questions regarding the business strategy of the organisation, the skills and the mindset of people within your work within the workplace, and also touch a little bit on the health and safety practices of the organisation. So we'll start with the first question, which is it is perceived that in Industry 4.0 people will need to have specific skills to advance? Can you talk about the skills of the people in your organisation's that they have? Or will need in order to successfully advance in Industry 4.0?

PARTICIPANT Y 22:11

So one skill that doesn't change is the ability to understand the network and what's happening with the physical assets? Because it's a business that relies on those physical assets to provide a customer service. Yeah, it's, it is should be customer centric business. So everything should be driven by customer. So the need to understand those (Omitted) doesn't change and how they work. It's then how you apply that knowledge is the thing that changes? Yeah, I saw, like I said, Before, it moves from collecting data on the database, doing that to something else collecting the data for using sensors using Yeah, whatever else to collect the data. And then you using your knowledge to actually analyse it, add the value to it, and make decisions based on it.

CS- Yeah, so data analytics,

PARTICIPANT Y- yeah, analytics is there.

PARTICIPANT Y 23:20

Part of the analytics, and this is weird thing. And it's something engineers are really bad at is presenting that information in a way that it makes sense to non engineers to support your decision. So communication is actually a really big skill gap for engineers. They're very good at that detailed, detailed information. But presenting it in a way that to someone who sits in another part of the business, for example, customer service, or finance makes sense, or even presenting it to a customer. It makes sense is something that they really struggle with, so that and they haven't had to have that communication skill, because they've settled and done their thing and didn't matter. Whereas with this shift, and then move to customer centricity and also customer demand for access to information, it's got to be there. Because it's, it's an industry that's it's not just about the

technology within the industry. It's also that customer access to technology, which means they want different ways to interact and different ways to be informed.

Chanvi Singh 24:36

So from like recruiting point of view, you think that you want people who are good at what they do, but are also good at doing other things in other areas, and are able to communicate? So if I am a social scientist, I should still be able to speak the language of the business analytics person and explain to them that this is my perspective, but in your field. This is how it is.

PARTICIPANT Y- Ye! so a lot of my work with the kind of work I do now it's to be that translator. Work with the people with the technical people and the business side of things. Being able to translate what the (Omitted) saying to the (Omitted) person. I'm being that middle person and doing the translation.

Chanvi Singh 25:33

It's a little bit more than communication.

Chanvi Singh 25:35

Yeah,

PARTICIPANT Y 25:35

yeah. It's that adaptability and that understanding and being able to explain something 10 different ways stipulating.

Chanvi Singh 25:45

that someone has to learn about someone else's field, and then be able to communicate Yeah, yeah. Very interesting. Thinking about your current business strategies, yeah. How do you foresee needing to change your approach in line with the needs of Industry 4.0 like, what changes do you need or expect to see in the business strategy?

PARTICIPANT Y 26:11

One of the biggest shifts was actually, this is So weird, it drove a lot of the 4.0 things that we were doing, but it was customer, it was that changing customer expectations, both in terms of service they received, and then that communication on the access piece as well. Like, a customer wants you to be able to tell them that there's a (Omitted) as soon as that happens, so that they know that what is going to go off when it's going to come back on? Or does it affect their (Omitted)? Yeah, they're going to have to take an extra half an hour in a different way. That actually drove a lot of the shift in the strategy and a lot of the move to implement the new technologies and new ways of working.

Chanvi Singh 27:04

So an increase in the need for customisability?

PARTICIPANT Y 27:08

customisability, but also, that that data is being collected and made available quickly. Yeah, yeah. Real time real time. Yeah, the real time was a real is a real shift. For (Omitted) industry (Omitted), have been doing better. So as a (Omitted) networks have been able to tell you for years now, you get that notification that your (Omitted) Yeah, that's (Omitted) still aren't there?

Chanvi Singh 27:35

So why do you think that they're not talking to each other?

PARTICIPANT Y 27:39

It's just because it's a broader base real weird thing about what they do (Omitted) when it can't learn anything from them? (Omitted)? Whereas because I've worked in (Omitted) and (Omitted) yeah. And in my current role, I've worked with (Omitted) and I work with whoever, seriously you all operate pipelines, distribution systems. So like you all operate utility, you should be able to learn from each other. The data piece gets challenging and privacy laws get interesting as well around that informing customers. Yeah. Customers have to nominate, if they want that, because you get challenges around things like this (Omitted). Because the not empowerment and (Omitted) goes to the owner, not the not the renter. And so the mobile number that's associated with it will be for the owner, not the renter, so not necessarily the same house. Whereas (Omitted) it's the renter. Yeah. So there's a slight difference in terms of access to information about who's actually on the property.

PARTICIPANT Y 29:05

They should be sharing information together. So yeah, SMS notifications was a real light. Why aren't we doing this? Yeah. It's a really old technology. It's really old technology, if (Omitted) have been doing it for a really long time customers expect it. Now, yeah, they don't want to have to go and look for information that expected to be pushed to them. Why? Why can't we do this? I think they finally ran a trial about four years ago. And it was a trial.

Chanvi Singh 29:36

There's a big lag.

PARTICIPANT Y 29:37

A huge lag. And it's a huge lag in things like even being able to log in to have a portal, look at your (Omitted) and things. It's only really recently and yet as a customer. I've been able to do that for the (Omitted), and lots of other things for a really long time. Why is that cross industry learning?

Chanvi Singh 29:59

And this is getting a little bit off script. When you when we're talking about that lag, what do you think the barrier is? And why is that lag present?

PARTICIPANT Y 30:08

Some of its cultural. Some of its very insular industry. Even. I was lucky, (Omitted), and we had a new (Omitted) come in, who pushed us to think differently. Yeah. And he came in from a commercial background. So he didn't traditionally, he'd worked in (Omitted) but as part of a (Omitted) entity, not as part of a (Omitted) entity, as I bought, like, commercial mindset, but also he bought into national experience. And yeah, I was more than happy for us to go look internationally for best practice. Whereas a lot of other suit was like, there's an arrogance. Yes. We don't have any peers.

Chanvi Singh 30:57

Keeping Up With appearance.

PARTICIPANT Y 30:58

Yes. Just that. Yeah. Don't want to show it's almost like a don't want to show weakness. Yeah.

Chanvi Singh 31:36

Can you tell me how you think Industry 4.0 might help the organisation be more innovative?

PARTICIPANT Y- I think it’s that going back to what we were saying before. It will free up people from doing mundane work focus more on the problem-solving aspect. It gives them time and space to think and add value . Without Industry 4.0 they are stuck doing the daily day to day grind. They are busy but not achieving anthing..real

Chanvi Singh 32:30

that intrinsic motivation. Yeah,

PARTICIPANT Y 32:33

it's just that yeah, I'm happy. I just I sit and I do this and it's fine. And I work nine to five and then I go home, and it's fine. Whereas it's like, we now don't need to spend three months collecting that. Here it is. We can do with it now.

Chanvi Singh 32:48

I had a very interesting conversation with someone who said that. Originally when computers were invented, people thought that instead of having eight hour workdays, they'll have three hour workdays. Yeah, it's probably increase. Yeah, so I wouldn't know what Industry 4.0 is going to bring for us.

PARTICIPANT Y- Best not to think about. I was talking to someone who said that yeah 16 hour work days are pretty normal but don't charge me for more than 14 because I get in trouble. But sometimes I wish there was a cloning machine when I am being pulled in five different directions for five different projects. For me it that, it gets rid of that mundane thing -I do things this way and don't want to think about it differently.

Chanvi Singh 33:41

Is there a risk for them? People who do?

PARTICIPANT Y 33:43

absolutely it's they they get called Dinosaurs for a reason. They get called dinosaurs within organisations is just that we're going to do this is gonna make your life easier. No its not. I learned something new. I don't like learning new things. Not sure you're the right person for this job. But yeah, it's

Chanvi Singh 34:11

It's a great job tagline. 'I don't like learning' (joking)

PARTICIPANT Y 34:15

Yeah, when I'm interviewing, I will say how I recruit for aptitude and attitude. Yeah. Not necessarily that qualification or experience.

CS- makes complete sense.

Chanvi Singh 34:29

Now, keeping in mind, the employees of your organisation, could you describe the mindset or the attitudes towards organisational change that your organisation has or will need in order to successfully advance and Industry 4.0

PARTICIPANT Y 34:44

very resistant to change? Yeah. Still very resistant to change. It's changing as people retire. And the average age we choose is traditionally, (Omitted) have very mature. Yes, yeah. For example, somebody who used to work for me is just celebrated 50 years with the organisation. So it was always a job for life. Yeah. You went in when you were.. If you were a (Omitted) you started as a teenager and then you stayed there for 4050 years until you're retired. And that was it – that was life. It's that shift the change of the type to work that you do.

Chanvi Singh 35:39

Yeah. Do you think that when it comes to having get enabling that shift in the mindset, that there is a generational barrier there?

PARTICIPANT Y 35:51

For some I'd say not for all, generally, I mean, one of the guys in the team is awesome. He's in his 50s. But he's an (Omitted) who can code and he's always been passionate about doing that stuff and progressing and machine learning and stuff. And the he loves the new challenge. And yet there are others the same generation who just absolutely resistant to it. I think the real cultural challenge of (Omitted) is there's going to be widening gap between different bits of the organisation. Yeah. Cuz there's always going to be people on the toes. Yeah. Because this physical stuff still needs fixing. And then the, the more white collar workers are going to be increasingly there's going to be that increasing gap between them, and the knowledge and the skill sets. Yeah. Traditionally, it's been very transferable, you go from the field and move into white collar and, and still do that kind of work. With the increases in technology and analytics of that, is that increasing gap between the two.

Chanvi Singh 37:02

Yeah, I just want, confirm and reframe the question again. So I think Have you noticed that as a whole, if you have noticed a difference between the generations, definitely there's obviously individuals who are more welcoming and work.

PARTICIPANT Y- Definitely. Yeah. So when we're like trying to change the mindset of the people, maybe there'll be different needs at different levels, completely different needs different generations or different personalities as well comes into it. Just that people's preferences, big part of it, but yeah, definitely a generational.

Chanvi Singh 37:44

Excellent. Now I understand that there would be clear laws and procedures about work health and safety, particularly regarding physical safety. So the advancement of the future may lead to introduction of new guidelines, new policies and practices. From your perspective, as a manager,

how do you think you could protect the psychological health in the workplace, keeping in mind what automation is going to do?

PARTICIPANT Y 38:10

For me, the biggest roles and (Omitted) actually listening, listening to people's concerns. And while you can't necessarily do anything about them, you can acknowledge them and make them feel heard. And provide the support the leadership support where it's needed. We went through a shift where we moved from as little shift, but big shift for a lot of them from having a desk that you went to everyday to activity based working, where you went in every day, and you chose where you sat, depending on what you were doing that day. So that was an enormous, enormous change. For a lot of people. There was a lot of resistance in that.

Chanvi Singh 39:10

was it taking away the sense of belonging?

PARTICIPANT Y 39:13

Yeah the belonging. And it was that interesting thing. A lot of people were very vocal about it and very loud. They're the easy ones to deal with. It's the ones who are quiet and angry and frustrated and everything else. And as a manager, you've got to have those conversations to find those people where you can have conversations and find people who are okay. It's like, yeah, okay, you're great. You're okay. I'm not gonna stop talking to you, but you're okay. It's fine. That person has got a problem, and they're not vocalizing and they're internalizing. And I need to find a way to help them through change, and you need need to have that EQ to be able to do that as well.

Chanvi Singh 39:50

Yeah. Excellent. And now as a manager, how do you ensure prioritizing and showing commitment to implement health and well being. Could you give me a few examples of how you might have done that?

PARTICIPANT Y- for me, it starts with the individual you get to know the individual. And having an open door policy there are no doors any more but yeah. Just being trusted as well as a leader so people feel like they can come and talk to you and they are being heard.

Chanvi Singh 40:50

So you build that trust and establish it early on by getting to know them better, so that even when they need to, you're available, and they come to you and they are heard.

PARTICIPANT Y 40:59

not just early, it's ongoing. Yeah. I've always I'm a horrible liar. So when something's going on, with him know this disruption coming? Yeah. And they know this big change coming in everything else. But equally at times as things I can't tell them. I'll be honest and say, I do know, but I can't tell you. I can't tell you. Yeah. Which has meant every time that trust, rather than – some managers lie. And it's just like, Such quick way to break trust. Trust takes a long time to build, and is really quick to break. And once it's broken, that's it.

Chanvi Singh 41:54

Yeah, we noticed that even with like, our family let alone a stranger that we work with, even our family when they break, trust me, it takes a while for them to rebuild it again. So

PARTICIPANT Y 42:04

if you and as a manager, if you ever do rebuild that trust, I've worked. I've worked for managers I didn't trust it's horrible. Yeah. It's just horrible.

Chanvi Singh 42:16

It changes the whole work dynamic completely.

PARTICIPANT Y 42:20

And you do feel isolated. See, it is psychologically damaging. To have that. you need somebody that you can go and talk to about this stuff, for sure. And if it's not in the workplace, and there's some stuff in the workplace that you can't take anywhere else. So then you have to confess somewhere else within the business. And equally that makes your leader look bad because youre not talking to them. You can't say, Well, don't trust them. Yeah.

Chanvi Singh 42:47

Because they haven't established that channel with you. Yeah. Yeah. That makes complete sense. The last follow up question from that one, which is, do you think having a bigger focus on employee health and well being including psychological health will enable you to be better prepared for the future of work? If yes, how? And if not, why do you think that might be?

PARTICIPANT Y 43:10

For me? Yeah. So it's got to be that it's linked to all the other things we've talked around, change and changing skill sets, adaptability, all of that is you've got to focus on the well being of people who are going through this stuff, because we no longer live in a world where change comes at certain times. Yeah, we're in this state of continuous change. It's not an event. It's not an event. It's just ongoing. And for some people who are change resistant, that psychological impact of just that continuous having to but they don't think causes other issues, whether it's performance issues or other things. So, again, I've had team members who were credibly incredibly change resistant, said they weren't, but they were. And the knock on impact was they then ended up underperforming.

Yeah. Which then has different psychological issues, because then non performance improvement plans, that threat of being sacked, at the end of the day, don't improve their performance.

Chanvi Singh 44:24

So like from a change management perspective, having a big focus on employee health and hoping really enable them to help people better adapt to change. And then what about from a performance? Perspective? Yeah, yeah, definitely

PARTICIPANT Y 44:40

help them performance, because they'll understand the why they're being asked to change. Yeah. And help them on that Change journey. They might not be as quick as some other people. If they're being supported and coached and mentored and whether it's peer coaching, peer mentoring or whatever to actually help them on that journey. Yeah, rather than necessarily being a manager all the time going, you must be well, you're not directional

PARTICIPANT Y 45:06

It's because managers don't always have the time to, if you've got depends on your team as teams are varying sizes, which it shouldn't be, but sometimes it is, you don't have the time to take every single individual on that journey. You've got to pick and choose and know that some of them as well would prefer to be peer coached than manager coached.

PARTICIPANT Y 45:28

Because they just take it better from people, same generation or same gender or same background.

Chanvi Singh 45:34

Yeah, whatever. What we were talking about before, like sometimes people just have different needs. So you need to cater to different needs. And sometimes

PARTICIPANT Y 45:41

it's it's cultural, sometimes it's whatever is just because there is that. Unfortunately, within society, there is still that racism, sexism, of course, all of that stuff underlying how some people act as well. Yeah.

Chanvi Singh 45:57

So weve come to the last question of this section, which is how do you think your job will change? The more you advance in Industry 4.0 ?

PARTICIPANT Y 46:09

I think for me, it's just a continuation of how my jobs changed throughout my career anyway. And I think it's such changed as you go from technical roles into leadership roles as you move from being in the detail of the technical to So knowing enough of the technical to ask the correct questions, people push some of their thinking and probe their thinking. But be a leader, you take them on that journey.

Chanvi Singh 46:42

so more communication?

PARTICIPANT Y- Yea more communications and soft skills definitely.

PARTICIPANT Y 46:47

The technical team was really technical guys actually like working for me, because they've worked for managers who had no technical background. And they just saw somebody to talk to. Because there was something incredibly technical people and you need to be able to talk their language. And at least match. I don't need to know detail. Yeah, like I said, I need to know enough to be able to go

Chanvi Singh 47:09

that's good or not

PARTICIPANT Y 47:12

Why? Just convinced me of why this is the right decision. Yeah. Okay. You lost me in the data. And part of that, as well as helping them improve their communication skills by me forcing them to lift. Get out the detail. Yeah. Lift?

Chanvi Singh 47:25

Yeah. Yeah, that makes complete sense as well. And I think it's really cool to see people talk about how their roles are going to evolve. Do you think any parts of your job role might get automated and how that might change your job role

PARTICIPANT Y 47:46

I really wish some of it did. Where somebody did approve your timesheets? Just the admin stuff, admin stuff? Yeah. automation of admin will be such a saver for. I also watched some of my meetings, go. meetings, and it's just just put a transcriber there, it's gonna be key points. It's an information share. Yeah, we really didn't need to sit in a room for three hours and listen to each

other. We could have shared a lot of this as pre reading. And then maybe met for an hour and had discussions. Yeah.

Chanvi Singh 48:20

sometimes meetings are not as useful as you'd want them to be in general. Yeah.

PARTICIPANT Y 48:26

But number times you come out and go that was three hours I'm not getting back!

PARTICIPANT Y 48:33

Like some of the stuff- could have been an email. Alright, document that I got to read or I didn't need to listen to that. Oh. But yeah, so that was the admin stuff being automated. I think a lot of people would love

Chanvi Singh 48:53

the bureaucracies in places like one form two forms, three forms submitted to this. I know you have to submit it to that.

PARTICIPANT Y 49:00

Mine at the moment. And so I need this, which form, Oh, I filled in the wrong form . Yeah. I told you. The automated robot told me which form to fill in and it told me that. Yeah, it's like, it's automated. It's meant to generate my bill for me. I started to fill in all the information. I'm still typing all of this. I don't understand what the bots doing. Yeah. And I still have to approve it. So I typed in in the first place can you not just assume that I typed in the right things that's that that's really nice but yeah,

Chanvi Singh 49:37

hopefully we'll get there I think it's getting better already but yeah so now we've come to the last section of this interview which is specially and specifically looking at women in Industry 4.0 so in light of the conversation that we've been having about Industry 4.0 what do you think women excel in that make them future ready

PARTICIPANT Y 50:00

so difficult? Well, for me, I've worked in male dominated industry my whole career. Yeah. Right from uni. So my first year at uni, I was the only female on my course. So I've always been surrounded by males. So I don't know how much of the females stuff I've suppressed the tactics of working with men.

PARTICIPANT Y 50:29

genuinely and this is I've got generally females, females, in my experience tend to be better with the EQ side of it. tend to be not Yeah, you get this is a very general good experience in both, I'm sure. You always get. You always get the one who's not who's different. I think And this is again something I'm not typical- women tend to be tend to better at the communication and the lifting communication. Again, it's anything you get different levels. But yeah, generally within big organisations comms teams tend to be following.

Chanvi Singh 51:27

Yeah. Yeah. Was it because they're being attracted into certain roles? I

PARTICIPANT Y 51:32

think so. Yeah. Yeah. To use their skill set. And again, customer service stuff tends to be females. Again, this.

Chanvi Singh 51:46

Yeah. So when we're looking at the future of work, for example, we know that communication is becoming an important aspect. And we know that customer service is becoming a very important aspect where we are moving towards more personalization. So perhaps these things will help them be better prepared for the future. But I

PARTICIPANT Y 52:04

But I think the other Yeah, yeah, there's are challenges. So I think Yeah, good question. Against personalities mean, I'm a complete introvert. Yeah. So for me, I prefer the one to one conversations. And so for me, the soft skill stuffs easier. And yeah, being trusted leader, and all of that comes more naturally, naturally to me, much more so than sitting in a team meeting and run it and that kind of thing. But I think as well, again, I think that communication, that EQ that other thing helps me take people on that journey and take people through the change and sell over the why some benefit and the vision and where we're going and and keep people engaged with it as well. Because it's not like, this is where we're going. Yeah, it's a lesson and I talk and I understand that have those conversations?

Chanvi Singh 53:03

And then, what do you think could be a general barrier for women in the future of work that you might have already noticed?

PARTICIPANT Y 53:22

A couple of ones. Some of it's that unwillingness to speak up sometimes that unwillingness to be to be the challenger to be there. Or be the innovator. I've got this really great idea or not sure. That's just that willingness to just speak up. I was not there. Doesn't bother me at all. But that's just me.

Yeah, I've seen other women. I also have seen a lot of women I've worked with, and again, it's not make some useless on it is the women to speak up when they're in a group of women. But the minute that's an male in the group, it's almost that regressed to whatever their opinion is not voiced their own opinion. I always speak up.

CS- I think that's good.

PARTICIPANT Y- I think the other thing that women are better and I know I'm bad at is that selling themselves to them push themselves forward to get the promotions to then be in those positions of influence.

Chanvi Singh 54:34

It's almost like negotiating.

PARTICIPANT Y 54:37

No, I think it's selling. It's, it's that this is me, this is what I'm great at, look at all the awesome things I've done. I deserve picks.

PARTICIPANT Y 54:52

Knowing their strengths, but just not being able to, like sell, communicate, push themselves. I know my strengths, but I'm used to that. I work in a working organisational culture at the moment, which is very much a look at me culture. And all these people have all these career plans and everything else. And it's just like, I'd rather be recognized for the work I do. Rather than having to be there. Make me look me for what I did. That's just not how I work.

Chanvi Singh 55:20

Yeah.

PARTICIPANT Y 55:22

And generally, the males are better at selling and pushing themselves forward.

Chanvi Singh 55:30

But can you think of why that might be?

PARTICIPANT Y 55:35

Us? Is that horrible Nurture and nature thing?

PARTICIPANT Y 55:58

I like just sitting quietly in the corner just getting on with stuff. And that's true about both genders. Yeah, yeah.

PARTICIPANT Y 56:06

If you get a horrible combination. I grew up in a household and (Omitted), so mainly female household and worked and everything else. And I was never told to shut up Be quiet girls behaviour. None of that ever happened. Yeah. So with me, it is just nature. My (Omitted) the complete opposite. Forever. That's just not me. But I think the probably the biggest barriers are women. But equally, I've worked in, I've worked in organisations that had quotas, and yeah, with bias towards recruiting women, things I hate. And I've had conversations with a lot of women in leadership roles. And it's like, I want to be chosen for something because I'm the best person. Yeah. Not because I'm female. Yeah. It's like, they've said, yeah, they want to, they want stuff on there.

PARTICIPANT Y 57:16

I want to get stuff on there. Yeah. But for me, the challenge is getting it out there to show I should get it on there.

Chanvi Singh 57:23

Yeah, that makes sense. What about societal roles that women have to play sometimes?

PARTICIPANT Y 57:32

I'm biased cause I don't have kids.

PARTICIPANT Y 57:42

I think it's less of a barrier than it was? Yeah,

Chanvi Singh 57:44

definitely changed, he

PARTICIPANT Y 57:46

definitely changed. But I think that's probably a reflection on a lot of people I work with as well. And that a lot of them are very, a lot of the men I've worked with have been very much in the I want to

spend time with my children, I don't expect my wife to not work. It's about equality and sharing, and all of that. So

Chanvi Singh 58:08

living by the values that you hold.

PARTICIPANT Y 58:10

So and whether that's because I tend to work more with a recruit people who have aligned to my values, and my ways thanking me for me. For me, my husband, I'm married. I've always earned more than he does. So we've always shared chores and everything else. And now he doesn't work. And he does all the household chores. Yes, that's fine. But now I work with a lot of people who share child minding whatever else with it's really

PARTICIPANT Y 58:50

Yeah. That elements don't see it as much. And I think it's and the other end of the spectrum about caring for parents and the elderly and everything else.

PARTICIPANT Y 59:04

I think that's starting to shift as well, in terms of expectations of the genders, depending on culture, of course, yeah,

Chanvi Singh 59:35

Yeah. We've come to the last question of this interview. What skills do you think women could learn and develop in order to better prepare themselves for the future of work? And this can obviously like include the barriers we've discussed itself? Yeah.

So learning to sell themselves

PARTICIPANT Y 59:53

Yes sell themselves. I think it's some it's like almost picking up some of the positive male traits but not the negative ones- asserting yourself without aggression, I think is the softly Yeah, cuz it's. And again, it's a cultural personality thing again, if that in your face thing just makes me go woah!

PARTICIPANT Y 1:00:23

Go away. I don't want to deal with you. Yeah

Chanvi Singh 1:00:25

I think we're also moving towards being a more inclusive world that doesn't have as much space for aggression as it once did.

Chanvi Singh 1:00:43

like you were perhaps talking to a group of young women in school or at uni, and you told them that you're trying to enter the workforce and you know that there's going to be automation, robotics business, like all kinds of integration, what kind of skills would you ask them to work on, so that they are better prepared?

PARTICIPANT Y 1:01:02

Well, one of the things that I have pushed, I've always been a fan of is continual learning, and that openness to new ideas? Yeah. And I think that's true, whatever, but just, especially with the rate of change. Is that going to learn? Listen, read whatever it is, however, whatever your learning style, find a way to keep progressing. What I saw somebody talking recently, and they were saying that, and it's, it's one of their things is that every day they try and read something different and learn something new, to broaden their thinking. And that openness to new ideas, yeah. By doing that, I think as well something is this the some basic skills around technology and but also not limiting as yourself as well by doing that. Yeah. So. And I think as well, you don't have to be able to code to do stuff. You have to be able to communicate what you want to people. Yeah, do that stuff for you.

Chanvi Singh 1:02:15

So yeah, but like also analytic skills and communication.

PARTICIPANT Y 1:02:19

that I worked with somebody and he said he liked employing engineers, because engineers are taught to think a certain way. And it's around that analysing problem solving, ways of thinking. I think the key things to move forward for sure, because it's to be able to look at something and go, Okay, I don't understand the details of how it works. I know generally how it works and how it can benefit and then now I can use How can I apply this to solve this problem? Okay, that doesn't fit but that does. Excellent.

Chanvi Singh 1:02:54

Well, that's everything I wanted to ask, Have you got anything else that you would like to say or any kind of final thoughts that you would like to follow up and follow up with that I haven't already asked.

PARTICIPANT Y 1:03:06

I think just for me, it's just excited what this stuff is going to do for industry and for the future. Yeah. I think there are far too many people scared that it's going to get rid of jobs and Everything else I think it's gonna create more jobs it's gonna create more opportunities and different kind of jobs yea.

Chanvi Singh 1:03:23

different kinds hmm thank you thank you very much for you time! I'll stop the recording now if you're okay?

Yes ofcourse!

Appendix J: Book Chapter: ‘Engineering Innovation: The Impact of Digital Transformation’

This Appendix contains the book chapter that was written for and will be published in 2023 as follows:

Cropley, D. H., & Singh, C. (In Press). Engineering Innovation: The Impact of Digital Transformation.

Showcasing the advancement of Industry 4.0 understanding beyond the PhD, this appendix is referenced in Sections 1.10 and 6.4.

Engineering Innovation: The Impact of Digital Transformation

David H Cropley and Chanvi Singh

University of South Australia

Introduction

Engineering, applied across a wide range of domains (manufacturing, mining, power generation, transport, aerospace, healthcare and more), has two main functions. On the one hand, engineering is about *replication*: solving existing problems with existing solutions (Cropley, 2021). This acknowledges that many of the problems we face are precedented. They do not need a new solution, because nothing has changed and existing solutions provide a low-risk, cost-effective, efficient pathway. Indeed, replication may comprise the majority of what engineers do. On the other hand, albeit somewhat less commonly, engineering is a matter of *innovation*: solving new problems with new solutions. This acknowledges that some of the problems we face are unprecedented: we have not encountered them before, and therefore have no existing solution to draw on. Sometimes, the level of innovation required is merely incremental in nature: an improvement to what already exists (Cropley, 2021). Engineers frequently refer to making things *better, faster, or cheaper*, in an expression of incremental innovation. Other times, by necessity, the level of innovation is radical, or disruptive (Salter & Alexy, 2014). This occurs when the new problem is *so new*, and the circumstances *so different* or unique, that merely improving on an old solution is not enough.

One thing is clear. Engineering, whether replication or innovation, is a problem-solving activity (Buhl, 1960). When new problems require new solutions, engineers must innovate, placing a particular premium on the engineer's ability to generate and deploy novelty. In other words, an important part of the job of an engineer is creative problem solving (Cropley, 2015).

Several important questions arise from this discussion. First, what is the impetus for innovation in engineering? What gives rise to new problems that require new solutions? Second, how is engineering innovation changing in the 21st century? Are new technologies changing the way that engineers engage in innovation: the *culture* of engineering innovation (Cropley, 2016)? Third, how does engineering need to respond to new technologies that are reshaping the future of work? What will the work of engineers look like in the future, and what skills will they need? This chapter explores these issues to understand the impact of digital transformation on engineering innovation.

Change: The Driver of Innovation

Change is the fundamental driver of innovation (Cropley & Cropley, 2020). Over the course of human history, it has been changes in technology, climate, population, and health, for example, that have spurred the identification of new needs (or *problems*) and the development of new *solutions* to those problems. When the primary effect of change is the recognition and definition of a new problem, we refer to *Market Pull*. Conversely, when the primary effect of change is to stimulate the development of a new, potential solution, we refer to *Technology Push* (Sony & Naik, 2021). Regardless of whether the initial impulse is top-down *invention* (Market Pull) or bottom-up *discovery* (Technology Push) (Cropley, 2021), the net effect of change is to drive innovation. (Figure 1).

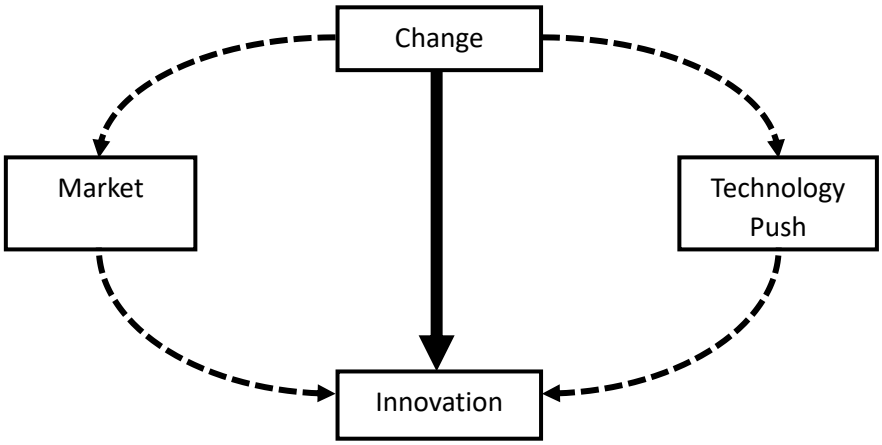


Figure 1: Change drives Innovation

When the innovations that are developed in accordance with the model depicted in Figure 1 are comprised principally of *technological* products (e.g., new machines), processes (e.g., novel production methods), systems (e.g., complex, novel arrangements of interacting hardware and software) and services (e.g., a new scheduling tool) then it becomes apparent that innovation (and therefore creativity) are central to engineering (Cropley, 2015). Throughout human history change of all kinds has been a catalyst for technological innovation (engineering), however, there is a new change – *Digital Transformation* – that is exerting its effect on engineering in new and unique ways. How is digital transformation changing the core process of innovation in engineering?

Change: The Black Death

To understand the impact that digital transformation is having on engineering, it is instructive first to examine the impact of *past* changes. Do these examples give us any clues about the likely impact of change on the engineering process itself? Human history, in fact, is replete with examples of changes that have acted as the catalyst for technological innovation.

The Black Death, for example, beginning in central Asia in around 1346, and reaching Western Europe in 1347, killed 30-60% of Europe's population before it abated in the mid-1350s. This disease caused an

unprecedented *demographic* change. The massive decline in the population of most European countries, among other things, resulted in shortages of farm laborers. At the same time, the survivors of this pandemic still had to be fed. With insufficient numbers of farm workers available to provide the required food, the question of how to increase agricultural productivity quickly arose. Handheld sickles had long been used for harvesting crops, but the larger, two-handed scythe – to this point generally only used to cut hay – was as much as 33% more efficient. The scythe was a solution waiting for this productivity problem to emerge (see a discussion of the Scythe in Cropley, 2019). The catalyst for this innovation in farming – using the scythe to increase farm productivity – was an underpinning demographic change, itself driven by a change in population health. The change led to the identification of a new problem (Market Pull: How to increase food production?), even as a solution (the Scythe) waited to be discovered (Technology Push). The net effect of the change was to connect the problem to the solution giving rise to an innovation in farming methods (Figure 2).

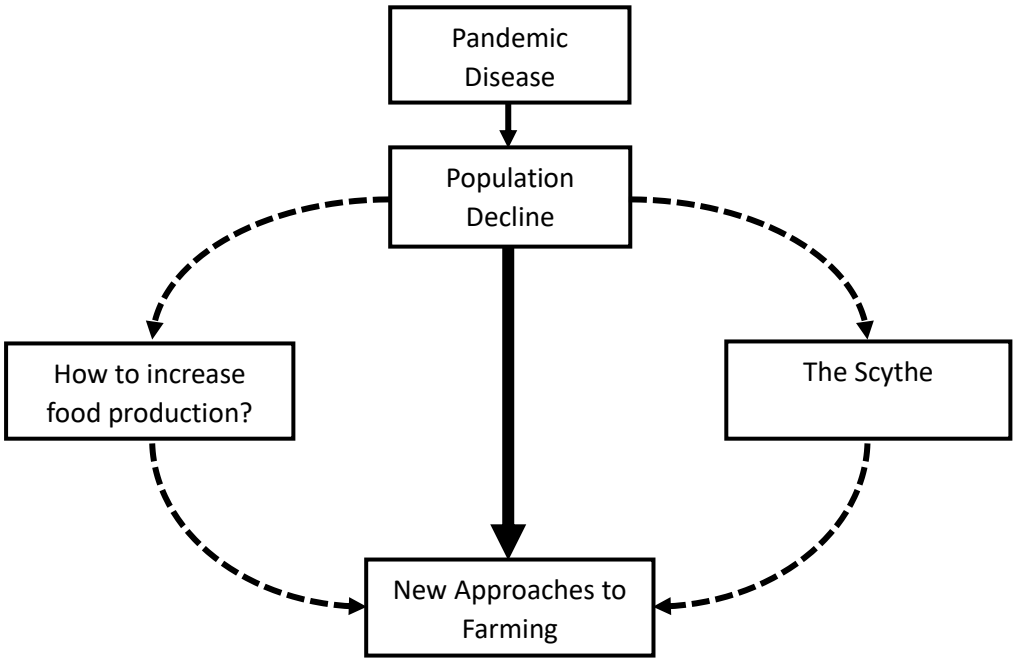


Figure 2: The Black Death as a Catalyst for Innovation

Change: The Industrial Revolution

The change that stimulates innovation may be very obvious, as was the case with the Black Death. Other times, the change(s) driving innovation may be less directly apparent. Take the case of the first Industrial Revolution[1]. Over a long period, Great Britain's economic and military power had developed and increased. This in turn led to the development of new markets, from North America to the Far East, bringing new goods and raw materials to Great Britain. As the country's wealth increased, there was a corresponding growth

[1] Generally accepted as occurring between approximately 1760 and 1840.

in demand for new and more sophisticated goods. Simultaneously, the same economic growth and development had seen a rise in the scientific capital of the country leading, for example, to the discovery of new ways of producing useful work. Thomas Savery's *Steam Pump* (see Cropley, 2019, pp. 78-82), developed in 1698, was able to lift water in vertical stages of up to 9 metres, demonstrating that labour, previously performed by humans, could be undertaken more efficiently and more effectively by machines. The subsequent development of steam *engines* that could produce rotational motion, from the mid-18th century, then closed the loop on the demand for value-added, manufactured goods (see, for example, Cropley, 2019, pp. 87-92). The underpinning change – e.g. economic growth – created a demand for value-added, manufactured goods that could be satisfied by the new technology of steam power and steam engines. In fact, not only were the kinds of goods that could be produced changed, but the speed and efficiency with which these goods could be produced improved. The net effect of the change in this example was to connect steam engines to the problem of a demand for value-added goods, giving rise to a series of innovations, not only in manufacturing (Figure 3), but also in mining, transport, farming and more.

Importantly, for the present discussion, this process of *innovation as a response to change* also had two other significant, if indirect, effects. The first industrial revolution – synonymous with steam power applied to manufacturing – altered the *kind of work* that people performed, and the *skills* they needed to perform that work (Figure 3).

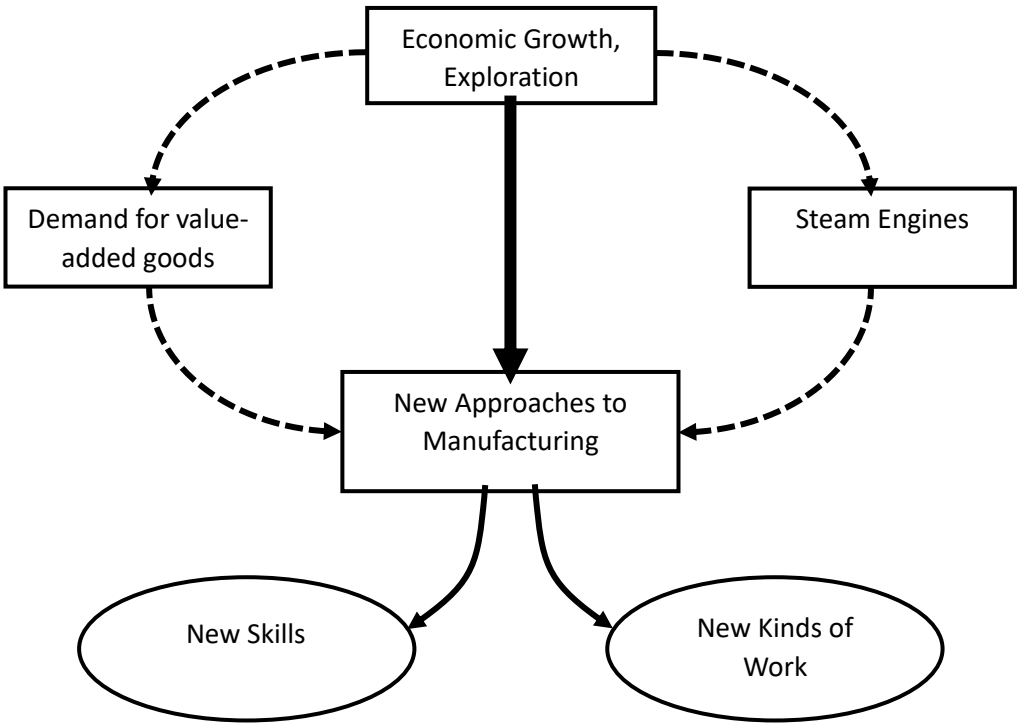


Figure 3: Change as a Driver of *more than* Innovation

Change: Electronics and Computers

Engineering, and its core of technological innovation, has never simply been a closed loop of connecting a problem to a solution in response to change. As Figure 3 illustrates, each cycle of technological innovation also impacts the work of the technoligcal *innovator* – the engineer – influencing *what* can be done in the future, *how* it can be done, and *who* does it. A simple example serves to illustrate. Even in pre-historic times, the development of the stone hand axe (Cropley, 2019, pp. 14-17) was itself a solution to a problem, but also the means by which other future needs could be more easily satisfied. An innovation, in other words, is itself a change that stimulates further innovation, and, changes the *system* of innovation.

The third industrial revolution, characterised by the development and deployment of electronics and automation, in the mid-20th century, illustrates the same point. Not only did these technologies provide the means to satisfy new needs – for ever-cheaper, higher-quality manufactured goods, and for a manufacturing environment that was safer and more efficient – they also changed the kind of work that people performed, and the skills they needed in order to perform that work. The era of the third industrial revolution also demonstrated that the systemic impact of technological innovation was not necessarily positive. Changes to the kind of work people perform, and the skills they need, frequently come with direct negative impacts. For example, as machines replaced people with the widespread use of robots in automobile manufacturing from the early 1960s, many societies dependant on advanced manufacturing had to deal with fundamental changes to employment. Indeed, it is estimated (Acemoglu & Restrepo, 2017[2]) that in the United States, between 1993 and 2007, for every industrial robot introduced into the workplace, 6.2 workers lost their jobs.

What are the implications of change for technological innovation (engineering)? On the one hand, there seems almost no limit to the ability of technological innovation to respond to the problems presented by change. Even existential 21st century challenges such as climate change lead to problems that can be connected to technological solutions. New forms of clean energy and power generation, and new mechanisms for capturing and sequestering carbon, for example, show great promise. However, in the same way that steam engines in the 18th and 19th centuries, and industrial robots in the mid-late 20th century changed the kind of work that people undertook and the skills they needed for that work, the 21st century technologies that are available to the innovation process are exerting far-reaching, systemic changes on engineering and on engineers.

Change: Industry 4.0 & Digital Transformation

[2] https://voxeu.org/article/robots-and-jobs-evidence-us

In the second and third decades of the 21st century, another change is taking place with a similar catalyzing effect on innovation. In this case, technological change (Figure 4), in the form of ever-cheaper and faster processors, low-cost and high-capacity digital memory, low-cost, smart sensors and the availability of digital communications networks has created a reservoir of technological solutions comprising (Kamble, Gunasekaran, & Gawankar, 2018; Szabó-Szentgróti, Végvári, & Varga, 2021) Artificial Intelligence (AI), Big Data, the Internet of Things (IoT), Automation, and Cyber-Physical Systems (CPS). One effect of this change – commonly referred to as Industry 4.0 (or simply *I 4.0*) – is to bias the innovation process somewhat towards *Technology Push* (Figure 4) with this reservoir of new technologies leading, or preceding, the identification of new problems (e.g., how to increase productivity?). In the present environment, arguably, there is a surplus of solutions waiting for suitable problems.

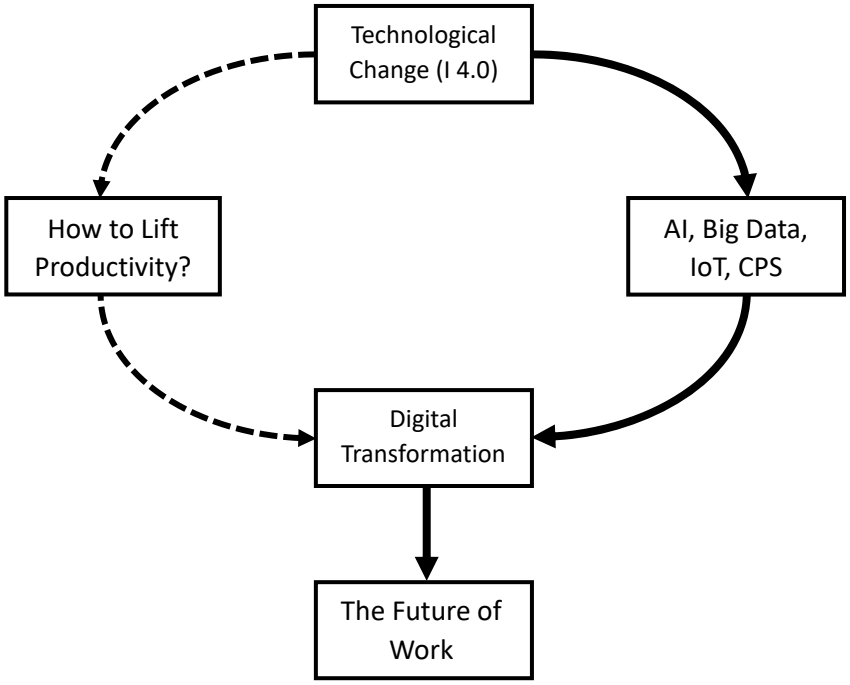


Figure 4: New Technology Driving Digital Transformation and the Future of Work

Perhaps most important of all, this *solution-first* innovation pathway, in addition to defining, and solving all kinds of problems (some of which we did not know we had!), is changing the kind of work that people do, and the skills needed to perform that work. In the 21st century, driven by the technologies of Industry 4.0 and digital transformation, this phenomenon now has a name: *The Future of Work*. Before the effects of the future of work can be explored, especially insofar as technological innovation – engineering – is concerned, it is useful to examine what Industry 4.0 is, and why it has created such a wide-ranging digital transformation.

Industry 4.0 and Digital Transformation

The term Industry 4.0 was first used by the German government in 2011 when they announced their industrial development program (Bartodziej, 2017; Kamble, Gunasekaran, & Gawankar, 2018; Szabó-Szentgróti, Végvári, & Varga, 2021; Xing, Cropley, Oppert, & Singh, 2021). In an attempt to move strategically towards further computerization of manufacturing processes, the German government promoted 'Industry 4.0' as an initiative to advance the interconnection of products, value chains and business models. Higher customisation and more flexible mass production were some key goals of this initiative.

As a society however, we have gradually moved away from the strict definition of Industry 4.0. The concept is now broadly understood as creating and applying automated systems in the workplace through the Internet of Things (IoT), Artificial Intelligence (AI), robotics and Cyber Physical Systems (CPS) as its central technologies (Cooper & James, 2009; Cropley & Cropley, 2021; Kamble et al., 2018; Kovacs, 2018; Sarfraz, Sarfraz, Iftikar, & Akhund, 2021; Schumacher, Erol, & Sihn, 2016; Szabó-Szentgróti et al., 2021). Industry 4.0 has built on what started as the third industrial revolution (see earlier: the application of electronics and automation) and enhanced this with cyber physical systems driven by data and automation. The systems created in Industry 4.0 also consist of automated feedback loops and, due to the high adaptability of the CPSs, it is common to see its application in hospitals, traffic control systems, power generation and energy distribution (Kamble et al., 2018).

It is also central to the this new paradigm that, due in part to the ever-evolving needs of the consumers of Industry 4.0, Cyber Physical Systems (CPS) are designed such that they are able to address the modern complexity of processes by being 'smart' and self-regulating (Sony & Naik, 2020). As a result of the growing demand and sophistication of consumer needs, organisations across the globe are grappling with issues such as volatility of the market, shorter product lifecycles, higher complexities and global supply chains. These challenges provide the opportunity for technology push: smart solutions exist to prevent these issues from emerging in the first place. It also gives the creators of Cyber Physical Systems an opportunity to predefine problems and henceforth design pre-emptive, self-regulating systems for their consumers. By keeping innovation at the centre of their designs, and using these opportunities arising from challenges, engineers have the means to convert latent technologies and processes into marketable outcomes (Metallo et al., 2018). There is, indeed, room for problem solving (i.e., innovation) in Industry 4.0 to become more personalised and tailored to client needs. Businesses that are continually advancing in Industry 4.0 agree that it is conducive to positive business outcomes and it is also expected that use of digital supply chains, smart systems, industrial internet and other modern technologies will open many doors for us to be more innovative, more productive and continue to engage in effective problem solving (Hamada, 2019).

Industry 4.0 continues to prove itself a radical and important paradigm shift with a sweeping impact on people's daily lives. An important marker of Industry 4.0 is the unprecedented rapidity with which it is changing, creating a stronger need or 'market pull' as well as a 'technology push' for novelty and innovation (Cropley & Cropley, 2021; Sony & Naik, 2020). The *solution-first* innovation pathway will propel engineers in a world with a constant need for technological innovation. As a result, in order to prepare themselves for the *Future of Work,* engineers will need to develop skills and innovation capabilities where they are able to identify the opportunities arising from this 'push' and 'pull' and use them for creative problem solving.

Of course, Industry 4.0, in the narrow sense, or digital transformation more broadly, affects not only technological innovation (engineering). In fact, the impact of digital transformation is being felt across all sectors, from retail trade and real estate, through to manufacturing and healthcare, and across all types of activities, to greater or lesser degrees. In order to appreciate the impact specifically on engineering and technological innovation, it is instructive first to examine the impact of the future of work in its widest possible sense.

The Future of Work

The key to understanding the impact of digital transformation – what we call the future of work – on engineering begins with an examination of the *potential for automation* of various activities across a diverse range of industry sectors. The consulting firm McKinsey (www.mckinsey.com) has published[3] an analysis of the technical potential for automation of various activities and industry sectors in the US (Chui, Manyika, Miremadi, 2016). Table 1 reproduces the McKinsey data, highlighting several important facts:

1. Predictable physical work and highly algorithmic, data-driven activities (e.g., data collection, data processing) have the *greatest likelihood* of automation by the technologies associated with Industry 4.0 and digital transformation.
2. The greater the percentage of time devoted to highly automatable activities, in a given industry, the greater the likelihood of automation in that industry (e.g., Accommodation & Food Services).
3. Conversely, activities involving unpredictable, non-algorithmic and interactive elements (e.g., managing others, applying expertise) have a far *lower likelihood* of automation by the technologies associated with Industry 4.0 and digital transformation.
4. The greater the percentage of time devoted to less automatable activities, in a given industry, the lower the likelihood of automation in that industry (e.g., Educational Services).

[3] https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/where-machines-could-replace-humans-and-where-they-cant-yet

Table 1: Time (%) Spent on Core Activities, by Industry Sector (US)*

Automatability	Low		Moderate		High		
Activity / Industry Sector	Managing Others	Applying Expertise	Stakeholder Interactions	Unpredictable Physical Work	Data Collection	Data Processing	Predictable Physical Work
Educational Services	22	29	10	8	13	10	7
Professional Services	7	27	16	2	19	23	5
Management	10	25	16	3	17	24	5
Information	5	25	20	7	16	20	6
Finance & Insurance	6	19	23	1	16	34	3
Arts, Entertainment, & Recreation	10	13	24	15	13	11	14
Healthcare & Social Assistance	8	14	14	11	20	13	21
Utilities	7	14	13	19	23	13	12
Administrative	6	13	14	23	21	13	10
Manufacturing	5	13	8	8	22	11	33
Other Services	7	12	17	13	15	11	25
Real Estate	7	12	21	19	16	17	8
Mining	7	11	8	24	21	12	17
Wholesale Trade	5	12	24	11	17	19	12
Construction	5	10	8	41	15	11	10
Transport & Warehousing	4	8	14	14	22	14	24
Retail Trade	3	6	26	5	15	28	17
Agriculture	3	5	7	51	11	9	13
Accommodations & Food Service	2	5	22	5	8	10	48

*This table is compiled using data in the report by Chui, Manyika and Miremadi (2016).

It is apparent (Table 1) that *every* industry sector will be impacted by digital transformation to a greater or lesser degree. However, the general shift in the *kind of work* performed by people, prompted by digital transformation, is a shift to, or a concentration on, unpredictable, non-routine, non-algorithmic tasks, frequently also involving the application of particular expertise, and frequently focused on *soft skills* (e.g., managing people). Technological innovation (engineering) – the process of connecting new problems to new solutions in response to change – is no different. Digital transformation is driving a similar shift. As more and more *highly automatable* activities in engineering see the replacement of humans with digital technologies, the core skills required of human engineers coalesce on those tasks, and skills, that automation *cannot* perform.

Therefore, while the digital transformation is impacting the future of work across almost all industry sectors and all types of activities, the effects are arguably most acute in science, technology, engineering and mathematics (STEM). Industry sectors strongly characterized by engineering (and STEM more broadly), and with high proportions of low and moderately automatable activities (see Table 1) – e.g., Construction (64%), Management (54%), Utilities (53%), Professional Services (52%), Mining (50%), Manufacturing (34%) – will need to focus very sharply on the skills that support the activities that cannot be automated.

The future of work has changed, and is changing, the kind of work that engineers perform, and the skills needed, by creating an increasingly sharp dichotomy. As more and more *routine work* is, and can be, taken on by digital technologies (AI, automation), what work do engineers perform, and what skills are needed for this work? How does this situation impact on technological innovation?

21st Century Engineering Innovation

To understand the skills needed by engineers in the future of work, it is necessary first to understand what it is that engineers do, and how this is changing in response to digital transformation.

What do engineers do?

Cropley (2021) asked two questions in relation to engineering. What is engineering's true purpose? What is the primary function of engineers? Without referring to self-evident examples such as "engineers build cars" or "engineers design bridges," what is the common, unifying purpose of all engineering specializations, whether electronic, mechanical, civil, or any other? There is a enduring answer to this question in the discipline's literature. For instance, Jensen (2006) stated that "Engineers solve problems" (p.17). Additionally, he noted that problem solving requires the ability to comprehend and define the problem, to apply established methods for resolving the problem, and to supplement established methods for resolving the problem *with creativity and insight*. Burghardt (1995) defined engineering as a profession

dedicated to *problem-solving creativity*, whereas Voland (2004) talked of a process of creatively, yet pragmatically, resolving technical problems.

The term *design* is also used routinely to refer to the process of resolving technological problems. Buhl (1960) described a *designer* as an individual who satisfies humankind's needs through novel (new) solutions to old problems. He went on to suggest that a *designer* must purposefully create new products and processes that will meet humanity's needs, emphasizing that designers must be inventive throughout the problem-solving process. Horenstein (2002) also defined *design* as a key activity of engineers, stressing that design can be defined as any activity that results in the synthesis of something that meets a need. In a similar vein, Dieter and Schmidt (2012) spoke of design as an activity that entails synthesizing something new or rearranging existing things in novel ways to meet a recognized need of society. Brockman (2009) also made a connection between engineering and problem solving motivated by a desire to "satisfy mankind's complex needs and desires" (p.3).

It is clear, then, that engineers design technological solutions to society's needs, reinforcing the examples given earlier in this chapter. More importantly, we also gain some insight into the types of reasoning required for this process. Notable among these is *creativity*.

What are the core activities of engineering in this sense?

If the job of engineers is to solve technological problems, what specific activities does this involve? Numerous models exist for the engineering design process. Cropley (2021), drawing on Dieter and Schmidt (2012), noted that *problem definition* and *data collection* lay the groundwork for *concept generation*. This is followed by *concept evaluation and selection*, followed by a series of steps that define the *product architecture*, *configuration design*, *parametric design*, and *detailed design*. This is frequently then continued with a stage of *design implementation* and/or *validation*. The process of problem solving therefore, in a broad sense, recognizes not only the existence of distinct stages/activities, but also that each stage requires a *distinct type of cognitive reasoning*. Guilford (1959), in his study of the psychology of creative thinking, identified four key stages of problem solving along with the supporting form of reasoning for each stage (Table 2).

Table 2: The Stages of Creative Problem Solving

Stage	**1**	**2**	**3**	**4**
Description	Recognition that a problem exists	Production of a variety of relevant ideas	Evaluation of the various possibilities produced	Drawing of appropriate conclusions that lead to the solution of the problem
Summary	Problem Recognition	Idea Generation	Idea Evaluation	Solution Validation
Dominant Form of Reasoning	Convergent	Divergent	Convergent	Convergent

This table is based on Cropley (2015, p. 43)

Numerous other authors have identified comparable stages of problem solving, both from a psychological and cognitive perspective (e.g., Bartlett, 1932; Wallach & Kogan, 1965; Cropley, 1999) and from a business or technical/engineering perspective (e.g., Prindle, 1906; Wallas, 1926; Pugh, 1991; Higgins, 1994; Cropley, 2017). Indeed, a number of contemporary creative problem-solving processes (for example, *Design Thinking* and *Appreciative Inquiry* – see Puccio & Cabra, 2010) follow a similar pattern.

What can be concluded here is that the core of engineering/technological innovation – finding new solutions to the new problems stemming from change – is simply a special case of a more general *creative problem-solving* process. With the activities and associated cognitive skills of engineering innovation established, we can now begin to explore the implications of digital transformation on these activities.

The *Soft* Side of Engineering

Recall that the broad impact of digital transformation on human labor – the future of work – is a shift *away from* predictable physical labor and routine, algorithmic tasks (because these are highly amenable to automation) and a *shift towards* unpredictable, interactive, non-algorithmic tasks and soft skills. Applying this concept specifically to engineering innovation allows us to identify, very clearly, the impact of digital transformation in this domain. In simple terms, the work of engineers involved in technological innovation is focusing, more and more, on those parts of the creative problem-solving process that are least amenable to automation. What does this mean in practice?

The first stage of creative problem solving (see Table 2), an activity which is uniquely human, is Problem Recognition/Definition. As a first step towards understanding the future of work in engineering innovation we see that the overall process cannot be divorced from human input or *sovereignty*, regardless of how sophisticated the automation employed is. Change drives innovation, in part, by stimulating new needs, and those needs can only be expressed by humans. What this means is that even a sophisticated artificial system can only, ultimately, make a [creative] decision "because my [human] programmer told me to." Guckelsberger et al. (2017).

After confirming that the driver for creativity (*Problem Definition*, Table 2) is uniquely a human task, we next examine the underlying cognitive processes. In other words, what are core cognitive processes that lead to novel solutions? These stages encapsulate the central issue that Guilford (1950) sought to address: he argued that human intellectual ability had been oversimplified in terms of speed, accuracy, and correctness, or what he termed *convergent* thinking. There was, in his opinion, more to mental *sovereignty* than simply knowing that 1 + 1 = 2, or that the capital city of France is Paris. This is not to say that this is a trivial mode of cognition. Much of our lives is dependent on our ability to know or find the correct answer and apply it. Our ability to solve problems efficiently and economically is contingent upon our ability to evaluate alternatives, to select among constraints, to execute an algorithm, and to apply logic. All of these cognitive activities are examples of convergent thinking, and Guilford (1959) encapsulated them under the single stage of *Idea Evaluation* in a creative, problem-solving process (see Table 2).

Critically, for the present discussion, Guilford (1950) contended that human intellectual ability was *also* a function of our capacity to generate alternatives, for seeing multiple possibilities, and for connecting disparate ideas. Divergent thinking – Idea Generation – he defined as the counterpart, or flip side, of convergent thinking. Once a problem has been defined, a range of possible solutions must be generated using divergent thinking, before being evaluated and the best solution chosen using convergent thinking (Figure 5).

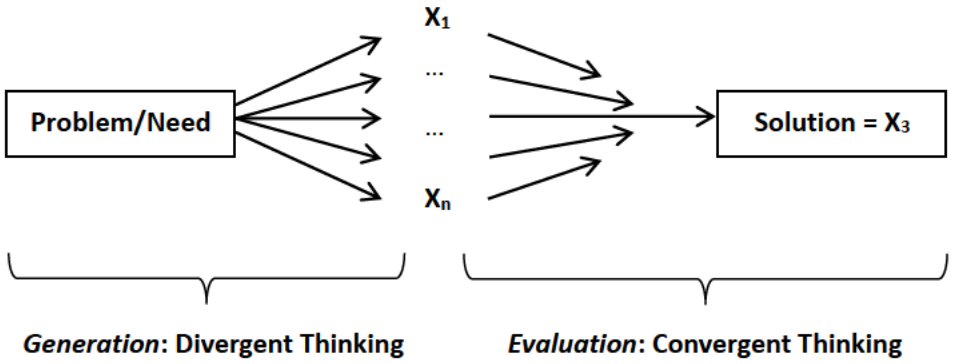


Figure 5: Divergent and Convergent Cognition (Based on Cropley, 2015)

The impact of digital transformation – automation, artificial systems, AI – as we have discussed, is to take over from humans those tasks that are algorithmic, predictable, and routine in nature. The tasks that remain – those activities that artificial systems *cannot* readily perform (non-algorithmic, unpredictable, *soft skills* tasks), for example problem definition, are where human activity now focuses. However, this division of labor is not as simple as saying that humans do the divergent thinking, while an AI does the convergent thinking, as the example of Problem Definition illustrates.

If an artificial means of creativity – or, more precisely, an artificial aid to human creativity – is to be discovered, it will be found in the divergent and convergent *process* stages of creative problem solving. Not so much because Idea Evaluation, for example, is a convergent process, but because both Idea Generation and Idea Evaluation are driven by *closed questions*. In the former case, divergent idea generation is driven by a closed question: the problem we are trying to solve is…? Similarly, idea evaluation is driven by a closed question: which of the ideas generated meets the constraints of this problem?

Turning to the other end of the process (Table 2), Guilford (1959) defined *Solution Validation* as the final stage in the process of creative problem solving. This stage seeks to confirm how well a product actually resolves the identified problem or meets the driving need. It is critical to distinguish between *verification* and *validation* at this point. The former verifies that a solution satisfies a technical specification: the Car travels at 60 miles per hour; the Kettle heats water to 212 degrees Fahrenheit. Validation, on the other hand, is the process of establishing that the solution addresses the human need: the Car *does* enable me to travel to work more quickly and comfortably; the Kettle *does* allow me to make coffee and tea quickly and cheaply. Thus, any process for generating creativity (and engaging in technological innovation) – whether human or artificial – is sandwiched between two distinctively, and uniquely, human stages: (1) a front-end of *problem definition* (what is the need to be satisfied?) and (2) a back-end of *solution validation* (has the need been satisfied?). The consequence of this for the future of work in engineering innovation – the *division of labor*, so to speak, between humans and automation is that any likely application of automation in this process must lie between the two exclusively *human* stages (shaded cells, Table 3).

Table 3: The Roles of Human and artificial creativity

Actor	Problem Definition	Idea Generation	Idea Evaluation	Solution Validation
Human	✓	✓	✓	✓
Artificial	×	???	???	×

The Technological Innovator of the Future

Cropley and Cropley (2021) give a detailed discussion of the rise of Industry 4.0 and its roles in heightening awareness of the ever-increasing interaction between humans and technology, particularly artificial intelligence (AI). This interaction is becoming increasingly important not just in industry, but in an ever-widening range of life domains, many of which would have been unthinkable just a few years ago had digital technologies such as AI played a role: Indeed, according to one recent survey, attention is spreading beyond "Industry 4.0" to include "Information Management 4.0," "Knowledge 4.0," "Education 4.0," and "Thinking 4.0." What is certain is that engineers will continue to play a critical role in the development of cyber-physical systems, and this chapter has examined the psychological underpinnings of this interaction and the implications for engineering innovation. What will Industry 4.0 mean for processes such as acquiring information (learning), transforming it into knowledge (thinking), and adapting to change in the emerging cyber-physical world, and how will engineering innovation need to respond?

At the moment, it is impossible to predict how drastically life will change and for how long. However, the situation is deteriorating into an "open-ended" one. This means that we are confronted with increasing uncertainty and dealing with uncertainty is a risky endeavor to which most humans are averse. Thus, what is required is not an attempt to forecast concrete details of a specific, imagined future and to define a set of "hard" skills that engineers will be able to acquire and then apply unchanged for the rest of their lives – in the world of twenty-first-century engineering, skills acquired today may well become obsolete in a decade or two. What is required is the promotion of psychological characteristics that enable people to function effectively (and achieve personal satisfaction) regardless of the circumstances, wherever they occur, and whenever they occur. Psychologically, this is a matter of what Cropley and Cropley (2021) refer to as "capability": the capacity to face novelty fearlessly, to adapt to change and become effective in new circumstances, or to acquire and discard well-loved knowledge, skills, and techniques as change requires. On the one hand, this capability protects people from the effects of factors such as fear of change,

resistance to change, or lack of self-confidence (and the resulting inability to acquire new hard skills), while on the other hand, it fosters their capacity to acquire, organize and reorganize, integrate, and apply knowledge as and when it is required – even if it contradicts what they already know and can do – as seems likely in the face of digital transformation.

Of course, engineers will still be required to design cars that do not explode and bridges that safely transport traffic across rivers, as well as to ensure that trains run on time (or even at all!) – assuming such things continue to exist – even if the precise technology involved and the precise human skills required are unknown or are changing. However, the proliferation of Industry 4.0 necessitates models that foster not only the acquisition of the technological skills necessary to conceive, design and construct the bridges (i.e., technology fluency – TF), but also the development of appropriate personal capability (i.e., capability focus – CF): Combining CF and TF requires a broad "mindset" (rather than a toolbox of specific skills or a body of never-changing fundamental knowledge) that is centered on the idea of "immunization." In a manner reminiscent of the World Economic Forum's "great reset," we refer to the development processes that combines CF and TF as "dual-track" (Schwab & Malleret, 2020). One purpose of this chapter is to shed light on what CFTF entails psychologically and how to foster it in engineering (technological innovation). At the conclusion of our analysis, we arrive at the conclusion that future of work in engineering innovation – the response to digital transformation – is a renewed focus on the creative problem solving and soft skills of humans, complemented by the appropriate, tailored and focused use of artificial systems to support the human innovators. In the uncertain and rapidly changing environment of Industry 4.0 and digital transformation, engineers must themselves innovate and not just replicate!

Summary/Conclusions

In this chapter, we broadly discussed the impact of digital transformation on Engineering Innovation keeping in mind the *Future of Work*. How can engineers prepare themselves to continually innovate and design systems that keep up with consumer needs? This is an important question, not only for researchers, but also for practitioners/businesspeople searching for the key to staying competitive in a rapidly changing business environment. To answer this question we offer some important insights focusing more specifically on engineering innovation: 1) change is one of the biggest driver of innovation; 2) trends observable across industrial revolutions suggest engineers will continue needing to design systems and processes that offer both incremental and disruptive innovation solutions, and lastly; 3) focus on the 'human' work of engineering and leverage the artificial systems to support what humans do best – using soft skills for creative and effective problem solving.

References

Bartlett, F. C. (1932). *Remembering*. Cambridge, UK: Cambridge University Press.

Bartodziej, C. J. (2017). The concept industry 4.0. In *The concept industry 4.0* (pp. 27-50): Springer.

Brockman, J. B. (2009). *Introduction to engineering: modeling and problem solving*. Hoboken, NJ: John Wiley & Sons Inc.

Buhl, H. R. (1960). *Creative engineering design*. Ames, IA: Iowa State University Press.

Burghardt, M. D. (1995). *Introduction to the Engineering Profession.* (2nd ed.). New York, NY: HarperCollins College Publishers.

Chui, M., Manyika, J., & Miremadi, M. (2016). Where machines could replace humans - and where they can't (yet). *McKinsey Quarterly*(July).

Cooper, J., & James, A. (2009). Challenges for database management in the internet of things. *IETE Technical Review, 26*(5), 320-329.

Cropley, A. J. (1999). Creativity and cognition: Producing effective novelty. *Roeper Review, 21*(4), 253-260.

Cropley, D., & Cropley, A. (2021). *Core Capabilities for Industry 4.0: Foundations of the Cyber-Psychology of 21st Century Engineering Education*: wbv Media GmbH.

Cropley, D. H. (2015). *Creativity in engineering: Novel solutions to complex problems*. San Diego: Academic Press.

Cropley, D. H. (2016). Creativity and culture in engineering. In V. P. Glaveanu (Ed.), *The Palgrave Handbook of Creativity and Culture Research*, Chapter 27 (pp. 486-506). Basingstoke, UK: Palgrave MacMillan Ltd.

Cropley, D. H. (2019). *Homo Problematis Solvendis - Problem-solving Man: A History of Human Creativity*. Singapore: Springer Nature.

Cropley, D. H. (2021). Creativity and Discovery in Engineering. In D. Neelke, D. Michelfelder (Eds.), *The Routledge Handbook of the Philosophy of Engineering*, Chapter 10 (pp.138-148). Routledge.

Cropley, D. H. and Cropley, A. J. (2020). Creativity as a Driver of Innovation: The Challenges of Studying Human Capital in Organisations, In M. Stierand and V. Dörfler (Eds.), *Handbook of Research Methods on Creativity*, Chapter 20 (pp. 275-289). Cheltenham, UK: Edward Elgar Publishing.

Cropley, D. H., & Cropley, A. J. (2021). *Core Capabilities for Industry 4.0 - Foundation of the Cyber-Psychology of Engineering*. Bielefeld, Germany: Wbv Media.

Cropley, D. H., Cropley, A. J., & Sandwith, B. L. (2017). Creativity in the Engineering Domain. In J. C. Kaufman, V. P. Glăveanu, & J. Baer (Eds.), *The Cambridge Handbook of Creativity Across Domains* (2nd ed.). New York, NY: Cambridge University Press.

Dieter, G. E., & Schmidt, L. C. (2012). *Engineering design* (5th ed.). New York: McGraw-Hill Higher Education.

Guckelsberger, C., Salge, C., & Colton, S. (2017). *Addressing the" why?" in computational creativity: A non-anthropocentric, minimal model of intentional creative agency*. Paper presented at the 8th International Conference on Computational Creativity, Atlanta, GA.

Guilford, J. P. (1950). Creativity. *American Psychologist, 5*, 444-454.

Guilford, J. P. (1959). Traits of creativity. In H. H. Anderson (Ed.), *Creativity and its cultivation* (pp. 142-161). New York, NY: Harper.

Hamada, T. (2019). Determinants of Decision-Makers' Attitudes toward Industry 4.0 Adaptation. *Social Sciences, 8*(5). doi:10.3390/socsci8050140

Higgins, J. M. (1994). *101 creative problem solving techniques: The handbook of new ideas for business*. Winter Park, FLA.: The New Management Publishing Company.

Horenstein, M. N. (2002). *Design concepts for engineers* (2nd ed.). Upper Saddle River, NJ: Prentice-Hall, Inc.

Jensen, J. N. (2006). *A User's Guide to Engineering*. Upper Saddle River, NJ: Pearson: Prentice Hall.

Kamble, S. S., Gunasekaran, A., & Gawankar, S. A. (2018). Sustainable Industry 4.0 framework: A systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection, 117*, 408-425. doi:https://doi.org/10.1016/j.psep.2018.05.009

Kovacs, O. (2018). The dark corners of industry 4.0–Grounding economic governance 2.0. *Technology in Society, 55*, 140-145.

Prindle, E. J. (1906). The art of inventing. *Transactions of the American Institute for Engineering Education, 25*, 519-547.

Puccio, G. J., & Cabra, J. F. (2010). Organizational Creativity: A Systems Approach. In J. C. Kaufman & R. J. Sternberg (Eds.), *The Cambridge handbook of creativity* (pp. 145-173). New York, NY: Cambridge University Press.

Pugh, S. (1991). *Total design: integrated methods for successful product engineering* Wokingham, UK: Addison-Wesley.

Salter, A., & Alexy, O. (2014). The Nature of Innovation. In M. Dodgson, D. M. Gann, & N. Phillips (Eds.), *The Oxford handbook of innovation management* (pp. 26-49). Oxford, UK: Oxford University Press.

Sarfraz, Z., Sarfraz, A., Iftikar, H. M., & Akhund, R. (2021). Is COVID-19 pushing us to the Fifth Industrial Revolution (Society 5.0)? *Pakistan journal of medical sciences, 37*(2), 591-594. doi:10.12669/pjms.37.2.3387

Schumacher, A., Erol, S., & Sihn, W. (2016). A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing Enterprises. *Procedia CIRP, 52*, 161-166. doi:https://doi.org/10.1016/j.procir.2016.07.040

Schwab, K., & Malleret, T. (2020). *The Great Reset*. Geneva: Switzerland Forum Publishing.

Sony, M., & Naik, S. (2020). Industry 4.0 integration with socio-technical systems theory: A systematic review and proposed theoretical model. *Technology in Society, 61*, 101248.

Szabó-Szentgróti, G., Végvári, B., & Varga, J. (2021). Impact of Industry 4.0 and digitization on labor market for 2030-verification of Keynes' prediction. *Sustainability, 13*(14), 7703.

Voland, G. (2004). *Engineering by Design* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

Wallach, M. A., & Kogan, N. (1965). *Modes of thinking in young children*. New York: Holt: Rinehart and Winston.

Wallas, G. (1926). *The art of thought*. New York, NY: Harcourt Brace.

Xing, K., Cropley, D. H., Oppert, M. L., & Singh, C. (2021). Readiness for digital innovation and industry 4.0 transformation: studies on manufacturing industries in the city of Salisbury. In *Business Innovation with New ICT in the Asia-Pacific: Case Studies* (pp. 155-176): Springer.

Appendix K: Book Chapter: 'Readiness for Digital Innovation and Industry 4.0 Transformation: Studies on Manufacturing Industries in the City of Salisbury'

This book chapter was an output from a 7-month joint collaborative project involving UniSA and The City of Salisbury. It was published in 'Business Innovation with New ICT in the Asia-Pacific' as a case study as follows:

Xing, K., Cropley, D. H., Oppert, M. L., & Singh, C. (2021). Readiness for digital innovation and industry 4.0 transformation: studies on manufacturing industries in the city of Salisbury. In *Business Innovation with New ICT in the Asia-Pacific: Case Studies* (pp. 155-176). Springer.

Showcasing the advancement of Industry 4.0 understanding beyond the PhD, this appendix is referenced in Sections 1.10 and 6.4.

Chapter 8

Readiness for Digital Innovation and Industry 4.0 Transformation:

Studies on Manufacturing Industries in the City of Salisbury

Ke Xing, David H. Cropley, Michelle Leanne Oppert, and Chanvi Singh

Abstract City of Salisbury in South Australia has strong industrial footprint in the manufacturing sectors and sees Industry 4.0-inspired technology advancement and business innovation playing a defining role to reshape the industry structure of the region. This chapter is to present a systematic analysis on barriers and chal- lenges faced by, capability and readiness of, as well as potential strategies for local manufacturing firms (most of which are SMEs) in City of Salisbury in adopting digital innovation toward Industry 4.0 transformation. Key factors analyzed span:

(a) Business; (b) Technology; (c) Ills; (d) Supply Chain; (e) Innovation.

8.1 Introduction

The Australian manufacturing sector has been experiencing an increasing pace of transition driven by globalized trade, technological advancement, as well as volatile market demand and supply chains. Although the last two decades have seen a relative decline of manufacturing's share in overall employment, the sector remains a substantial and important generator of economic activity and jobs in Australia, accounting for 26.9% of annual export earnings, 5.7% of GDP, approximately one million employees, and the highest business expenditure on R&D over all industry sectors (AiGroup 2019). While Australia's manufacturing sector is disadvantaged by suffers from high labor costs, geographical remoteness and a relatively small domestic market, the comparative competitiveness of Australian manufacturers is

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dependent on whether and how they can effectively capitalize on the full potential of globalization, digitalization and the increased demand for more tailored and multifarious solutions (CSIRO Futures 2016). Key to achieving such success are efforts by manufacturing firms in engaging with digital technology for value creation through innovative product/service designs and with digital transformation for value capture through innovative business models. It is recognized by both governments and industry that the adoption of *Industry 4.0* within Australia has the potential to significantly improve the capability of Small-to-Medium Enterprises (SMEs) toward advanced manufacturing.

Industry 4.0 is a policy response that was launched by the German government in 2011 in recognition of the profound changes that digital technologies, AI and big data were having on manufacturing firms and the view that this impact would only intensify over time. It aims to drive a transformation of manufacturing through increasing digitalization and strengthening interrelations of products, value chains and business models. The fundamental objective of this initiative is to support the integration of cyber-physical systems (CPS), the Internet of Things (IoT), cloud computing, automation and artificial intelligence (AI), leading to the creation of smart factories.

As the initiative has matured and spread throughout the developed world, Industry 4.0 has become a foundation of digital innovation for the transformation of business models and product/service delivery, not only in the manufacturing sector, but also in the wider economic system. Known also as the *Industry Renaissance* in some countries, and by many other national initiatives (e.g. 'Manufacturing USA' in the United States), the digital transformation of industry is regarded by global business leaders as pre-requisite for improved productivity, improved efficiency, flexibility, agility, improved customer satisfaction, cost reductions, and improved innovation (Lee et al. 2015). Some of the key technologies of Industry 4.0 based on the literature are CPS, additive manufacturing, IoT, cloud computing, big data analytics, simulation and modelling, automation and Industrial Robots, augmented Reality, cybersecurity and several others (Ghobakhloo 2018). Automation in Industry 4.0 enables companies to offer new and better digital solutions to their customers, such as Internet-based services (Dalenogare et al. 2018).

For Australia, embracing digital transformation and innovation is essential for continued economic development, competitiveness and prosperity. Previous research has shown that Industry 4.0 can have an impact on political, economic, social, technical, environmental, and legal factors (e.g. Hecklau et al. 2016). Industry 4.0 represents a shift toward the innovation-oriented economy with knowledge, data and the IoT as its central components (Liao et al. 2017). Organizations are expected to modify business models for their innovation, allowing for a more interactive relationship between the firm and its clients, to better fulfil consumer needs (Ibarra et al. 2018; Morrar et al. 2017). Many companies have also begun to introduce new marketing interfaces and manufacturing processes to the customized needs of the clients who are willing to pay for customized features of their goods and services (Morrar et al. 2017). Whilst Industry 4.0 is expected to bring immense benefits, it also brings many challenges. The main challenge that most stakeholders are concerned with is the cybersecurity risk, given that the IoT is the backbone of Industry 4.0 (Ibarra et al. 2018). The rate of growth of this industrial revolution is exponential, making it difficult to foresee all the benefits, risks and challenges that may result. Current policies and regulations may become redundant due the speed of progress and growth of Industry 4.0, posing a threat to businesses and compelling firms to constantly update their policies and procedures. One of the social challenges of Industry 4.0 is likely to be the job losses resulting from widespread automation of large segments in many industries. While Industry 4.0 can also open the window for new opportunities that may appear in 'high-skilled' categories of employment, a question still remains as to whether these opportunities will meet the supply of labor (Morrar et al. 2017).

A focus on how Industry 4.0 can work for the Australian manufacturing industry is still limited in the extant body of literature. Although it is reasonable to expect that some local manufacturers may have started Industry 4.0-related innovation, mostly in relation to process automation and big data, little is known regarding the patterns, the extent, and the outcomes of their transformation. Furthermore, implementing Industry 4.0 will require coherent digital strategies and data-driven business approaches, flexible production and service provision, strong customization, and cognitive and intelligent support. Both opportunities and challenges associated with digital transformation faced by Australian manufacturing SMEs necessitate empirical studies to shed light on *what to do, how to do it, what hurdles to overcome, and what enabling mechanism need to be provided* for the transition towards Industry 4.0.

Having this in mind, the case study presented in this Chapter is to explore how manufacturers operating in a particular region, i.e. City of Salisbury, in the state of South Australia, consider Industry 4.0 and digital innovation. The investigation was designed to inform current knowledge and practices, identifying capability, readiness, barriers and challenges to the adoption of Industry 4.0 and digital innovation. The context of the case and the methodology of the study are explained in Sect. 8.2, followed by discussions on the results of Industry 4.0 awareness analysis (Sect. 8.3) and of digital innovation readiness assessment (Sect. 8.4). Then, the barriers and the recommendations for changes and actions are reported in Sect. 8.5. The chapter is concluded in Sect. 8.6 with suggestions for further studies.

8.2 Case Context and Methodology

Australia's manufacturing sector is overrepresented with the number of small firms. While most of them operate locally, many have the potential and capability to serve supply chains at the global scale. The manufacturing industry based in the City of Salisbury shares much the same characteristics. The City of Salisbury is a local government area situated on the northern outskirts of metropolitan Adelaide, the capital city of South Australia. It consists of 32 suburbs and covers an area of 158 km^2 (see Fig. 8.1).

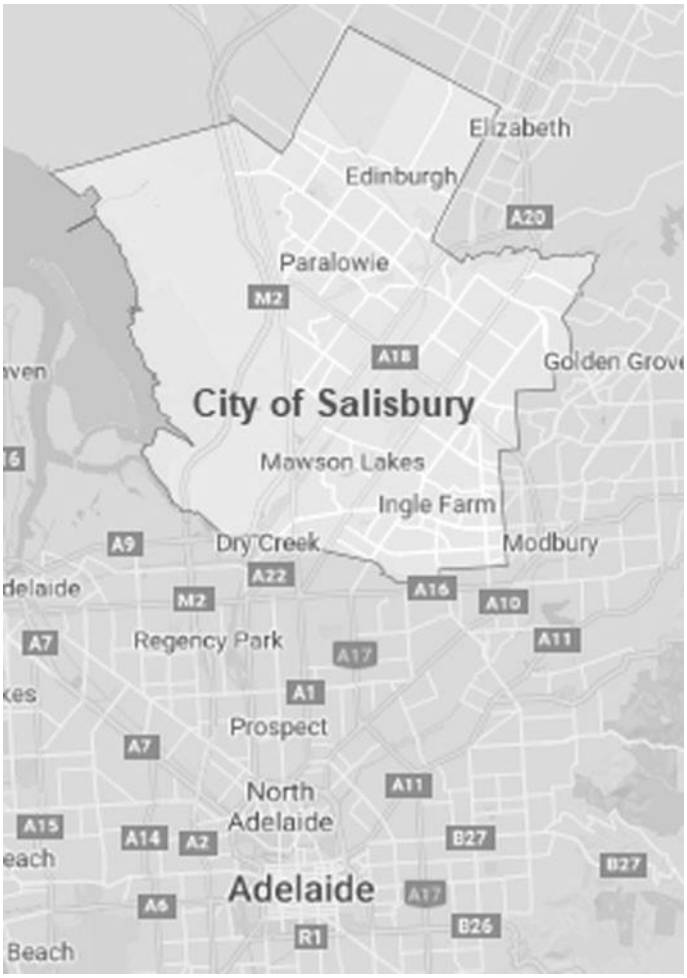


Fig. 8.1 Google Map® of City of Salisbury

The region has a strong industrial footprint and a long-term strength in manufacturing. Despite a slight slip in recent years, the sector still represents 15.8% of total local employment (https://economy.id.com.au/salisbury/industry-sector-ana lysis). Although the City of Salisbury has a diverse industry base, it has been affected by long term structural changes in the Australian economy as well as cyclical down- turns. The closure of a major car manufacturer in 2017 has led to the end of mass-production assembly line based automotive manufacturing. This led to multinational component manufacturers leaving the region, smaller firms scaling back or in the case of some recreating themselves. As an example, Salisbury's history and workforce skills in automotive manufacturing are now applied to bus making and the production of the Brabham BT62 supercar. However, the manufacturing sector as a whole remains the most significant contributor to the local economy but it is changing. Path dependency is a term in economics that describes the transition of local economies. Simply stated, the future of a local economy is based on today's skills, infrastructure and capability. City of Salisbury's traditional strengths in defence manufacturing are being applied to space and electronic warfare. Its tradition as a manufacturing region provides the workforce skills for health manufacturing firms to expand and locate. Also, being as the home of South Australia's largest food market forms the base to support the growing food manufacturing sector in the area. As such, transforming traditional manufacturing towards new advanced manufacturing processes is central to the future economic viability for the City of Salisbury. Industry 4.0-inspired technology advancement and business innovation will play a defining role to reshape the existing industry structure of the region and to transition its industrial base towards more value-adding goods and services over time.

For the manufacturing businesses in the City of Salisbury, exploring and adopting new strategies and operations models for Industry 4.0 has become a crucial and urgent need. Understanding the barriers, challenges, opportunities and rewards associated with the transformation to Industry 4.0 will help the City of Salisbury to advocate for the necessary support required by manufacturers and their supply chains in this region and for institutions such as universities to shape the way in engaging with local industries. To accelerate the drive for Industry 4.0 maturity, three fundamental questions must be investigated:

What factors affect an organization's transformation to Industry 4.0?

- How far along this Industry 4.0 transformation path do organizations in the City of Salisbury sit?
- What changes, support and resources are needed to accelerate and improve Industry 4.0 transformation among manufacturing organizations in the City of Salisbury?

Several studies in the past have measured Industry 4.0, or digital, transformation maturity and the readiness of organizations to adopt Industry 4.0 (e.g. Kopp and Basl 2017; Schumacher et al. 2016). There is, however, a lack of research that addresses the maturity and readiness of organizations within an Australian manufacturing industry context, and the City of Salisbury specifically. To address this gap and to understand the awareness and readiness of manufacturing firms in the City of Salisbury for Industry 4.0, this project has combined both qualitative and quantitative approaches for the investigation.

The case study employed a mixed-methods approach through a process involving two phases of data collection and analysis, i.e. qualitative interviews and a quantitative survey. As depicted in Fig. 8.2, the two phases occurred sequentially after the initial literature review to obtain a thorough understanding of manufacturing firms' innovation capability and readiness, and uncover barriers, challenges and opportunities for manufacturing in the City of Salisbury region. Considering that the emerging literature on Industry 4.0 is still growing, interviews were conducted prior to the survey to uncover a deeper understanding of the local manufacturing sectors' needs

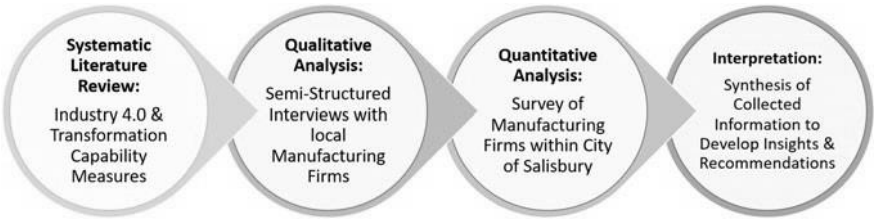


Fig. 8.2 The case study process and methods

and knowledge Industry 4.0. The information collected and analyzed in the inter- views was combined with existing literature of Industry 4.0 and existing Industry

4.0 maturity models to develop a quantitative survey instrument. Then, the synthesis of information collected from both phases of analysis was used to develop a set of recommendations for accelerating, supporting, and developing Industry 4.0 maturity for manufacturing firms in this region, and ostensibly, the wider global manufacturing sector.

For the qualitative analysis of the study, firms considered to be manufacturers in the City of Salisbury region were contacted with a request to participate in interviews. Conducted over a period of 12 weeks, this phase of the data collection comprised of face-to-face semi-structured interviews between investigators and interviewees. Individuals participated in the interviews were all part of middle and senior management from local manufacturing firms (see Table 8.1).

The quantitative analysis phase of the study invited senior employees from manufacturing firms in the City of Salisbury region to complete the online quantitative survey distributed on the SurveyMonkey platform. The characteristics of the firms that participated in online survey were representative of the firms that participated in the interviews during the previous phase, including micro businesses (fewer than 5 employees) through to large businesses (200 or more employees).

8.3 Qualitative Analysis on Readiness for Industry 4.0 Transformation

Information gathered from the literature review and existing Industry 4.0 maturity models helped to devise a set of questions that queried interviewees about their knowledge of Industry 4.0 and associated key technological issues, internal and external issues, data analytics and protection, and employees. The questioned were created to align with the five dimensions of Industry 4.0 transformation, i.e. Business, Skills, Technology, Supply Chain, and Innovation, which also represent the five primary Industry 4.0 readiness categories that the project aimed to explore. The format of the interviews was semi-structured with open-ended questions in order to capture other potentially salient information.

Table 8.1 Descriptive information of interview participants

Firm Description	Interviewee Role/s
Food & Beverage	• Engineering Manager
Fashion	• General Manager Supply Chain Procurement • Chief Information Officer
Communications	• Vice President & General Manager • Operations Manager
Electronics	• Operations Manager • Engineering Manager & Defence Liaison • Special Project Officer (I4.0)
Specialised Medical Equipment	• Chief Technology Officer • Manufacturing & Supply Chain Manager
Food & Beverage	• Non-Executive Director
Specialised Equipment	• Chief Executive Director • Sales & Technical Director
Engineering	• Managing Director
Metal Fabrication	• Director
Food & Beverage	• Maintenance Manager • Packaging Manager • Control Systems Engineer • Quality Manager • Technical Brewer • ICT Coordinator
Electronics	• Managing Director • Software Engineer
11 Firms	***23 Interview Participants***

The interviews were analyzed using Braun and Clarke's six-step method of Thematic Analysis (2006, 2013, p. 202). Thematic Analysis (TA) is a simple qualitative method that is useful in research when the participants or groups of the research are relatively homogenous. A deductive approach to TA provided a deeper under- standing of the needs of the local manufacturing firms and revealed rich insights into the opportunities, risks, and barriers facing those manufacturing firms for adopting Industry 4.0. The codes for the current TA were predefined. Direct or indirect responses to the interview questions were identified by applying a common under- standing of the code and a description of how this would be identified or extrapolated (see Table 8.2).

Once the codes were applied, the investigators followed the steps of TA to uncover the salient themes. Through interpretation and discussion, interrater validity of the themes was established. Table 8.3 presents the eight themes identified from the TA,

Table 8.2 Descriptions of predefined codes for thematic analysis

Codes	Common Understanding	Description
Barrier	Anything impeding, blocking stunting, or stopping	Identified and extrapolated when barriers were mentioned or implied from the interview meaning
Challenge	An issue exists, but can be overcome	Identified when issue discussed could be overcome with knowledge, funding, or skills
Facilitator	Anything that enables, promotes, or helps function	Identified when enablers were present to allow a process or pathway forward
Knowledge	Understanding, lack of knowledge, depth of knowledge	Identified in 3 ways: example of understanding; complete lack of understanding, or the need for more understanding
Motivation	Reasons for going forward or doing something (internal or external)	Identified when interviews revealed reasons for moving forward or not
Opportunity	Possibilities, identified room for improvement	Identified when possibilities were revealed, ideas discussed, or examples of firms expressing reasons for moving forward
Strength	Within a firm or from stakeholders/supply chain	Identified when a factor was presented as a strength to the firm
Weakness	Within firm or from a stakeholder/supply chain	Identified when a factor was presented as a weakness to the firm

each of which includes the number of firms that mentioned this theme, the number of comments pertaining to it, and an illustrative comment.

By analyzing these themes in relation to the TA codes, it was found that the eight themes all pertain to the transformation associated with Industry 4.0 readiness of the participating manufacturing firms. Some themes were identified as, for example, both a barrier and an opportunity, or both a challenge and strength, as indicated by the presence of multiple codes. Furthermore, each theme was considered from the perspective of the five dimensions of Industry 4.0 readiness, as illustrated in Fig. 8.3.

Innovation

Overall, the firms interviewed presented as relatively advanced in terms of Industry

4.0 transformation, appearing to be influenced by their stakeholders' proactive approaches to Industry 4.0 initiatives. Workplace **culture and values** presented as key when discussing Industry 4.0 aspects pertaining to advancements in technology and systems, and associated security threats that could cause friction between policies and employees within firms. For example, some participants expressed concern that employees may not understand the value and reasoning behind any increases in security measures such as restrictions to smartphones in plant environments and the need to frequently change passwords. Poor understanding of the benefits of innovation may lead to employee resistance to change and progression. Meanwhile, some firms have found the adoption of new CPS assists them to be more agile in

Table 8.3 Identification of themes with illustrative comments

#	Identified Theme	# of Comments	Illustrative Quote
1	Return on Investment	10 Firms 44 Comments	*One of the big Industry 4.0 capable solution requires such a major expense and buying across the organisation where the benefits are only clear to certain people.* – 4D
2	Culture & Values	10 Firms 46 Comments	*So, the attitude in terms of embracing is quite important and that's also about how management sell it [Industry 4.0] to everyone.* – 15O
3	Appropriate Digital Systems Software	11 Firms 41 Comments	*One is, perhaps, that there is not necessarily a common standard. There's a number of different types of technology or application who claim to be Industry 4.0 or whatever and not necessarily or directly easy to connect on the same platform. So, it required skills, technical knowledge to be able to have a machine be able to transfer the information to the ERP or to equipment to be able to communicate together. It's getting easier. It's not necessarily fully standardised.* – 6F
4	Knowledge of Industry 4.0	11 Firms 40 Comments	*Well, we need to understand it first, so the biggest barrier is I don't think we understand it yet. So, before we do anything, we need to understand what's possible, how we do it, how are we going about it and things like that. So, I'd start there. Digital manufacturing: we've only just sort of started getting into it and understanding it.* – 15O
5	Strategy to do with Manufacturing Method	11 Firms 37 Comments	*If we want to continue manufacturing in Australia, which we do, which means we want to continue employing people in Australia to do that, then you have to be looking for those methods to change so that people know that to keep doing what we're doing now, to keep doing, to keep manufacturing, we need to be looking at different ways to do that effectively. You've seen so many examples of other companies having offshore and then it all just changes, you know? Whether it's [well-known international brand] or whoever it might be, it just doesn't have that same feel of an Australian made product and therefore the whole sales relationship just changes in the market and we don't want to lose that.* – 6F
6	Management & Leadership	11 Firms 34 Comments	*For us, we're lucky that the, I suppose, corporately in management, that they're supportive [of] us trying to develop an infrastructure that's going to support Industry 4.0. Even though we don't really know what it is going to deliver down the track.* - 18R
7	Security Policies	11 Firms 34 Comments	*So, everything has gone a bit harder or a bit more complex, but we are, you know, it's a real compromise for our IT team to give people enough access so they can do their jobs, but not to make the system vulnerable. It's an ongoing challenge.* – 4D
8	Supply Chain Data	9 Firms 31 Comments	*So, probably the data on finished goods and then getting through these is where we've got a big gap. That will be good. I don't know how to capture that, but that would take someone on site to sort of say 'this is where we've got to go.'* – 13M

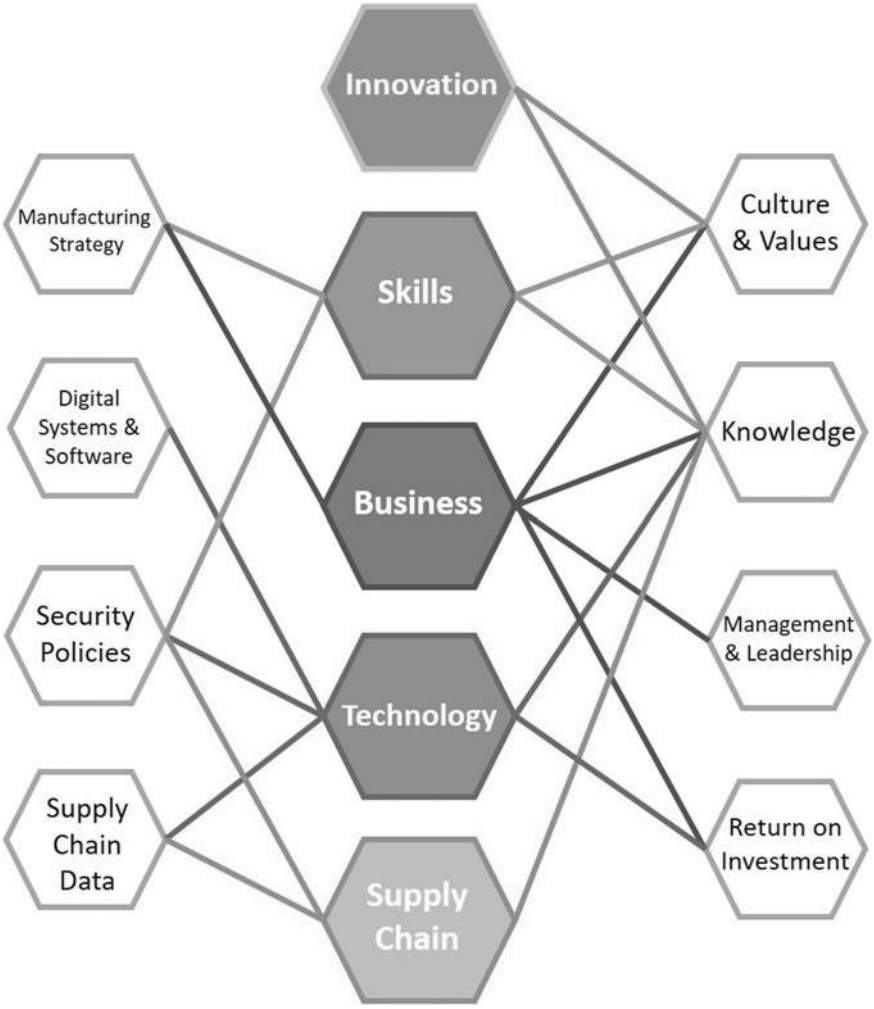


Fig. 8.3 The primary themes and connections with the dimensions of Industry 4.0 readiness

the work environment and locations, for example, by being able to perform their tasks from home or most global locations. Some managers reported that providing a workplace that encourages open discussion and facilitates worker innovation has improved some of their product designs and resulted in better adoption of innovation in the manufacturing environment.

Another facet of innovation challenges to adopting and engaging in innovation was a state of confusion as to what firms need to do in order to transform to Industry 4.0, or why they would need to aspire to do this. Many firms explained that they lack adequate **knowledge** and technical capabilities to identify and acquire new and innovative products or software that would fulfil their Industry 4.0 readiness or progression.

Skills

Finding individuals with the technical expertise to support Industry 4.0 initiatives within companies appears to be a key challenge at most organizational levels. There were frequent comments related to the challenge of recruiting graduate students with appropriate **knowledge** and skills, requiring months of technical training once employed. Additionally, it appears to be equally difficult to afford the competitive salaries for employees with specific technical skills that are required and are often outbid by the Defence sector, to the extent that some firms have taken to poaching employees from other firms. This a threat to some of the firms interviewed and as a result some firms are doing their best to create a positive **workplace culture and values** to both attract and retain skilled employees.

Strategies to do with manufacturing methods for Industry 4.0 transitions included the trade-off between automation and manual operation, loss of employee morale, and potential public backlash at employee redundancies. Many participants expressed a desire to create new roles for employees who have roles that are to be replaced by automation and machines. In

fact, some firms reported that employee morale increased in the workplace when employees realize that machines would improve their roles and the work they were now provided with was more interesting and protected against redundancy.

Business

Collectively, while aware of it, the firms did not have a complete understanding of Industry 4.0. Participants suggested that access to examples of Industry 4.0 best-practice would be beneficial and indicated their interest in attending training sessions or events educating them on Industry 4.0 therefore assisting in identifying opportunities for further applications within their firms. Despite a paucity of explicit **knowledge**, the interviews revealed that many firms have begun transitioning towards Industry 4.0 without putting any policies or strategies in place. The impact of this transition with poor **management and leadership** can, and appeared to be, creating some workplace confusion about how the firms are transitioning to the future. Some long-term firm owners or board directors have been accused of viewing Industry

4.0 adoption as a challenge to their leadership or management styles. The highly skilled and experienced participants expressed the desire for their senior manager/s to be willing to listen to ideas and adapt to the changes of Industry 4.0. In terms of family-owned businesses, a characteristic of some of the manufacturers in the City of Salisbury, will mean changing traditional methods of operation that have been successful in the past, but that might not suit the current technological and economic climate. Some firms expressed their desire to remain culturally static and were challenged by attempting to maintain a balance between automation and retaining their workforce. That is, they are satisfied with their **workplace culture** and would prefer it to remain unchanged.

The interview data revealed that manufacturers predominantly see a positive **return on investment** (ROI) in Industry 4.0 applications, but only if the demand for their manufactured products grows. At the times the firms were interviewed, there were limited consumers in a growing marketplace already saturated with mass-produced commoditized products. There appeared limited thinking and under- standing on how to using Industry 4.0 as leverage to realign the business model towards building higher profit margins through specialized/customized products. For Industry 4.0 to be integrated into the manufacturing process, a transformation across all aspects of the business is required, which is a significant expense for firms posing challenges in terms of technology cost, implementation, and educating staff on integration and use. Technology related to Industry 4.0 is still relatively expensive and, at this stage, appears to be accessibility only to firms with sufficient economic security and resources to become early adopters. In the interviews, it was suggested that SMEs favor observing what other firms elect to do and then assess the ROI based on that information.

Several firms revealed knowledge of the Industry 4.0 **manufacturing processes** being led by European manufacturers and are attempting to incorporate them. In this case, the **knowledge** of senior management is a key driver for adoption of Industry

4.0 methods in reference to manufacturing. The association of quality Australian- Made products was a reoccurring theme between all of the firms investigated. This was more important to the manufacturers than Industry 4.0 readiness or capabilities. For example, one of the firms designs and hand-tailors luxury fashion products. This firm had previously purchased a laser cutter for patterns and returned to hand-held scissors as the hand cut products were better. This example of handcrafting may be an exception to the rule, but one that should be considered nonetheless.

Technology

Most firms appear to be dissatisfied with their current **digital and software systems**, with a primary challenge existing in regard to finding systems that integrate with each other, are user-friendly and allow easy comprehension of the data collected, acknowledging this is simply due to a dearth of **knowledge** at their end. Irrespective of the size of the firm interviewed, many aspects of the business that had employed new digital systems reported challenges and barriers to linking the multiple systems or identifying a system for the entire firm that meets their needs. The **ROI** of on- boarding new systems including the cost of training staff, is of concern to many firms. Additionally, implementing Industry 4.0 software and machinery revealed issues experienced with international stakeholders; some of their systems are often in different languages and can incur a significant expense to bridge this gap of translation between the interfaces, presenting as another barrier to understanding **supply chain data**.

Supply Chain

Between the firms investigated, there was a paucity of data actively being collected through the supply chains, although the opportunity to do so exists. This could be linked back to **knowledge** of Industry 4.0 because firms are not aware how to collect data from these processes nor how to analyze it, even if the data collected could potentially drive business decisions. No firms had a formal data analyst employed, however one firm was advertising a position for one, as they could foresee the opportunity. Despite the firms' overall lack of knowledge on data analytics and Industry 4.0, a few firms were aware of the

benefits of **supply chain data** tracing for quality assurance purposes, for example, tracking of where each ingredient of a product originated from or checking test data of products. The firms were enthusiastic about the quality control they could implement if they were able to track every point or resource along the supply chain from the beginning all the way to the consumer.

Overall, the interviews revealed that the firms who have a significant amount internal Intellectual Property (IP) have been early adopters of advance **security policies,** particularly those firms that operate in the Defence sector, which has a stronger emphasis on partnership and demands for a focus on innovation and capability building driven by supply chain stakeholders. At the time of this study, the Australian Government had instituted the *Essential 8* with three levels of maturity to mitigate cyber security incidents (ASD 2019)—only one firm mentioned knowledge of this initiative. This finding exemplifies the potential lack of information provided to these firms on needs and growth in managing digital assets and data security matter along with adopting Industry 4.0. While there was a breadth of difference on the importance of security policies between the firms investigated, all participants agreed that there is a growing need for security policies to be put in place, particularly with the increase in data collection, use of cloud storage, and the risks of infiltration.

8.4 Quantitative Surveys

Based on the information acquired from assimilation of existing literature of Industry

4.0 maturity, the key themes uncovered from Industry 4.0 readiness analysis, and existing Industry 4.0 maturity models, an online quantitative survey instrument was developed to address the five specific domains of maturity relevant to the adoption Industry 4.0. The questions were designed to probe into the key factors covered in the five domains, defined as:

- **Business**—a range of factors including strategy, models, return on investment (ROI), cybersecurity and corporate social responsibility (CSR); **Technology**—including infrastructure, vertical and horizontal integration, ICT platforms, and digital resources;
- **Skills**—spanning leadership and management, soft skills, workforce readiness and change management;
- **Supply Chain**—exploring digital transformation factors in the wider manufacturing environment;
- **Innovation**—including culture, processes, and people.

Each of the five dimensions was assessed at one of five possible *levels of maturity*, ranging from *Very Low* (indicating either that no level of Industry 4.0 maturity could be assessed, or that the maturity was at the lowest possible level), through to *Very High* (defining a level of Industry 4.0 maturity that is consistent with best practice). Responses to the survey questions were captured by using a six-point, Likert-type scale, from "1" (completely disagree) through to "6" (completely agree) with no neutral option. The data obtained were analyzed and converted into the scores of *Industry 4.0 Transformation Maturity Index (I4-TMI)*, with *Median* and *Range* values calculated for each sub-variable listed under the five key variables outlined previously, as presented in Table 8.4.

Figure 8.4 shows the median scores of Industry 4.0 Transformation Maturity against the firm sizes. Based on the data obtained, it indicates that, among those participated in the survey, small firms have medium readiness for Industry 4.0 and medium-sized firms have a higher (i.e. medium-high) readiness for Industry 4.0. While such results appear disadvantaging small firms, these may not serve as the base to extrapolate for general conclusions about the manufacturers in the region, due to limitations in scope and sample size. However, as majority the manufacturing firms in the City of Salisbury are SMEs, this finding does highlight the need for further and broader investigations on relations between "being small" and the readiness for Industry 4.0.

As indicated by the results of Industry 4.0 Transformation Maturity Index, there are some notable strengths in the sample, representing elements that are driving Industry 4 Transformation Maturity in the organizations, and present opportunities for continued growth and exploitation. Overall, however, **Skills**, **Supply Chain** and **Technology** are the three main areas standing out as three main areas of weakness for all firms, providing the greatest opportunities for remediation and improvement.

Under **Skills**, the main weaknesses are with *Technical Skills* and *Soft Skills*. *Leadership*, in contrast, emerged as a strength. Firms appear having reasonable levels of confidence in their ability to adapt, and their readiness for changes, which is a promising sign, showing their willingness and potential to transform to Industry 4.0;

Under **Supply Chain**, the *Skills of Partners* and *Broad Horizontal Integration* are the weakest factors. Although *Technological*

Advancements and *Collaboration* may be strengths, there appears to be a lack of a systems approach to foster and leverage innovation for digital integration and more effective/efficient data management across the whole supply chain;

Under **Technology**, *Vertical Integration*, *Data Analytics* and *IT Digitalization and Interoperability* are all emerged weaknesses. Despite having sound IT infrastructure, competent manufacturing methods and reasonable confidence over own business information management capability, confidence regarding the interoperability of systems and data sharing across production process internally is low;

Under **Business**, the main, and only, weakness is *Government and Education Support*. This may also correlate with the weaknesses in *Workforce Readiness* and *Technical Skills* observed under **Skills**;

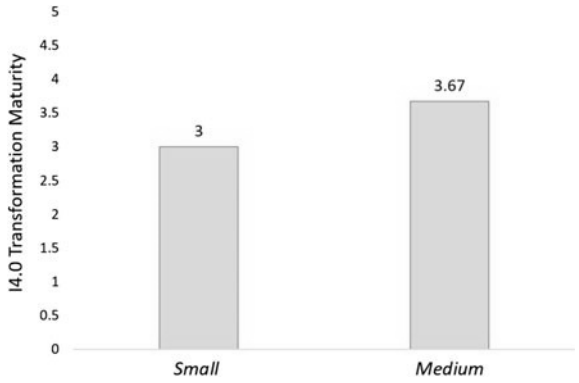
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Table 8.4 Industry 4.0 transformation maturity index scores measured

Elements *Category: Business*	1-2 Very Low	2-3 Low	3-4 Medium	4-5 High	5-6 Very High
Strategy				4.3	
Re-thinking/adapting the Business Model				4.0	
Protection of IP & Cybersecurity				4.0	
Corporate Social Responsibility				4.7	
Business culture & Values				4.5	
Government & Education Support			3.4		
Customer Orientation/Individualisation & Data Driven Decision Making				4.5	
Business Score				**4.5**	
Elements *Category: Technology*	1-2 Very Low	2-3 Low	3-4 Medium	4-5 High	5-6 Very High
Technology & Infrastructure				4	
Vertical Integration			3.5		
IT (End-to-End) Digitalisation & Interoperability			3.3		
Use of Technological Resources & Digitalisation			3.8		
Narrow Horizontal Integration					5.0
Manufacturing Methods				4.0	
Big Data Technologies & Data Analytics (Storage, Management, & Insights)			3.3		
Technology Score			**3.8**		
Elements *Category: Skills*	1-2 Very Low	2-3 Low	3-4 Medium	4-5 High	5-6 Very High
Leadership					5
Soft Skills			3.0		
Technical Skills			3.3		
Workforce Readiness			3.6		
Adaptability to Change				4.0	
Skills Score			**3.9**		
Elements *Category: Supply Chain*	1-2 Very Low	2-3 Low	3-4 Medium	4-5 High	5-6 Very High
Collaboration					5.0
Business Model of the Partners*			3.7		
Broad Horizontal Integration (IT & Digitalisation across the Supply Chain from the Initial Suppliers all through to Customers)		2.0			
Technological Advancements of Partners in the Supply Chain*					5.0
Skills of the Partners in the Supply Chain*			3.0		
Innovation in the Supply Chain*				4.0	
Supply Chain Score			**3.3**		
Elements *Category: Innovation*	1-2 Very Low	2-3 Low	3-4 Medium	4-5 High	5-6 Very High
Environments for Innovation				4.7	
Attitudes to Innovation			3.8		
Processes for Innovation			3.8		
Innovation Score				**4.3**	
Industry 4.0 Transformation Maturity Index			**3.8**		

Note Items marked with an * indicate 'relative to and as perceived by the company

Fig. 8.4 Industry 4.0 transformation maturity versus firm size



- Generally, the results show that small firms appear to struggle the most with Industry 4.0 transformation. Among many contributing factors, **Skills** (particularly Soft Skills) and *Digital Capability* (particularly in managing data for internal and external operations), or lack of them, present as the main impediments to Industry 4.0 transformation.

8.5 Discussion

The results derived from the interviews and survey analysis provide a picture of current readiness and maturity for Industry 4.0 transformation for typical manufacturing firms in the City of Salisbury. The findings help to identify a number of main **barriers** for the manufacturing firms, mostly SMEs, to adopt Industry 4.0 and are used to develop a set of **recommendations** for supporting, developing and accelerating digital transformation of manufacturing firms in this region towards Industry 4.0.

8.5.1 Barriers for Industry 4.0 and Digital Transformation

The information collected through the interviews from manufacturers revealed a strong interest in Industry 4.0—even if their understanding is still limited—and transforming to more digitally innovative pathways to improve their operations and business models. Highlighted in both readiness analysis and maturity analysis are a number of challenges and barriers to successful transformation to manufacturing in Industry 4.0 in the City of Salisbury region. These challenges may be representative of other regions, however the current study specifically aimed to explore a single region to identify support, resources and actions that could improve Industry 4.0



Fig. 8.5 Primary barriers for Industry 4.0 transformation of manufacturing firms studied

maturity in this region; a tailored response to a specific region. In total, six primary barriers are identified, as shown in Fig. 8.5.

Overall, relating back to the key themes identified (see Table 8.3), the firms reported a **general lack of understanding** and explicit knowledge of Industry 4.0 which was compounded by the lack of a succinct and accepted definition of Industry

4.0 in both the literature and industrial domains. Firms are also **wary of engaging in Industry 4.0 transformation**. This could potentially be attributed to their lack of knowledge, but it was identified that there is a general cautiousness among manufacturing firms in the City of Salisbury region with regard to engaging in changes associated with Industry 4.0.

The firms were overall positive about the future of Industry 4.0, it was also evident that they are not sure how this would affect their employees, ROI, and data security. This is exemplified with the firms' **weakness and uncertainty in cyber-security**. Cyber-security was a common concern for all firms interviewed, the firms that completed the survey component reported a belief that their cyber-security capabilities and policy frameworks were sound. The investigators concluded that this issue of cyber-security appears to pertain to the firms' acute awareness and uncertainty over how new ICT and/or CPS under Industry 4.0 will affect their current security measures, how they can/should operate, and whether their current systems could cope with the extra resources required. Paired with cyber-security uncertainty, the firms involved reported **difficulties in integrating different digital systems within and across their businesses**, and this was evident in both the interviews and the survey responses. ITC systems interoperability appears to be a common and significant barrier affecting (as well as affected by) the integration of digital platforms and data management across horizontal and vertical integrations. The challenge of integration is a perceived as a major barrier to the adoption of Industry 4.0, predominantly in how it would impact the supply chain both internally and externally. Overall, the firms involved reported a **lack of resources to support better use of data analytics** and business information capability. Similar to a concern over cyber-security, this can be interpreted as both an awareness of a much higher level of demand imposed by the adoption of Industry 4.0, and a lack of confidence or certainty as to whether the firms could cope with changes and afford the upgrades.

And, finally, a significant challenge for all firms was the **difficulties experienced in accessing relevant training resources for their current workforce or recruiting appropriate technical expertise to support the transformation to Industry 4.0**. The interviews attributed to this issue to factors such as leadership, business

culture, government support, remuneration and career attractiveness, tertiary education and professional training, and the socio-economic aspect. The survey analysis revealed concerns over government funding and education support, technical skills of their workforce, workforce readiness for change (skills and mindset) as well as technical skills of supply chain partners. Correlating the findings from both phases, it is apparent that the capability of the workforce (or lack of it) across the manufacturing industry eco-system presents as the most fundamental challenge for Industry 4.0 readiness.

Opportunities and Recommendations

By drawing upon existing literature and Industry 4.0 maturity models, the analysis of the interviews and Industry 4.0 Transformation Maturity Index results also identified opportunities in response to those barriers and challenges for transition toward Industry 4.0 and digitalization. The findings from the case study have led to key recommendations (see Fig. 8.6) to inform relevant stakeholders about what can be done at the organizational level, at the government level, and what role higher education providers can play to support Industry 4.0 readiness and maturity of the industry sector.

Based on the findings from the qualitative interviews and quantitative surveys, *culture change, workforce readiness* and *capability* for digital technology and data security were identified as the key barriers and challenges faced by individual organizations in the City of Salisbury. To overcome these challenges, **senior leaders need to embrace and support digitalization and a culture of innovation within organizations**. This requires senior leadership to view Industry 4.0 and digital innovation an essential, rather than optional, strategic direction for business growth. This can



Fig. 8.6 Recommended actions for enhancing Industry 4.0 maturity

be informed by successful examples and best practices. To help firms overcome the inertia of transitioning into Industry 4.0, it is especially crucial to foster improvement of readiness and aptitude for changes. This means that organizations also need to **invest in upskilling their workforces and upgrading digital technology**. This includes investing in IT resources, data analytics, and engagement with universities and professional education institutes to leverage the development of internal capability. Upgrading the workforce should start with fostering cultural changes and overcoming inertia (both organizational and individual) imposed by established habits and legacies. Then, organizations can start introducing specific skills for their employees in relation to digitalization, data capability and security, and business model innovation.

Meanwhile, organizations can benefit by **actively engaging with external collab- orations** for peer learning and peer-support by working closely with universities, and government agencies. This can be enabled by taking part in themed workshops, roundtables, forums, Industry 4.0 test labs and hubs, and 'living lab' consortia. For the role of universities, the findings from this investigation encourage enhancing **education and research in Industry 4.0-related skills and knowledge**. It is important to develop a suite of case studies and learning resources to support manufacturing SMEs for their confidence and motivation to develop their own Industry 4.0 initiatives and paths of transformation through learning from peers and examples of 'best practice' relevant to their businesses. It is also recommended that universities establish/enhance an Industry 4.0 focus by including important aspects in their education and engagement programs, within the realms of engineering and business, to create a platform that supports industries, especially SMEs, in developing and testing new technological and business solutions. The role of governments can focus on providing **support and funding opportunities for fostering Industry 4.0 transformation**. These include designing, and advocating for, grant schemes, taxation, and other bene- fits to incentivize manufacturing SMEs to adapt their equipment, digital technology and business models for Industry 4.0 capability. Also, tailored programs need to be implemented to support manufacturing SMEs to access reskill/upskill training resources and activities for their workforce development.

Furthermore, it is vital for having **regional strategies and initiatives for Industry**

4.0 to establish a collaborative eco-system to nurture and facilitate digitalization and business innovation of the manufacturing sector, fostering opportunities for knowledge sharing, for testing and adopting new technology and business ideas, and for developing confidence in Industry 4.0 Transformation. Such strategies and initiatives also need to advocate change and innovation to local firms, at all levels. Innovation associated with business transition toward Industry 4.0 is always risky, and always brings a level of discomfort to firms and to individuals. Supporting the concept of change and innovation in the City of Salisbury—in firms as well as in schools and in the public mindset—will help to position industries and broad communities to embrace the changes that are needed.

8.5 Conclusion

This chapter presents a study exploring how manufacturers operating in the City of Salisbury, South Australia, embrace transition toward Industry 4.0 and digitalization. By employing a combination of literature review, qualitative interviews and analysis, and quantitative survey, the case study was designed to inform current knowledge and practices, identifying barriers and challenges to the adoption of Industry 4.0 and digital innovation. The investigation conducted in-depth analysis on readiness and maturity of manufacturing SMEs for Industry 4.0 transformation on key factors such as Business; Technology; Skills; Supply Chain; and Innovation.

Manufacturing firms in the City of Salisbury region were assessed on a 5-level (Very Low to Very High) Industry 4.0 Transformation Maturity Index (I4-TMI), showing an **overall median maturity of 3.8** (**Medium**). Supported by both qualitative analysis and quantitative evidence, particular weaknesses in Industry 4.0 Transformation Maturity affecting SMEs were identified under the areas Business, Technology, Skills and Supply Chain. As a result, a range of recommendations were proposed to tackle these issues, as a means for accelerating Industry 4.0 transformation in the City of Salisbury.

The recommendations address not only what needs to be done, but also the key stakeholders involved. In general, across different stakeholders, there is a need for a renewed and concerted effort to identify, capture and create synergies across existing initiatives, programs and entities. Creating a strong partnership between local manufacturers, government authorities (both local and state), and tertiary education institutions should be prioritized to enhance the understanding of and the impact of Industry

4.0 on jobs and business growth and to ensure a successful journey in adopting the Industry 4.0 and digitalization for the manufacturing industry and beyond.

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References

Australian Industry Group (AiGroup) (2019) Australian manufacturing in 2019: local and global opportunities. Retrieved from https://cdn.aigroup.com.au/Economic_Indicators/Economic_Out look/Australian_Manufacturing_in_2019.pdf

Australian Signals Directorate (ASD) (2019) Essential eight explained. Australian Government. Retrieved from https://www.cyber.gov.au/sites/default/files/2020-01/PROTECT%20-%20Esse ntial%20Eight%20Maturity%20Model%20%28July%202019%29.pdf

Braun V, Clarke V (2006) Using thematic analysis in psychology. Qualit Res Psychol 3(2):77–101. https://doi.org/10.1191/1478088706qp063oa

Braun V, Clarke V (2013) Successful qualitative research. A practical guide for beginners. Sage Publications, London

CSIRO Futures (2016) Advanced manufacturing: a roadmap for unlocking future growth opportunities for Australia. Commonwealth Scientific and Industrial Research Organisation (CSIRO). Retrieved from https://www.csiro.au/en/Do-business/Futures/Reports/Advanced-man ufacturing-roadmap

Dalenogare LS, Benitez GB, Ayala NF, Frank AG (2018) The expected contribution of Industry 4.0 technologies for industrial performance. Int J Prod Econ 204:383–394. https://doi.org/10.1016/j. ijpe.2018.08.019

Ghobakhloo M (2018) The future of manufacturing industry: a strategic roadmap toward Industry 4.0. J Manuf Technol Manage 29(6):910–936. https://doi.org/10.1108/jmtm-02-2018-0057

Hecklau F, Galeitzke M, Flachs S, Kohl H (2016) Holistic approach for human resource management in Industry 4.0. Procedia CIRP 54:1–6. https://doi.org/10.1016/j.procir.2016.05.102

Ibarra D, Ganzarain J, Igartua JI (2018) Business model innovation through Industry 4.0: a review. Procedia Manuf 22:4–10. https://doi.org/10.1016/j.promfg.2018.03.002

Kopp J, Basl J (2017) Study of the readiness of Czech companies to the Industry 4.0. J Syst Integr 8(3):39–45. https://doi.org/10.20470/jsi.v8i2.313

Lee J, Bagheri B, Kao H-A (2015) A cyber-physical systems architecture for Industry 4.0-based manufacturing systems. Manuf Lett 3:18–23. https://doi.org/10.1016/j mfglet.2014.12.001

Liao Y, Deschamps F, Loures EDFR, Ramos LFP (2017) Past, present and future of Industry 4.0— a systematic literature review and research agenda proposal. Int J Prod Res 55(12):3609–3629. https://doi.org/10.1080/00207543.2017.1308576

Morrar R, Arman H, Mousa S (2017) The fourth industrial revolution (Industry 4.0): a social innovation perspective. Technol Innov Manage Rev 7(11):12–20. http://doi.org/10.22215/timrev iew/1117

Schumacher A, Erol S, Sihn W (2016) A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises. Procedia CIRP 52:161–166. https://doi.org/10.1016/j.pro cir.2016.07.040