Organisational Dynamic Capability for Innovation Waves in the Australian Heavy Industry

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ABSTRACT

The heavy industry, a cornerstone of Australia’s economy, faces distinct challenges necessitating the adoption of advanced technologies to maintain global competitiveness. Unlike standardised manufacturing, the heavy industry requires customised technological solutions that seamlessly integrate with existing processes and infrastructure. This thesis addresses the organisational capabilities that are crucial for a successful transformation using advanced technologies, focusing on the shipbuilding, mining, and oil and gas sectors. The existing literature on organisational capability has primarily employed dynamic capability theory, concentrating on digital transformation and Industry 4.0, while neglecting the interconnected nature of Industry 5.0. Studies on organisational dynamic capabilities have often been fragmented, with limited categorisation under sensing, seizing and reconfiguring capabilities, and have seldom been conducted within the heavy industry context. Further, the existing research has inadequately explored the interrelationships among these capabilities.

This thesis aimed to investigate the organisational dynamic capabilities required for a successful transformation for the waves of innovation, namely digital transformation, Industry 4.0 and Industry 5.0, in the Australian heavy industry. The central research question explored how the Australian heavy industry builds organisational dynamic capabilities for these innovation waves. A qualitative research methodology was employed, comprising 24 semi-structured interviews with Australian heavy industry practitioners, including one Chief Operating Officer, 12 managers and 11 senior engineers, each with a minimum of three years’ experience in transformation processes in innovation waves.

The findings revealed 10 capabilities and 41 attributes under the categories of sensing, seizing and reconfiguring. Additionally, 25 interrelationships were identified, and reconfiguring capabilities, particularly leadership, communication, and cultural transformation emerged as the most significant. The thesis findings highlighted sector-specific differences, noting that, despite government transformation initiatives fostering a digital vision and strategic alignment in the shipbuilding sector, the findings may not fully capture its innovativeness. In contrast, the mining sector focuses on purpose-driven technology adoption, while the oil and gas sector is shaped by external influences. The thesis found that all three sectors exhibit distinct innovative characteristics, each driven by their unique priorities and external pressures. Age differences also affected innovation processes, with older employees providing valuable product knowledge despite resistance to new technologies, while younger employees are more open to change but may lack industry-specific expertise.

This thesis concluded that sensing (strategic foundation, knowledge management), seizing (value recognition, implementation strategies, resistance management) and reconfiguring (continuous integration, leadership, communication, cultural and skill transformation) capabilities are vital for successful transformations in the Australian heavy industry. Understanding their interrelationships, particularly the significance of leadership and communication, is critical. The implications for the Australian heavy industry include the need to develop tailored organisational capabilities aligned with sector-specific challenges. For policymakers, several strategic recommendations for navigating the innovation waves were made, including strengthening strategic foundations, fostering knowledge sharing, supporting tailored value recognition, promoting clear communication, facilitating continuous integration, enhancing leadership development, encouraging cultural transformation and investing in skill transformation. These measures are aimed at ensuring sustained competitiveness and growth in the Australian heavy industry.

DECLARATION

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

Ryan Jang

10 November 2024

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LIST OF ABBREVIATIONS

AI	artificial intelligence
AR	augmented reality
CDO	chief digital officer
CIO	Chief Information Officer
CMM	Capability Maturity Model
COO	Chief Operating Officer
GDP	gross domestic product
IoT	Internet of Things
IT	information technology
ML	machine learning
R&D	research and development
ROI	return on investment
RQ	research question
SME	small and medium-sized enterprise

CHAPTER 1: INTRODUCTION

1.1 Objective

This chapter presents an overview of the thesis, outlining its background and research rationale, aims and guiding research questions. It details the scope, methodology and structure of the thesis, followed by the theoretical framework and contribution.

1.2 Background and Research Rationale

This thesis is a study investigating organisational dynamic capabilities for innovations waves (digital transformation, Industry 4.0 and Industry 5.0) in the Australian heavy industry. It also seeks to uncover the interrelationships between the capabilities.

In the context of the Australian heavy industry, the significance of innovations such as digital transformation and Industry 4.0 and Industry 5.0 has been recognised. These advancements are crucial for maintaining competitiveness in sectors such as shipbuilding, mining, and oil and gas. For example, the Australian shipbuilding industry is currently undergoing a significant shift towards digital transformation, underscored by BAE Systems Australia’s AUD 100 million investment as part of an AUD 35 billion frigate project initiative (Defence Connect 2017). This investment is expected to double the number of contractors and supply chains by 2026 (Defence 2017).

Despite the promising potential of such innovations, the heavy industry faces substantial challenges owing to its inherent complexities, with multiple layers of management to engage and numerous concurrent issues. The industry is characterised by custom-designed products, extended delivery times and large-scale operations. Projects often involve intricate processes, with hundreds of kilometres of pipes or cables, and thousands of personnel required to complete tasks (Bock 2015). These unique characteristics underscore the difficulties inherent in innovation with advanced technologies in the industry. BAE Systems Australia has articulated a vision for an entirely digital shipyard that highlights the necessity for robust sovereign shipbuilding capabilities for national security and industrial resilience (Roberts 2022). However, the discourse on innovation within the heavy industry often overlooks a crucial component: organisational capabilities. Jabbour et al. (2020) stressed that these capabilities are essential for overcoming the challenges posed by advanced technologies and leveraging the opportunities they present.

Organisations globally are navigating technology-driven shifts, and advanced technologies are posing a persistent challenge in terms of both theory and practice (Baiyere et al. 2023). Over the past decades, scholars have investigated various concepts of industrial innovation, including digital transformation (Andriole 2017), Industry 4.0 (Fatorachian & Kazemi 2021) and Industry 5.0 (Horvath 2023), with the aim of enhancing organisational efficiency and productivity through the strategic deployment of advanced technologies. Although these innovations have been recognised as progressive (Lookman, Pujawan & Nadlifatin 2023; Ramírez-Gordillo et al. 2023), they are inherently interconnected and complementary. For instance, Industry 5.0 is viewed as an extension of Industry 4.0 rather than a distinct industrial revolution (Thomas et al. 2023). Industry 4.0 itself is driven by the advancement of digital transformation alongside intelligent objects, and these are all interconnected through rapidly evolving internet infrastructure (Lookman, Pujawan & Nadlifatin 2023).

These interconnections suggest that digital transformation, Industry 4.0 and Industry 5.0 should be studied as cohesive innovations, referred to as 'innovation waves' in this thesis, rather than in isolation. The concept of innovation waves provides a more comprehensive understanding of how advanced technologies can collectively drive organisational innovation. Additionally, these waves can be viewed through the lens of innovation cycles, where each wave progresses through phases of adoption, integration, and renewal. Innovation cycles underscore the iterative nature of technological advancements, as organisations continually refine their approaches in response to evolving challenges and technological developments (Tidd & Bessant 2018).

Despite the widespread discussion and implementation of the innovation waves over the past decade, many organisations continue to face challenges in executing successful innovation. While Industry 5.0 builds upon the digital advancements of Industry 4.0, it introduces a shift towards human-centric, sustainable, and socially responsible applications of technology, marking a distinct evolution that extends beyond pure digitalisation (Horvath 2023). This new emphasis brings challenges in areas such as human-machine collaboration, social impact, and ethical technology management, which remain underexplored in dynamic capability research.

Many studies have explored digital transformation and Industry 4.0, but many industries still struggle with implementation issues, particularly because of the lack of guidance on capability development (Ghosh et al. 2022). To effectively navigate this technology-driven shift, it is essential for organisations to develop robust capabilities. Organisational capability refers to the ability of an organisation to effectively utilise resources, processes and knowledge to achieve its strategic objectives. It is reflected in how well an organisation's activities contribute to improving and enhancing operational performance (Al-Khatib 2022). Although much research has focused on technological and organisational capabilities, recent studies have underscored the importance of organisational capabilities as the most critical factor (Amaral & Peças 2021, Chonsawat & Sopadang 2021).

Organisational capability is the capacity of a firm to effectively adopt, manage, integrate, and innovate with acquired technologies, ensuring they contribute to sustained value and competitive advantage (Yalcin & Daim 2021). Organisational dynamic capabilities are a subset of organisational capability specifically focused on an organisation's ability to sense environmental changes, understand their implications, and effectively coordinate resources to adapt and respond to these shifts (Yan, Xi & Wu 2024). Unlike operational capabilities, which focus on maintaining stable and efficient routines, organisational dynamic capabilities encompass higher-order skills that enable organisations to sense, seize, and reconfigure to drive long-term strategic shifts (Yan, Xi & Wu 2024). This theoretical framework, rooted in the dynamic capability theory, provides insight into the proactive, adaptive processes that organisations deploy to align with strategic shifts and emerging demands.

While much of the current dynamic capability literature centres on Industry 4.0’s digital transformation, the Industry 5.0 context presents unique challenges and opportunities related to human-centred and sustainable transformation, highlighting a significant research gap. These two realms are not only additions but transformative shifts that redefine how organisations interact with technology, workers, and the environment. This distinction is critical because dynamic capabilities in Industry 4.0 predominantly focus on technology-driven adaptability, efficiency, and automation, while Industry 5.0 necessitates capabilities that embrace ethical considerations, worker well-being, and environmental sustainability as central to organisational adaptation and innovation. Understanding and enhancing these dynamic organisational capabilities is, therefore, crucial for successfully navigating the transformation necessary for the upcoming waves of innovation, particularly as Industry 5.0 brings new dimensions to organisational adaptation and resilience.

1.3 Research Aims and Questions

The aim of the thesis was to investigate the organisational dynamic capabilities required for successful transformation for innovation waves (digital transformation, Industry 4.0 and Industry 5.0) in the Australian heavy industry (shipbuilding, mining, oil and gas). It sought to contribute to the body of knowledge by synthesising the thesis findings into those from recent studies to serve as a resource for industry leaders, policymakers and researchers. It aimed to offer guidance on how to navigate capability building to capitalise on the opportunities presented by the innovation waves. This involved making a significant contribution to the academic discourse on dynamic capability in relation to digital transformation, Industry 4.0 and Industry 5.0 by providing a nuanced understanding of the capabilities and their interrelationships within the Australian heavy industry. It also aimed to draw conclusions about how the Australian heavy industry shapes the trajectory of dynamic capability building required for innovation waves. To make a meaningful contribution to theory and practice, the aim of the thesis was to answer the overarching question below:

"What are the key organisational dynamic capabilities and their interrelationships that enable the Australian heavy industry to build and support innovation waves (digital transformation, Industry 4.0, and Industry 5.0)?". This overarching question is expanded into the following two sub-research questions (RQs):

> *RQ1: What are the key organisational dynamic capabilities (sensing, seizing and reconfiguring) required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0) in the Australian heavy industry?*
>
> *RQ2: How are organisational dynamic capabilities interrelated in the Australian heavy industry?*

1.4 Theoretical Foundation

The theoretical foundation of the thesis lay in a combination of the literature related to digital transformation, Industry 4.0 and Industry 5.0, collectively referred to as innovation waves throughout this thesis. These waves capture the ongoing phases of technological and organisational transformation that shape modern industry practices. Industry 4.0, driven by digitalisation and smart technologies, prioritises efficiency and automation, while Industry 5.0 extends this by focusing on human-centric, sustainable approaches to technological advancement. This combined framework highlights the need for organisations to continually adapt, learn, and evolve to leverage new technologies and remain competitive.

The concept of innovation waves underscores the recurrent and iterative nature of industrial transformation, where each wave builds upon the technological and strategic advances of the previous one. This progression reflects an ongoing cycle in which organisations are challenged to enhance their capabilities to navigate emerging innovations effectively. In this context, innovation waves are not merely isolated advancements; they represent an interconnected continuum of transformation that requires a cohesive approach to capability development.

To investigate how organisations can strategically respond to these evolving waves of innovation, this thesis adopted organisational dynamic capability theory. Dynamic capability theory emphasises the higher-order capabilities necessary for organisations to sense, seize, and reconfigure resources in response to changing environments, making it a fitting framework to examine the adaptive responses required for innovation waves. This framework allows for a nuanced exploration of the organisational capabilities needed for both incremental and transformative change.

Through an initial theoretical framework, this thesis identifies the organisational dynamic capabilities required for innovation waves within the Australian heavy industry, focusing on sectors such as shipbuilding, mining, and oil and gas. By drawing on established dynamic capability literature, the framework highlights critical interrelationships among these capabilities, specifically how sensing, seizing, and reconfiguring capabilities collectively drive adaptation and innovation within these sectors. Figure 1 illustrates the theoretical positioning of the thesis, situating organisational dynamic capabilities as a foundational element in navigating the continuous waves of innovation.

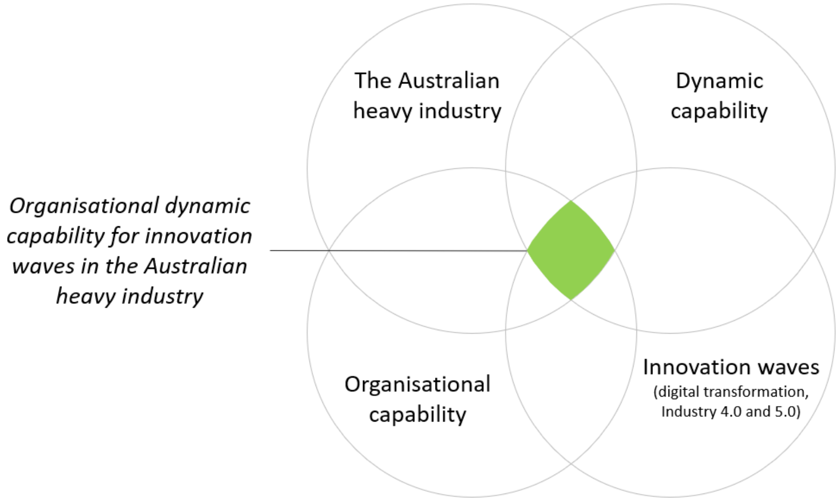


Figure 1: Theoretical foundations of the thesis

This framework serves as the basis for the empirical investigation, guiding the analysis which explores how Australian heavy industry organisations develop and deploy these capabilities to meet the demands of digital transformation and evolving industry paradigms.

1.5 Methodology

This thesis adopted a constructivist philosophical stance to facilitate an in-depth exploration of the participants' experiences and perspectives. It aimed to understand the subjective human experiences and the meanings attributed to events and activities within their own contexts (Crotty 1998, p. 256).

To comprehend the complexity of the participants' meanings, a qualitative research methodology was employed. This methodology allows for a thorough exploration beneath the surface, yielding nuanced insights (McMurray, Pace & Scott 2004). A total of 24 semi-structured interviews were conducted with practitioners from the Australian heavy industry. The participants included one chief operating officer (COO), 12 managers and 11 senior engineers, all with a minimum of three years' experience in the industry and involvement in digital transformation processes. This approach enabled a detailed examination of the research questions (Minichiello, Aroni & Minichiello 1990).

The research design of the thesis comprised six sequential phases, as illustrated in Figure 2.

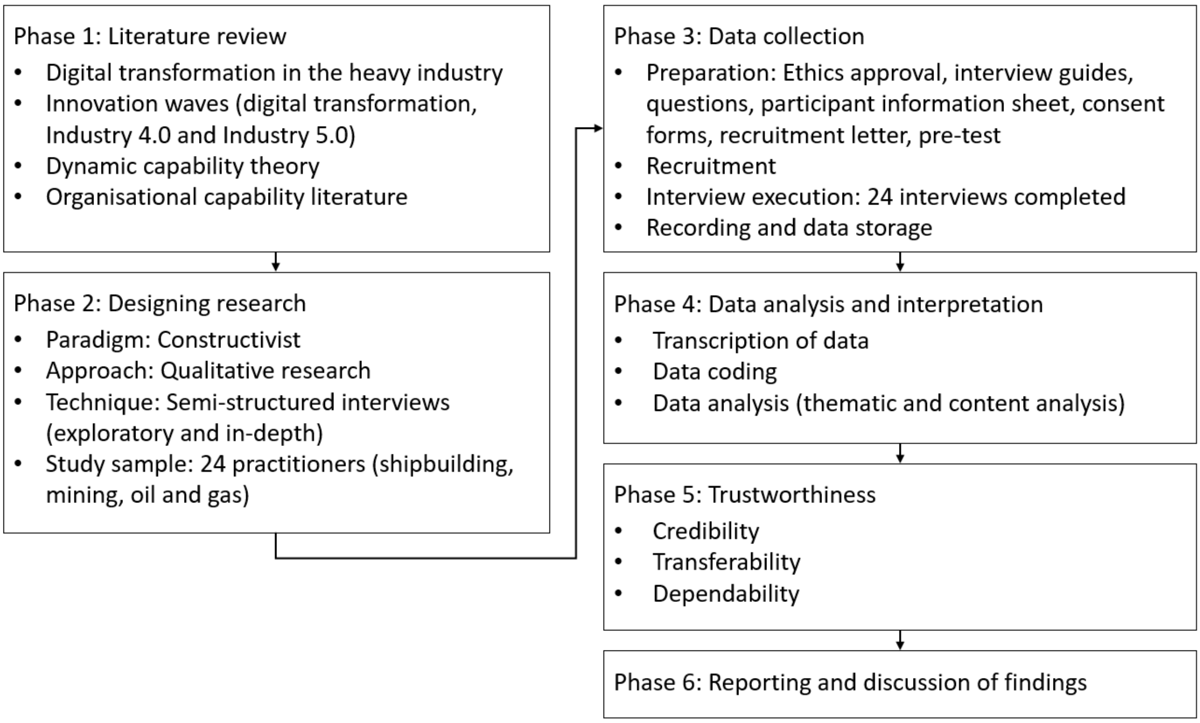


Figure 2: Research methodology process

In the Phase 1 literature review, an extensive review of digital transformation and Industry 4.0 within the heavy industry sector was conducted for the research context. The subsequent review included various innovation waves concepts, such as digital transformation, Industry 4.0 and Industry 5.0, to understand the relationships among them. Additionally, organisational capability and dynamic capability theories relevant to these innovation waves were reviewed to position the thesis within the theoretical research landscape.

The Phase 2 research design explained how the research paradigm, the methodological approach and specific techniques were selected.

The data collection in Phase 3 involved preparing ethics approval documents, including interview guides, questions and participant information sheets, followed by the recruitment of participants. A total of 24 practitioners were interviewed.

In Phase 4, the data analysis and interpretation illustrated how the collected data were transcribed and analysed using Microsoft Excel and NVivo 12.

The Phase 5 trustworthiness stage established how the credibility, transferability and dependability of the research were ensured.

The reporting and discussion of findings in Phase 6 involved reporting and discussing the thesis findings.

This methodological framework provided a comprehensive approach to investigating the research questions, ensuring robust and credible results.

1.6 Structure of Thesis

Following the first introduction chapter, Chapter 2 (Context) explores the significance of the Australian heavy industry and its future direction in digital transformation. It highlights the challenges faced by the industry, particularly focusing on the need to develop organisational capabilities to navigate these challenges effectively. The chapter underscores the importance of recognising and cultivating the specific organisational capabilities essential for facilitating digital transformation, ensuring long-term success and maximising the impact of advanced technologies.

Chapter 3 (Literature review) reviews the existing literature on organisational dynamic capabilities in the context of recent innovation waves, including digital transformation, Industry 4.0 and Industry 5.0. It derives the research questions and informs the development of a conceptual framework tailored to the Australian heavy industry context. The chapter lays the groundwork for subsequent empirical investigation, aiming to elucidate the organisational capabilities needed for successful transformation with innovation waves.

Chapter 4 (Methodology) details the research process, beginning with the research design, including the research paradigm, approach, technique and study sample. It explains the data collection process, encompassing preparation, recruitment, interview execution, recording and data storage.

The chapter also covers data analysis and interpretation, including transcription, coding and analysis methods, and addresses the trustworthiness of the research by highlighting its credibility, transferability and dependability.

In Chapter 5 (Analysis of RQ1,) the first part of the qualitative data analysis is presented. It begins with an overview of the interviews conducted with Australian heavy industry practitioners, providing insights into the empirical study informants. The chapter then addresses the first research question by outlining the analysis results regarding the organisational dynamic capabilities required for innovation waves in the Australian heavy industry.

Chapter 6 (Analysis of RQ2) continues the qualitative data analysis, focusing on the second research question. It details the insights gathered in relation to the interrelationships among the organisational dynamic capabilities required for innovation waves. The chapter integrates the analysis results from both research questions into a comprehensive empirical framework.

The outcomes of the thesis within the context of the existing organisational dynamic capability literature and findings on the Australian heavy industry are discussed in Chapter 7 (Discussion). The organisational dynamic capabilities required for innovation waves and the interrelationships among these capabilities are considered. The chapter revises the theoretical framework established from the literature review and underscores the significance of the findings, outlining their contributions to the theoretical body of knowledge.

Finally, Chapter 8 (Conclusion) presents the thesis conclusion. It begins by summarising the significance of the findings, then details the contributions to theory and the practical implications. The chapter also addresses the limitations of the thesis and suggests directions for future studies.

1.7 Significant Contribution

This thesis significantly contributes to the existing body of knowledge by answering the proposed research questions since it examines ‘particular contemporary phenomenon within its real-life context using multiple sources of evidence’ (Robson 2002, p. 178). Significant contributions include the following:

1. The thesis contributes to the body of knowledge on organisational capability by identifying and validating organisational dynamic capabilities within the context of the Australian heavy industry, thereby extending the current research into dynamic capabilities for digital transformation (Feroz et al. 2023; Ghosh et al. 2022) and Industry 4.0 (Cruzara et al. 2023;

Lepore et al. 2023), and contributing to the understanding of Industry 5.0 (Chavez et al. 2023; Narkhede et al. 2024).

2. This thesis unveils and explains the interrelationships among dynamic capabilities in the Australian heavy industry, providing empirical evidence that supports the theoretical propositions by Helfat and Winter (2011) regarding the strategic complexity created by these capabilities. It extends the broader literature on dynamic capabilities (Brewis, Dibb & Meadows 2023; Di Stefano, Peteraf & Verona 2014; Schilke, Hu & Helfat 2018; Yeow, Soh & Hansen 2018) and offers a clearer roadmap for leveraging synergistic interactions.
3. This thesis develops a comprehensive framework of organisational dynamic capability tailored to the Australian heavy industry. It offers a holistic perspective on each capability, addressing a gap in the research that has not been previously explored. By extending the discourse to include Industry 5.0, this thesis provides insights specifically relevant to the heavy industry, unlike most of the existing literature, which focuses primarily on digital transformation and Industry 4.0 (Warner & Wäger 2019; Ghobakhloo et al. 2023c; Vu et al. 2023; Dubey et al. 2024).
4. By identifying the context-specific boundary conditions of the organisational dynamic capabilities required for innovation waves in the Australian heavy industry, this thesis addresses a gap in the existing literature that has often provided generic insights or has been focused on other industries (Dubey et al. 2024; Ellström et al. 2022; Feroz et al. 2023; Ghobakhloo et al. 2023c; Lepore et al. 2023; Vu et al. 2023; Warner & Wäger 2019).
5. This thesis generates knowledge to guide policies that can enhance organisational capability building and support the Australian heavy industry’s transition towards robust organisational capabilities, thereby helping to meet global demands.

1.8 Summary

This introductory chapter outlined the thesis aims and questions, providing a comprehensive overview of the thesis. It showed the background and rationale for the research, clarified the scope and presented the structure of the thesis. This chapter also established the theoretical foundation, highlighting the detailed the contributions to both theory and practice. The subsequent chapter introduces the theoretical underpinnings of the thesis, offering a detailed exploration of the relevant concepts and frameworks.

CHAPTER 2: CONTEXT

2.1 Objective

The aim of this chapter is to provide an overview of the thesis context, with a specific focus on heavy industry sectors including shipbuilding, mining, and oil and gas. Section 2.2 includes the definition of 'heavy industry', underscoring its characteristics and significance within the Australian economy. Building on this foundation, Section 2.3 examines the emerging trends and future directions of the heavy industry. Further, Section 2.4 investigates the nuanced organisational challenges pervasive in the heavy industry, shedding light on the critical, yet little studied, area of organisational capabilities for successful transformation required for innovation waves within the heavy industry.

2.2 Heavy Industry and Its Significance in Australia

The 'heavy industry' is defined as 'an industry that produces large industrial products, which requires large and heavy machinery and facilities and involves complex production processes' (CFI 2024, p. 1), and the products include coal, iron, oil and ships (Kenton 2021). These sectors, encompassing shipbuilding, mining, and oil and gas, are characterised by their labour-intensive operations and intricate supply chains. The heavy industry operates on a grand scale, involving massive machinery, complex logistics and extended project timelines (CFI 2024). These distinctive features mean that the technology adoption journey is challenging, as shown in Table 1, but this adoption is essential for sustained growth and competitiveness.

Table 1: Characteristics of the heavy industry

No.	Characteristics	Description
1	Custom orders	Heavy industry often deals with highly specialised and unique products tailored to individual client specifications. This customisation requires specialised skills, resources, and extended production times to meet specific project demands.
2	Long delivery time	Due to the complexity and scale of heavy industry projects, production and delivery timelines are often extended. This is compounded by intricate manufacturing processes, high levels of customisation, and coordination across multiple stakeholders.
3	Labour-intensive	Heavy industry frequently relies on a large workforce, requiring manual effort across various stages of production. The work often demands specialised skills and can involve physically demanding tasks, contributing to high labour costs.

No.	Characteristics	Description
4	Expensive	Manufacturing in the heavy industry incurs significant costs due to factors like complex machinery, specialised materials, and high labour needs. The custom and large-scale nature of projects further increases financial requirements.
5	Heavy and big	Products in the heavy industry are typically large in size and weight, such as machinery, infrastructure components, and vessels. This characteristic adds logistical challenges in handling, transportation, and storage.
6	Large required	The production and assembly of large, complex products require extensive space, from manufacturing facilities to storage areas. This need for substantial physical space can increase operational costs and logistical complexity.
7	High-risk safety	Heavy industry involves high-risk activities, such as operating large machinery or handling hazardous materials. Ensuring worker safety requires stringent regulations, safety protocols, and constant monitoring to minimise accidents.
8	Complex stakeholders (client, vendor, sub-contractor, supplier)	Heavy industry projects involve multiple stakeholders, including clients, vendors, subcontractors, and suppliers. Coordinating these diverse interests and requirements adds layers of complexity to project management and communication.
9	Interconnection (stages, stakeholders)	Projects in heavy industry require the integration of multiple stages and the collaboration of various stakeholders. Effective communication and coordination across these interdependent stages are essential for successful project completion.
10	Designed millions of times and manufactured once	Products are typically highly customised, requiring extensive design iterations before a single, final product is manufactured. This design-intensive process ensures the product meets exact specifications but adds to the project's time and cost.
11	Many changes (change order, design changes, as built)	Heavy industry projects often undergo multiple design and specification changes during production. These changes, such as change orders and design adjustments, add complexity to project management and
12	Massive information volume	Managing projects in the heavy industry involves processing a large amount of information, from technical data to regulatory compliance documents. Handling this volume of information requires robust data management systems and coordination among project teams.

Source: Author.

Heavy industry sectors operate on a scale that sets them apart from conventional manufacturing. For instance, shipbuilding involves the construction of immense vessels using complex processes such as design, engineering, procurement and commissioning, often spanning several years (Sánchez-Sotano et al. 2020). Mining involves the extraction of resources from vast landscapes, necessitating enormous equipment and intricate logistics (Muduli et al. 2013). Oil and gas operations range from field development to exploration, drilling and refining on a massive scale, involving a time-consuming process and taking several years to complete a production facility (Wanasinghe et al. 2020).

The heavy industry relies on intricate supply chains that encompass multiple tiers of suppliers, globally sourced components and varied raw materials. The extended supply chains require efficient coordination and management to ensure uninterrupted operations and timely project deliveries (Sánchez-Sotano et al. 2020). Moreover, the heavy industry often operates in demanding environments, from the extreme conditions of offshore oil rigs (Roberts et al. 2021) to the remote and challenging terrain of mining sites (Shook 2015). This adds an additional layer of complexity in terms of implementing and maintaining advanced technologies, which must withstand harsh conditions and provide accurate data in real time.

The large scale of equipment, machinery and infrastructure required by heavy industry sectors translates to the need for substantial initial investments (Baginski, Pitassi & Barbosa 2017). Integrating advanced technologies into these operations requires considerable capital, with the added challenge of demonstrating a clear return on investment over the long term. However, understanding the clear return on investment is challenging owing to the high level of resistance to the adoption of advanced technologies (Roberts et al. 2021) and their extended lifecycles that span years (Wanasinghe et al. 2020). The extended timeline complicates technology adoption, since solutions must remain relevant and effective over the long term. Further, the perceived speed at which new technologies can be developed and commercialised is inefficient, given that it takes several years to develop and implement new technology in the mining sector (Bartos 2007).

The heavy industry is a cornerstone of Australia’s economy, contributing significantly to gross domestic product (GDP), and creating direct and indirect employment opportunities and export earnings. For instance, the Australian Government is investing a substantial amount, approximately AUD 90 billion, in new naval ships and submarines, and up to AUD 62 million in workforce growth and upskilling (Australian Government Defence 2024b). This initiative, representing the largest capital investment in Australia’s history, signifies a pivotal shift in how the nation safeguards its security interests, particularly through the shipbuilding industry. This investment is not only about constructing ships and submarines, but also aims to cultivate a sustainable naval shipbuilding and maintenance capability, fostering industry growth and creating secure job opportunities for the future (Australian Government Defence 2024a). However, achieving this goal requires consistent, long-term planning and commitment to develop the naval shipbuilding sector, its infrastructure and its workforce. A coordinated approach involving the entire nation, industry and government is essential for its success.

Regarding the mining, and oil and gas sectors, in 2021–22, Australia's exports of minerals, metals and energy commodities amounted to AUD 13 billion, constituting 69% of total export revenue (Constable 2023). The export of minerals and energy products significantly contributes to the nation's trade balance and strengthens diplomatic ties with trading partners. Additionally, in 2022, the Australian minerals sector contributed an estimated AUD 64 billion in company taxes and royalties, marking a AUD 21 billion increase from the previous year (Constable 2023). Moreover, the mining sector alone employs a substantial portion of the country's workforce (approx. 200,000) and generates billions of dollars in export revenue (Statista 2023). The heavy industry drives infrastructure development in the regions where the operations are located. Ports, roads, railways and energy facilities are established to facilitate the transportation of goods and resources, contributing to regional growth and connectivity.

2.3 Future Direction for Digital Transformation

The unique characteristics of the heavy industry introduce distinct challenges and underscore the necessity for embracing digital transformation via the use of advanced technologies to remain competitive on a global scale (Roberts et al. 2021). The emergence of digital transformation, characterised by the integration of advanced technologies into industrial processes, offers transformative opportunities for the various sectors of the heavy industry (Wanasinghe et al. 2020). Digital transformation can play a crucial role in improving the heavy industry for the following reasons: (1) it is a labour-intensive industry so wellbeing and safety are of vital importance, (2) there are many contractors within entire supply chains and (3) there are a variety of materials that can be reused for sustainability (Fraga-Lamas, Varela-Barbeito & Fernandez-Carames 2021). Since the heavy industry is a low-volume, high-mix industry with long-term, complex characteristics, work and production progress vary greatly over time. Production progress is often monitored and reported on by people surveying sites, describing issues such as task delay, quality issues and preventive maintenance (Torres Saenz 2018). The production process can be digitised, resulting in the effective management of progress, resources and tasks (Balasingham 2016).

As a future direction, it is critical for heavy industry sectors to continue adopting smart technologies that enable real-time monitoring, predictive maintenance, and enhanced safety protocols. This involves not only integrating existing Industry 4.0 technologies but also progressively moving towards Industry 5.0's human-centric, sustainable approach, thereby addressing both efficiency and social responsibility. There are many different approaches to transforming the traditional heavy industry, and it is important to look closely at the various approaches to determine the best way forward. Digital transformation through the adoption of Industry 4.0 technologies is seen as vital in realising this transformation to be competitive, as shown in Table 2.

Table 2: Benefits and examples of Industry 4.0 in the heavy industry

Industry 4.0 Technology	Benefits and examples	References
Intelligent robots	Next-generation robots are advancing towards enhanced functionality when integrated with other Industry 4.0 technologies, becoming more autonomous, flexible and cooperative through interactions with each other and in closer collaboration with humans (e.g. in welding and spraying applications).	Ang et al. (2017); Dharmawan et al. (2014); Meng et al. (2016); Rivas (2018)
Vision-based system	Automated maintenance processes include inspection, paint stripping and repainting.	Prabakaran et al. (2020)
Exoskeleton	Assists with tasks that require unfavourable postures, such as welding or heavy lifting.	Chu et al. (2014); Kondo et al. (2017)
Additive manufacturing	Create new components or repair worn ones, and produce batches of customised products, with construction benefits such as complex and lightweight designs.	Ang et al. (2017); Ziółkowski & Dyl (2020)
Augmented reality (AR) (head-mounted displays)	Provides employees with real-time information to enhance decision-making and work procedures through AR devices and helps create digitised visual workflows for worker training.	Ang et al. (2017); Fraga-Lamas et al. (2018)
Artificial intelligence (AI)	Utilised for object detection based on deep learning and AI-based safety management to oversee safety.	Choi, Park & Jang (2019)
Internet of Things (IoT)	Links physical objects with their virtual representations on the internet, allowing field devices to communicate and interact within an Industry 4.0 environment. This facilitates decentralised analytics and decision-making, enabling real-time responses.	Ang et al. (2017)
Big data analytics	Refers to the analysis of very large or complex datasets to support real-time decision-making by collecting and evaluating data from various internal and external sources within an organisation.	Ang et al. (2017)

Source: Author

Digital transformation is garnering significant interest and investment in the Australian heavy industry, which promotes technology integration to manufacturers and supply chains. A global example illustrating the future direction of the heavy industry is the Navantia shipbuilding. Navantia, a shipbuilding company, may be the global benchmark for naval shipbuilding projects since their digital strategy was globally recognised by international partners including the USA, the Netherlands and France (Rivas 2018). The company developed and implemented the Shipyard 4.0 model, aimed at inserting Industry 4.0 technology into future shipbuilding processes (Rivas 2018). The Shipyard 4.0 model pursues business outcomes by implementing specific transformation projects. The adoption of Industry 4.0 technologies enables vertical integration into different areas including workshops and docks, as well as with workers (Rivas 2018). The Shipyard 4.0 concept was developed along with information and communication technology (ICT) for interconnections among products, people and machines, a so-called cyber–physical system. The use of advanced sensors, big data, data mining and robots enables the detection of errors or defects in advance, which results in quality improvements and risk reduction in complex processes (Rivas 2018). Further, it allows the full flow of information between shipyard and supply chains, as well as value integration for clients. This can be considered horizontal integration, which enables effective collaboration between a wide range of stakeholders (Rivas 2018). In addition to the building process, the ship itself can be built with the smart ship concept through Shipyard 4.0 if smart sustainment is one of the business models (Rivas 2018). Thus, the effective implementation of Industry 4.0 technologies requires horizontal and vertical integration in all processes in the Shipyard 4.0 model (Rivas 2018). In this context, future direction in digital transformation involves pursuing greater horizontal and vertical integration across sectors, facilitating seamless communication and data flow within organisations and throughout the supply chain. This approach is essential for realising the full potential of digital transformation, enabling both operational efficiency and innovation.

In the context of the Australian shipbuilding sector, the construction of frigates for the Royal Australian Navy at the Osborne Naval Shipyard in Adelaide marks Australia’s largest manufacturing endeavour (Roberts 2022). Industry specialists BAE Systems Australia highlighted their vision of an all-digital shipyard at Osborne, emphasising the importance of developing a strong sovereign shipbuilding capability for national security and industrial resilience (Roberts 2022). Central to this effort is Australia’s first digital shipbuilding course, the Diploma of Digital Technologies, aimed at equipping employees with essential digital skills (Newsdesk 2020). By embracing smart manufacturing and digital technologies, BAE Systems Australia aims to attract the next generation of shipbuilders and STEM (science, technology, engineering and maths) students, fostering innovation and industry growth (Roberts 2022). As a future direction, building digital skills and fostering a skilled workforce through dedicated training programs and educational initiatives is critical. This direction is essential not only for supporting ongoing digital transformation but also for attracting talent and driving innovation within the sector. In shipbuilding, various benefits can be expected with the use of advanced technologies. For instance, IoT sensors are being integrated into vessels to monitor performance, fuel consumption and equipment health in real time (Ang et al. 2017). AI-driven simulations optimise ship simulations for efficiency and environmental impact (Sánchez-Sotano et al. 2020). Robots are being employed in shipyards for tasks such as welding and painting, enhancing precision and reducing human exposure to hazardous environments (Dharmawan et al. 2014).

Regarding other heavy industry sectors, the mining sector's transition to digitisation presents challenges, but by leveraging technology and confronting communication obstacles directly, mining organisations with advanced technologies can enhance both efficiency and safety (Eastwood 2023). At the 2023 Future of Mining event in Perth, Western Australia (WA), the critical role of digital transformation was emphasised for the future success of the mining industry, and the importance of digital transformation in remaining competitive and addressing challenges such as skilled labour shortages and environmental concerns was discussed (ABB 2023). The expected benefits include IoT-enabled equipment that offers remote monitoring, aiding predictive maintenance and optimising equipment usage. Mining companies may utilise AI algorithms to predict geological conditions, enhancing resource extraction and the use of autonomous vehicles for material transport, thus reducing risks for human operators (Shook 2015). The oil and gas industry in WA is experiencing a profound shift as companies increasingly integrate digital technologies to enhance production, safety and cost efficiency (Energy Club WA 2023). The potential benefits of this transformation are improved efficiency and productivity across the value chain (Energy Club WA 2023). For instance, by leveraging data analytics, IoT, AI and machine learning, companies can optimise processes, minimise downtime, and enhance safety and environmental performance (Energy Club WA 2023). However, challenges such as data management, cybersecurity and skill shortages accompany this digital evolution (Energy Club WA 2023). Future directions for digital transformation in these sectors involve addressing key challenges such as data management, cybersecurity, and skill shortages. Ensuring secure, efficient, and sustainable technology adoption across the value chain will be essential for realising the potential benefits of digital transformation in the heavy industry.

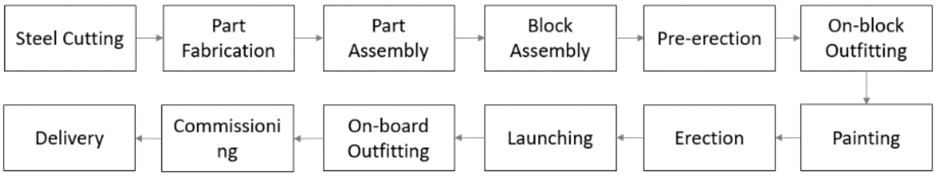
2.4 Challenges in the Heavy Industry

The scale, complexity and legacy systems of heavy industry operations demand bespoke solutions that can cater to specific requirements. Unlike standardised manufacturing, where off-the-shelf solutions can be easily adopted, the heavy industry requires tailored technologies that can seamlessly integrate into existing processes and infrastructure (Wanasinghe et al. 2020). The integration of Industry 4.0 technologies poses challenges in ensuring compatibility between various systems. The following sections illustrate the challenges for the various sectors of the heavy industry.

2.4.1 Challenges in Shipbuilding

Shipbuilding is a key heavy industry sector that contributes greatly to the Australian economy. The shipbuilding process is segmented into various processes (Figure 3), and each process involves numerous operations that utilise different technologies and materials. The operations interact with, and depend on, each other, resulting in a massive amount of data for each process (Iwańkowicz and Rutkowski 2023). Further, a shipbuilding project generally requires supervisors to attend to a wide range of issues and requests from workers on site. Their work is heavily dependent on paper-based activities. This non-digital work has long been the tradition in shipbuilding and has a detrimental impact on workflow and work performance. This has resulted in an issue with progress visibility, since real-time data collection is not possible with the existing paper-based management system. Consequently, the digital transformation of the entire shipbuilding process presents significant challenges. It is not uncommon to see most people working on a range of dangerous and challenging tasks.

Figure 3: Shipbuilding process



Source: Author

Tasks include cable installation, welding cutting, painting, erecting heavy blocks, scaffolding and pipe fitting (Pejić et al. 2023, p. 545). Working on these tasks in a large shipyard often requires exposure to hazardous environments, including working in confined spaces and at heights. A ship compartment can easily weigh over hundreds of tons, and steel plates are lifted and handled by cranes. Because of the complex characteristics of shipbuilding, various intrinsic issues have been found in relation to the digital transformation process in the shipbuilding sector (Ang, Goh & Li 2016), and this may add another layer of complexity when adopting Industry 4.0 technologies.

In modern shipbuilding, vessels are increasingly tailored to meet the specific needs of ship owners and operators. This customisation often involves adding additional equipment, such as monitoring systems, which necessitates changes in compartment shapes and the related systems (Ang, Goh & Li 2016). Additionally, changes in building materials, such as switching from stainless steel to titanium, are common. These deviations from the standard design and production processes disrupt the typical workflow, requiring extra manpower and inevitably leading to increased costs and extended project schedules (Ang, Goh & Li 2016). The volume and amount of design changes can be substantial. For example, according to Australian National Audit Office, there were approximately three revisions per drawing, which resulted in costly rework where production work was carried out using drawings that did not follow the latest design. Consequently, cost of design changes on the Air Warfare Destroyer program was estimated at around AUD 122 million (ANAO 2014, p. 89).

These types of issues can cause safety concerns since they may require work to be conducted overhead or in unusual positions, and there may be potential damage around other parts that require rework, such as painting and additional inspections. These design changes can also result in wasted parts. One example of this is a large-scale replacement of pipes in which 570 pipes were replaced after an inspection of 2,000 pipes, as shown in Figure 4.

Image removed due to copyright restriction.

Original can be viewed online at

https://www.anao.gov.au/sites/default/files/AuditReport_2013-2014_22.pdf

Figure 4: Pipe waste at Australian Submarine Corporation (ANAO 2014, p. 234)

As a result, the project productivity was lower than expected, showing a 60% increase in project production costs (ANAO 2014, p. 47).

Smart shipbuilding must encompass the entire product lifecycle, including design, production, commissioning and delivery. Implementing a comprehensive lifecycle perspective is fraught with challenges. Key difficulties include integrating various systems, fostering management collaboration and establishing effective lifecycle-tracking mechanisms (Vuletic 2015). These tasks are complex and require robust strategies to ensure smooth operation throughout a ship's lifespan. One of the most significant obstacles in the product lifecycle is the integration of various software tools used by shipyards and design firms. These tools, essential for modelling and structural analysis, often do not communicate effectively owing to their proprietary nature (Ang, Goh & Li 2015). Effective communication and system alignment become paramount, especially with the increased use of automated and sophisticated computer numerical control machines on the production floor, which also require consistent system architecture to function seamlessly during production (Ang, Goh & Li 2016).

Further, the existing mechanisms supporting Industry 4.0 adoption often fall short in handling the complexity and volume of modern data. Limitations include inadequate wireless connection speeds and insufficient system integration capabilities (Ang, Goh & Li 2016). Addressing these shortcomings is essential for the successful implementation of smart shipbuilding. Adopting Industry 4.0 in shipbuilding processes requires a large pool of highly skilled information technology (IT) professionals and computer engineers. These experts are essential for designing, implementing and maintaining the complex and integrated systems. However, finding such skilled personnel is challenging and costly, creating a significant barrier for companies aiming to implement these advanced technologies (Ang, Goh & Li 2016).

2.4.2 Challenges in Mining

The mining sector is undergoing a significant technological transformation that needs careful management to promote healthy and appealing work environments (Lund, Johansson & Lööw 2024). This transformation is conceptualised by the concepts of Industry 4.0 and, specifically, Mining 4.0 within the mining industry (Bongaerts 2020). The mining sector is experiencing unparalleled expansion, yet it confronts a multitude of internal and external obstacles. Within the industry, a scarcity of proficient workers has prompted mining firms to embrace automation and digitisation for operational enhancement (Eastwood 2023). Externally, fluctuations in worldwide resource prices affect the sector, necessitating swift adjustments (Eastwood 2023). The pressing challenge confronting Australian mining companies is underscored as the simultaneous presence of an aging skilled workforce and a younger generation showing a diminished interest in mining roles (ABB 2023).

Innovation in the mining sector is distinct from innovation in many other sectors (Shook 2015). It is frequently characterised as an industry that resists or slowly adopts technological changes (Fältholm & Norberg 2017). The sector has long been seen as having a conservative culture that is resistant to change, with structural obstacles to innovation. Several factors contribute to the difficulty of implementing technological changes in mining, including remote work locations and extreme hazard levels (Shook 2015). The negative effects of technology adoption on achieving daily production targets have hindered employee acceptance of new innovations. Additionally, the perceived time required to develop and commercialise new technologies is considered inefficient, since it often takes several years for new technology to be developed and implemented in the mining sector (Bartos 2007). These characteristics of the mining sector result in a reluctance to adopt novel and disruptive solutions. Innovation in mining presents unique challenges compared with other industries such as manufacturing (Shook 2015).

The study conducted by Ediriweera and Wiewiora (2021) revealed the barriers to technology adoption in the mining sector, encompassing several key challenges, as shown in Table 3.

Table 3: Barriers to technology adoption in mining sector (Ediriweera & Wiewiora 2021)

Barrier	Description
Resistance	There is a notable resistance to adopting unproven technologies owing to the associated high risks, particularly with disruptive innovations. The mining industry, focused on immediate production targets, often prioritises existing technologies over potentially beneficial but unproven alternatives.
Safety concern	Concerns regarding safety further exacerbate the reluctance to experiment with untested technologies.
Limited trust	Limited trust between management and employees, exacerbated by retrenchments during downturns, poses a significant barrier to technology adoption. Building trusting relationships is hindered by the hierarchical structure of mining firms and the geographical dispersion of operations, limiting collaboration and communication between different units.
Focus on short-term gain	Performance and recognition systems within the mining industry primarily prioritise efficiency and short-term gains over creativity and innovation. This narrow focus inhibits employees' creative abilities and discourages the pursuit of disruptive technological changes.
Limited employee involvement	Limited employee involvement in decision-making processes further stifles innovation, since employees lack the autonomy to propose and implement improvements.

Despite these challenges, there are several enabling capabilities that can facilitate technology adoption in the mining sector. These include fostering a learning culture that encourages experimentation and knowledge sharing, promoting cross-disciplinary collaboration, engaging external stakeholders in cooperative partnerships and empowering employees to participate in decision-making processes (Ediriweera & Wiewiora 2021). These enablers can mitigate barriers to technology adoption and promote innovation within the mining industry.

2.4.3 Challenges in Oil and Gas

The digital transformation journey within the oil and gas industry heralds a new era of innovation and efficiency, promising significant benefits, ranging from enhanced asset performance to streamlined operations. However, amid this wave of technological advancement, several challenges emerge, hindering the seamless adoption and implementation of digital technologies. The literature highlights the digital transformation challenges in the oil and gas sector (Cameron, Waaler & Komulainen 2018; Føllesdal Tjønn 2018; Salazar, Rauniar & Blodgett 2021; Sylthe & Brewer 2018; Zornio 2018), as shown in Figure 5.

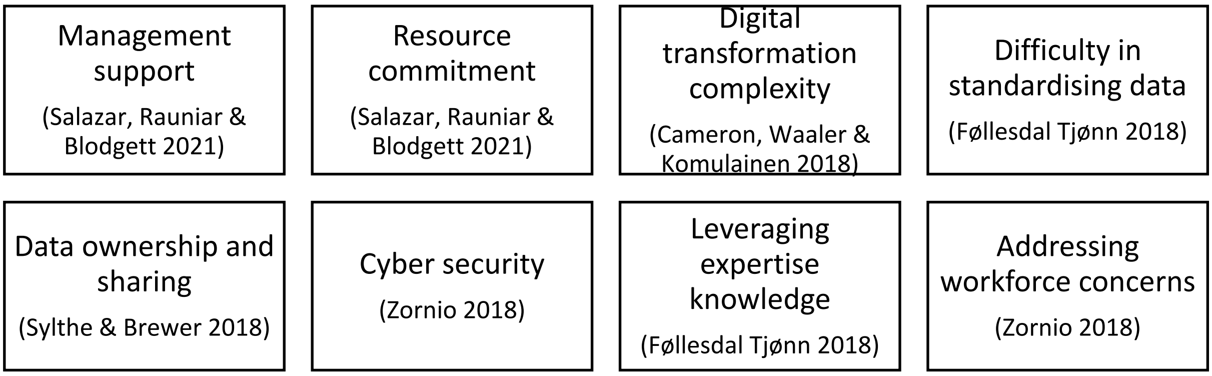


Figure 5: Eight challenges for digital transformation in the oil and gas sector

A study by Salazar, Rauniar & Blodgett (2021) highlighted the lack of top-level organisational support and task technology fit for technology adoption in the sampled organisations. The study suggested that purposeful innovations aligned with the organisation's existing needs are more likely to be adopted. Organisational support was found to directly influence adoption and drive resource commitment. However, Salazar, Rauniar & Blodgett (2021) indicated that simply committing resources to technology adoption does not guarantee success.

In addition, the complexity inherent in digital transformation initiatives, including the implementation of digital twins, necessitates a clear understanding of scope and focus (Cameron, Waaler & Komulainen 2018). Balancing the available technologies with organisational objectives is crucial to avoid the pitfalls of overcomplication or fragmented data sources. This challenge underscores the importance of strategic planning and alignment with broader digital transformation goals.

Standardising data across various sources poses a significant hurdle in the digital transformation journey (Føllesdal Tjønn 2018). Inconsistencies in data formats and structures impede seamless integration and analysis, highlighting the need for interoperability standards and data management frameworks to enable effective digital transformation initiatives. Moreover, aligning digital tools with operational needs and user preferences is necessary for driving adoption and realising benefits (Cameron, Waaler & Komulainen 2018). The customisation of digital interfaces and insight delivery enhances usability and utility, facilitating seamless integration into existing workflows. User-centric design principles underpin successful digital transformation initiatives.

The significant increase in data within digital transformation initiatives raises questions of ownership and sharing (Sylthe & Brewer 2018). Clarity on data rights and responsibilities is vital to fostering collaboration while safeguarding intellectual property. Overcoming regulatory barriers and encouraging a culture of trust are essential for effective data sharing across stakeholders. The interconnected nature of digital transformation initiatives, including digital twins, amplifies cybersecurity concerns (Zornio 2018). Protecting assets against cyber threats is imperative to ensure the integrity and reliability of digital systems. A robust cybersecurity framework is essential to safeguard critical infrastructure and data throughout the digital transformation journey.

Managing big data and implementing advanced analytics capabilities are necessary components of digital transformation (Sharma et al. 2017). Robust data management infrastructure, including secure storage and analytics platforms, enables organisations to derive actionable insights from vast datasets. Balancing scalability, security and usability is key to maximising the value of data assets. The continuous improvement and evolution of digital systems are imperative for sustained digital transformation (Cameron, Waaler & Komulainen 2018). Proactive maintenance strategies, coupled with lifecycle management practices, ensure the longevity and relevance of digital assets. Investment in talent development and technology refresh cycles underpin effective digital transformation maintenance strategies.

Leveraging decades old expertise and tacit knowledge is a challenge in the digital transformation journey (Føllesdal Tjønn 2018). Capturing and codifying experiential insights enable organisations to capitalise on past learnings and drive continuous improvement. Knowledge management strategies play a pivotal role in facilitating knowledge transfer and retention amid digital transformation efforts.

Digital transformation initiatives necessitate organisational change and stakeholder engagement (Zornio 2018). Addressing workforce concerns, fostering digital literacy and establishing clear governance structures are critical for driving adoption and sustaining digital transformation efforts (Zornio 2018). Effective change management strategies underpin successful digital transformation initiatives. Striking a balance between incremental improvements and disruptive innovation is pivotal in driving impactful digital transformation (Sylthe & Brewer 2018). Strategic planning and innovation management frameworks allow organisations to identify opportunities for transformative change while mitigating the risks associated with incremental advancements. Agility and adaptability are hallmarks of successful digital transformation journeys.

In navigating the complexities of digital transformation within the oil and gas sector, organisations must confront a myriad of challenges spanning technological, organisational and regulatory domains. By addressing these challenges holistically and leveraging the insights gleaned from the deployment of digital twins, stakeholders can pave the way for a seamless transition towards a digitally enabled future, unlocking unprecedented value and resilience in the process.

2.4.4 Capabilities to Overcome Challenges

Sections 2.4.1, 2.4.2 and 2.4.3 above show that many scholars have focused on investigating the challenges associated with advanced technology adoption in the heavy industry, including shipbuilding, mining, and oil and gas. However, the insights from Jabbour et al. (2020) underscore a critical aspect that has been somewhat overlooked: the indispensable role of organisational capabilities in navigating these challenges and capitalising on the opportunities presented by advanced technologies. The essence of transformation encompasses not only the challenges in adopting innovative solutions, but also the evolution of processes and organisations. Achieving a successful adoption necessitates a more agile organisational structure, an engaging management culture and talent management, both within the organisation and in its external interactions (Sánchez-Sotano et al. 2020).

Understanding the specific organisational capabilities is essential for facilitating innovation in the heavy industry. By recognising and cultivating these capabilities, the heavy industry can effectively overcome the hurdles encountered during the adoption of advanced technologies (Jabbour et al. 2020). Moreover, a comprehensive understanding of these capabilities enables the heavy industry sectors to harness the full potential of digital transformation initiatives, thereby maximising their impact and ensuring long-term success. For instance, Singh and El-Kassar (2019) proposed that, although technological challenges in integrating big data increase when firms adopt sustainable practices, these challenges can be mitigated by fostering corporate commitment and enhancing human resource management capabilities. Organisations need organisational capabilities to effectively manage innovation processes such as digital transformation (Abdurrahman, Gustomo & Prasetio 2024). The presence of these capabilities is essential for the success of business enterprises (Mady, Masa Halim & Omar 2022). Organisations with strong capabilities are well equipped to steer and manage their digital transformation initiatives (Hussain & Papastathopoulos 2022). Additionally, Dubey et al. (2019) highlighted the significance of investing in a skilled workforce and promoting knowledge-sharing capabilities for the successful implementation of big data.

Therefore, amid the discourse surrounding the challenges and barriers to digital transformation, it is imperative to redirect attention towards identifying and nurturing the organisational capabilities that serve as prerequisites for successful innovation. By doing so, the various sectors in the heavy industry can position themselves strategically to not only address challenges, but also thrive in an increasingly digitised landscape.

2.5 Summary

This chapter provided an overview of the different heavy industry sectors, including shipbuilding, mining, and oil and gas, highlighting their significance within the Australian economy and their distinct characteristics, which make technology adoption particularly challenging. It explored the future direction of digital transformation in these sectors, emphasising the transformative potential of Industry 4.0 technologies. The chapter also addressed the unique challenges faced by the heavy industry in integrating digital solutions, such as non-digital workflows in shipbuilding, a conservative culture in mining and data standardisation issues in oil and gas. It underscored the critical role of developing organisational capabilities in overcoming these challenges and ensuring successful digital transformation. This context sets the stage for the following literature review, which focuses on these essential organisational capabilities.

CHAPTER 3: LITERATURE REVIEW

3.1 Objective

This chapter aims to review and analyse the recent literature to inform the development of a conceptual framework in the context of organisational dynamic capability for the recent innovation waves. Section 3.2 presents the scope of literature review. Section 3.3 reviews the recent innovation waves: digital transformation, Industry 4.0 and Industry 5.0. Section 3.4 underscores the historical evolution of dynamic capability and its importance in digital transformation. The significance of organisational dynamic capability is presented in Section 3.5, based on the literature from 2018 to 2024. In Section 3.6, a comprehensive review and analysis of organisational dynamic capability are presented, leading to the conceptual framework in Section 3.7. The conceptual framework is adopted for a further empirical validation of the distinctive capabilities present in the Australian heavy industry. The research gaps, objectives and questions for this thesis are provided in Section 3.8.

3.2 Scope

The scope of the thesis focused on the organisational dynamic capabilities required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0). Empirical data in this thesis were limited to the Australian heavy industry (shipbuilding, mining, oil and gas), which may limit the generalisability of the thesis findings. Ten search keywords were used over four different databases (Table 4). The timeline of the literature reviewed in this thesis varied depending on the area, and the differences are shown in Table 5. For instance, research on dynamic capability theory begins in 1997, reflecting foundational work in the field, while organisational dynamic capabilities specific to innovation waves are reviewed from 2018 to 2024, given the recent emergence of Industry 4.0 and Industry 5.0. The inclusion and exclusion criteria considered literature type, language, and timeline, with specifics shown in Table 5.

Table 4: Search keywords and boundaries

Keywords	Digital transformation, Industry 4.0, Industry 5.0, capability, organisational capability, dynamic capability, heavy industry, shipbuilding, mining, oil and gas
Boundaries	Google Scholar, Emerald, ScienceDirect, Scopus

Table 5: Inclusion and exclusion criteria

	Inclusion	Exclusion
Literature type	Book chapters, journals, conference proceedings, industry reports	Blogs, magazine articles, non-indexed journals
Language	English	Non-English
Timeline	Dynamic capability theory: from 1997 Organisational dynamic capability required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0): from 2018 to 2024 (refer to Section 3.6)	Technical capability literature

The timeline beginning in 2018 was selected because this period marks a significant increase in literature on digital transformation, Industry 4.0, and Industry 5.0 as shown in Figure 9. While foundational concepts were introduced earlier, the research from 2018 onwards reflects a substantial growth in studies focusing on the practical applications, challenges, and implications of these advanced technologies, particularly for organisational dynamic capabilities within heavy industry. This focus ensures that the review is grounded in the latest insights and trends, capturing the most relevant and impactful findings as the field has developed.

3.3 Innovation Waves: Digital Transformation, Industry 4.0 and Industry 5.0

3.3.1 Overview

Innovation serves as a cornerstone of organisational growth and adaptation, embodying the pursuits of improvement and advancement. Over the past decade, scholars and practitioners have examined the multifaceted realm of innovation, exploring its various dimensions within organisational contexts. Amid this exploration, three overarching concepts have emerged as prominent drivers of innovation: digital transformation, Industry 4.0 and Industry 5.0.

These innovation waves represent successive phases of technological and organisational transformation, each wave building on the advances and insights of the previous one. This iterative and interconnected nature of innovation waves mirrors a continuous process of evolution, where organisations are compelled to adapt to ongoing advancements. In this regard, these waves can also be understood in terms of innovation cycles, where each wave follows a cyclical process of adoption, integration, and renewal. Innovation cycles help emphasise the iterative nature of each phase, as organisations revisit and refine their approaches in response to emerging technologies and shifting industry demands (Tidd & Bessant, 2018, p. 27).

Digital transformation laid the groundwork by digitising organisational processes, followed by Industry 4.0, which emphasised automation and smart manufacturing. Now, Industry 5.0 expands this focus to include human-centric and sustainable approaches, reflecting an evolution rather than a distinct break from previous stages. The cyclical perspective of innovation cycles also highlights how organisations continually evolve their strategies and processes within each wave, enabling a continuous refinement that enhances adaptability and resilience (Cooper, 2019).

3.3.2 Digital Transformation

Organisations globally are confronting technology-driven shifts, and digital transformation is emerging as a persistent challenge in both theory and practice (Baiyere et al. 2023). In this ever-evolving landscape of industrial transformation, organisations must continuously leverage digital solutions to address new opportunities and threats, thereby maintaining their competitiveness (Kraus et al. 2022). ‘Digital transformation’ is defined as a process aimed at enhancing entities through significant changes facilitated by information, computing, communication and connectivity technologies (Vial 2019). It encompasses a broad scope of value creation across organisations (Vial 2019) and various aspects such as business models, strategies, operations, processes, people, culture, tools and data (Chanias, Myers & Hess 2019). The literature suggests that digital transformation promotes operational efficiency through the automation of production (Andriole 2017) and improved business processes (Gust et al. 2017)**.** Recognised as a key driver for economic growth (Pan et al. 2022), digital transformation induces substantial changes in external market strategies and internal organisational tactics (Schallmo & Williams 2018). Scholars have offered diverse perspectives on digital transformation, highlighting its dynamic and transformative nature (Abdurrahman, Gustomo & Prasetio 2024). Definitions range from leveraging technology to enhance enterprise performance to driving continual business improvements through innovation and new digital technologies (Brazo et al. 2022).

Success in digital transformation necessitates a reconsideration of the strategic vision, as well as organisational culture, knowledge and capabilities (Gurbaxani & Dunkle 2019). Despite its importance for strategic planning and long-term advantages, organisations often limit themselves to short-term changes (Nishant, Kennedy & Corbett 2020). Digital transformation requires actions across different organisational levels, including cultivating a digital-first mindset, embracing digital opportunities and prioritising digital solutions over traditional ones (Vial 2019). Success is contingent upon developing digital competencies across the organisation, empowering employees and innovatively leveraging customer operations data (Soluk & Kammerlander 2021). This implies that digital transformation, in addition to its impact on physical products, profoundly affects, or is affected by, business nature, organisational structure and strategic approaches (Dremel et al. 2017). Further, companies must foresee the simultaneous evolution of the Industry 4.0 technological paths (Ciarli et al. 2021), restructure manufacturing facilities and personnel (Calabrese, Levialdi Ghiron & Tiburzi 2021), enhance cross-unit coordination (Horváth & Szabó 2019), accumulate adequate expertise (Cugno, Castagnoli & Büchi 2021), overcome internal resistance (Birkel et al. 2019) and cultivate complementary human skills (Kiel et al. 2017). Digital transformation represents a multifaceted and dynamic process that transcends technological innovation, encompassing strategic, operational and cultural dimensions within organisations. Success in digital transformation requires a holistic approach that integrates technological advancements with a strategic vision, an organisational culture and human capital development.

3.3.3 Industry 4.0

The concept of Industry 4.0, or the Fourth Industrial Revolution, was first introduced in Germany in 2011, heralding a significant space for innovation and encapsulating a cluster of modern technological concepts (Felsberger et al. 2022). At its core, Industry 4.0 is propelled by the progression of digital transformation alongside advancements in intelligent objects and interconnections through a rapidly evolving internet infrastructure (Lookman, Pujawan & Nadlifatin 2023). Industry 4.0 is an advanced concept that enables real digital transformation of business processes, resulting in efficiency, productivity and quality improvement with regard to the principles shown in Figure 6. It underscores the importance of interconnectedness, decentralised decision-making and information transparency (Fatorachian & Kazemi 2021). Industry 4.0 is underpinned by technologies that enable organisations to pursue strategic objectives and gain competitive advantages, with a primary focus on enhancing innovative capabilities (Mubarak & Petraite 2020). By leveraging advanced technologies such as AI, big data and the IoT, as shown in Figure 7, organisations aim to transition towards intelligent and sustainable manufacturing practices (Al-Khatib 2022).

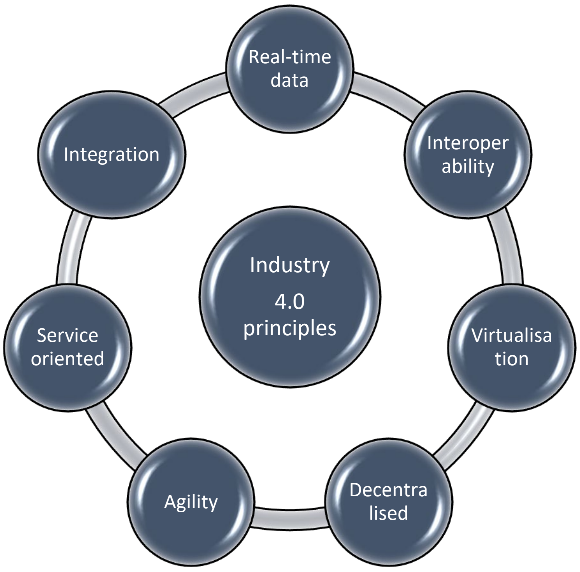


Figure 6: Industry 4.0 principles (Akdil, Ustundag & Cevikcan 2018)

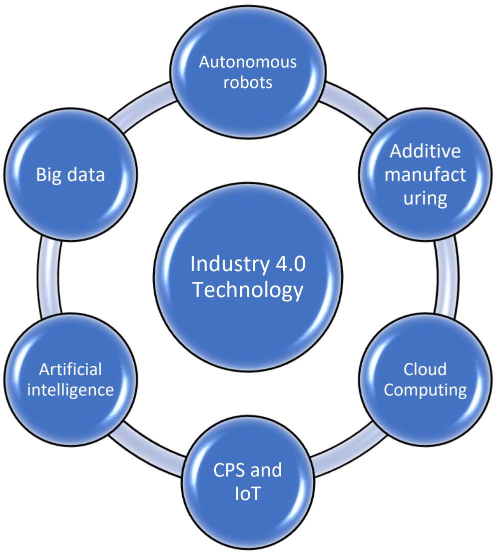


Figure 7: Industry 4.0 technologies (Ghobakhloo 2018; Yavuz et al. 2023)

The adoption of these technologies is geared towards optimising the production environment, rendering it smarter and more sustainable, thereby facilitating the attainment of operational objectives (Yavuz et al. 2023). Essentially, Industry 4.0 technologies serve as a wellspring of modern innovations, pivotal in propelling digital transformation within manufacturing (Sharma et al. 2022). The discourse among academic and industrial circles is increasingly centred on exploring the technological and organisational capabilities essential for leveraging Industry 4.0 technologies to enhance performance (Tortorella et al. 2023).

The impact of Industry 4.0 has been significant, resulting in cost reduction, productivity and efficiency improvements, and flexible customisation in many different industries, and some industries expect it to have long-term benefits (Ghadge et al. 2018). However, Schumacher, Erol and Sihn (2016) found that various industries encountered issues during their adoption of Industry 4.0, including unclear guidance on a complex concept of Industry 4.0 and uncertain benefits from its adoption. Organisations face many challenges and problems because of the great changes in business processes on the macro and micro levels (Schuh et al. 2014). A study from IBM emphasised that many businesses experienced difficulties during Industry 4.0 transformation owing to the lack of knowledge, imperfect IT technologies and considerable investment costs (Erol, Schumacher & Sihn 2016). These difficulties may be more critical in small and medium-sized manufacturing companies because of the uncertain outcomes, including the financial benefits and the impact on business models after procuring new technologies (Schumacher, Erol & Sihn 2016). Industry 4.0 is heavily focused on profits, efficiency and technical improvement in business processes so the effect of people's interaction with the optimisation processes has not been closely examined (Nahavandi

2019). This has raised a variety of issues from societal, people and environmental perspectives (European Commission 2021). Industries need to pursue responsible innovation, not only focusing on profit maximisation and efficiency improvement, but also ensuring the prosperity of all, including people, society and environments (European Commission 2021).

3.3.4 Industry 5.0

Approximately a decade after the inception of Industry 4.0, the European Commission introduced Industry 5.0, characterised by features such as a digital smart society, the integration of virtual and physical spaces, and human-centred technologies (European Commission 2021). The transition to Industry 5.0 is critical to addressing key social expectations and focusing on human-centric technology, sustainability and resilience (Horvath 2023). In contrast to Industry 4.0, Industry 5.0 is perceived as a vision of industrial transformation that prioritises human values and contributes to real social needs, positioning humans as the strength behind the value-creation process, rather than a mere cost factor (Golovianko et al. 2023). This anticipated industrial revolution is poised to induce profound changes in the landscape of sustainable manufacturing, reshaping the nature of work, productivity and value creation.

Industry 5.0 emerges as a new concept building on the groundwork laid by Industry 4.0, with a primary aim to advance the integration of humans and machines within industrial settings (Ramírez-Gordillo et al. 2023). Industry 4.0 was initially introduced to bolster productivity through the adoption of advanced technologies including AI, and its potential for enhancing sustainability was recognised at the micro level of individual firms (Malek & Desai 2020). However, the introduction of Industry 4.0 and the insufficient governance of its technologies, including AI and robotics, have resulted in adverse effects on various socio-environmental aspects of sustainable manufacturing (Narkhede et al. 2024). Broader discussions surrounding its socio-environmental impact, particularly at the macro level, have sparked controversies and debates owing to concerns about sustainability, circularity and the preservation of workplace dignity (Ghobakhloo et al. 2023b). Amid these debates, there is an ongoing discourse among academics and policymakers regarding the necessity for embracing a regulatory framework termed Industry 5.0 (Khan, Haleem & Javaid 2023).

Although lacking a universally accepted definition or framework, Demir, Döven and Sezen (2019) conceptualised Industry 5.0 as a paradigm emphasising coexistence between humans and machines. It acknowledges human capabilities such as creativity and adaptability, aiming to harness these qualities alongside advanced technologies to foster innovation and tackle challenges (Wang et al. 2022). Envisioning a future where humans and machines work synergistically, Industry 5.0 proposes humans focus on tasks requiring cognitive abilities, problem-solving and decision-making, while machines handle repetitive and physically demanding tasks (Carayannis & Morawska-Jancelewicz 2022).

The concept of industrial revolutions has undergone various developmental stages, and the recent exponential growth in big data, IoT and AI has paved the way for Industry 4.0 (Adel 2022). Industry 5.0 is seen more as a value-driven approach than technology-driven, as shown in Appendix 1. The essence of Industry 5.0 lies in its people-aware approach, wherein industries aim to offer more personalised products and services, necessitating the successful integration of digital technologies and human creativity in the design process (Ghobakhloo et al. 2023a). There exist differing opinions within academic and industrial circles regarding Industry 5.0, and some experts consider it an extension or evolution of Industry 4.0 rather than a distinct revolution (Thomas et al. 2023). They contend that the fundamental principles of Industry 4.0, such as digitisation, connectivity and data-driven decision-making, remain pertinent in this evolving landscape (Thomas et al. 2023). Therefore, Industry 4.0 and Industry 5.0 are viewed more as complementary concepts rather than substitutes.

As discussed in Section 3.3, the evolution of industrial revolutions—from digital transformation to Industry 4.0 and the emerging Industry 5.0—represents successive waves of innovation. Each wave shares the common goal of enhancing organisational efficiency, productivity and innovation through the strategic deployment of advanced technologies. Viewing these revolutions as interconnected rather than isolated is crucial to understanding their cumulative impact on the industrial landscape. Industry 4.0 laid the groundwork by introducing advanced technologies and digital transformation, and Industry 5.0 builds on this foundation by emphasising human-centric approaches and integrating intelligent systems with human capabilities. Recognising the synergies and interdependencies among these concepts is critical to fostering innovation, improving productivity and promoting human wellbeing within a sustainable and resilient economy. This holistic perspective can be conceptualised as ‘innovation waves’.

3.4 Dynamic Capability

3.4.1 Overview

The origin of dynamic capability theory can be traced back to the exigencies faced by enterprises in adapting to the dynamic market scenarios of the 1990s (Yu, Wang & Moon 2022). Shaped by factors such as economic globalisation and evolving consumer demands, dynamic capability denotes an organisation’s adeptness in flexibly allocating internal and external resources, swiftly producing marketable products, seizing evolving business opportunities and consistently upholding a competitive edge (Yu, Wang & Moon 2022). Since the pioneering work conducted by Teece, Pisano and Shuen (1997), the dynamic capability framework has been a guiding concept, defined as a firm's capacity to build, reconfigure, and integrate internal and external competencies in response to rapid environmental changes. Rooted in theories such as information processing (1970s), a resource-based view (1980s) and core competence theory (1990s), dynamic capability emphasises an enterprise's purposive adaptation of fundamental resources to environmental shifts (Yu, Wang & Moon. 2022). In the current digital era, businesses are compelled to construct their organisational capability to align with new digital strategies and navigate environmental changes effectively (Yu, Wang & Moon 2022).

3.4.2 Dynamic Capability and Digital Transformation

Dynamic capabilities manifest through three primary mechanisms: first, by recognising shifts in the environment; second, by possessing a profound comprehension of the implications and trajectory of such shifts; and finally, by proficiently orchestrating resources to enable transformation and adeptly address these shifts (Yan, Xi & Wu 2024). Dynamic capabilities are pivotal in organisational digital transformation, facilitating the agile adaptation and utilisation of both internal and external competencies to navigate swiftly changing environments (Ellström et al. 2022). In the face of relentless technological advancements, market shifts and global competition, dynamic capabilities empower firms to proactively sense and respond to opportunities and threats, and they enable businesses to not only react, but also shape their future, ensuring relevance and competitiveness in an ever-changing environment (Warner & Wäger 2019). Dynamic capabilities, as distinct from operational capabilities, govern the pace of change in a firm's ordinary capabilities and support evolutionary fitness (Warner & Wäger 2019). Dynamic capabilities are based on doing the right things, underscoring their non-replicable nature compared with ordinary capabilities (Warner & Wäger 2019). The literature highlights the interplay of dynamic capabilities with strategy and business models, emphasising their role in responding efficiently to future and existing contingencies (Warner & Wäger 2019).

Within the strategic management literature, the lens of dynamic capabilities has been frequently applied to study how organisations adapt to technological changes (Teece 2007, Warner & Wäger 2019). Dynamic capabilities are often recommended as a concept used to improve company performance via digital transformation (Ellström et al. 2022; Gong & Ribiere 2021; Marino-Romero, Palos-Sanchez & Velicia-Martin 2023; Warner & Wäger 2019). Dynamic capabilities offer a consistent method for exploring digital transformation, considering the profound and continuous impact of digital technologies on business performance (Warner & Wäger 2019). The era of digital transformation ushered in a disruptive force, compelling markets and customers to navigate increased complexity. In the face of rapid and dynamic changes, organisations are challenged to reassess their resources, capabilities and competencies to effectively navigate the evolving environmental landscape (Ellström et al. 2022). Digital transformation represents a fundamental shift propelled by digital technologies, prompting organisations to strategically leverage key competencies for the redefinition of business logic and processes (Vial 2019). Developing the organisational capability to manage digital transformation requires the cultivation of dynamic capabilities tailored specifically for this purpose (Schneider, Hofmeister & Kanbach 2022). Given the ubiquity and inherent uncertainty of digital transformation, the dynamic capability view emerges as a pertinent theoretical framework for understanding digital transformation.

Various perspectives exist regarding the application and relevance of a dynamic capability framework in the context of digital transformation (Ghosh et al. 2022). Teece (2018) emphasised the role of enabling digital transformation technologies, particularly big data, in generating value and fostering organisational dynamism. Mendonça and Andrade (2018) linked Industry 4.0 technologies, such as AI, machine learning (ML) and IoT, to the seizing capability within the traditional dynamic capability framework. Li (2020) underscored the direct influence of emerging technologies on business model innovation and digital transformation. Harnessing dynamic capabilities becomes essential for systematic and continuous adaptation, enabling firms to sustain competitiveness amid environmental changes (Correia, Dias & Teixeira 2020). Taking a hierarchical perspective, the dynamic capabilities required for digital transformation extend beyond operational capabilities and routine processes. These capabilities, described as higher order, transcend ad hoc responses or routines (Ellström et al. 2022). In the context of the new digital normal, successful changes demand a specific set of capabilities that facilitate changes in business models and organisational structures (Ellström et al. 2022). Mele et al. (2023) proposed that the requisite capabilities are higher order and context-dependent, and that they interact with lower-order capabilities and both internal and external knowledge sources.

Hess et al. (2016) stressed the strategic priority of making digital transformation integral to a company’s agenda, warning against the risk of obsolescence without a continuous evaluation of the technology utilisation options. In navigating the transition to this new normal, possessing the relevant dynamic capabilities is indispensable for the strategic reconfiguration of resources and competencies, enabling organisations to capitalise on digital opportunities (Amit & Han 2017). However, the process of developing dynamic capabilities required for digital transformation requires a meticulous approach to prevent resource waste and the overextension of the capacities, capabilities and cognitive abilities necessary for accommodating change (Lanzolla, Pesce & Tucci

2021). Digital transformation, marked by its inherent uncertainties, exerts significant pressure on organisations during implementation (Schneider, Hofmeister & Kanbach 2022). The intersection of dynamic capabilities and digital transformation arises from the profound impact of digital technologies on traditional businesses, requiring firms to adapt to emerging market opportunities. Brewis, Dibb and Meadows (2023) suggested prioritising the strategic imperative of developing dynamic capabilities required for digital transformation to capitalise on market opportunities in the digital age. However, despite the escalating academic interest, the exploration of all facets of digital transformation is still in its nascent stages owing to the evolving nature of this field (Appio et al. 2021). The strategic construction of dynamic capabilities tailored for digital transformation remains a critical aspect that is not fully understood (Warner & Wäger 2019).

3.4.3 Sensing, Seizing and Reconfiguring

Recent research has underscored the pivotal role of three dynamic capabilities—sensing, seizing and reconfiguring—in achieving digital transformation (Abdurrahman, Gustomo & Prasetio 2023). The initial component, sensing, encompasses activities such as scanning, creation, learning and interpretive endeavours to identify and shape emerging opportunities (Teece 2007). Firms require sensing capabilities to anticipate rapidly evolving digitisation trends and continually refine their digital transformation strategies (Warner & Wäger 2019). The second capability, seizing, involves making judicious investment decisions once opportunities have been identified (Hodgkinson & Healey 2011). After sensing a new opportunity, organisations must exploit it through innovative business model designs and strategic investment decisions, considering factors such as optimising existing models or introducing novel revenue sources (Lehong & Waller 2017). The optimal path for each organisation hinges on its strategic objectives, industry context, competitive pressures and customer expectations (Berman 2012). The reconfiguring capability is pivotal in translating sensing and seizing into tangible advantages, emphasising the execution of the digital transformation strategy (Warner & Wäger 2019). Exploring this capability unveils the intricate complexities associated with digital transformation and offers valuable insights into its successful implementation (Sousa-Zomer, Neely & Martinez 2020).

3.4.3.1 Sensing Capability

In the dynamic and competitive landscapes of today's global markets, the constant changes in consumer needs, technological opportunities and competitor activities create an imperative for organisations to develop robust sensing capabilities (Chirumalla 2021). This need is particularly crucial for incumbents, since both new entrants and existing players face risks to their profit streams from emerging opportunities (Helfat & Raubitschek 2018). Sensing, as highlighted by Teece (2007) in the context of dynamic capabilities, entails a multifaceted activity that involves scanning, creating, learning and interpreting. This activity encompasses the identification, development, co-development and assessment of technological opportunities aligned with customer needs (Teece 2014). To effectively carry out sensing activities, organisations must have this capability at all levels, fostering an environment where lower-level employees contribute valuable information and insights on external trends for middle and top-level managers (Teece & Linden 2017). Achieving meaningful sensing and shaping necessitates the establishment of embedded organisational routines specific to these activities (Teece 2007). Further, firms need to have a comprehensive awareness of their entire ecosystem that extends beyond their immediate surroundings and direct competitors to encompass potential threats from new entrants and other competing activities (Teece 2007). However, the process of building and enhancing sensing capabilities poses significant challenges for mature firms. The ability to predict, leverage and implement the latest technology becomes a formidable task (Matt, Hess & Benlian 2015). Additionally, foreseeing the latest trends in digital transformation, as highlighted by El Sawy et al. (2020), adds another layer of complexity to the challenges faced by incumbents in nurturing effective sensing capabilities (Warner & Wäger 2019). Overcoming these hurdles becomes imperative for organisations aiming to remain adaptable and competitive in rapidly evolving environments.

3.4.3.2 Seizing Capability

Seizing capabilities, an integral component linked to sensing capabilities, play a critical role in converting identified opportunities into tangible outcomes, either through the introduction of new products, processes or services, or a combination of these alternatives (Teece 2007). This capacity allows a firm to not only recognise potential opportunities, but also determine the necessary organisational changes required to capture the associated value (Yeow, Soh & Hansen 2018). Teece (2007) underscored that, although many organisations may sense opportunities, they often falter in seizing the value owing to reasons such as a lack of commitment, risk aversion or financial constraints. Overcoming these challenges requires improvements in rules, routines, leadership and strategies to effectively understand, capture and assess potential business opportunities (Teece 2007). The introduction of new technologies into established firms may create a capability gap (Karimi & Walter 2015), emphasising the importance of a seizing capability to capture value from emerging opportunities (Ellström et al. 2022). The essence of seizing opportunities lies in a firm's ability to instigate organisational change while securing the commitment of key stakeholders (Chirumalla 2021). These capabilities encompass activities that facilitate the development of new products, processes and services based on identified opportunities (Teece 2007). Successful seizing involves understanding resource requirements, making decisions regarding technology and resource investments, and managing the necessary changes (Chirumalla 2021). Overcoming the structural inertia of entrenched routines, path dependence on prior commitments and the historical imprinting of past strategic initiatives becomes crucial, especially when faced with emerging technologies or evolving market competition (Suddaby et al. 2020). Challenges may arise when firms, influenced by path-dependent routines and assets, demonstrate a reluctance to invest in sensed opportunities, particularly those related to the exploration of radical innovations (Henderson & Clark 1990).

Different types of seizing capabilities have been studied, including sustainable and digital seizing capabilities. The spectrum of seizing capabilities encompasses sustainable seizing capabilities, which align with strategic digital agility, fast digital redirection, digital strategy redesign, digital new deal adoption, strategic prioritisation, integrative technology utilisation, a novel technology skill set, technology–value fit and leadership shift (Feroz et al. 2023). These capabilities empower organisations to capitalise on the opportunities presented by digital technologies, ensuring the digitisation of core business models in harmony with sustainability goals (Feroz et al. 2023). Within the realm of digital seizing, sub-capabilities, such as strategic agility, rapid prototyping and balancing digital portfolios, come to the fore. Since digitisation disrupts the traditional paradigms, incumbents are increasingly employing entrepreneurial methods to cultivate digital seizing capabilities, enhancing their strategic agility for swift responses to unforeseen opportunities and threats (Warner & Wäger 2019). This shift, propelled by technologies such as cloud computing and social media, not only accelerates new product launches, but also maximises customer centricity while rapidly scaling at a marginal cost (Warner & Wäger 2019).

3.4.3.3 Reconfiguring Capability

Reconfiguring capabilities, as a pivotal aspect of dynamic capabilities, involve the continuous renewal and transformation of organisational routines, and are essential for sustained profitable growth in the face of evolving markets and technologies (Teece 2007; Yeow, Soh & Hansen 2018). This capability encompasses the capacity to align existing resources with new strategies, build new resources and address gaps in the resource base (Yeow, Soh & Hansen 2018). In the context of more stable environments, firms often fine-tune their asset base and build on existing resources, yet substantial reconfiguration becomes imperative in rapidly changing markets (Helfat et al. 2009). The significance of reconfiguration lies in its role as a dynamic capability that is crucial for sustained profitable growth, allowing firms to recombine assets and organisational structures in response to growth and environmental changes (Teece 2007). Reconfiguration activities involve combining, integrating, recombining and reconfiguring internal processes, routines, assets, organisational structures, values and culture to align with seizing opportunities (Teece 2007). Overcoming structural rigidity, hierarchical constraints, and established rules and procedures is essential, requiring decentralisation, autonomy and the management of specialised assets to achieve a fit with strategy, structure and processes (Teece 2007). Additionally, creating learning, knowledge-sharing and knowledge-integrating procedures is crucial for successful reconfiguration (Teece 2007).

In a rapidly changing environment, reconfiguration becomes synonymous with business philosophy, emphasising the continued renewal to ensure steady surveillance of technologies and markets for the adoption of best practices (Teece, Pisano & Shuen 1997). The ability to reconfigure and recombine organisational structures and assets enables sustained profitable growth, breaking free from unfavourable path dependencies (Teece 2007). Transformational examples in family businesses transitioning from domestic to international markets underscore the evolutionary nature of reconfiguration (Duarte Alonso, Kok & O'Shea 2018). With the advent of digital transformation and Industry 4.0, the emphasis shifts from accumulating valuable assets to reorganising, reconfiguring and integrating resources and skills for innovation and adaptation (Labory & Bianchi 2021).

There are different types of reconfiguring capabilities. Digital transformation capabilities within reconfiguration involve navigating innovation ecosystems, redesigning internal structures and enhancing digital maturity (Feroz et al. 2023). These microfoundations are crucial for managing the tensions related to collaboration, flexible governance structures, and improving the digital maturity of the workforce in response to technological and market changes (Warner & Wäger 2019). Sustainable transformation capabilities further extend to green innovation portfolio building, digitisation strategy renewal, structural and digitised change, win-win value propositions, the convergence of sustainability and digital strategies, and green value alternation. These capabilities drive sustainable digital transformation by reconfiguring business models to embrace green value-generating mechanisms (Feroz et al. 2023). Moreover, the impact of digital transformation on business models is twofold—new firms can experiment with entirely new models and established firms experience business model reconfiguration (Lanzolla et al. 2020). The influence of digital transformation extends to various capabilities such as the digital customer experience and smart contracts, illustrating its profound impact on value creation, delivery and capture (Dutra, Tumasjan & Welpe 2018; Weill & Woerner 2013).

3.4.3.4 Combination of Sensing, Seizing and Reconfiguring

The framework by Teece (2007) provides a useful overview of the dynamic capability categories; however, previous studies have tended to focus on these categories in isolation (Khan, Daddi & Iraldo 2021; Kump et al. 2019; Wagner et al. 2017). Schilke, Hu and Helfat (2018) suggested that each organisation requires a unique combination of dynamic capabilities aligned with specific decisions and investments, challenging a one-size-fits-all approach and indicating the interrelationships among capabilities (see Figure 8).

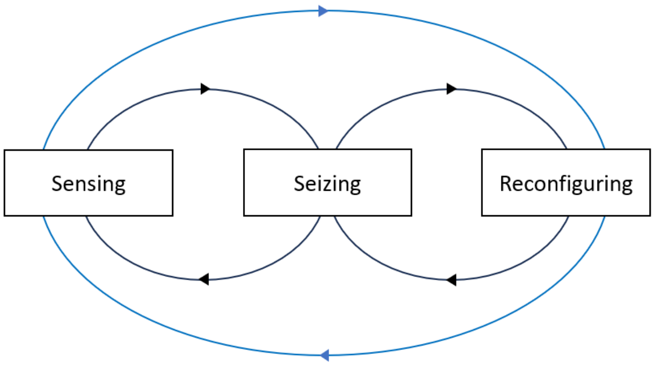


Figure 8: Interrelationship between sensing, seizing and reconfiguring (Warner & Wäger 2019)

Helfat and Winter (2011) proposed that a combination of seizing and reconfiguring capabilities complicates any imitation by competitors. Frequent engagement in sensing and reconfiguring activities enhances organisational adaptability to a changing environment (Brewis, Dibb & Meadows 2023). Di Stefano, Peteraf and Verona (2014) emphasised the interrelationships among sensing, seizing and reconfiguring capabilities, revealing how organisational actions must synergise to effect change. Yeow, Soh and Hansen (2018) proposed that dynamic capabilities interact in a process of 'sensing-reconfiguring-seizing', in which reconfiguration plays a central role in enabling organisations to respond to turbulence in their external environment. This aligns with the call for a system of dynamic capabilities rather than independent capabilities, especially in the face of digital transformation challenges and complex big data (Warner & Wäger 2019).

3.4.4 Microfoundations

The literature underscores that understanding macrophenomena can be enhanced by revealing or deconstructing the components behind it (Chen et al. 2023). Microfoundations are deeply rooted in behavioural theory (Greve 2013) as well as knowledge from human resources, leadership, culture, philosophy, psychology and social disciplines (Gond & Moser 2021). This approach involves moving down the hierarchy of a macrophenomenon to search for sources and employing diverse methods from various fields (Felin, Foss & Ployhart 2015). Aligning individual and collective phenomena is crucial for understanding their impact on organisational outcomes (Barney & Felin 2013). The behavioural definitions of dynamic capabilities highlight the importance of aligning macro and micro insights (Wang, Senaratne & Rafiq 2015). Organisational innovation strategies, representing human resource management strategies, are integral to developing dynamic capabilities, and an innovative climate acts as a critical intermediary between managerial intent and the manifestation of dynamic capabilities (King et al. 2007). Emphasising the alignment of macro and micro perspectives enriches the understanding of the microfoundations of dynamic capabilities for innovation (Felin et al. 2012).

The research stream related to the microfoundations of dynamic capabilities has gained prominence owing to the demonstrated positive performance effects of dynamic capabilities (Bendig et al. 2018). Although organisational-level studies are common, scholars have emphasised the lack of research into the roles of managers and individuals in capability development (Eriksson 2014). Abell, Felin and Foss (2008) argued that individual actions and interactions must be involved in explaining how routines and capabilities relate to firm-level outcomes (Bojesson & Fundin 2021). Research into microfoundations is beneficial for understanding the nature of dynamic capabilities, and Abell, Felin and Foss (2008) contended that causal explanations often require elaboration at the micro level (Bojesson & Fundin 2021). Organisational change capacity, encompassing human capabilities and organisational culture, systems and processes, emphasises the need to consider leadership, employee attitudes and organisational readiness for change (Heckmann, Steger & Dowling 2016). Microfoundations offer insights into the varying success probabilities revealed during change processes, allowing for recognition of the diverse structures, strategies and human resources across organisations (Al-Haddad & Kotnour 2015).

The exploration of digital transformation is a relatively recent undertaking for industrial organisations (Ghosh et al. 2022). Over the past few years, an increasing body of research has examined this phenomenon (Li 2020; Sousa-Zomer, Neely & Martinez 2020; Warner & Wäger 2019). Sousa-Zomer, Neely and Martinez (2020) highlighted three microfoundation capabilities embedded in organisational cultures—digital-savvy skills (individual dimension), digital intensity (process dimension), and context for action and interaction (structure dimension)—forming a comprehensive digital transformative capability. Li et al. (2018) pointed to the significance of managerial capabilities as the primary impetus for digital transformation. Concurrently, Vial (2019) accentuated the role of IT capabilities, positing that these capabilities propel firm performance, and that digital transformation initiatives serve as a mediating factor (Ghosh et al. 2022). Microfoundations are crucial for the continuous execution of digital strategy, ensuring sustained value over time (Sousa-Zomer, Neely & Martinez 2020). Essentially, organisations with a robust digital transformation capability exhibit individual, procedural and structural microfoundations, enabling them to navigate dynamic environments through continuous strategic renewal, fostering responsiveness and competitiveness (Sousa-Zomer, Neely & Martinez 2020). This substantiates a direct positive relationship between digital transformation capability and firm performance (Sousa-Zomer, Neely & Martinez 2020). Microfoundations elucidate the driving factors behind variations in the development of a critical capability for digital transformation, unravelling how digital transformation manifests in firms and revealing its subsequent impact on performance (Sousa-Zomer, Neely & Martinez 2020). Although the literature acknowledges the relevance of the dynamic capability framework in comprehending the digital transformation phenomenon at the organisational level, a detailed exploration of the roots of these dynamic capabilities has been somewhat overlooked (Vial 2019; Warner & Wäger 2019).

3.5 Significance of Organisational Dynamic Capability

3.5.1 Overview of the Capability Literature

Capability refers to the ability of an organisation to effectively utilise resources, processes and knowledge to achieve its strategic objectives and is represented by the contribution of its activities to improving and enhancing operational performance (Al-Khatib 2022). From 2018 to early 2024, scholarly interest surged in relation to capabilities required for digital transformation, Industry 4.0 and Industry 5.0, resulting in a total of 541 studies conducted on this topic. Figure 9 illustrates a consistent annual increase in the number of studies conducted since 2018, including a projection for 2024.

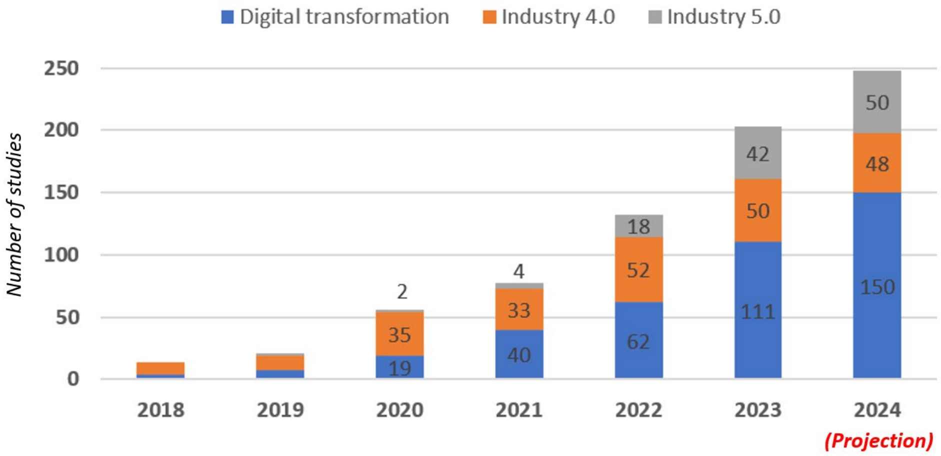


Figure 9: Number of studies of capabilities required for digital transformation, Industry 4.0 and Industry 5.0 from 2018 to 2024[1]

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[1] The projection of the number of articles for 2024 is based on the number of articles published from January to February, multiplied by six. This method assumes a consistent publication rate across all months of the year, as the data collection concluded at the end of February.

From 2022 onwards, there has been a dramatic increase in research focusing on Industry 5.0, underscoring the recognition of the importance of not only technological capabilities, but also organisational capabilities in driving innovation and industrial revolutions.

The two main capabilities (technological and organisational) have been studied and found to be critical when promoting innovation in an organisation. Firstly, regarding the incorporation of digital transformation technologies, scholars have emphasised the significance of technology capabilities (Konopik et al. 2022; Yalcin & Daim 2021). Technological capability denotes the capacity that furnishes an organisation with technological prowess, offering the potential to forge a competitive advantage using innovations such as AI (Li & Chan 2019).

Second is organisational capability. While the acquisition of technology is crucial, the effective adoption, management, integration, and innovation using these technologies is even more critical (Yalcin & Daim 2021). Organisational capabilities are needed to oversee innovation processes, including digital transformation (Abdurrahman, Gustomo & Prasetio 2024). The presence of strong organisational capabilities is crucial for the success of business enterprises (Mady, Masa Halim & Omar 2022). An organisation with robust organisational capabilities can direct and manage its digital transformation initiatives (Hussain & Papastathopoulos 2022). This involves the ability to reorganise, adapt processes, and cultivate a culture that facilitates digital transformation (Grover, Tseng & Pu 2022). Moreover, it encompasses the capacity to shape and execute a digital strategy (Alnuaimi et al. 2022), align digital initiatives with the overall organisation’s strategy (Xie et al. 2022), reorganise resources and the workforce as needed (Guenduez & Mergel 2022), nurture a culture conducive to digital transformation (Grover, Tseng & Pu 2022), and create an environment that promotes testing and learning (Wu & Zhou 2021). Research into organisational capability has gained prominence and importance over recent decades (Abdurrahman, Gustomo & Prasetio 2024).

3.5.2 Significance of Organisational Capability

The significance of organisational capability has been increasingly emphasised in the context of digital transformation, Industry 4.0 and Industry 5.0. A total of 99 studies have focused specifically on organisational capability within the three innovation waves since 2019. Figure 10 illustrates the growing trend, showing the increasing number of studies exploring organisational capability each year, including the projection for 2024.

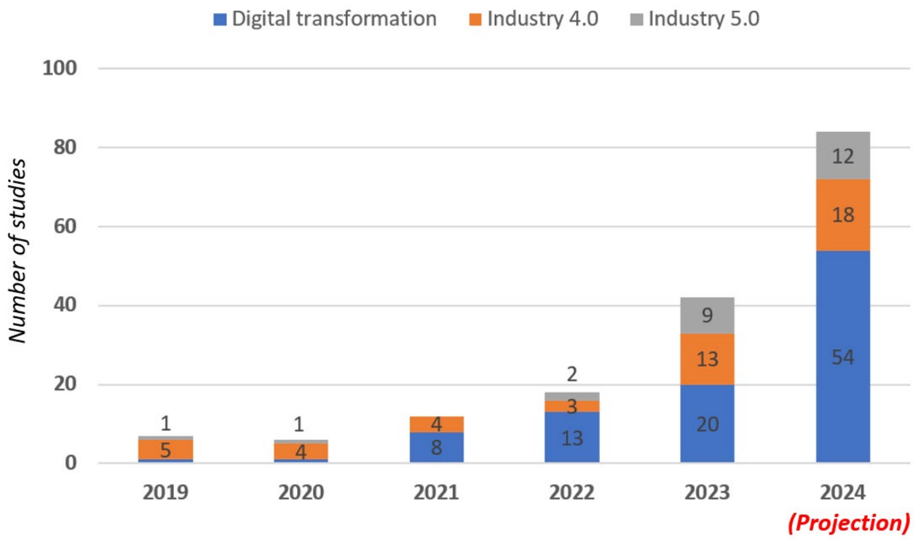

Figure 10: Number of studies of organisational capabilities required for digital transformation, Industry 4.0 and Industry 5.0 from 2019 to 2024[2]

Despite the growing trend, technological capability has received more attention, owing to the strong technological foundation of digital transformations and Industry 4.0. Consequently, the earlier literature focused primarily on the implementation process through a lens that prioritised technological capability (Nayernia et al. 2022), concentrating on the field of technology and engineering (Liere-Netheler, Packmohr & Vogelsang 2018). Although technological development is crucial, technological capability is only part of the transformation journey. Other aspects, such as changes in organisation structure, processes and culture (Svahn, Mathiassen & Lindgren 2017), need to be taken into consideration in building capabilities for a successful transformation. This transformation affects, and is influenced by, the behaviour of different individual and organisational levels, as well as the environment (Liere-Netheler, Packmohr & Vogelsang 2018). This implies that digital transformation should focus not only on technical or scientific developments, but also contextual implementation that considers other aspects (Kane et al. 2015). This has led to the advent of Industry 5.0, which represents a paradigm shift towards human-centric approaches to innovation and production. Industry 5.0 acknowledges the importance of organisational capability in fostering collaboration between humans and machines, driving cultural transformation and unlocking new sources of value.

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[2] The projection of the number of articles for 2024 is based on the number of articles published from January to February, multiplied by six. This method assumes a consistent publication rate across all months of the year, as the data collection concluded at the end of February.

3.5.3 Theoretical Significance of Dynamic Capability and the Gap

Various theoretical frameworks have been employed to investigate capabilities in the context of digital transformation, Industry 4.0 and Industry 5.0. These frameworks encompass diverse perspectives such as technology, organisation and environment; the Capability Maturity Model (CMM); Industry 4.0 readiness; the resource-based view; and dynamic capability.

The CMM has been well recognised in capability studies, offering a structured approach to assessing and improving organisational capabilities (Backlund, Chronéer & Sundqvist 2014). ‘Maturity’ is defined as ‘the ability to maintain or develop performance such that persistent satisfaction of the organisation’s stakeholders is guaranteed over time’ (Cheshmberah & Beheshtikia 2020, p. 103). It has long been used in various industries such as utility and energy (Ngai et al. 2013), design engineering (Pigosso, Rozenfeld & McAloone 2013) and manufacturing (Maasouman & Demirli 2015), since greater maturity can enhance business capability (Schumacher, Erol & Sihn 2016). One of the key benefits of CMM is its ability to provide a systematic framework for organisations to evaluate their current capabilities and identify areas for enhancement. By delineating maturity levels, the CMM enables organisations to progress along a defined path towards higher levels of capability maturity. The CMM can be the best solution for enabling organisations to obtain extensive knowledge of their current situation as well as a strategic direction for the future (Akdil, Ustundag & Cevikcan 2018).

The adoption of the CMM along with Industry 4.0 is about being ready to embrace Industry 4.0 technologies (Vazire 2018). This enables organisations to assess whether they are ready to transform their business processes using Industry 4.0 (Stentoft et al. 2019). The CMM plays a crucial role in assessing Industry 4.0 maturity in business processes, which supports many businesses to move towards Industry 4.0 transformation (Akdil, Ustundag & Cevikcan 2018). Many organisations try to innovate the way in which they conduct their business processes, but not many acknowledge where they are at and where they need to be for a successful Industry 4.0 transformation (Hizam-Hanafiah, Soomro & Abdullah 2020). A lack of understanding of the current situation may lead to an inappropriate focus on the transformation journey, and this can have a detrimental effect on organisations in a competitive market (Ivanov, Dolgui & Sokolov 2019). However, the CMM has a static nature, which tends to focus on assessing current capabilities rather than adapting to changing environments or driving continuous improvement. This static perspective may constrain an organisation’s ability to effectively respond to dynamic market conditions and emerging technological trends.

In contrast, the dynamic capability framework offers a compelling solution to the limitations of the CMM model. The framework recognises the need for organisations to continuously sense, seize, and reconfigure resources and capabilities in response to changing environments. This adaptive approach enables organisations to thrive amid uncertainty and disruption by fostering agility, resilience and innovation. The significance of dynamic capability is highlighted by the prevalence of studies adopting its frameworks over the past six years in relation to capability research, including the projection for 2024, as shown in Figure 11.

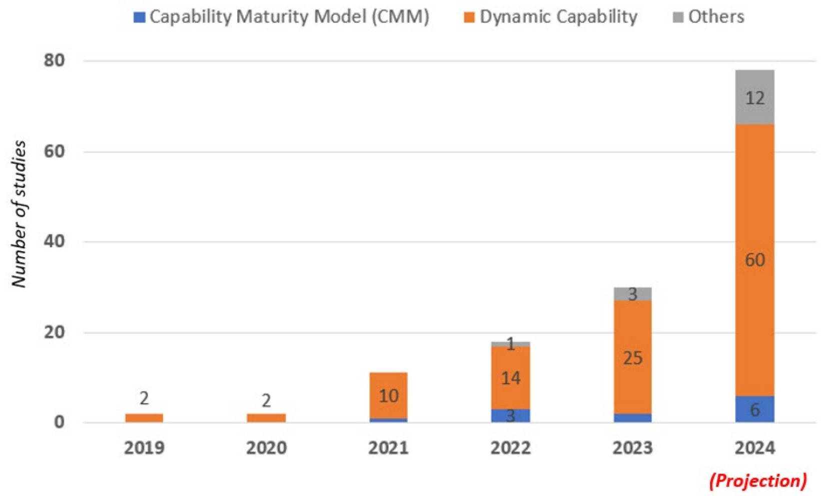

Figure 11: Theoretical frameworks employed to investigate capabilities from 2019 to 2024[3]

Figure 11 illustrates a notable trend indicating the significant adoption of the dynamic capability framework, particularly evident from 2021 onwards. Further, the dynamic capability framework provides insights into the fundamental and foundational capabilities that underpin organisational adaptability and competitiveness. It emphasises the importance of microfoundations, including individual skills, knowledge and behaviours, in driving organisational learning and renewal processes.

Despite the increasing recognition of the importance of Industry 5.0 and the growing focus on organisational capabilities, there appears to be very little research applying the dynamic capability framework to explore Industry 5.0. This gap presents an opportunity to examine the role of dynamic capabilities in Industry 5.0, which focuses on facilitating human–machine collaborations, fostering innovation ecosystems and driving value creation. Building on insights from the existing theoretical frameworks and addressing the gap in applying dynamic capability to Industry 5.0, the aim of this thesis was to propose a framework for organisational dynamic capabilities that is tailored to the

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[3] The projection of the number of articles for 2024 is based on the number of articles published from January to February, multiplied by six. This method assumes a consistent publication rate across all months of the year, as the data collection concluded at the end of February.

context of digital transformation, Industry 4.0 and Industry 5.0. The following chapter conducts a comprehensive review of the capability literature in this context.

3.6 Organisational Dynamic Capability

An initial review of the literature was conducted to obtain a thorough understanding of organisational capabilities required for digital transformation, Industry 4.0 and Industry 5.0, employing a robust, transparent and replicable method. Two prominent databases (Scopus and Web of Science) were utilised, chosen for their significance as trusted publisher-independent global citation databases, to search for the terms ‘Capability or Capabilities’, ‘digital transformation’, ‘Industry 4.0’ or ‘Industry 5.0’ within the keywords from 2018 to 2024. The search specifically encompassed journal articles, books, conference papers and works in progress written in English. This targeted literature investigation yielded a total of 541 possible articles.

Subsequently, only articles directly related to organisational capabilities (not technical) were included for consideration. Further, the articles that were not relevant to the prerequisite organisational capabilities were omitted. Given the focus on the dynamic capability framework in the thesis, the articles adopting dynamic capability theory were incorporated. This resulted in a total of 99 possible articles, as shown in Table 6.

Table 6: Number of articles of organisational and dynamic capability studies on digital transformation, Industry 4.0 and Industry 5.0

	Digital transformation	**Industry 4.0**	**Industry 5.0**	**Total**
Organisational capability with the dynamic capability framework	34	13	0	47
Organisational capability without the dynamic capability framework	18	18	16	52
Total	52	31	16	99

Table 6 illustrates the research landscape concerning organisational capability with and without the dynamic capability framework within three different innovation waves. Specifically, it reveals a concentration of articles with the dynamic capability framework, with only 13 investigations delving into Industry 4.0 and apparently no discernible research pertaining to Industry 5.0. Conversely, the investigations into organisational capability absent a dynamic capability framework exhibit a more balanced distribution across the three distinct innovation waves. The outcome suggests that, although the three innovation waves have garnered significant interest and are frequently touted as being a prerequisite for organisational innovation, limited theoretical research exists that fully conceptualises organisational capability with a dynamic capability framework.

Only 34 articles were deemed pertinent to this thesis, as shown in Table 7. This section examines these 34 articles focused primarily on the organisational capabilities pertinent to digital transformation, Industry 4.0 and Industry 5.0.

Table 7: Thirty-four articles of organisational capability focused on digital transformation, Industry 4.0 and Industry 5.0

	Digital transformation	**Industry 4.0**	**Industry 5.0**	**Number of articles**
With a dynamic capability framework	Dubey et al. (2024); Ellström et al. (2022); Feroz et al. (2023); Ghosh et al. (2022); Huang, Jiang and Chang (2023); Warner and Wäger (2019)	Cruzara et al. (2023); Ghobakhloo et al. (2023c); Lepore et al. (2023); Vu et al. (2023)		10
Without a dynamic capability framework	Chirumalla (2021); El Sawy et al. (2020); Heubeck and Meckl (2022); Sousa-Zomer, Neely and Martinez (2020); Tumbas, Berente and Vom Brocke (2020); Yeow, Soh and Hansen (2018)	Agarwal, Seth and Agarwal (2022); Dabić, Maley and Nedelko (2023); De Sousa Jabbour et al. (2018); Jiang et al. (2020); Naruetharadhol et al. (2022); Rangaswamy (2021); Saabye, Kristensen and Wæhrens (2022); Santos et al. (2023); Szalavetz (2019); Ul Zia, Burita and Yang (2023)	Chavez et al. (2023); European Commission (2021); Henriksen, Røstad and Thomassen (2022); Henriksen and Thomassen (2023); Mihardjo and Alamsyah (2019); Modgil, Singh and Agrawal (2023); Narkhede et al. (2024); Thomas et al. (2023)	24
Number of articles	12	14	8	34

Table 7 shows that, although the literature covers organisational capabilities for digital transformation and Industry 4.0, there is an absence of studies exploring capabilities for Industry 5.0 through the lens of a dynamic capability framework. This indicates a gap in the existing research, despite the acknowledged significance of the dynamic capability framework, as shown in Figure 11 in Section 3.5.3. As previously discussed in Section 3.4, the innovation waves emphasise the necessity for considering them together rather than in isolation. However, a notable gap persists in the current discourse; that is, the tendency to examine each innovation waves in silos rather than as interconnected waves of innovation. This isolated approach overlooks the cumulative impact and synergistic potential of Industry 4.0 and the emerging Industry 5.0. This gap in comprehensive analysis not only hinders an understanding of the evolving industrial landscape, but also undermines the ability to leverage the full spectrum of opportunities presented by digital transformation. To fully harness the benefits of these innovation waves, it is imperative to adopt a holistic perspective that recognises the interconnectedness of Industry 4.0 and Industry 5.0, as shown in Figure 12.

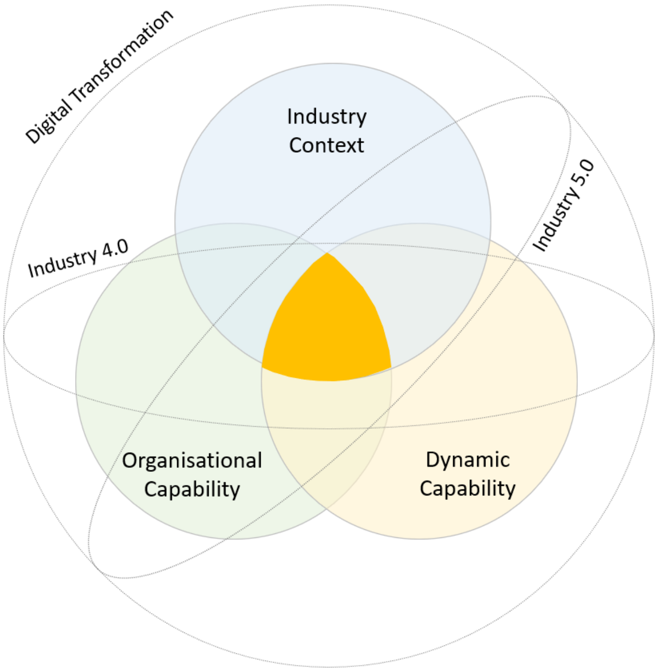


Figure 12: Holistic Venn diagram of organisational dynamic capability required for innovation waves

In aggregate, 10 capabilities and 51 attributes were discerned, accounting for overlapping capabilities across three different concepts among the 34 articles, as detailed in Appendix 2. A total of 12 articles specifically focused on organisational capabilities required for digital transformation, identifying a total of 8 distinct capabilities and 25 attributes. Additionally, 14 articles explored organisational capabilities for Industry 4.0, unveiling 9 capabilities and 27 attributes, and 8 articles investigated capabilities for Industry 5.0, revealing 10 capabilities and 22 attributes. The subsequent sections examine the specifics of these capabilities and attributes for each innovation wave.

3.6.1 Strategic Foundation

A strategic foundation emerged as a pivotal organisational dynamic capability, echoed consistently across all three innovation waves: digital transformation, Industry 4.0 and Industry 5.0. Defined as the bedrock on which organisational strategies are built, a strategic foundation encompasses eight attributes crucial for navigating the complexities of modern business environments, as shown in Table 8. From establishing a clear digital vision to fostering strategic alignment and foresight, the literature underscores the imperative of a robust strategic foundation in driving organisational success for disruptive digital transformation.

Table 8: Strategic foundations and eight attributes

Attributes of a strategic foundation	Digital transformation		Industry 4.0		Industry 5.0
	Dynamic capability framework	Other frameworks	Dynamic capability framework	Other frameworks	Other frameworks
Digital scenario planning and scouting	Warner and Wäger (2019)				
Digital strategy	Ellström et al. (2022); Feroz et al. (2023)	Chirumalla (2021)	Ghobakhloo et al. (2023c)		Chavez et al. (2023)
Long-term digital vision	Warner and Wäger (2019)				
Solution-centric strategy	Ghosh et al. (2022)				
Strategic alignment	Dubey et al. (2024)	Yeow, Soh and Hansen (2018)			
Strategic prioritisation	Feroz et al. (2023)				
Strategic foresight			Vu et al. (2023)		
Technology-based strategies				Naruetharadhol et al. (2022)	
Number of articles	5	2	2	1	1
Total number of articles			11		

Table 8 highlights the significance of a strategic foundation within the realm of digital transformation, indicating a greater number of attributes related to a strategic foundation. Digital strategy emerges as a significant capability, resonating across all three innovation waves, underscoring its pivotal role in shaping a strategic foundation.

In the digital strategy sphere, scholars have highlighted the importance of a well-defined and adaptive approach to digital transformation. Chirumalla (2021) advocated for a continuous digital improvement strategy, emphasising the iterative nature of digital transformation efforts. Similarly, Ellström et al. (2022) cautioned against a broad digital vision devoid of a strategic focus, stressing the need for coherent digital strategies aligned with evolving business objectives. Chavez et al. (2023) further accentuated the human-centric dimension of digital strategies, underscoring the role of flexibility and workforce prioritisation in fostering organisational resilience. Moreover, the literature highlights the multifaceted nature of a digital strategy, encompassing not only technological prowess, but also structural adaptability and strategic foresight (Feroz et al. 2023). Feroz et al. (2023) highlighted the imperative of rapid adaptation to evolving industry landscapes, advocating for the convergence of sustainability goals with digital transformation strategies.

Ghobakhloo et al. (2023c) extended this discourse by emphasising the holistic nature of Industry 4.0 principles, necessitating fundamental shifts in business models and operational paradigms.

In addition to a digital strategy, scholars have identified complementary capabilities that are essential for organisational agility and adaptive resilience. From solution-centric approaches to strategic prioritisation and foresight, Ghosh et al. (2022) stressed the dynamic nature of the organisational capabilities required to thrive in the digital age. Naruetharadhol et al. (2022) highlighted the potential for small and medium-sized enterprises (SMEs) to leverage technology-based strategies, and Yeow, Soh and Hansen (2018) emphasised the iterative nature of strategic alignments, characterised by the continuous adaptation and coevolution of strategies and resources. Further, the literature highlighted the pivotal role of scenario planning as a foundational organisational dynamic capability. Warner and Wäger (2019) underscored the imperative for organisations to develop new capabilities in digital scenario planning and scouting to anticipate technological, customer and competitor-based trends. Their findings emphasised the importance of leveraging both informal and formal networks within technology hubs and employing advanced analytical tools, such as big data analytics and AI, to detect emergent customer-centric trends.

Through a critical synthesis of the relevant studies, the dynamic nature of strategic alignments emerges as a central attribute, challenging the traditional notions of an alignment as a static state. Yeow, Soh and Hansen (2018) conducted a longitudinal examination of a business-to-business supplier that successfully conducted a resource realignment and digital strategy implementation over five years. The study revealed the alignment as an iterative and continuous journey rather than a fixed end point. Their findings illustrated three distinct phases of aligning—exploratory, building and extending—characterised by ongoing tensions in relation to the interdependencies between strategy and resource management (see Figure 13).

Figure 13: Interrelationship between strategy and resource management (Yeow, Soh & Hansen 2018)

This highlights the need for organisations to engage in iterative actions aimed at addressing discrepancies and facilitating the coevolution of strategy and resource management. Similarly, Dubey et al. (2024) shed light on the significance of strategic alignments in bridging generational divides within the workforce. Their study underscored the pivotal role of cohesive and collaborative work environments in driving organisational success, emphasising the need for strategic initiatives aimed at fostering alignment across diverse age groups.

Further, strategic prioritisation emerges as a critical organisational capability essential for navigating the complexities of the digital landscape. Feroz et al. (2023) stressed the requirement for organisations to understand and respond to the evolving external digital landscape. Their study revealed the need for strategic prioritisation in grappling with the impact of novel digital technologies on consumer behaviour, value chains and societal dynamics. Additionally, recognising the disruptive potential of emerging digital technologies necessitates the formulation of unified digital responses across organisations to effectively absorb digital shockwaves. Strategic prioritisation, coupled with adept technology integration, is identified as essential for taking opportunities and streamlining business operations in an increasingly digitised environment (Feroz et al. 2023).

Moreover, strategic foresight is revealed as a key attribute for strategic foundations for organisations seeking to navigate the uncertainties of Industry 4.0 and beyond. Vu et al. (2023) underscored the challenges faced by firms in identifying and capitalising on opportunities amid limited sensing capabilities. Their study highlighted the importance of strategic foresight and technological adaptation in guiding organisational responses to the uncertain path of Industry 4.0 implementation. By fostering novel modes of engagement and enhancing sensing capabilities, organisations can better anticipate and respond to emerging opportunities and threats in the dynamic business landscape.

The literature emphasises the critical importance of strategic alignments, prioritisation and foresight as essential components of organisational dynamic capabilities. By embracing these capabilities, organisations can enhance their resilience and adaptability in the face of ongoing technological disruptions and market transformations.

3.6.2 Knowledge

A total of 17 authors stressed the pivotal role of knowledge as a fundamental organisational dynamic capability. Knowledge, encompassing a breadth of insights, expertise and intellectual capital, emerges as a cornerstone of innovation. The importance of knowledge lies in its capacity to inform decision-making, facilitate learning and development, and drive organisational performance in dynamic and competitive environments. Within the literature, knowledge included four distinct attributes, highlighting its multifaceted nature, as shown Table 9.

Table 9: Knowledge and four attributes

Attributes of knowledge	**Digital transformation**		**Industry 4.0**		**Industry 5.0**
	Dynamic capability framework	**Other frameworks**	**Dynamic capability framework**	**Other frameworks**	**Other frameworks**
Collaboration	Ghosh et al. (2022)	Sousa-Zomer, Neely and Martinez (2020)		(Naruetharadhol et al. (2022); Santos et al. (2023)	Henriksen and Thomassen (2023); Mihardjo and Alamsyah (2019); Narkhede et al. (2024)
Knowledge enhancement			Vu et al. (2023)	Rangaswamy (2021)	
Knowledge management				Rangaswamy (2021); Naruetharadhol et al. (2022)	
Open innovation	Ellström et al. (2022; Feroz et al. (2023); Ghosh et al. (2022); Warner and Wäger (2019)		Cruzara et al. (2023); Ghobakhloo et al. (2023c); Lepore et al. (2023); Vu et al. (2023)	Jiang et al. (2020); Naruetharadhol et al. (2022); Rangaswamy (2021); Ul Zia, Burita and Yang (2023)	
Number of articles	4	1	4	5	3
Total number of articles			17		

Table 9 shows that knowledge includes four different attributes with an emphasis on collaboration and open innovation across all three innovation waves. Notably, collaboration assumes heightened significance within the context of Industry 5.0. This underscores the evolving nature of organisational dynamics and the increasing importance of collaborative networks and ecosystems in driving innovation and value creation in emerging innovation.

The literature review presents a critical exploration of organisational dynamic capabilities, focusing on collaboration, knowledge enhancement and open innovation within the contexts of digital transformation, Industry 4.0 and Industry 5.0. The studies offered valuable insights into the strategic importance of leveraging knowledge for innovation. Vu et al. (2023) underscored the requirement for companies to proactively enhance their knowledge and immerse themselves in the complexities of technology uptake. This perspective highlights the dynamic nature of knowledge acquisition and utilisation in driving value creation and managerial direction. The study by Vu et al. (2023) emphasised the need for organisations to adopt a holistic approach to knowledge management, integrating both internal and external knowledge sources to enhance organisational learning and innovation. Similarly, Rangaswamy (2021) revealed the multifaceted nature of knowledge management, stressing its role in enhancing organisational knowledge-processing patterns and improving knowledge outcomes. Rangaswamy (2021) highlighted the various processes involved in knowledge management, including creating, refining, sharing and applying knowledge within the organisation. This perspective reveals the significance of investing in knowledge management within the context of Industry 4.0, enabling organisations to effectively respond to market demands and enhance adaptive capability. Conversely, the study of Rangaswamy (2021) prompted consideration of the challenges associated with knowledge management, including issues related to knowledge silos, cultural barriers and organisational resistance to change.

The literature on collaboration presented varying perspectives on its role in acquiring knowledge. Sousa-Zomer, Neely and Martinez (2020) emphasised the strategic importance of building digital ecosystems through partnerships and acquisitions, and Henriksen and Thomassen (2023) underscored the significance of close collaboration between stakeholders in fostering a strong commitment to product quality and company success. These views reflect a recognition of collaboration as a vehicle for knowledge sharing and co-creation, aligning with the principles of knowledge management. Similarly, Mihardjo and Alamsyah (2019) highlighted the importance of the customer experience in Industry 5.0, particularly in the context of mass customisation through platform collaboration. This focuses attention on the role of collaboration in leveraging customer insights to drive innovation and enhance value creation. Narkhede et al. (2024) further emphasised the intrinsic value of collaboration among stakeholders in driving organisational success and innovation, reflecting a collective approach to knowledge creation and utilisation. In contrast, Santos et al. (2023) focused on the establishment of innovative collaboration networks with universities, research institutes, government entities, customers and suppliers as critical for Industry 4.0 implementation and competitive advantage creation. Their emphasis on collaboration with various stakeholders underscores its role in accessing external knowledge sources and resources to drive organisational innovation and adaptation.

The literature on open innovation encompassed a broad spectrum of perspectives, ranging from the strategies employed by the SMEs to the role of networking and collaboration in fostering innovation. Lepore et al. (2023) shed light on the diverse approaches adopted by the SMEs in engaging with open innovation to incorporate Industry 4.0 technologies. The comparison between companies highlights the importance of both formal and informal collaborations with external stakeholders. A broad engagement from one company facilitated radical adaptation, but another company’s reliance on informal relationships revealed a more incremental approach centred on business model refinement. This raised questions about the optimal balance between exploration and exploitation in open innovation strategies, particularly within SME contexts.

Naruetharadhol et al. (2022) emphasised the multifaceted nature of open innovation, pointing to centralisation, knowledge management, technology transfer evaluation processes and networking as critical factors. The findings underscored the significance of these elements in expanding market opportunities and enhancing innovation capabilities, particularly in larger corporations. However, the extent to which these findings are generalisable across different organisational contexts warrants further investigation, since the dynamics of open innovation may vary based on factors such as industry sector and firm size.

Jiang et al. (2020) provided insights into the relationships among network structure, knowledge acquisition capability and technology standardisation capability in the context of Industry 4.0. The study highlighted the positive correlation between network density, centrality and structural holes in relation to technology standardisation capability. However, the nuanced interplay among these factors suggests that the effectiveness of external networks in supplementing internal knowledge may hinge on the strategic positioning of enterprises within these networks. This raises questions about the mechanisms through which firms can leverage their network resources to sustainably enhance their innovation capabilities.

Warner and Wäger (2019), and Vu et al. (2023) stressed the importance of leveraging both informal and formal networks, and engaging external stakeholders in driving innovation in the Industry 4.0 landscape. These findings highlight the value of external perspectives and collaborative partnerships in stimulating innovation, particularly in technology hubs. However, the effectiveness of such strategies may vary depending on factors such as organisational culture, industry dynamics and the nature of external partnerships.

Ghobakhloo et al. (2023c) and Cruzara et al. (2023) emphasised the role of networking and partnership capability in facilitating organisational change and digital transformation, particularly in SMEs. These findings suggest that strategic collaborations with external entities can accelerate digitisation processes and enhance competitiveness. However, the challenges associated with managing such partnerships, including competing interests and the alignment of strategic objectives, underscore the complexities involved in leveraging external resources for innovation.

Rangaswamy (2021) and Ellström et al. (2022) highlighted the importance of exploring market needs and digital opportunities through cross-industrial sensing and intra-organisational networks. The findings in these studies reveal the dynamic nature of open innovation and the need for organisations to adapt to changing market conditions and technological trends. However, the extent to which organisations can effectively sense and respond to external stimuli may depend on their internal capabilities and resource allocation processes.

Feroz et al. (2023) and Ghosh et al. (2022) declared the need for organisations to possess the acumen to navigate the evolving digital landscape and leverage strategic partnerships to drive digital transformation. These findings highlight the strategic need to align internal capabilities with external opportunities and foster collaborative relationships with ecosystem partners. However, the challenges associated with managing these partnerships and balancing competing interests underscore the complexities involved in leveraging open innovation for organisational success.

3.6.3 Management

Management was revealed as a paramount organisational dynamic capability by 12 authors, as shown in Table 10. Management encompasses the orchestration of resources, strategic direction and decision-making processes within an organisation, playing a pivotal role in navigating complex and rapidly evolving environments.

Table 10: Management and three attributes

Attributes of management	**Digital transformation**		**Industry 4.0**		**Industry 5.0**
	Dynamic capability framework	**Other frameworks**	**Dynamic capability framework**	**Other frameworks**	**Other frameworks**
Fast decision-making					Mihardjo and Alamsyah (2019)
Management commitment	Dubey et al. (2024)			De Sousa Jabbour et al. (2018); Santos et al. (2023)	
Management leadership	Ghosh et al. (2022); Warner and Wäger (2019)	Chirumalla (2021); Heubeck and Meckl (2022); Tumbas, Berente and Vom Brocke (2020)	Ghobakhloo et al. (2023c); Vu et al. (2023)	De Sousa Jabbour et al. (2018); Saabye, Kristensen and Wæhrens (2022)	
Number of articles	3	3	2	3	1
Total number of articles			12		

Table 10 illustrates three distinct attributes: fast decision-making, management commitment and management leadership. Notably, there is a pronounced emphasis on management leadership in both digital transformation and Industry 4.0 contexts, signifying its critical role in driving innovation and adaptation. In contrast, the advent of Industry 5.0 heralds a shift towards prioritising fast decision-making as the key capability, reflecting the imperative for swift responses to dynamic market conditions and emerging technologies.

Mihardjo and Alamsyah (2019) demonstrated the importance of fast decision-making in their study, emphasising its role in supporting effective and efficient value creation across all company processes within the experience-agility innovation model. This highlights the critical need for organisations to adapt quickly to changing market conditions and sense opportunities promptly. Although fast decision-making is crucial for agility, it also raises questions about the balance between speed and thoroughness in decision-making processes. Organisations must critically assess whether rapid decisions sacrifice quality or strategic alignment.

Dubey et al. (2024) stressed the significance of strong top management commitment to providing direction and support for digital initiatives. Their study highlighted the necessity for clear directives and assistance from senior executives to effectively propel digital transformation forward. In contrast, Ghosh et al. (2022) revealed the need for senior management commitment and alignment with strategic priorities, emphasising the importance of solution-centric knowledge influenced by emerging technologies. This nuanced difference suggests varying perspectives on the depth and breadth of the management commitment required for successful digital transformation. Similarly, De Sousa Jabbour et al. (2018) demonstrated the importance of securing management's endorsement, active involvement and acceptance of pivotal changes for a successful digital transformation. The indispensable role of top management in providing support and direction for organisational change was emphasised in their study. Conversely, Santos et al. (2023) stressed the significance of robust top management commitment and a digital culture that permeates both individual and organisational levels for successful Industry 4.0 implementation. This highlights the broader cultural implications of management commitment beyond the strategic level.

Chirumalla (2021) advocated for fostering a management vision and adopting a bottom-up, evolutionary approach, stressing the importance of visionary leadership in driving organisational change. In contrast, Tumbas, Berente and Vom Brocke (2020) drew attention to the central management role of Chief Digital Officers (CDOs) and identified three distinct types of CDOs with varying objectives and capabilities. This suggests differing perspectives on the position of digital leadership within organisations and the specific competencies required for driving digital transformation efforts. Additionally, Vu et al. (2023) emphasised that effective management involvement and leadership are pivotal in guiding an organisation through transformative processes and fostering a conducive environment for employee commitment and support. Their study underscored the strategic domain, highlighting the significance of management openness and readiness for significant changes. In contrast, the employee self-learning domain revealed the importance of employee initiative and proactive behaviour in supporting organisational transformation. This draws attention to the multifaceted nature of management leadership in driving digital transformation and the importance of balancing strategic direction with employee empowerment and engagement.

Heubeck and Meckl (2022) noted the critical role of managers in driving innovation within firms undergoing digital transformation. This perspective resonates with the study by Sousa-Zomer, Neely and Martinez (2020), which reported on the importance of transformational management leadership in sustaining dynamic capabilities in the digital environment. Effective managers contribute to fostering a risk-taking culture (see Figure 14), promoting innovation and aligning organisational strategies with digital objectives.

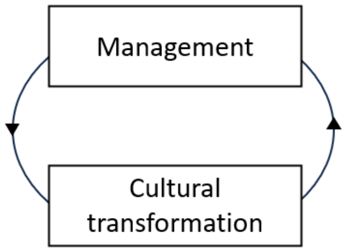


Figure 14: Interrelationship between management and cultural transformation (Sousa-Zomer, Neely & Martinez 2020)

However, this interrelationship also highlights the complexities of organisational change, since cultural transformation often requires a fundamental shift in the mindset and behaviour of management. Moreover, the integration of management and strategy, as elucidated by Tumbas, Berente and Vom Brocke (2020), focuses attention on the need for alignment between management vision and strategic implementation to drive digital transformation effectively (see Figure 15). Achieving this alignment requires ongoing communication, collaboration and adaptability to navigate evolving market dynamics and technological disruptions.

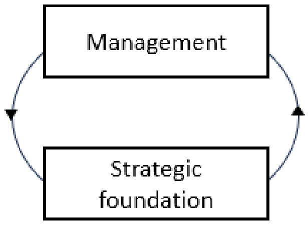


Figure 15: Interrelationship between management and strategy (Tumbas, Berente & Vom Brocke 2020)

Overall, while the literature has emphasised the importance of fast decision-making, management commitment and leadership in driving organisational dynamic capability, nuanced differences between the authors highlight the varying perspectives on the depth, breadth and locus of these principles within the context of digital transformation. These differences reveal the complexity of organisational change processes and the multifaceted nature of leadership in driving successful digital transformation initiatives.

3.6.4 Value Recognition

Value recognition, defined as the ability to identify and acknowledge the intrinsic worth of opportunities, was found to be a critical capability. Although four authors highlighted the importance of value recognition, Table 11 reveals a nuanced exploration of this capability across different attributes.

Table 11: Value recognition and two attributes

Attributes of value recognition	**Digital transformation**		**Industry 4.0**		**Industry 5.0**
	Dynamic capability framework	**Other frameworks**	**Dynamic capability framework**	**Other frameworks**	**Other frameworks**
Circular economy					Narkhede et al. (2024)
Sustainability					European Commission (2021); Henriksen and Thomassen (2023); Henriksen, Røstad and Thomassen (2022)
Total studies	0	0	0	0	4
Total number of articles	4				

Table 11 shows that Industry 5.0 stood out for its focus on value recognition, specifically emphasising the principles of circular economy and sustainability. This suggests a shift towards a more holistic and environmentally conscious approach to value creation in the Industry 5.0 context. Recognising value in terms of sustainability and circular economy principles reflects an evolving understanding of organisational capabilities within the dynamic landscape of Industry 5.0, highlighting the imperative for organisations to embrace responsible and ethical practices in pursuit of innovation and competitive advantage.

The literature on organisational dynamic capability reveals a notable gap in the exploration of value recognition in digital transformation and Industry 4.0, since there were limited studies examining this critical aspect. One possible explanation for this gap may be that it stems from the predominant focus on other dimensions such as the circular economy and sustainability within the broader context of Industry 5.0. Narkhede et al. (2024) drew attention to the collaborative approach of Industry 5.0, focusing on human–robot collaboration, flexibility, adaptability and ethical considerations. Although these aspects contribute to organisational agility and sustainability, they may overshadow the specific examination of value recognition as a distinct capability.

Further, the discourse surrounding Industry 5.0 often revolves around its key traits of human-centricity, sustainability and resilience, as outlined by the European Commission (2021) and reiterated by Henriksen, Røstad and Thomassen (2022). The emphasis on these overarching principles may inadvertently sideline more nuanced discussions on value recognition within organisational dynamics. The studies by Henriksen, Røstad and Thomassen (2022), and Henriksen and Thomassen (2023) underscored the importance of 'human-centricity' and sustainability in Industry 5.0, portraying them as fundamental principles driving organisational behaviour and decision-making.

However, despite the limited direct exploration of value recognition, it can be inferred that the principles of circular economy, sustainability and human-centricity inherently involve a form of value recognition. Circular economy practices, as advocated by Narkhede et al. (2024), and Henriksen and Thomassen (2023), entail recognising the value of resources and minimising waste through reuse, repurposing and recycling. Similarly, sustainability initiatives prioritise the long-term value of environmental stewardship and societal wellbeing over short-term profit-driven strategies, as highlighted by European Commission (2021) and Henriksen, Røstad and Thomassen (2022).

In essence, although explicit studies directly examining value recognition within organisational dynamic capability may be limited, the overarching themes of circular economy, sustainability and human-centricity inherently encompass elements of value recognition. Nonetheless, there remains a need for more focused research to elucidate the specific mechanisms through which organisations recognise, assess and leverage value in the context of dynamic capability frameworks. Such studies could shed light on the intricacies of organisational decision-making processes and inform strategies for enhancing adaptability, innovation and competitiveness in the era of Industry 5.0.

3.6.5 Implementation-Centred Approach

The implementation-centred approach refers to an organisation's approach to effectively execute and implement strategic initiatives, innovations and changes. A total of 12 authors highlighted its importance (see Table 12), illustrating that the implementation-centred approach is seen as a cornerstone of organisational success in navigating complex and rapidly evolving innovation.

Table 12: Implementation-centred approach and three attributes

Attributes of the implementation-centred approach	Digital transformation		Industry 4.0		Industry 5.0
	Dynamic capability framework	Other frameworks	Dynamic capability framework	Other frameworks	Other frameworks
People-centred approach					Chavez et al. (2023); European Commission (2021); Henriksen, Røstad and Thomassen (2022); Henriksen and Thomassen (2023); Mihardjo and Alamsyah (2019); Narkhede et al. (2024)
Human–machine collaboration					Narkhede et al. (2024); Thomas et al. (2023)
Resource management	Dubey et al. (2024); Ellström et al. (2022)	Chirumalla (2021)	Ghobakhloo et al. (2023c)		Modgil, Singh and Agrawal (2023)
Number of articles	2	1	1	0	8
Total number of articles	12				

Table 12 shows that the implementation-centred approach encompasses three attributes: a people-centred approach, human–machine collaboration and resource management. Notably, while resource management remains a key capability across all three innovation waves, there is a significant emphasis on the implementation-centred approach in Industry 5.0. This suggests a heightened recognition of the importance of effective execution and implementation strategies in realising the transformative potential of Industry 5.0. By prioritising the implementation-centred approach, organisations can enhance their agility, responsiveness and ability to capitalise on emerging opportunities, thereby strengthening their dynamic capabilities and competitive positioning in the digital era.

The literature on human-centred approaches within organisational dynamic capability offered valuable insights into the evolving landscape of Industry 5.0. Henriksen, Røstad and Thomassen (2022) highlighted human-centricity as a cornerstone principle. Human-centricity places people at the forefront, emphasising their control over technology and their pivotal role in driving positive societal change. This principle extends beyond improving working conditions to empowering employees as agents of sustainability and social development, advocating for technologies that adapt to their needs. Investments in improved working conditions, health, safety and environmental procedures reflect a growing focus on employee welfare (Henriksen & Thomassen 2023). However, despite the acknowledgment of its significance, Henriksen and Thomassen (2023) underscored the limited attention given to human-centric aspects in prior research, particularly within specific industries such as leisure boat manufacturing. This raises questions about the extent to which human needs are truly prioritised in practice. Chavez et al. (2023) stressed the critical role of human-centric digital transformation for SMEs, noting its potential to enhance process resilience and flexibility. Nonetheless, the practical implementation of such approaches may vary, and challenges persist in aligning technological advancements with human wellbeing. Similarly, Narkhede et al. (2024), and Mihardjo and Alamsyah (2019) advocated for a human-centred approach in Industry 5.0, citing benefits such as increased productivity and efficiency. However, the nuances of integrating human and technological capabilities, along with addressing competency gaps and fostering a culture of innovation, pose formidable challenges. Although the European Commission (2021) pointed out the need to tailor technology to accommodate workers' needs, the practical gap remains a focal point for critical examination. The literature reveals the importance of human-centred approaches in Industry 5.0 but also draws attention to the complexities and ambiguities inherent in their implementation and realisation.

In addition, a study by Thomas et al. (2023) flagged the shift towards human–machine collaboration, resilience and customisation in Industry 5.0. Although this transition highlights the importance of human empowerment as well as technology, it also poses challenges. Organisations must manage workforce dynamics, job roles and potential disparities. Balancing agility with stability and ensuring equitable benefit distribution are crucial. Even though Industry 5.0 offers transformative potential, consideration of the associated challenges is necessary for its effective implementation.

Conversely, Chirumalla (2021) noted the importance of understanding resource requirements and making strategic investment decisions within the framework of continuous digital improvement. However, there is a need for clarity in delineating specific resource needs and how they align with digital strategies. Dubey et al. (2024) drew attention to the critical part played by resource management in enabling digital transformation, particularly in terms of recruiting and retaining talent. This suggests that human capital is a central resource that requires strategic nurturing and development. Ghobakhloo et al. (2023c) focused on the significant resource investments needed for Industry 4.0 adoption, especially in areas of automation. This underscored the importance of financial resources, but it also raised questions about the allocation and optimisation of these investments. Modgil, Singh and Agrawal (2023) shed light on the crucial human capital abilities required in the Industry 5.0 landscape, pointing to talent acquisition, development and retention strategies. However, there is a need for further exploration of the way in which organisations can effectively cultivate these capabilities amid dynamic technological advancements. Ellström et al. (2022) proposed strategies for decomposing digital transformation into specific projects and aligning resource allocation with digital strategies. Challenges remain in operationalising these strategies and ensuring their seamless integration into organisational practices. Overall, these studies provide valuable insights into resource management; however, there is a call for more nuanced approaches that address the complexities and uncertainties inherent in dynamic organisational environments.

3.6.6 Understanding Resistance

A total of 11 authors noted the concept of understanding resistance as an organisational dynamic capability across the three innovation waves, as shown in Table 13. Understanding resistance refers to the capacity of an organisation to effectively identify, analyse and address resistance to change. This involves recognising the sources and underlying reasons for resistance within the organisational context and implementing strategies to mitigate its impact on transformation initiatives.

Table 13: Understanding resistance and three attributes

Attributes of understanding resistance	**Digital transformation**		**Industry 4.0**		**Industry 5.0**
	Dynamic capability framework	**Other frameworks**	**Dynamic capability framework**	**Other frameworks**	**Other frameworks**
Ethical consideration					Narkhede et al. (2024)
Policy and standard				Santos et al. (2023)	
Resilience				Agarwal, Seth and Agarwal (2022)	European Commission (2021); Henriksen, Røstad and Thomassen (2022); Henriksen and Thomassen (2023); Thomas et al. (2023)
Human social capability			Lepore et al. (2023); Vu et al. (2023)	Dabić, Maley and Nedelko (2023)	Modgil, Singh and Agrawal (2023)
Number of articles	0	0	2	3	6
Total number of articles			11		

Although Table 13 reveals that understanding resistance encompasses four different attributes, it notably indicates a significant emphasis on this capability within Industry 5.0. However, there are only a few studies that have addressed this capability within the context of Industry 4.0, and none from a digital transformation perspective. This discrepancy suggests a shift in focus towards addressing resistance as organisations progress through successive innovation waves, underscoring the evolving nature of dynamic capabilities in response to changing technological landscapes.

The literature offered nuanced perspectives on organisational dynamic capability, elucidating the complexities of ethical considerations, policy frameworks, resilience and human social capabilities, along with their interconnectedness. Narkhede et al. (2024) stressed the importance of ethical considerations in Industry 5.0, highlighting fair labour practices and responsible resource management. This suggests a shift towards more socially conscious organisational practices, aligning with broader sustainability goals. However, challenges may arise in balancing ethical imperatives with the competitive pressures of the market, raising questions about the practical implementation of these principles. In contrast, Santos et al. (2023) shed light on the challenges faced by SMEs in navigating policy and regulatory landscapes. Government support and standards are essential for fostering innovation, but there is also a need for more comprehensive policies to support digital transformation. This underscores the tension between regulatory compliance and innovation, revealing the need for adaptive policy frameworks that promote both.

The European Commission (2021) defined ‘resilience’ as the robustness of industrial production to withstand disruptions, particularly in critical sectors such as health care and security. This definition emphasises the importance of developing adaptable production processes and flexible business models to respond effectively to crises. In contrast, Henriksen, Røstad and Thomassen (2022), and Henriksen and Thomassen (2023) explained resilience as the ability to positively adapt to challenges. They noted the significance of modular production processes and digital tools in enhancing resilience. However, they also stressed the importance of fostering employee competence to navigate complex business environments, suggesting a more holistic approach to resilience that incorporates both technological and human elements. Thomas et al. (2023) further emphasised the critical role of resilience in Industry 5.0, particularly in enabling manufacturing systems to withstand disruptions. They discussed the importance of combining emerging technologies with human problem-solving abilities to effectively respond to unforeseen situations, revealing the need for strategic value chains and adaptable production capacity. Agarwal, Seth and Agarwal (2022) offered insights into the barriers and capabilities associated with enhancing supply chain resilience in the context of Industry 4.0. They identified various barriers, including a lack of top management support and technological constraints, and proposed six capabilities crucial for improving resilience. These capabilities, such as planning, collaboration and supply flexibility, are essential for mitigating barriers and enhancing resilience in Industry 4.0 environments.

Vu et al. (2023) shed light on the challenges organisations face in seizing opportunities amid bureaucratic inefficiencies and governmental regulations. Despite investments, uncertainty prevails, necessitating proactive efforts to enhance knowledge and navigate technological complexities.

Effective management involvement is deemed pivotal in guiding transformative processes and fostering employee commitment. In contrast, Lepore et al. (2023) drew attention to the role of informal relationships in shaping business models, noting the significance of social dynamics. Although informal networks may lead to business model refinement, they can also trigger employee resistance during technology implementation, underscoring the need for effective change management strategies. Dabić, Maley and Nedelko (2023) offered insights into the interplay between individual values, leadership capabilities and firm productivity in the context of Industry 4.0. They asserted that ‘hard’ values, such as drive and ambition, play an important part in productivity, overshadowing ‘soft’ values. This suggests a shift towards an economic-driven perspective in Industry 4.0, where productivity improvements take precedence over softer aspects of organisational culture. Modgil, Singh and Agrawal (2023) further emphasised the importance of addressing human social requirements, underlining the need for organisations to consider social factors in their strategic planning and decision-making processes.

Saabye, Kristensen and Wæhrens (2022) discussed the intricate interrelationship among management, knowledge management, cultural transformation and understanding resistance within organisations, particularly in the context of Industry 4.0 technology adoption (see Figure 16).

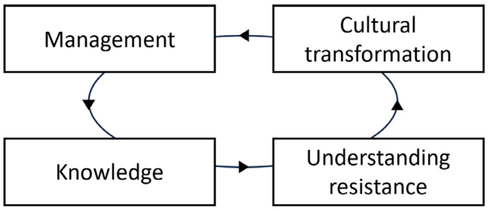


Figure 16: Interrelationship between management, knowledge, cultural transformation and understanding resistance (Saabye, Kristensen & Wæhrens 2022)

The study by Saabye, Kristensen and Wæhrens (2022) examined the notion of developing a learning-to-learn capability among organisational leaders to effectively navigate the challenges associated with Industry 4.0 adoption. By framing Industry 4.0 projects broadly, encouraging collaborative engagement and challenging conventional assumptions, leaders can foster an environment that is conducive to innovation and adaptation. Saabye, Kristensen and Wæhrens (2022) proposed five conditions for enabling Industry 4.0 adoption through learning-to-learn capability, noting the need for cognitive and behavioural changes among leaders to bridge the gap between current and desired states. Further, the study revealed the importance of creating a psychologically safe environment where participants can openly discuss failures and engage in co-learning processes without fear of judgement or reprisal. A study by Saabye, Kristensen and Wæhrens (2022) also highlighted the crucial link among leadership practices, knowledge management and cultural transformation in driving organisational dynamic capability. By promoting a culture of continuous learning and knowledge sharing, leaders can enhance organisational resilience and adaptability in the face of technological disruptions. Although the study provided valuable insights, it is essential to acknowledge the potential challenges and limitations associated with implementing learning-to-learn capability, such as resistance to change and resource constraints. Further research is needed to explore these complexities and provide a deeper understanding of the dynamics involved in organisational dynamic capability.

3.6.7 Continuous Integration

Continuous integration refers to the seamless blending of various processes, technologies and strategies within an organisation to ensure ongoing adaptation and improvement. It involves the consistent incorporation of new ideas, technologies and feedback into existing systems and practices. Table 14 reveals that continuous integration encompasses eight distinct attributes from continuous improvement to seamless integration.

Table 14: Continuous integration and eight attributes

Attributes of continuous integration	**Digital transformation**		**Industry 4.0**		**Industry 5.0**
	Dynamic capability framework	**Other frameworks**	**Dynamic capability framework**	**Other frameworks**	**Other frameworks**
Continuous improvement			Vu et al. (2023)	Rangaswamy (2021)	
Customisation	Ghosh et al. (2022)				Thomas et al. (2023)
Personalisation					Narkhede et al. (2024)
Process and IT know-how integration		Chirumalla (2021)			
Digital solutions integration	Ellström et al. (2022)				
Research and development	Ghosh et al. (2022); Warner and Wäger (2019)			Santos et al. (2023)	
Adept integration	Feroz et al. (2023)				
Seamless integration				Szalavetz (2019)	
Number of articles	4	1	1	3	2
Total number of articles			11		

Table 14 shows that, even though continuous integration was emphasised by 11 authors across the three innovation waves, the attributes varied considerably. This suggests that the overarching concept of continuous integration remains relevant, but its implementation and focus areas evolve to address the unique challenges and opportunities presented by each innovation wave.

The literature on organisational dynamic capability presented a diverse range of perspectives, and each author offered unique insights into continuous improvement, seamless integration, customisation, personalisation and research and development (R&D). Vu et al. (2023) and Rangaswamy (2021) both addressed the concept of continuous improvement, albeit from different angles. Vu et al. (2023) emphasised the need for a forward-thinking approach and continuous technological upgrades to remain competitive, and Rangaswamy (2021) stressed the importance of evaluating the existing processes to ensure their relevance to market needs. These perspectives reveal the multifaceted nature of continuous improvement, encompassing both technological advancement and process evaluation. Similarly, Szalavetz (2019) and Feroz et al. (2023) discussed the integration of technology into production processes. Szalavetz (2019) examined the importance of seamless integration in effectively leveraging advanced technologies, and Feroz et al. (2023) stressed the need for strategic prioritisation and adept integration to seize opportunities and streamline operations. These perspectives draw attention to the critical role of technology integration in enhancing organisational agility and competitiveness.

In terms of customisation and personalisation, Ghosh et al. (2022) and Thomas et al. (2023) provided insights into meeting customer demands and responding to unforeseen situations. Ghosh et al. (2022) emphasised the value of customisation and efficiency in meeting evolving customer demands, and Thomas et al. (2023) highlighted the part played by strategic value chains and flexible procedures in mitigating disruptions. These perspectives reveal how important adaptive strategies are in addressing dynamic market conditions.

Chirumalla (2021) investigated the significance of a continuous digital improvement strategy, which involves integrating data from various sources and forming agile teams to enhance organisational agility. The study noted the significance of digitally enabled reconfiguring capabilities, particularly in integrating process and IT know-how. By continuously improving digital initiatives, organisations can adapt to changing market conditions and technological advancements. In contrast, Ellström et al. (2022) focused on the integration of digital solutions into a cohesive infrastructure that is accessible across the organisation. Their study showed the value of creating a unified platform that enables seamless access to digital tools and resources. By integrating digital solutions into organisational infrastructure, companies can enhance collaboration, efficiency and innovation across departments.

Warner and Wäger (2019) advocated for the establishment of digital innovation laboratories as a means to drive R&D efforts. Their emphasis was on creating environments in which organisations can experiment with minimum viable products and gather real-time customer feedback. By leveraging digital innovation laboratories, companies can rapidly iterate on product development and better align their offerings with customer needs. In contrast, Ghosh et al. (2022) focused on joint product development initiatives with partners as a strategic foundation for enhancing R&D capabilities, highlighting the interrelationship between strategic foundations and integration R&D capability (Figure 17).

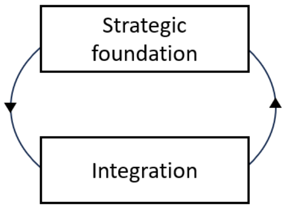


Figure 17: Interrelationship between strategy and integration (Ghosh et al. 2022)

The study highlighted the importance of collaboration with external partners to access complementary resources and expertise. By engaging in joint product development, companies can tap into new markets, technologies and ideas, thereby increasing their ability to adapt and innovate in response to market dynamics. Santos et al. (2023) offered a different perspective by emphasising the role of process and product innovation centred on digital technologies within SMEs. Their study examined the importance of aligning R&D efforts with digital transformation initiatives to leverage innovation capabilities crucial for Industry 4.0 adoption. By integrating digital technologies into R&D processes, SMEs can enhance their competitiveness and adaptability in the increasingly digitised marketplace.

3.6.8 Leadership and Communication

Leadership and communication were revealed as critical organisational dynamic capabilities, emphasised by seven authors across the three innovation waves, as shown in Table 15. Leadership involves guiding and inspiring individuals within an organisation to achieve common goals, and communication entails effectively conveying information and ideas among stakeholders. Both aspects are crucial for fostering innovation, driving change and enabling adaptability within organisations.

Table 15: Leadership and communication, and five attributes

Attributes of leadership and communication	Digital transformation		Industry 4.0		Industry 5.0
	Dynamic capability framework	Other frameworks	Dynamic capability framework	Other frameworks	Other frameworks
Leadership				Dabić, Maley and Nedelko (2023)	Thomas et al. (2023)
Proper communication	Dubey et al. (2024)				
Transparent communication	Dubey et al. (2024)			Santos et al. (2023)	
Transformational leadership	Huang, Jiang and Chang (2023)				
Digital leadership	Dubey et al. (2024)	El Sawy et al. (2020)			
Clear communication			Ghobakhloo et al. (2023c)		
Number of articles	2	1	1	2	1
Total number of articles			7		

Table 15 indicates that leadership and communication encompass six distinct attributes, highlighting the multifaceted nature of these capabilities. Although consistently emphasised across all three innovation waves, the specific attributes varied, which reflects the evolving needs and challenges associated with each wave. This underscores the necessity for tailoring leadership and communication strategies to the unique contexts of digital transformation, Industry 4.0 and Industry 5.0 to effectively harness organisational dynamic capability.

The literature on leadership and communication within the context of organisational dynamic capability revealed nuanced differences in approaches and perspectives across the various studies. Dabić, Maley and Nedelko (2023) noted the crucial role of leadership in driving productivity in Industry 4.0 environments, focusing on how individual leaders' values shape organisational capabilities and outcomes. In contrast, Thomas et al. (2023) examined the requirements of leadership in Industry 5.0, illustrating that continuous learning, collaboration and an understanding of technological domains are required to drive innovation and adaptability. They advocated for transformational and servant leadership styles that align corporate goals with individual needs, and that promote sustainability and digital transformation.

Regarding communication, Dubey et al. (2024) and Santos et al. (2023) discussed the importance of transparent and effective communication in digital transformation efforts. Dubey et al. stressed the significance of proper communication in fostering clarity, alignment and engagement, and Santos et al. drew attention to the need for clear communication of Industry 4.0 objectives to facilitate employee acceptance of change. Ghobakhloo et al. (2023c) similarly underscored the notion that effective change management through clear communication of digitalisation objectives and progress is vital.

Moreover, the concept of digital leadership emerged as a critical aspect in driving organisational change and innovation. Dubey et al. (2024) discussed digital leadership as encompassing various capabilities aimed at fostering effective leadership in the digital age, including proper communication, the empowerment of team members, and the cultivation of a culture of innovation and collaboration. El Sawy et al. (2020) investigated digital leadership further and revealed its transformative nature with regard to rethinking business strategies, models, IT functions and workplace culture.

Huang, Jiang and Chang (2023) showed that transformational leadership is significant in facilitating digital transformation, which aligns with the perspective of El Sawy et al. (2020) on the transformative nature of digital leadership. Santos et al. (2023) examined the need for robust top management commitment and a digital culture to drive successful Industry 4.0 implementation, noting that the transparent communication of objectives is key to fostering employee acceptance of change.

The literature on the interrelationship among strategy, digital leadership, communication and cultural transformation illustrated their interconnected nature in terms of driving organisational change and innovation. El Sawy et al. (2020) investigated the ways in which digital leadership involves rethinking various aspects of business, including strategy and workplace culture. This perspective emphasises the interplay between leadership and communication in shaping organisational culture and facilitating digital transformation (see Figure 18).

Figure 18: Interrelationship between leadership and communication, and cultural transformation (El Sawy et al. 2020)

Santos et al. (2023) examined the broader context of digital transformation, demonstrating the need for comprehensive government policies, educational initiatives and robust top management commitment to foster digital transformation. They showed that transparent communication is important in fostering employee acceptance of change and highlighted the interrelationship among leadership, communication and organisational resistance (see Figure 19). This perspective emphasises how effective communication can facilitate cultural transformation and support leadership initiatives in driving digital transformation efforts.

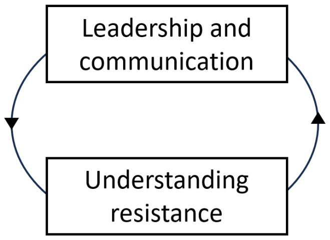


Figure 19: Interrelationship between leadership and communication, and understanding resistance (Santos et al. 2023)

3.6.9 Cultural Transformation

The critical role of cultural transformation as an organisational dynamic capability was also revealed in the literature. Cultural transformation refers to the process of reshaping organisational values, beliefs and norms to align with the demands of technological innovation and changing market landscapes. It involves fostering a culture of agility, adaptability and continuous learning to thrive in dynamic environments. The importance of cultural transformation was noted by 12 authors, as illustrated in Table 16.

Table 16: Cultural transformation and seven attributes

Attributes of cultural transformation	Digital transformation		Industry 4.0		Industry 5.0
	Dynamic capability framework	Other frameworks	Dynamic capability framework	Other frameworks	Other frameworks
Adaptability					Narkhede et al. (2024)
Agility	Feroz et al. (2023); Warner and Wäger (2019)	Chirumalla (2021); Sousa-Zomer, Neely and Martinez (2020)		Agarwal, Seth and Agarwal (2022)	Mihardjo and Alamsyah (2019)
Flexibility					Narkhede et al. (2024)
Risk-taking culture		Sousa-Zomer, Neely and Martinez (2020)			

Attributes of cultural transformation	Digital transformation		Industry 4.0		Industry 5.0
	Dynamic capability framework	Other frameworks	Dynamic capability framework	Other frameworks	Other frameworks
Digital culture	Dubey et al. (2024); Warner and Wäger (2019)			Santos et al. (2023)	
Culture of innovation	Dubey et al. (2024); Ghosh et al. (2022)		Cruzara et al. (2023)		Mihardjo and Alamsyah (2019)
Open culture			Vu et al. (2023)		
Number of articles	4	2	2	2	2
Total number of articles			12		

Table 16 shows that, although cultural transformation was evenly emphasised in all three innovation waves, seven attributes associated with it varied. Notably, the attributes of agility and digital innovation emerged as common themes across all three waves, indicating their importance in fostering organisational resilience and competitiveness in the face of technological change.

In the exploration of organisational dynamic capability, adaptability was revealed as a focal point. Feroz et al. (2023) stressed the need for strategic agility and the importance of being able to pivot digital strategies swiftly in response to evolving circumstances. This perspective aligns with the emphasis on rapid prototyping noted by Warner and Wäger (2019), indicating that adaptability is vital in experimenting with new approaches. Agility, closely related to adaptability, received significant attention in the literature. Chirumalla (2021) examined the significance of agile cross-functional teams in integrating data and driving digital initiatives, and Agarwal, Seth and Agarwal (2022) focused on agile capabilities for building resilient supply chains. Similarly, Sousa-Zomer, Neely and Martinez (2020) discussed decentralisation and the fostering of nimble structures as crucial for sustaining dynamic capabilities in the digital environment.

Flexibility was discovered as another key aspect of organisational dynamic capability, particularly in the context of Industry 5.0. Narkhede et al. (2024) emphasised the collaborative approach in Industry 5.0, promoting human–robot collaboration and adaptability for faster reconfiguration of production lines. This shows that flexibility is crucial when responding to changing market dynamics and technological advancements. The literature also highlighted the significance of a risk-taking culture in driving innovation and transformation. Sousa-Zomer, Neely and Martinez (2020) discussed the necessity for a risk-taking culture to support innovation, and stressed that digital congruence among cultures, people and structures is required. This aligns with the findings of Ghosh et al. (2022)

and Cruzara et al. (2023), who discussed the importance of fostering a culture that is conducive to innovation and open experimentation.

Warner and Wäger (2019) investigated the importance of building sensing capabilities through a strong digital culture, emphasising that a long-term digital vision and an entrepreneurial mindset are needed. They revealed the significance of digital maturity within the workforce and advocated for the involvement of younger digital natives in capability-building processes. In contrast, Dubey et al. (2024) focused on empowering team members and fostering a culture of innovation and collaboration. They looked into the foundational aspects of digital culture in successful digital transformation, including elements such as a data-driven culture and aligning business needs with digital technologies. The significance of digital culture permeating both individual and organisational levels was underscored by Santos et al. (2023), particularly in the context of Industry 4.0 implementation.

Ghosh et al. (2022) and Cruzara et al. (2023) discussed the need for a culture of innovation in navigating shifting business models influenced by digitalisation. Ghosh et al. (2022) recommended embracing a solution-centric mindset and fostering a culture conducive to innovation. In contrast, Cruzara et al. (2023) highlighted networking and the organisational ecosystem as crucial factors for facilitating Industry 4.0 advancement. However, they also identified organisational culture as a significant obstacle to innovation and digital transformation progress. They stressed that an open culture is essential for successful innovation and digital transformation, echoing the study of Vu et al. (2023), which emphasised the need for an open mindset and continuous technological upgrades to remain relevant in the ever-evolving Industry 4.0 landscape.

3.6.10 Skill Transformation

Another crucial organisational dynamic capability that became evident was skill transformation, which refers to the process of upgrading and adapting employees’ skills to align with evolving technological advancements and organisational needs. This capability encompasses various attributes, including training mechanisms, upskilling and reskilling initiatives, and continuous learning, as shown in Table 17.

Table 17: Skill transformation and six attributes

Attributes of skill transformation	**Digital transformation**		**Industry 4.0**		**Industry 5.0**
	Dynamic capability framework	**Other frameworks**	**Dynamic capability framework**	**Other frameworks**	**Other frameworks**
Continuous learning and resilience				Rangaswamy (2021)	Modgil, Singh and Agrawal (2023)
Managerial skills					Modgil, Singh and Agrawal (2023)
Reskilling and upskilling				Santos et al. (2023)	
Skill training			Ghobakhloo et al. (2023c); Lepore et al. (2023)		Mihardjo and Alamsyah (2019)
Training mechanisms		Chirumalla (2021); Sousa-Zomer, Neely and Martinez (2020)	Vu et al. (2023)	Szalavetz (2019)	
Soft skills					Modgil, Singh and Agrawal (2023)
Number of articles	0	2	3	3	2
Total number of articles			10		

Table 17 indicates that, although digital transformation initiatives primarily refer to training mechanisms to equip employees with basic digital skills, Industry 4.0 and Industry 5.0 place significant emphasis on broader skill transformation efforts. In Industry 4.0 and Industry 5.0, skill transformation initiatives encompass a more comprehensive approach, including basic training as well as upskilling and reskilling programs. This heightened emphasis on skill transformation in Industry 4.0 and Industry 5.0 reflects a recognition of the pivotal role that skilled and adaptable workforces play in driving innovation, competitiveness and organisational resilience in increasingly digitised and complex business environments.

In the pursuit of organisational dynamic capability, continuous learning and resilience emerge as foundational elements. Rangaswamy (2021) advocated for a focused approach to continuous learning and noted the mastery of specific technology stacks tailored to project requirements. This aligns with the broader concept of resilience, as highlighted by Modgil, Singh and Agrawal (2023), who stressed the importance of managerial skills along with continuous learning in the context of Industry 5.0. They underscored the significance of soft skills, such as ‘man management’ and operational skills, as well as advanced technical competencies. Within the landscape of Industry 5.0, the role of managerial skills is paramount. Modgil, Singh and Agrawal (2023) stated that managerial skills are critical components, along with continuous learning and resilience. They argued that effective leadership encompasses soft skills, such as man management, in conjunction with operational skills and advanced technical competencies. This highlights the multifaceted nature of managerial skills within the dynamic capability framework.

The challenges posed by digital transformation necessitate a focus on reskilling and upskilling initiatives. Santos et al. (2023) examined the importance of aligning departments and IT infrastructure to support data exploitation and decision-making processes. They discussed the need for human resource management practices focused on reskilling and upskilling, often facilitated through partnerships with external consultants and training organisations. Different approaches to skill training are evident across the studies. The differing strategies of two companies investing in employee training were explored by Lepore et al. (2023). One emphasised greater employee involvement across technological capabilities to improve wellbeing and organisational reconfiguration, yet the other's approach initially led to employee resistance during technology implementation. Additionally, soft skills play a vital role in organisational dynamic capability. Modgil, Singh and Agrawal (2023) concluded that soft skills such as man management are essential components of managerial skills, as are operational skills and advanced technical competencies. These soft skills contribute to the resilience of organisations in the face of technological advancements and changing business landscapes.

The implementation of strategic training mechanisms as a means to enhance organisational adaptability was promoted by Chirumalla (2021); however, the specifics of these mechanisms remain ambiguous in their study, leaving room for interpretation. In contrast, Sousa-Zomer, Neely and Martinez (2020) found that it is necessary for firms to possess specific conditions, processes and skills to thrive in a rapidly evolving digital landscape. Their emphasis extended beyond mere training mechanisms to include broader organisational transformations, noting the requirement for senior leadership teams and board members to be digitally savvy. This nuanced approach reveals the pivotal role of leadership and organisational culture in driving digital initiatives and transformation. Similarly, Vu et al. (2023) shed light on the importance of employee self-learning and technological adaptation, particularly in the context of Industry 4.0 implementation. Their focus on employee-driven learning aligns with the notion of fostering a culture of continuous improvement and adaptability within organisations. Contrastingly, the importance of investing in technological expertise at the subsidiary level to drive innovation and efficiency gains was investigated by

Szalavetz (2019). Although training and skill development are crucial components, their emphasis lay more on building specific technical capabilities rather than broad-based training mechanisms.

3.7 Conceptual Framework

This chapter has explored the landscape of organisational dynamic capabilities within the contexts of digital transformation, Industry 4.0, and Industry 5.0, drawing on 34 key studies in the field. The development of the framework began with an extensive analysis of the literature, which revealed 10 core organisational dynamic capabilities critical to enabling digital transformation in the heavy industry. Each of these capabilities was identified and refined through an iterative process of review and synthesis.

The review highlighted 10 recurring capabilities within the literature, each integral to organisational dynamic capability. These capabilities—strategic foundation, knowledge, management, value recognition, implementation-centred approach, understanding resistance, continuous integration, leadership and communication, cultural transformation, and skill transformation—were systematically drawn from prior studies focused on organisational responses to technology-driven change.

In addition to the primary capabilities, 51 supporting attributes (Appendix 2) were distilled to provide a finer level of detail, clarifying how each capability manifests specifically within the heavy industry. These attributes were identified by examining the specific requirements of each capability as described in the literature. The literature also underscored the importance of interconnectedness among these capabilities. Dynamic capabilities, such as sensing, seizing, and reconfiguring, do not operate in isolation; they interact and reinforce one another within organisational contexts. This realisation led to an integrated view of the capabilities, where each is interdependent.

Once these capabilities and their interrelationships were identified, they were organised into a coherent framework that reflects the layered and interdependent nature of dynamic capabilities. Figure 20 illustrates this framework, where capabilities are grouped according to their function (sensing, seizing, and reconfiguring) and interconnectedness, highlighting how each supports organisational adaptation within the context of innovation waves.

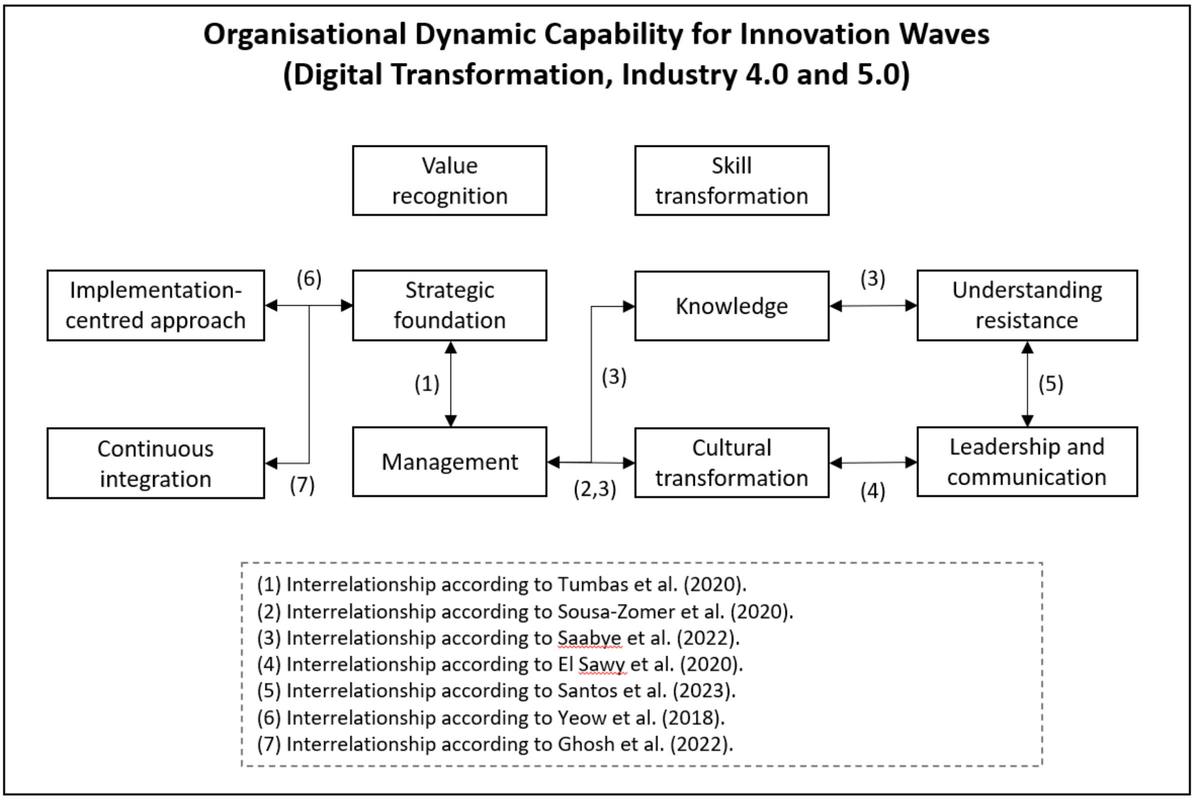


Figure 20: Conceptual framework of organisational dynamic capability required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0)

By presenting these capabilities within a single, unified framework, this section provided both a theoretical foundation and a practical guide for organisations navigating innovation waves. The conceptual framework is deeply rooted in literature, and its structure reflects a synthesis of recurring themes across studies, supporting the thesis's objectives of examining and empirically validating these capabilities within the Australian heavy industry. This framework will be further examined in subsequent chapters, where its applicability to real-world contexts will be validated, underscoring the framework's relevance and robustness in guiding organisations through the complex landscape of Industry 4.0 and Industry 5.0.

3.8 Research Gaps, Objectives and Questions

The existing literature on organisational dynamic capabilities exhibits a notable gap, resulting in the formation of a comprehensive organisational dynamic capability framework that considers all three innovation waves: digital transformation, Industry 4.0 and the emerging Industry 5.0. Further, there has been limited research examining Industry 5.0 through lens of the dynamic capability framework (Section 3.6). Additionally, the recent literature on organisational dynamic capabilities tends to overlook the main dimensions of dynamic capability: sensing, seizing and reconfiguring.

In the Australian heavy industry, encompassing sectors such as shipbuilding, mining, and oil and gas, innovation with advanced technologies is paramount for sustaining economic growth and competitiveness in the global market (Section 2.3). Despite substantial investments in this digital journey, the industry remains in an early developmental phase, grappling with the intricate challenges inherent in its innovation (Section 2.4). Given this context, understanding the foundational organisational capabilities required for innovation waves emerges as a critical pursuit. Hence, the following overarching research question guided this thesis:

> *"What are the key organisational dynamic capabilities and their interrelationships that enable the Australian heavy industry to build and support innovation waves (digital transformation, Industry 4.0, and Industry 5.0)?"*

This central inquiry led to two sub-RQs. First, the prevailing literature on organisational dynamic capabilities, whether generic or tailored to other sectors, lacks transferability to the intricate landscape of the Australian heavy industry. To illuminate pathways for the industry to emerge as a digital innovator, with a specific emphasis on its capabilities to harness advanced technologies for transformative outcomes, the initial objective of the thesis was to investigate the organisational dynamic capabilities required for innovation waves within the Australian heavy industry. This pursuit was guided by the following sub-research question:

> *RQ1: What are the key organisational dynamic capabilities (sensing, seizing and reconfiguring) required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0) in the Australian heavy industry?*

Second, the dynamics of innovation underscore the interconnectedness among organisational dynamic capabilities, necessitating nuanced comprehension to navigate the complexities effectively (Section 3.6). As highlighted by the conceptual framework, understanding and leveraging these interrelationships are pivotal for comprehensive capability development within the Australian heavy industry. Thus, the second sub-research question sought to unravel the interdependencies among organisational dynamic capabilities, specifically within the Australian heavy industry context:

> *RQ2: How are organisational dynamic capabilities interrelated in the Australian heavy industry?*

By addressing these research questions, this thesis endeavoured to offer insights that can inform strategic initiatives aimed at bolstering the transformation efforts required for innovation waves within the Australian heavy industry, thereby contributing to its long-term sustainability and competitiveness in the global arena.

3.9 Summary

This chapter reviewed and analysed the organisational dynamic capability literature, focusing on the recent innovation waves (digital transformation, Industry 4.0 and Industry 5.0) utilised in this thesis, and derived the research questions. The primary objective was to inform the development of a conceptual framework tailored to the context of organisational dynamic capability. The conceptual framework, derived from a synthesis of the extant literature, serves as a foundational tool for further empirical validation of the distinctive capabilities within the Australian heavy industry. By synthesising and critically examining the existing literature, this chapter laid the groundwork for the subsequent empirical investigation, aimed at investigating the organisational dynamic capabilities required for innovation waves within the Australian heavy industry.

The next chapter details the methodology employed to empirically validate the conceptual framework and contributes to a deeper understanding of organisational capabilities in the context of innovation waves within the Australian heavy industry.

CHAPTER 4: METHODOLOGY

4.1 Objective

The purpose of this chapter is to reveal the research methodology adopted to answer the following research question:

> *"What are the key organisational dynamic capabilities and their interrelationships that enable the Australian heavy industry to build and support innovation waves (digital transformation, Industry 4.0, and Industry 5.0)?"*

First, it presents the research design, including the most appropriate research paradigm, approach, technique and study sample chosen to answer the research questions. Next, the data collection method is reported, which includes details regarding the preparation, recruitment, interview execution and recording, and data storage. Subsequently, it elucidates the data analysis and interpretation process, encompassing the data transcription, data coding and data analysis methods. Last, it specifies the research trustworthiness of the selected methodology.

4.2 Research Design

The term ‘research design’ encompasses a comprehensive plan that outlines the structure, procedures and methods for collecting, analysing, interpreting and reporting data, as described by Creswell and Creswell (2017). Its primary aim is to ensure the alignment between the evidence gathered and the research questions guiding the investigation, as emphasised by Richards and Morse (2012).

In this thesis, the research design consists of five sequential phases, which are elaborated on in the subsequent section and illustrated in Figure 21.

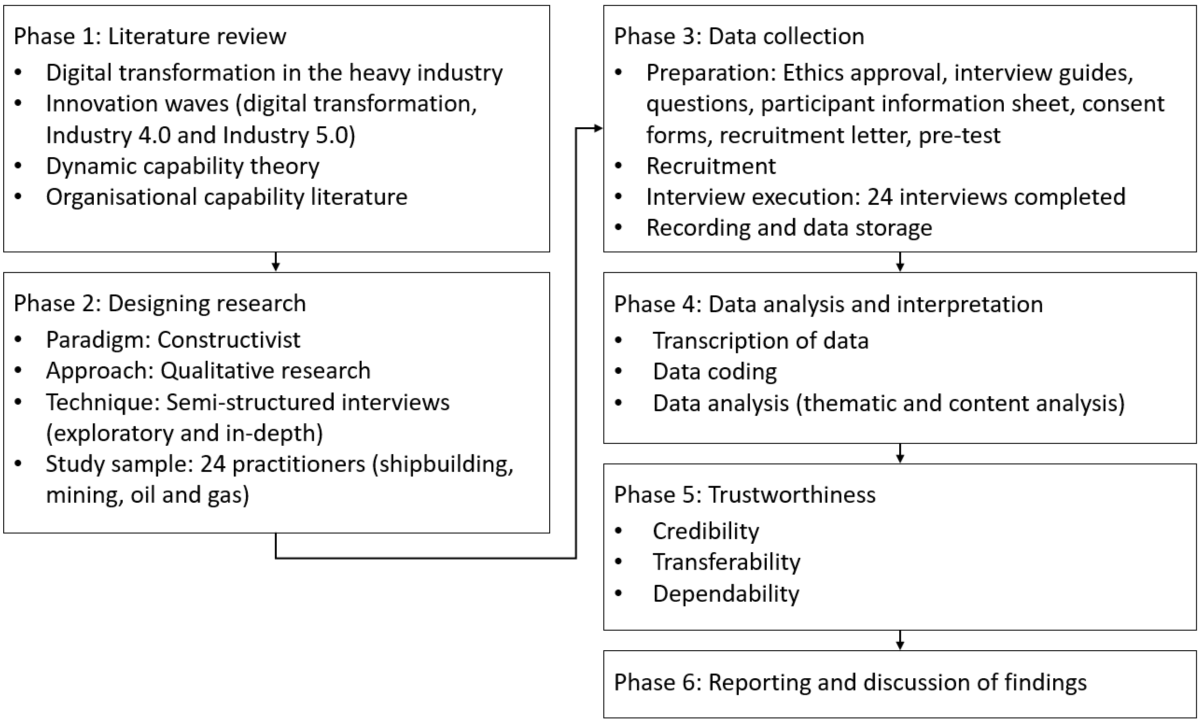


Figure 21: Research design diagram

Figure 21 shows that the initial phase involved an extensive review of the literature related to the industry context (heavy industry), innovation waves (digital transformation, Industry 4.0 and Industry 5.0), dynamic capability theory and organisational capability, as presented in Chapters 2 and 3. This literature review served the purpose of thematically situating the thesis within the theoretical research landscape. Additionally, following established research practices, the literature review served a threefold purpose: (1) it generated the research framework, (2) it identified gaps in the existing research and (3) it guided the development of specific research objectives and questions, drawing insights from both the scholarly literature and practical contexts. Literature review methodology and approach are generally outlined in Section 3.2. Specific details about the literature review methodology are provided in the introduction of Section 3.5 and Section 3.6, giving a comprehensive overview as part of the literature review chapter.

The second phase represented the research design stage, starting with the selection of the research paradigm and approach. Since this thesis employed a qualitative technique to answer the research questions, semi-structured interviews were chosen. The population sample for the data collection was set at 24 participants from the Australian heavy industry. The participants nominated for this research were mostly employed in mid-level senior positions such as senior engineers, managers or consultants. This selection was based on their extensive knowledge of the transformation process for innovation waves, their involvement in wide-ranging processes and their interaction with stakeholders at all levels, from tradespeople to executives, providing valuable insights into the organisational dynamic capabilities required for innovation waves. The details of the population sample are reported in Section 4.2.4.

The third phase was concerned with data collection. The data collection stage included preparation, recruitment, interview execution, recording and data storage. Initially, the preparation for data collection was performed, which aimed to prepare all the documents required, including ethics approval, interview guides and questions, a participant information sheet, a recruitment letter and consent forms. All documents related to these were tested and confirmed by a principal supervisor. The finalised documents were used to obtain ethics approval by the ethics committee in line with the Australian Research Council guidelines. This phase included the pre-tests with two scholars to validate and test the designed research questions. The details of the pre-tests are explained in Section 4.3.1.5. Regarding the interview execution, 24 interviews were completed (each interview took approximately one hour), and the details of how the interviews were executed, recorded and stored are reported in detail in Sections 4.3.3 and 4.3.4.

The fourth phase involved data analysis and interpretation. The data analysis followed an established analysis approach introduced by Creswell and Creswell (2017), which consisted of six different stages from organisation and preparation for data analysis to the interpretation of the data, as shown in Figure 21. A total of 24 interviews were transcribed and analysed using Microsoft Word and NVivo 12, and the details are reported and outlined in Section 4.4.

The fifth phase related to trustworthiness. Ensuring trustworthiness in qualitative research is vital. This thesis focuses on three key measures: credibility, transferability and dependability. Credibility is achieved by aligning theoretical frameworks with data and reflecting participants' perspectives. Transferability is ensured through the detailed documentation of the methodology and findings, making the results applicable to other contexts. Dependability, similar to reliability, is maintained by adhering to standardised research practices and thorough reporting. These criteria enhance the rigour and quality of the research, supporting the evaluation of the organisational dynamic capability required for innovation waves.

The last (sixth) phase involved the results and a discussion of findings.

4.2.1 Research Paradigm

A research paradigm is a common agreement shared between researchers or scientists about how the research problems should be solved (Kuhn 1970). Three major research paradigms are pragmatism, post-positivism and constructivism, and there are three different philosophical dimensions: ontological, epistemological and methodological aspects (Creswell & Clark 2017). These dimensions support researchers in understanding the nature of existence and the holistic view of the way in which knowledge is seen, as well as the methodological strategy adopted (Creswell & Clark 2017). It is important to acknowledge the philosophical foundation that has had a significant influence on the development of a research design and its integrity.

Ontology is a philosophical approach to studying 'what reality is', which seeks to understand what exists in the world, and epistemology examines the way in which people can examine reality to address the question 'how can I know reality?'. Methodology is concerned with the way in which researchers discover knowledge. Last, the method refers to the tools used to discover reality and knowledge. Table 18 shows a clear overview of the main research paradigms.

Table 18: Overview of main research paradigms (Crotty 1998, p. 256)

Paradigm	**Ontology**	**Epistemology**	**Methodology**	**Method**
	'What is reality?'	*'How can I know reality?'*	*'How do you go about finding out?'*	*'What tools do you use to find out?'*
Positivism	A single reality or truth	Reality can be measured using reliable designs and tools	Experimental research, survey research	Quantitative
Constructivist	No single reality or truth (multiple)	Reality needs to be interpreted to discover the underlying meaning of events and activities	Grounded theory, phenomenological research	Qualitative
Pragmatism	The reality is constantly negotiated, debated, interpreted	The knowledge should be examined using the best tools to solve the problem	Mixed methods, design-based research, action research	Combination

This thesis aimed to uncover the organisational dynamic capabilities required for innovation waves in the Australian heavy industry. Constructivism was chosen as the research paradigm because this thesis investigates the in-depth nature of taking perspectives from industry practitioners and listening to their interpretation. As shown in Table 18, constructivism assumes various meanings, so scholars employing the constructivist paradigm seek to understand the complex but fundamental aspects of participants' meanings. The qualitative research method was also chosen, allowing an in-depth exploration through interviews, reflective sessions and observations (Creswell & Creswell 2017).

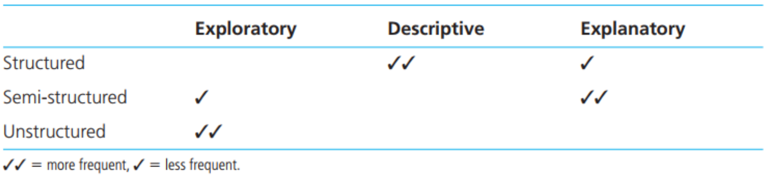
4.2.2 Research Approach

The research approach is an important step in answering the research question. Bouchard (1976, p. 402) stated that 'the key to good research lies not in choosing the right method, but rather in asking the right question and picking the most powerful method for answering that question'. As mentioned in Section 4.2.1, the qualitative approach was selected to meet the objectives of the thesis and to answer the research questions. The qualitative research approach allows the author to understand the subjective perceptions of the phenomenon (Creswell & Creswell 2017). Qualitative research has been criticised owing to the difficulty of determining the 'truthfulness' of qualitative findings and the lack of scientific evidence (Sandelowski 1986). However, many studies have indicated the importance of qualitative research and management (Symon, Cassell & Johnson 2018). For example, highly recognised top-tier journals, including the *Academy of Management Journal*, have recognised qualitative research, emphasising its potential to introduce new ways of seeing and provide 'insights that challenge taken-for-granted theories and expose new theoretical directions' (Bansal, Smith & Vaara 2018, p. 1189). In employing the qualitative approach, researchers can take advantage of its ability to embrace the 'complexity within the topic, rather than narrowing its meaning down to a limited set of categories or ideas' (Creswell & Creswell 2017, p. 8). As specified in Chapter 2 (Context), this thesis is focused on complex and large industry sectors that are not easily assessed or studied. Thus, the qualitative research approach is appropriate for interpreting in-depth knowledge about a particular circumstance by examining it more deeply and providing valuable insights (McMurray, Pace & Scott 2004).

4.2.3 Technique

This thesis conducted qualitative interviews as a data collection technique which is the most common method used in qualitative research (Myers & Newman 2007). The interviews enabled participants to freely discuss the reality of the phenomenon with individual perceptions. This eventually provided rich data and subjective interpretation (King, Horrocks & Brooks 2018). Data collection using the qualitative approach can potentially introduce challenges and biases that may influence research outcomes (Myers & Newman 2007). Thus, the technique employed for data collection and the associated processes became pivotal determinants in the success of the research.

The interviews can be categorised into unstructured, semi-structured or structured, as shown in Figure 22.



	Exploratory	Descriptive	Explanatory
Structured		✓✓	✓
Semi-structured	✓		✓✓
Unstructured	✓✓		

✓✓ = more frequent, ✓ = less frequent.

Figure 22: Interview types (Saunders, Lewis & Thornhill 2009)

Unstructured interviews aim 'to find out what is happening and to seek new insights' (Robson 2002, p. 59). Data collected from unstructured interviews may be difficult to analyse compared with structured interviews, which usually follow a strict research rule with predefined questions (Saunders, Lewis & Thornhill 2009).

This thesis employed semi-structured interviews, which were best suited for gaining in-depth and rich data about individual experiences and perspectives on the research topic, as shown in Table 19. The interviews allowed the researchers to navigate the conversations about the research topic and enabled the flexibility to explore further and additional data on the research themes (Minichiello, Aroni & Hays 2008).

Table 19: Semi-structured interview features

No.	Characteristics	Rationale
1	Flexibility	It does not follow an established structure or use close-ended questions, and it provides the opportunity for participants to openly discuss the topics that they perceive as important (Brinkmann 2014).
2	Guided conversation, but explore additional data	Researchers can lead the conversation around the topic of interest while being allowed the freedom to explore, dig and seek further data on themes that may evolve during the interview (Minichiello, Aroni & Minichiello 1990).
3	In-depth and rich data	It may be best suited for obtaining in-depth data about interviewees' perspectives on the research topic (Tanggaard 2009). Researchers can explore a wide and rich spectrum of information provided by the participants (King, Horrocks & Brooks 2018).

No.	Characteristics	Rationale
4	In-depth perceptions	Interviewees answering questions according to their perceptions can help to determine their subjective experience, opinion and beliefs (Smith 1975).

4.2.4 Study Sample

Study sampling is an important process because it determines the scope of knowledge that influences the research outcomes (Pyo et al. 2023). Well-designed sampling ensures that the study sample has a significant impact on the research outputs (Dubé & Paré 2003). Sampling can be a confusing area of the study design process, so it must be chosen for a particular research purpose (Johnston, Leach & Liu 1999) with the most suitable participants providing valuable data for the research (Marshall 1996a).

This qualitative research approach revolved around the exploration of the organisational dynamic capabilities required for innovation waves within the Australian heavy industry. The research was carried out in a single comprehensive phase, which combined both exploratory and in-depth data collection to gain a holistic understanding of the organisational dynamic capabilities required for innovation waves in the Australian heavy industry. As shown in Table 20, each interview included two different types of questions, providing both exploratory and in-depth data.

Table 20: Sampling—A single and comprehensive phase (Biernacki & Waldorf 1981; Marshall 1996b; Merriam 1988; Pyo et al. 2023; Suri 2011)

	A single and comprehensive phase
Purpose	***Exploratory***—to capture their broad perspectives on the organisational dynamic capabilities required for innovation waves with an open question (*e.g. What are the key organisational dynamic capabilities required for innovation waves?*) ***In-depth***—to verify, specify and contextualise the findings from the literature review with a specific question (*e.g. Cultural transformation was emphasised as a reconfiguring capability required for innovation waves. Can you tell me about your thoughts on this?*)
Rationale	• Adopt ***judgemental sampling***, also known as ***purposive sampling***, which is the most common naturalistic approach to seek the most productive sample (Marshall 1996b). • Adopt ***typical case sampling*** to determine the organisations of the participants for interviews. This is to include a representative sample of the typical population, which is considered a crucial quality factor in qualitative research (Merriam 1988). • Adopt ***criterion sampling***, also known as ***purposive sampling***. This involves a criteria-based selection of interview subjects. It enables the author to pinpoint

	A single and comprehensive phase
	participants who possess the capacity to enhance the depth of the insights gained from the initial qualitative investigation. Expert sampling is particularly useful (Suri 2011). • Adapt ***snowball sampling*** since the number of experts in the field is limited and proved difficult to access (Biernacki & Waldorf 1981; Pyo et al. 2023).

This thesis sought to unravel organisational dynamic capabilities in everyday practices for innovation waves within the Australian heavy industry, and this required a naturalistic sampling approach. The thesis applied judgemental sampling, also known as purposeful sampling, encompassing various forms to effectively address the research inquiries (Marshall 1996b). To identify the organisations pertinent to this research, this thesis employed a typical case sampling technique, mirroring its critical role in ensuring a representative sample of the typical population and the quality of the qualitative research (Merriam 1988). To follow is an elaboration of the characteristics of the samples included in this thesis.

This thesis is dedicated to validating, specifying and contextualising the insights gained from the literature review, leveraged using a criterion sampling approach. This approach involved the strategic selection of interview subjects based on predefined criteria (Patton 1990). The objective was to identify participants who possess extensive experience and profound knowledge of the Australian heavy industry, particularly in shipbuilding, mining, and oil and gas. The following criteria were used to guide the selection of the participants:

- A minimum of 3 years' experience within the Australian heavy industry (shipbuilding, mining, or oil and gas): This criterion ensured that the participants had a robust understanding of the sector's dynamics and historical context.
- Hold a position as manager, mid-senior level engineer or consultant, with a comprehensive knowledge of the sector. Participants need to demonstrate a deep understanding of the industry's various aspects, including its technological landscape and the roles played by different stakeholders.
- A minimum of 3 years' involvement in digital transformation with advanced technologies in their organisation and a deep understanding of the sector's journey for innovation waves. These people were chosen for their ability to provide valuable insights into the challenges, opportunities and best practices in capability development required for innovation waves.

This thesis verified the eligibility of participants based on specific criteria before conducting interviews, underscoring the importance of selecting participants who could offer meaningful insights into the organisational dynamic capability required for innovation waves within the

Australian heavy industry. In addition, key informants were selected from potential organisations based on their potential to provide rich and valuable data (Marshall 1996a). The selection of key informants was a pivotal step in ensuring the meaningfulness of the insights gathered in the qualitative research (Neumann 1997). In the context of the Australian heavy industry, these key informants were often individuals in mid-senior level roles, such as senior engineers or managers, because they had a deep understanding of the requirements for innovation waves, and a comprehensive grasp of the intricate interconnections between various factors. Thus, the key informants identified for this thesis were individuals holding manager or mid-senior level engineer or consultant positions. This choice was made because these people are typically involved in broad processes engaging with various stakeholders from the bottom (e.g. tradesmen) to the top (e.g. executives) levels before decision-making processes, thereby offering profound insights into the organisational dynamic capability.

Given the specific context and subject matter of this research, the availability of individuals meeting these criteria proved to be limited. To address these challenges and identify suitable participants who could enrich the research data, this thesis adopted the snowball sampling technique (Biernacki & Waldorf 1981; Pyo et al. 2023). This technique relied on referrals from individuals familiar with organisations that met the specific criteria. The snowball sampling technique has been criticised for potentially providing a limited perspective, owing to referrals from individuals with shared characteristics and views. To mitigate this limitation, this thesis adhered to the recommendations of Coleman (1958) and Goodman (1961), taking care to control the number of chains and referrals within each chain. This approach helped achieve a balanced sample from key sectors within the heavy industry—shipbuilding, mining, and oil and gas—by encouraging referrals that spanned across these different sectors. A total of 24 interviewees were identified through nine referral chains distributed into three sectors equally, with a limit of three participants per chain to avoid overrepresentation of any single viewpoint. Prior to arranging the interviews, the individuals were asked about specific criteria to determine their suitability for the research. A comprehensive overview of the sample can be found in Table 27 in Section 5.2, providing a detailed snapshot of the participants' backgrounds and roles within the Australian heavy industry.

This qualitative research approach entailed an examination of various representative organisations within the Australian heavy industry. This multi-organisation approach aimed to enhance the representativeness and generalisability of the findings, facilitating comparisons and a comprehensive exploration of the organisational dynamic capabilities required for innovation waves within these sectors. Similar to Marshall (1996b), this thesis refrained from predetermining an exact sample size. Instead, this thesis commenced the research with an initial set of interviews, typically numbering around 10, with participants drawn from a diverse range of organisations within each sector—shipbuilding, mining, oil and gas.

The iterative nature of the sample selection process allowed for ongoing refinement, with interviews expanding until a saturation point was reached. Saturation, as advocated by qualitative research standards, denotes the stage at which no new substantial insights emerge from additional interviews, signifying a comprehensive understanding of the phenomenon under investigation. The qualitative research approach often involves smaller sample sizes, necessitating that selected participants contribute in-depth knowledge and insights (Hamilton & Bowers 2006). The sample selection process in this study was iterative, with interviews conducted until saturation was reached rather than setting a fixed number of participants at the outset. The study achieved saturation with 24 interviewees, as no new insights were emerging from additional interviews at this point. This sample included participants from the three main sectors of the Australian heavy industry (shipbuilding, mining, and oil and gas), enabling a well-rounded exploration of organisational dynamic capabilities required for innovation waves. Given the sectoral diversity and the depth of information obtained, reaching saturation with 24 participants was sufficient to address the research questions comprehensively. Convergent interviewing was not used, as the objective was to explore dynamic capabilities across sectors, not to compare or contrast specific interview responses. The concept of saturation ensured that the sample size was robust, allowing for data redundancy and a thorough understanding of the themes relevant to the study.

Although the sample size was small, it is essential to underscore its representativeness within the Australian heavy industry sector. The decision to prioritise representativeness over sheer numerical magnitude was rooted in the belief that the selected participants, drawn from various organisations and sectors, offered a rich tapestry of insights reflective of the broader industry landscape. This strategic sampling approach facilitated exploration of the diverse perspectives, practices and challenges inherent in the unique context of the Australian heavy industry. It is worth noting that the small sample size did not compromise the validity or reliability of the thesis findings. Rather, it reinforced the qualitative research principle that emphasises the depth and richness of data gleaned from selected participants. The inclusion of diverse organisations within each sector ensured that the findings were not only contextually rich, but also applicable to a broad spectrum of heavy industry practices.

In selecting an appropriate study sample, careful consideration was given to the characteristics that define the participants who contributed to the investigation. The aim was to ensure that the study sample was both representative and relevant to the research objectives, providing valuable insights into the intricacies of dynamic capability within the Australian heavy industry, with a specific focus on the transformation journey for innovation waves. To achieve this, a set of inclusion and exclusion criteria was formulated, each designed to refine the participant pool and align it with the objectives of the thesis. The following sections elucidate these criteria and the reasoning behind their incorporation into the research methodology.

4.2.4.1 Inclusion Criteria

Three different inclusion criteria were adopted in this thesis. The first one was the sector. The Australian heavy industry, which encompasses shipbuilding, mining, and oil and gas, emerged as the focal point of the investigation. Section 2.2 explains the significance of the Australian heavy industry. These sectors hold pivotal roles in the national economy and technological landscape. Hence, the investigation concentrated on organisations within these specific sectors. The second inclusion criterion was the company type. Prime companies were selected for this thesis. ‘Prime’ refers to a company entrusted with the overarching program responsibility for successfully delivering a significant project to a client. Studying these companies provided insights into the state of the industry, since they often set the standard for practices, technology and performance. The interview participants were involved in a wide range of R&D, production and operations processes that can benefit from digital technologies.

The third inclusion criterion was a level of commitment to preparing for innovation waves. All participants were asked to choose their organisation’s level of commitment from three categories: low, mid or high. Low-level commitment refers to organisations that have implemented basic digital technologies but have not initiated a strategic transformation journey for innovation waves. Mid-level commitment indicates organisations with advanced digital technologies implemented, an initiated strategic transformation journey for innovation waves and an allocated fund. High-level commitment refers to organisations that have advanced digital technologies in place, have embarked on a highly strategic transformation journey for innovation waves and have committed substantial funds for long-term digital innovation programs. An organisation’s level of commitment to innovation waves has direct implications for managerial practices. Managers in organisations with a low level of commitment may face different challenges compared with those in organisations with a high level of commitment. This criterion, therefore, allowed for the exploration of practical implications for management strategies and decision-making. These inclusion criteria collectively created a comprehensive and diverse sample for the thesis, considering the various dimensions that influence managerial practices and innovation waves within the Australian heavy industry.

To minimise potential bias in participants' self-assessment of their organisation's level of commitment, each participant was provided with clear, predefined criteria for categorising commitment levels (low, mid, high). These criteria included tangible indicators such as the implementation of digital technologies, the initiation of a strategic transformation journey, and allocated funding. This structured approach aimed to ensure consistency across participants' assessments, reducing the likelihood of subjective bias. Additionally, the sample included participants from different companies and departments within the mining, oil and gas, and shipbuilding sectors, ensuring a balanced representation of perspectives across the heavy industry.

4.2.4.2 Exclusion Criteria

There were also three exclusion criteria adopted in this thesis, and the first one was working abroad (not Australia). Participants working outside Australia were excluded to maintain a focused perspective on the local context and practices within the Australian management landscape. International experiences may have introduced variables that could diverge from the specific objectives of the study, making it challenging to draw relevant conclusions for the Australian heavy industry.

The second exclusion criterion was no experience in the Australian heavy industry. To ensure that the participants had a contextual understanding of the challenges and dynamics within the Australian heavy industry, individuals without prior experience in this sector were excluded. This criterion aimed to enhance the relevance of the study findings to the specific industry under investigation, promoting a more targeted and industry-specific analysis.

The last exclusion criterion was no experience in the digital transformation journey. Since the focus of the study included aspects of dynamic capability required for innovation waves, including digital transformation, participants who lacked experience in digital transformation journeys were excluded. This criterion was crucial to ensuring that the selected participants possessed insights and perspectives relevant to the capabilities required for innovation waves within the Australian heavy industry. Excluding those without such experience helped maintain the coherence and alignment of the thesis with its objectives.

4.3 Data Collection

This section examines the intricacies of the data collection process, including the preparation, recruitment process, execution of interviews, and methods employed for recording and storing the collected data.

4.3.1 Preparation

The preparation process for conducting interviews is a critical aspect, since it significantly affects the success and depth of data obtained, as noted by Evers and De Boer (2012). The interviewer's role extends beyond merely steering the conversation towards relevant topics. They must skilfully prompt the interviewee to share profound insights and ensure there is comprehensive coverage throughout the interview (Moser & Kalton 2017). To ensure the effectiveness of the interview process, several key steps were taken in preparation, including ethics approval, interview guide and question development, participant information sheet and consent form creation, recruitment letter drafting and pre-testing. The following subsections outline the details in the steps.

4.3.1.1 Ethics Approval

In anticipation of the ethical dimensions inherent in this research endeavour, preparation was undertaken to ensure that the ethical approval process was appropriately addressed. The ethical documentation prepared for the submission encompassed essential documents, including consent forms, a recruitment letter, a participant information sheet, and the interview questions and guides. All of these components underwent a rigorous review process conducted by a principal supervisor, validating their alignment with ethical standards and principles.

A concise lay summary, offering an accessible overview of the primary aims and objectives, was integral to the submission. This summary served as a foundational element, aligning with the commitment to provide clarity and transparency in communicating the research's purpose. To further enhance transparency, the application provided a comprehensive overview of the locations the research was conducted. Emphasis was placed on detailing the research environment and fostering an understanding of the contexts within which data collection occurred. In acknowledging any pre-existing relationships with participants, the application demonstrated a commitment to ethical considerations. Explicit attention was given to addressing any ethical implications arising from these relationships, ensuring a responsible and conscientious approach to participant engagement.

The academic and societal relevance of the research was robustly justified through a thorough literature review. This foundational step served to substantiate the significance of the thesis, establishing its context within existing scholarship and broader societal discourse. Methodologically, the application detailed the research approach and methods employed in the thesis. This exposition facilitated a clear comprehension of the methodology, contributing to the overall transparency and credibility of the research. A comprehensive account of the recruitment process further enriched the application. Details on participant identification, approach and invitation were articulated, providing insights into the procedures and ensuring diverse and representative participant involvement.

Integral to the ethics application was the submission of the participant information sheet and the consent form. This step underscored the commitment to transparency, ensuring that participants were well informed about the nature and purpose of the research. The informed consent process received attention, with detailed data provided on how participants could provide consent voluntarily. This approach reinforced the ethical foundation of the research, prioritising participants' autonomy in decision-making. The procedures for participant withdrawal were explicitly outlined, again emphasising the commitment to respecting participants' autonomy. Participants were assured that they could withdraw from the research project without incurring any penalty or discomfort. Last, the application addressed the risks associated with the research, presenting comprehensive mitigation strategies. These strategies were designed to minimise any potential risks, prioritising the wellbeing and comfort of the participants throughout the study.

This comprehensive preparation and adherence to ethical guidelines aimed to create a robust foundation for the ethical approval process, promoting the integrity and ethical conduct of the research.

4.3.1.2 Interview Guide and Questions

The interview guide and questions for this thesis were developed based on the literature review (see Appendix 3). The decision to adopt a qualitative research approach, specifically in the form of interviews, was informed by the need to explore and understand the experiences and expectations of employees in the context of the organisational dynamic capabilities required for innovation waves within the Australian heavy industry. This approach served as a crucial phase in the research, aiming to validate the findings from the literature review and address the overarching research question:

> *"What are the key organisational dynamic capabilities and their interrelationships that enable the Australian heavy industry to build and support innovation waves (digital transformation, Industry 4.0, and Industry 5.0)?"*

This question was further broken down into three sub-RQs to guide the interview process:

> *RQ1: What are the key organisational dynamic capabilities (sensing, seizing and reconfiguring) required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0) in the Australian heavy industry?*

RQ2: How are organisational dynamic capabilities interrelated in the Australian heavy industry?

The introduction to the interview process in the interview guide involved confirming participants' understanding of the participant information sheet and obtaining their consent to record the conversation. This was followed by a brief overview of the background and objectives of the thesis. This thesis aimed to explore the organisational dynamic capability required for innovation waves within the Australian heavy industry, focusing on the shipbuilding, mining, and oil and gas sectors. The emphasis lay on sensing, seizing opportunities and reconfiguring to adapt to a rapidly changing environment. The dynamic capability framework was defined as a firm's ability to construct, modify and integrate internal and external competencies in response to dynamic environmental shifts. The interview sought to explore organisational capabilities at individual and managerial levels to provide detailed insights into organisational capacity for adaptation.

Demographic questions were included to gather essential data about the participants and their professional background within the Australian heavy industry. These questions covered aspects such as business area, job role, age range, duration of employment in the industry, international work experience, the organisation's status in innovation waves and the level of commitment to innovation waves within the organisation.

As specified in Table 20 in Section 4.2.2, the questions were shaped by two different approaches: exploratory and in-depth. The exploratory questions aimed to reveal participants' perspectives with open-ended inquiries, such as 'What are the key sensing capabilities required for innovation waves?'. The subsequent questions were designed to investigate further, seeking more details from participants within specific contexts identified from the literature review. For instance, an example of an in-depth question is 'People's appreciation of the bigger picture for innovation waves can be improved by leadership or effective communication. What kind of leadership and communication should businesses have as a reconfiguring capability?'. This approach allowed the research to not only explore the overarching topic broadly, but also gain a nuanced and detailed insight into various aspects of the innovation waves phenomenon.

This dual-questioning strategy facilitated a comprehensive understanding of the participants' experiences and perspectives. The exploratory questions set the stage by inviting the participants to share their general views, while the in-depth questions guided the conversations towards specific areas of interest identified through the literature review. This methodological approach ensured that the research captured a broad spectrum of insights.

4.3.1.3 Participant Information Sheet and Consent Forms

The creation of the participant information sheet (see Appendix 4) and consent form (see Appendix 5) for the interviews in this study involved a process that took into consideration ethical guidelines, participant comprehension and overall study transparency. The language used in both was chosen to ensure clarity and ease of understanding for the potential participants. Technical terms were explained, and jargon was avoided, fostering an environment where participants could make informed decisions about their involvement in the study. Both documents were closely aligned with the overarching objectives of the research, providing a clear description of the study's purpose, focus and potential benefits. By emphasising the exploration of the organisational dynamic capability required for innovation waves within the Australian heavy industry, participants could grasp the relevance and significance of their involvement.

The development process adhered to the ethical guidelines governing research involving human participants. Key components such as confidentiality, anonymity and data storage were addressed in the consent form, emphasising the commitment to protecting participants' rights and ensuring the ethical conduct of the study. The language used in both documents ensured that the participants were well informed about their rights, the voluntary nature of their participation and the right to withdraw at any stage without consequences. The potential risks and discomforts were transparently communicated, with a clear pathway for participants to seek support if needed. The documents underwent a feedback and iterative development process. Input was received from colleagues to ensure that the language used was accessible, and that potential areas of confusion or concern were addressed. This iterative approach contributed to the refinement of both the participant information sheet and the consent form.

The participant information sheet and consent form were crafted to clearly articulate the expected contributions and involvement of the participants in the study. By outlining the interview topics, duration and voluntary nature of participation, potential participants could gauge the level of commitment and make an informed decision about their willingness to engage in the research.

In summary, the development of the participant information sheet and consent form was a process guided by ethical principles, participant clarity and alignment with the study's objectives. These documents served as crucial tools for ensuring the ethical conduct of the research and the informed and voluntary participation of individuals in the study.

4.3.1.4 Recruitment Letter

The recruitment letter was crafted with great attention to detail, guided by ethical considerations, and designed to effectively communicate the study's objectives and potential benefits to the prospective participants (see Appendix 6). The development process aimed to strike a balance between professionalism, clarity and participant engagement. The letter began with a clear statement about the purpose of the research study, providing a brief overview of the exploration of the organisational dynamic capabilities required for innovation waves in the Australian heavy industry. A concise description of the study's background and context was provided, including the affiliation of the author and the supervisor. This information established credibility and transparency regarding the origin of the study. The letter reiterated the voluntary nature of participation, assuring participants that they were free to decline or withdraw at any time without consequences. It communicated flexibility by offering multiple options for the interview format (telephone, video-call or in-person), allowing participants to choose the method that suited them best.

The letter emphasised the value of the participant's insights, positioning them as a major stakeholder and pioneer in the industry sector. It communicated the importance of their contribution in determining the organisational dynamic capability required for innovation waves to enhance innovation in the Australian heavy industry. Clear and detailed instructions were provided on how to express interest in participating, including contact details for the author. For participants in Adelaide, guidance was provided on scheduling an in-person meeting, while those outside Adelaide were encouraged to provide preferred times and contact details for virtual interviews. This ensured accessibility and convenience for participants. The letter explicitly communicated the ethical considerations in the study, guaranteeing the confidentiality of participant data. It reassured participants that the researchers were ethically bound to keep all data confidential, addressing any potential concerns related to privacy. The letter closed with expressions of gratitude, thanking the participant for considering being part of the study and expressing anticipation of their response. It reassured participants that requesting more information did not obligate them to participate.

In summary, the recruitment letter was developed to be informative, engaging and respectful of participants' autonomy and time. It served as a critical communication tool in inviting individuals to contribute their valuable insights to the research study.

4.3.1.5 Pre-testing

Preparation for the main data collection phase involved the implementation of a series of pre-test interviews. These pre-test interviews were strategically designed, and their development was guided by the need to validate and refine the interview guides and questions for the forthcoming research.

The primary objective of the pre-test interviews was to ensure the effectiveness and appropriateness of the interview guides and questions. These sessions were conducted to identify any potential shortcomings, ambiguities or barriers in the questions that could impede the collection of accurate data. By utilising a simulated environment, the pre-test interviews aimed to refine the interview approach and enhance the overall quality of the research process. The pre-test interviews followed an iterative process, involving three rounds, each with two scholars. This iterative approach allowed for continuous refinement and improvement based on the feedback received after each round. By conducting multiple rounds, the author was able adapt and enhance the interview guides and questions in response to evolving insights and lessons learned from the preceding sessions.

The pre-test interviews served as a valuable simulation of the actual interactions that would take place with key participants during the main data collection phase. This simulation provided a controlled environment to test the effectiveness of the questions, ensuring that they were clear, relevant and capable of eliciting the desired data. It allowed the author to anticipate potential challenges and address them proactively. Engaging in pre-test interviews also facilitated the development and refinement of the author's interviewing skills. This hands-on experience was crucial for building confidence, becoming familiar with the interview process and fine-tuning the ability to navigate different responses. It contributed to the development of adaptability in responding to unforeseen circumstances during interviews. The pre-test interviews encouraged self-reflection by providing an opportunity for the author to critically evaluate their performance. This reflective practice was essential for identifying areas of improvement and acknowledging strengths in conducting interviews. It contributed to the author's continuous learning and growth throughout the data collection preparation phase.

Beyond the technical aspects of question formulation, the pre-test interviews emphasised the importance of qualitative skills such as active listening, empathy and emotional intelligence (Guion, Diehl & McDonald 2011). These qualities were deemed vital for extracting in-depth insights from participants, ensuring that the author could not only gather data, but also understand the nuances and emotions embedded in participants' responses. The development of pre-test interviews aligned with established research methodologies, such as that outlined by Marshall and Rossman (2014). This approach highlighted the significance of iterative processes and continuous refinement in the research design and data collection strategies.

In summary, the pre-test interviews were instrumental in fine-tuning the interview guides and questions, enhancing the author's skills and preparing for the main data collection phase. This iterative and reflective approach ensured that the research instruments were well prepared and aligned with the goals of the study, setting the stage for a robust and effective data collection process.

4.3.2 Recruitment

The recruitment process for this thesis began by identifying suitable organisations and key informants based on the previously outlined criteria. This identification was carried out through two primary methods: active searches and referrals. Three mining and three oil and gas mining practitioners were discovered via a targeted search on LinkedIn, and four shipbuilding practitioners were recruited through the author's existing contacts. The other 14 participants were found through referrals, as shown in Table 21. To ensure an equal distribution of the number of participants from each sector, the minimum number of interviewees was set at seven. The author contacted potential participants using various means such as LinkedIn and email, adhering to the ethical guidelines established by the Australian Research Council (2007). Each prospective participant received a recruitment letter (see Appendix 6) with a participant information sheet that summarised the purpose and scope of the thesis and encouraged them to respond and take part in the study. Further, the recruitment letter assured participants of their anonymity and the commitment to publishing results without revealing any identifying data, as specified in the ethics application (Ethics project number: 5455).

Table 21: Recruitment status and interview types

No.	Sector	Total	Recruitment			Interview type	
			Existing contact	Target search	Referral	Remote	Face-to-face
1	Shipbuilding	9	4	0	5	2	7
2	Oil and gas	7	0	3	4	5	2
3	Mining	8	0	3	5	5	3
	Total	24	4	6	14	12	12

Those who expressed a willingness to participate were invited for interviews, with the option of conducting the interviews in person when feasible or online if it was more convenient for them. Half of the interviews were carried out face-to-face, as shown in Table 21. This dual approach was implemented in response to restrictions related to COVID-19. Prior to the interviews, all participants were required to sign a participation consent form (see Appendix 5). In cases where key informants were referred by previous interviewees or other network participants, the same recruitment procedure as that outlined above was followed. If the individual referring another potential participant preferred not to disclose their identity or share their contact information, they were provided with the recruitment letter, which they could distribute to potential organisations.

4.3.3 Interview Execution

The interview started by providing the interviewees with enough time to review the participant information sheet, which included the research background, objectives and expected questions. Following this, informed consent was obtained from all participants, with each individual signing a consent form to indicate their willingness to participate in the study, since all interviews were recorded by an audio recorder.

The demographic questions were asked first, which specifically included questions regarding age range and the organisation's level of commitment for innovation waves, as defined in Section 4.2.4.1. The purpose of the age range question was to ensure a blend of both seasoned wisdom and contemporary viewpoints, fostering a rich tapestry of insights into the transformation journey for innovation waves in the Australian heavy industry. This thesis explored organisations that had started the transformation journey for innovation waves to drive innovative outcomes. This encompassed those with robust digital infrastructure and purposeful utilisation of these technologies to achieve successful transformation for innovation waves. Thus, all of the participants were working in companies that had embarked on the transformation journey for innovation waves at different levels of commitment, which allowed for a nuanced understanding of the barriers and challenges to digital innovation in these sectors. All the participants were asked to choose from three different levels of commitment for innovation waves, as specified in Section 4.2.4.1.

The interviews were semi-structured with open-ended interview questions. Each interview lasted between 40 and 60 minutes approximately. The responses were de-identified using participant ID numbers. Data for this research were gathered through two distinct modes: face-to-face and remote interviews. The choice of these interview modes was based on the participants' preferences and situations. Face-to-face interviews took place in a controlled and private environment in one of the meeting rooms located within the Flinders University Tonsley campus. The meeting room was chosen for its privacy, featuring non-transparent glass windows to ensure that the conversations remained confidential. These face-to-face interviews provided an opportunity for the participants to engage in a one-on-one in-depth discussion with the interviewer. Remote interviews were conducted using Microsoft Teams, a widely used virtual communication platform. The use of remote interviews allowed for a broader reach, since it eliminated geographical constraints and accommodated those participants who were unable to attend in person. The participants were provided with a secure and user-friendly digital environment for the interview, and this approach was chosen to promote inclusivity in the thesis. In both face-to-face and remote interviews, the process was standardised to ensure consistency and reliability.

These data collection procedures were implemented to obtain comprehensive and accurate data from the participants. The use of remote and face-to-face interviews, along with standardised protocols, guaranteed data integrity and facilitated a robust analysis of the research objectives.

4.3.4 Recording and Data Storage

Audio recording served as a crucial component of the data collection process, enabling the valuable insights shared by the interviewees to be captured. Two distinct methods were employed for recording, depending on whether the interviews were conducted remotely via Microsoft Teams or in person.

For remote interviews conducted using Microsoft Teams, the integrated recording feature within the software was utilised. This feature ensured the seamless capture of audio data during the virtual interviews, simplifying the data collection process and allowing for real-time synchronisation with interview sessions. In the case of face-to-face interviews, a dedicated audio recorder was employed to ensure that the audio recording was secure and of the highest quality. This approach was chosen to maintain the integrity of the data and minimise the risk of data loss or corruption. The use of a separate audio recorder provided redundancy, adding an extra layer of assurance in the event of technical issues or interruptions during the interview process.

Privacy and confidentiality were paramount in our data handling procedures. Despite the interviewer’s awareness of the interviewee’s identity during the interview, all data collected, including the audio recordings, were promptly de-identified as soon as each interview session was completed. This de-identification process helped protect the anonymity and privacy of the participants, a critical ethical consideration in this research.

On completion of each interview, the audio recording was immediately transferred to a secure USB drive. The USB drive was selected for its portability and reliability in data storage. To further enhance data security, the USB drive was stored in a lockable cabinet specifically designated for this purpose. This cabinet was located in a secure and controlled-access area to prevent unauthorised access or tampering with the recorded data.

These stringent recording and data storage procedures were implemented to guarantee the confidentiality, integrity and security of our audio data throughout the research process, aligning with the ethical standards and best practices for data management in qualitative research.

4.4 Data Analysis and Interpretation

Scholars have emphasised the significance of having an analytic strategy with a systematic approach to the empirical data for qualitative data analysis (Denzin & Lincoln 2011). This thesis followed an established analysis approach introduced by Creswell and Creswell (2017), which consisted of six different stages, after data transcription, from organisation and preparation for data analysis to interpretation of the data, as shown in Table 22.

Table 22: Data analysis approach (Creswell & Creswell 2017)

Step	Name	Description
1	Organisation and preparation for data analysis	Organise and prepare the data for thematic and content analysis (data are transcribed, printed for manual coding and inserted into NVivo 12).
2	Familiarising with the dataset reading	Read the data several times so that the research is reviewed as a whole and could be interpreted for meaning before going into details.
3	Coding of data	Two different coding processes are adopted (thematic and content analysis): (1) generate the initial relevant themes by moving from concrete statements to analytic interpretations and (2) analyse the reoccurrence of concepts or keywords at a more surface level of analysis. Employ both manual coding and NVivo 12 to ensure accuracy of the analysis process.
4	Generating and describing themes	Based on generated codes, repetitive contents are grouped into thematic categories and the respective categories are described.
5	Representing themes in a qualitative narrative	A narrative presentation of the themes and categories identified is developed.
6	Interpretation of data	Data interpretation.

The following subsections illustrate how the data analysis and interpretation were performed.

4.4.1 Data Transcription

In the lead-up to the data analysis, an essential step was the transcription of all interview records. This process involved transforming audio-recorded interviews into written text, effectively rendering spoken content into textual form (Bernard, Wutich & Ryan 2016). Transcription in qualitative research is more than a mere technicality; it plays a pivotal role in organising interview data systematically and facilitating subsequent analysis (Heritage & Atkinson 1984; McLellan, MacQueen & Neidig 2003). Qualitative research has gained widespread acceptance and popularity over time, bringing to light various transcription challenges, such as incomplete sentences, unclear speech endings, overlapping speech, poor audio quality and background noises (McLellan, MacQueen &

Neidig 2003). In anticipation of these issues, this thesis took preventive measures by ensuring high-quality audio recordings and conducting interviews in a quiet environment. Some difficulties in terms of interviewees' speech and verbal expressions were inevitable, but they were overcome by repeated listening to contextualise the conversations.

The transcription process offers advantages beyond efficiency in data analysis. It allows authors to recall not only the interview content, but also the nuances, such as tone, expression and interviewee behaviours, which might otherwise be overlooked (Morehouse 2002). However, transcription decisions require careful consideration since they can significantly influence the analysis process (MacQueen & Milstein 1999). This process is initiated by a preliminary data reduction step in which researchers determine what to transcribe and what to omit, even considering non-linguistic aspects such as body language (McLellan, MacQueen & Neidig 2003). The transcripts underwent a rigorous quality check, with corrections made for inaccuracies and missing words, as recommended by Fasick (1977). In line with the guidance from Strauss and Corbin (1990), this thesis excluded social conversations aimed at building rapport between the interviewer and interviewee, since they were unrelated to the thesis objective. Consequently, the final transcripts varied in length, ranging from 5,000 to 10,000 words.

In this thesis, all audio recordings were transcribed within two weeks of each interview, utilising the online transcription service Otter. Although audio data transcription can be time-consuming and tedious, it aids in enhancing the researcher's understanding of the data and, consequently, its meaningful analysis (Saldaña 2021). Poland and Pederson (1998) recommended approaching transcripts as written text, emphasising their role as the foundation for qualitative data analysis and the necessity for repetitive reading for in-depth analysis. After the initial transcripts were generated by the chosen provider, the author engaged in a comprehensive review process, involving repeated listening to the audio files while reading the corresponding transcripts to become familiar with the content. To minimise the risk of incompatible transcripts that might hinder the research process, a standardised format was used, as recommended by MacQueen and Milstein (1999). In this thesis, transcripts were read as written text, structured into paragraphs based on their meaning and presented in a consistent format.

4.4.2 Data Coding

In the process of analysing the research data, the next step after transcription involved coding. Coding entailed the exploration of the dataset, extracting meaning from raw data, and the generation of the initial relevant themes. This transformation from concrete statements to analytical interpretations was integral to the research process (Charmaz 2006). It involved reading the transcripts and identifying text segments that pertained to the research topic, tagging them with codes that represented their thematic content (Bernard, Wutich & Ryan 2016). Each code encapsulated a theme emerging from the data, which helped to identify commonalities and key categories (McMurray, Pace & Scott 2004). In this thesis, coding played a crucial role in uncovering the organisational dynamic capability required for innovation waves in the Australian heavy industry, ultimately refining the previously introduced theory-based research framework.

When approaching coding, researchers have two main methods to choose from: deductive or inductive coding. The deductive approach involves developing ‘a priori codes’ before engaging in empirical work, typically derived from research aims, questions and a review of the relevant literature (Miles & Huberman 1994). In contrast, the inductive approach is driven by the data, where researchers create ‘empirical codes’ based on their examination of the dataset (Boyatzis 1998). Applying a priori codes not only allows the researcher to develop coding skills, but also encourages reflection on the existing literature and an evaluation of its applicability (Boyatzis 1998). In contrast, empirical codes facilitate the discovery of unforeseen perspectives, thereby refining the initial theory-based framework and contributing to new theory development (Boyatzis 1998). This thesis employed a combination of both approaches by utilising a priori-derived codes based on the existing literature and introducing empirical codes inductively derived from the data.

Before commencing the coding process, a hybrid approach to coding was employed, incorporating both manual and computer-supported techniques. Manual coding was initially chosen for its ability to immerse the author in the data, facilitating a deeper understanding of its meaning, and allowing for flexibility and creativity in generating the initial themes (Flick 2022). After preparing the data, the transcripts were read multiple times to familiarise the author with the content, gain an overall sense of the dataset and identify the data relevant to the research questions before the in-depth analysis (Saldaña 2021). In the subsequent step, the data were analysed by reading cohesive paragraphs and identifying data excerpts that aligned with the a priori codes derived from the literature and the new themes. Next, manually coded data with the transcribed data were imported into NVivo 12. All the data were coded in NVivo 12 with these manually identified themes. The text excerpts that corresponded to the previously identified themes were assigned to nodes, enabling a more detailed analysis, since multiple codes could be assigned to a theme. Additionally, revisiting the data revealed the potential for uncovering additional themes, particularly if the created nodes did not fit into the existing thematic categories.

The combined use of manual coding and coding with NVivo 12 ensured the rigour of the analysis process (Jackson, Bazeley & Bazeley 2019). Employing both approaches contributed to the integrity of the data, ensuring its reliability and accuracy throughout its lifecycle (Jones & Noble 2007). Data reduction in the initial phase of the analysis was executed with care to avoid prematurely discarding valuable data. This involved analysing all data multiple times. Ultimately, by using two complementary methods that compensated for each other's limitations, the author gained a comprehensive and enriched understanding of the topic.

4.4.3 Data Analysis Method

Data analysis in this thesis served several crucial purposes. It involved the condensation of extensive and diverse raw textual data, the establishment of clear connections between the research objectives and the findings derived from this raw data, and the development of theoretical insights based on the knowledge embedded in the data (Thomas 2006). To achieve these objectives, this thesis employed two complementary data analysis techniques: thematic analysis and content analysis. These two analysis methods were employed not only to elucidate and refine the results of the thematic analysis, but also to ensure that valuable insights within the dataset were not overlooked during the thematic analysis selection process (McMurray, Pace & Scott 2004). These methods are explained in detail in the subsequent sections.

4.4.3.1 Thematic Analysis

Thematic analysis is a systematic approach used to identify, organise and uncover meaning within a dataset (Braun & Clarke 2006). It enables researchers to make sense of the data by recognising and categorising patterns that emerge. These patterns are then organised into themes that are central to understanding the phenomenon under investigation (Fereday & Muir-Cochrane 2006). Thematic analysis is well suited to both inductive and deductive coding, making it a widely recognised method for qualitative data analysis (Braun & Clarke 2006). Thematic analysis is frequently criticised for its generic application and lack of a well-defined structure (Antaki et al. 2003). To ensure rigour in the qualitative data analysis, this thesis followed the established six-phase approach outlined by Braun and Clarke (2006). These phases encompassed becoming familiar with the data, generating initial codes, searching for themes, reviewing potential themes, defining and naming themes and, finally, producing the report. All interview data were analysed, adhering to the coding process proposed by Strauss and Corbin (1990), which includes open, axial and selective coding.

This thesis utilised these varied coding approaches, which proved instrumental in comprehending the data and generating systematically derived fundamental categories. To gain familiarity with the data, the initial step involved thoroughly reviewing the interview transcripts multiple times while listening to the associated audio recordings. This process included taking notes on potentially noteworthy details. These notes guided the researcher to commence an in-depth analysis, essentially constituting a raw and unrefined flow of ideas rather than polished prose, as illustrated by Braun and Clarke (2006).

After gaining a thorough understanding of the data, the author proceeded to examine each transcript, conducting an initial coding of specific text segments that were pertinent to addressing the research questions guiding this thesis. During the initial coding phase, the extensive dataset was distilled into preliminary codes and eventually transformed into 'nodes', as described by NVivo 12. These nodes illustrated the idea, concepts and thoughts extracted from the data, as defined by Edhlund (2011). To maintain analytical integrity and minimise any potential bias resulting from data fragmentation, a thorough line-by-line approach to the data analysis was employed, ensuring comprehensive scrutiny of the entire dataset and aligning with recommendations by Bowen (2009). Following the initial open coding, the subsequent coding cycle was executed using axial coding, corresponding to the third and fourth stages of the data analysis process as proposed by Braun and Clarke (2006). In the process of axial coding, codes that shared similar content or relationships were clustered into thematic nodes. These aggregated codes, offering robust support, facilitated the emergence of dominant themes. The initial codes were then refined and filtered, contributing to a precise portrayal of the interviewees' experiences, as recommended by Braun and Clarke (2006). These emerging themes were subsequently compared with those found in the literature-based framework of dynamic capability required for innovation waves, ensuring a close alignment with both practical applications and theoretical foundations, thereby enhancing their representativeness (Eisenhardt & Graebner 2007).

The final coding approach was selective coding, as proposed by Strauss and Corbin (1990). During this stage, core themes related to the organisational dynamic capability required for innovation waves were identified, labelled and defined, forming a theoretical framework encompassing all previously identified codes. This represented the fifth stage of the analysis process in this thesis. Once again, NVivo 12 proved advantageous, offering an overview of the connections between nodes and higher-order themes. The depiction of parent and child nodes provided a deeper understanding of the relationships among these nodes, enriching the analysis and its findings (Strauss & Corbin 1990).

4.4.3.2 Content Analysis

Content analysis served as a complementary method, addressing the limitations of the thematic analysis. This approach involved systematically quantifying the qualitative data by recording the frequencies of relevant variables, such as words, events and actions related to the organisational dynamic capability required for innovation waves. In essence, content analysis, known as the constant comparative method (Boeije 2009; Fram 2013), converts qualitative data into a numerical format, allowing for the discovery of evidence supporting specific propositions. According to Morse and Field (1995), the fundamental principle of content analysis is to compare each piece of data with every other relevant piece, thus identifying the most mentioned factors and revealing the underlying patterns and themes within the data (Leininger 1994). NVivo 12 software was utilised for the content analysis. It facilitated coding queries to examine the sources of each theme and their corresponding references within the dataset. This approach enabled the author to identify the most frequently cited organisational dynamic capabilities, providing insights into their significance. Moreover, NVivo matrix queries were employed to detect patterns in the data, offering a better understanding of the connections and contradictions among the themes.

4.5 Trustworthiness

The outcomes of qualitative research and the truths it uncovers depends on the researcher's personal perspective (Kuhn 1970). This inherent subjectivity raises concerns about its objectivity (Patton 2014). One significant challenge is the lack of specific evaluation standards and guidelines for assessing qualitative research (Morse 1994). Traditional quantitative criteria such as validity and reliability, rooted in a positivist epistemology (Golafshani 2003), are discouraged because they do not align with the purposes, objectives and philosophical underpinnings of qualitative research (Morse 1994). Scholars have emphasised the need to establish appropriate criteria tailored to qualitative research to enhance its rigour and quality (Morse 1994). The academic discussion about suitable criteria has been the topic of numerous publications (e.g. LeCompte & Goetz 1982), illustrating the complexity of creating a comprehensive system for assessing quality in qualitative research. Some authors, such as Rolfe (2006), have contended that standardised criteria cannot evaluate the quality and rigour of qualitative research owing to the diverse research paradigms used, each shaping the researcher's philosophical approach and execution. However, over time, a set of criteria specifically tailored to evaluating qualitative research emerged, drawing from the work of authors such as Leininger (1985), and Trochim and Donnelly (2001).

This thesis was assessed using three criteria: credibility, transferability, and dependability, which function as alternative measures to the quantitative criteria of internal and external validity, reliability and objectivity (Creswell & Creswell 2017). Credibility and transferability in the qualitative research pertained to ensuring the accuracy and applicability of the findings, analogous to the concept of validity in the quantitative research of the thesis. Dependability is concerned with the consistency and reliability of the research approach, akin to the traditional concept of reliability.

Recognising the potential challenges related to trustworthiness and the inherent complexity of comprehending reality (Healy & Perry 2000), this thesis treated the key quality criteria (credibility, transferability and dependability) as essential, paying particular attention to them in the research design, as explained in the following section.

4.5.1 Credibility, Transferability and Dependability

This thesis addressed the conventional concept of validity in a qualitative research context by focusing on credibility, transferability and dependability. To establish research credibility, the author ensured alignment between the theoretical framework derived from the existing literature and the collected data. Further, credibility was maintained by reconstructing research findings in line with the perspectives of the research participants, employing various strategies for this purpose. The initial step involved systematic coding of the data using both bottom-up and top-down approaches, allowing for the comparison of emerging themes with those found in the relevant literature, as recommended by Yin (2009). This approach facilitated the identification of themes that either supported or contradicted the existing theoretical understanding of the topic. The second step encompassed the utilisation of two complementary analysis techniques to provide a comprehensive and in-depth exploration of participants' experiences. Additionally, a parallel analysis of the interview transcripts and the audio recordings was conducted to avoid overlooking important data and correctly interpret non-verbal cues conveyed through the participants' voices.

The alternative criterion of qualitative research, transferability, pertains to the extent to which the research findings can be applied to other contexts and the broader population. While quantitative research aims for statistical generalisation across entire populations (Greenhalgh & Taylor 1997), qualitative research, particularly in the context of this thesis, is focused on a particular population being studied, as highlighted by Higginbottom (2004). Consequently, in qualitative research, it became imperative to establish the applicability of findings within a specific context.

To enhance the transferability of the findings and facilitate the applicability of the thesis results to different contexts or populations, the author focused on thorough documentation of the research methodology and evidence of findings. Regarding the research methodology, it was well documented and closely aligned with established qualitative research practices, making it easier for readers to understand the approach taken. This clarity in methodology enhanced the trustworthiness of the research and facilitated the evaluation of its applicability to other contexts. The author employed typical case sampling, a purposeful sampling technique, ensuring that the selection of cases represented the characteristics of the population under investigation. This method was chosen with well-defined inclusion and exclusion criteria, reinforcing the applicability of the findings to the specific population. The use of snowball sampling with nine referral chains and a maximum of three participants per chain was aimed at achieving diversity within the population sample. This strategy contributed to the robustness of the findings, capturing a range of perspectives within the studied context. The research methodology was transparently and comprehensively reported, providing detailed information on the sampling process, inclusion/exclusion criteria and the rationale behind these choices. This ensures that future researchers can replicate or adapt the study to different contexts, enhancing the transferability of findings.

In terms of evidence of the findings, throughout the thesis, the author attempted to align the research findings with the theoretical foundations. This not only bolstered the credibility of the findings, but also provided a clear link between the study and established theories, aiding in the transferability of the insights. The thesis included a thorough comparison of its findings with the existing literature. This strengthened the validity of the results and provided a basis for the author in different contexts to understand the relevance and potential transferability of the findings.

Dependability, akin to reliability, pertains to the production of consistent and stable outcomes (Golafshani 2003). By following the principles of Trochim and Donnelly (2001), as well as Creswell and Creswell (2017), this thesis adopted research dependability, which signified the capacity to replicate the research and yield identical results. To bolster dependability, several strategies were employed. First, the author thoroughly explained the research design, encompassing research methods, data collection, and data analysis and interpretation. Second, the author adhered to established and standardised guidelines for all data collection and analysis methods, rendering them accessible to future researchers interested in replication. Third, the author provided a comprehensive explanation of the semi-structured interview guide, offering it as an attachment for potential use in subsequent studies.

4.5.2 Author’s Positionality

The author had previously been employed in one of the world’s largest shipbuilding companies, focusing on its capabilities. This ‘insider’ position provided access to a wealth of information and insights that would be challenging for an outsider to obtain and interpret. As an insider, the author developed a deep understanding of the sector’s challenges and therefore navigated the research context more effectively (Bonner & Tolhurst 2002), having observed and experienced it firsthand. The significance of processes and their complexity is often more comprehensible within the context of an industry’s history. A researcher who shares common values or experiences with participants can achieve a deeper understanding and facilitate a smoother interview process, particularly when the researcher and the participants have similar backgrounds (DeVerteuil 2004). Merton (1972) highlighted that both insider and outsider researchers have unique advantages and disadvantages. Mercer (2007) added that the success of research often depends on the focus and approach rather than the insider or outsider status.

Conversely, there are ongoing debates regarding the objectivity of studies conducted by insider researchers, particularly concerning issues related to the potential for bias (DeLyser 2001). It has been suggested that an insider researcher might be influenced by having a similar background to the participants, which could affect data interpretation. Smyth and Holian (2008) stressed the importance of the researcher's ability to mitigate these biases to achieve objective results.

This thesis employed strategies to mitigate both the author's influence and the participants' responses to the author. Recognising the pre-existing relationship between the participants and the author helped address potential issues associated with being an insider. By engaging in reflexivity and critically examining the author's assumptions and actions during data collection and analysis, the potential for author bias was reduced, as suggested by Bonner and Tolhurst (2002). Reflective practices were documented through the author's personal note taking and participants' reflections, which examined the relationship with the participants and analysed the feelings experienced during interviews (Lipson 1984).

Further, the author implemented several practical measures to avoid becoming overly involved or 'going native'. These measures included refraining from active participation in discussions or problem-solving during interviews, and avoiding hands-on practical work as a practitioner, as advised by Bonner and Tolhurst (2002). On one occasion, the author was asked to provide examples related to questions, which momentarily shifted the role from observer; however, this did not undermine the primary objective of data collection (Bonner & Tolhurst 2002).

In summary, leveraging the insider status allowed for a deeper understanding and richer data collection, while careful measures were taken to mitigate any potential biases, enhancing the credibility of the thesis and its contribution to the literature on organisational dynamic capabilities in the heavy industry.

4.6 Summary

The methodology chapter detailed the research process. It began by defining the research objective, then the research design was thoroughly outlined, including research paradigm, approach, technique and study sample. Next, the data collection process was explained in detail, encompassing preparation, recruitment, interview execution and recording, and data storage. Subsequently, the chapter examined data analysis and interpretation, which incorporated details regarding data transcription, data coding and the data analysis method used. The trustworthiness of the research was addressed, highlighting the concepts of credibility, transferability and dependability. This chapter served as a vital guide, underpinning the entire research endeavour and informing the subsequent chapters in which the findings and conclusions are presented. The following chapter presents the data analysis by providing a detailed analysis of the data collected.

CHAPTER 5: ANALYSIS—RQ1 SENSING, SEIZING AND RECONFIGURING CAPABILITY

5.1 Objective

This analysis chapter addresses the first research question '*RQ1: What are the key organisational dynamic capabilities required for innovation waves in the Australian heavy industry?*' by analysing the qualitative data collected from Australia heavy industry practitioners.

First, sample characteristics for the participants are presented in Section 5.2. An overview of the data is shown in Section 5.3. The research questions are answered in three different sections, sensing in Section 5.4, seizing in Section 5.5 and reconfiguring in Section 5.6. The structure of the thesis has been intentionally designed to first provide a clear data-driven analysis in Chapter 5 and 6, followed by a comprehensive literature-based discussion in Chapter 7.

5.2 Sample Characteristics

A total of 24 practitioners from the Australian heavy industry were interviewed for this thesis. Participants were from prime[4] companies representing three different sectors: mining, oil and gas, and shipbuilding. The participant selection criteria were tailored to ensure robust data collection, encompassing a variety of demographics such as commitment levels to innovation waves, position, years of experience, age and gender.

First, the companies reflect a mix of commitment levels to innovation waves, as shown in Table 23 (the commitment levels are defined in Section 4.2.4.1[5]).

Table 23: Distribution of commitment levels to innovation waves

Sector	Number of participants			
	Low	Mid	High	Total
Mining	1	6	1	8
Oil and gas	1	5	1	7
Shipbuilding	1	0	8	9
Total	3	11	10	24

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[4] A 'prime' company is a company entrusted with the overarching program responsibility for successfully delivering a significant project to the client.

[5] Low-level commitment refers to organisations that have implemented basic digital technologies but have not initiated a strategic transformation journey for innovation waves. Mid-level commitment indicates organisations with advanced digital technologies implemented, an initiated strategic transformation journey for innovation waves and an allocated fund. High-level commitment refers to organisations that have advanced digital technologies in place, have embarked on a highly strategic transformation journey for innovation waves and have committed substantial funds for long-term digital innovation programs.

Table 23 illustrates that eight participants were from the mining sector (M), comprising one from a company with a low-level of commitment to innovation waves, six from a middle level and one from a high level. Seven were from the oil and gas sector (O), consisting of one from a company with a low-level of commitment to innovation waves, five from a middle level and one from a high level. Nine participants represented the shipbuilding industry (S), where one was from a company with a low-level of commitment to innovation waves and a notable eight were from a high level. This indicated a pronounced emphasis on innovation waves within the Australian shipbuilding samples in comparison with their counterparts in mining, and oil and gas. This trend may stem from the intrinsic characteristics of shipbuilding, which demand a higher inclination towards innovation and technology integration. Additionally, the Australian Government's substantial investment in digital transformation within the shipbuilding sector is likely to have catalysed this advancement, as detailed in Section 2.3. The distribution of participants across sectors and companies, as shown in Table 23, provided a diverse range of perspectives on organisational commitment to innovation waves. While each commitment level reflects participants' perceptions, the predefined criteria (outlined in Section 4.2.4.1) provided an objective framework to guide these assessments. Additionally, to ensure robustness, the sample included participants from multiple companies and departments, especially in the shipbuilding sector where participants represented distinct departments within large organisations. This cross-sectoral and departmental diversity strengthens the reliability of the commitment level assessments by reducing the influence of individual biases.

Second, the participants were COOs, managers and senior engineers with profound knowledge in various disciplines. They all had a minimum of three years' experience working on innovation waves initiatives within their positions. Such criteria ensured that the insights drawn were from professionals entrenched in the innovation waves narrative of the industry, aware of the challenges, prospects and best practices.

Table 24: Distribution of positions

Sector	Number of participants			
	COO	Manager	Senior engineer	Total
Mining	0	5	3	8
Oil and gas	1	3	3	7
Shipbuilding	0	4	5	9
Total	1	12	11	24

Table 24 reports that, in the mining sector, the distribution comprised five managers and three senior engineers, while in the oil and gas sector, there were three managers and three senior engineers. In shipbuilding, there were four managers and five senior engineers. This distribution reflects a relatively balanced representation across positions, with the exception being the presence of only one COO position in the oil and gas sector.

Third, each participant possessed a wealth of experience ranging from a minimum of five years to a maximum of 37 years within the Australian heavy industry, ensuring a profound comprehension of its complexities and historical shifts.

Table 25: Distribution of years of experience

Sector	Number of participants			Total
	5–9 years	10–19 years	20–40 years	
Mining	1	4	3	8
Oil and gas	3	4	0	7
Shipbuilding	1	8	0	9
Total	5	16	3	24

Table 25 reveals that, in the mining sector, the distribution of participants' experience was as follows: 1 participant had 5–9 years of experience, 4 had 10–19 years and 3 had 20–40 years. In the oil and gas sector, 3 participants reported 5–9 years of experience, while 4 had 10–19 years. In shipbuilding, 1 participant had 5–9 years of experience, while 8 reported 10–19 years. Most participants in the shipbuilding sector fell within the range of 10–19 years of experience. This clearly shows that only the mining sector had participants aged between 20 and 40 years. The mining sector may attract individuals at a relatively young age because of the availability of entry-level positions and the industry's reputation for offering competitive salaries and benefits. As a result, many individuals may start their careers in mining in their early twenties and accumulate significant experience over the course of several decades.

Fourth, the age distribution among the participants spanned from a minimum of 20 to 60 years and above. A total of 9 practitioners fell within the 20–39 years age bracket, 12 were aged between 40 and 59 years, and 3 were in the 60 years and above age group.

Table 26: Distribution of ages

Sector	Number of participants			Total
	20–39 years	40–59 years	60+ years	
Mining	3	4	1	8
Oil and gas	2	4	1	7
Shipbuilding	4	4	1	9
Total	9	12	3	24

Table 26 illustrates that, in the mining sector, the age distribution among participants was as follows: 3 participants were in the 20–39 years age bracket, 4 were in the 40–59 years age range and 1 participant was aged 60 years or above. In the oil and gas sector, 2 participants were in the 20–39 years age range, 4 were in the 40–59 years age bracket, and 1 participant was aged 60 years or above. Similarly, in shipbuilding, there were 4 participants in the 20–39 years age bracket, 4 in the 40–59 years age range, and 1 participant aged 60 years or above. The distribution was well balanced between the ages, except for 60 years and above.

Finally, in terms of gender representation, only one participant identified as female, while 23 identified as male. Although there has been some progress in increasing the representation of women in the heavy industry, most participants being male underscores the industry's continued male dominance. Consequently, gender is not considered a significant factor in the analysis.

The details of the sample characteristics of each participant are shown in Table 27.

Table 27: Sample characteristics of 24 participants

Code	Commitment level to Innovation waves	Sector	Role	Experience in sector (years)	Age range
M1	Mid	Mining	Senior engineer—Mechanical	14	40–59
M2	Mid	Mining	Senior engineer—Mechanical project	8	20–39
M3	Low	Mining	Manager—Business adviser	37	60+
M4	Mid	Mining	Manager—Technology facilitation	20	40–59
M5	Mid	Mining	Manager—Technology implementation	14	40–59
M6	High	Mining	Manager—Technology implementation	26	40–59
M7	Mid	Mining	Manager—Business development	6	20–39
M8	Mid	Mining	Senior engineer—Technology research project	5	20–39
O1	Mid	Oil and gas	Project manager—Contract/control	14	20–39
O2	Mid	Oil and gas	Manager—Enterprise architect development	6	40–59
O3	Mid	Oil and gas	Manager—Industry 4.0 delivery	6	40–59
O4	Mid	Oil and gas	Senior engineer—Planning	5	40–59
O5	High	Oil and gas	Senior engineer—Safety	17	40–59
O6	Mid	Oil and gas	Principal engineer—Electrical	14	20–39
O7	Low	Oil and gas	Chief Operating Officer	15	60+
S1	Low	Shipbuilding	Senior engineer—Corrosion protection	10	60+

Code	Commitment level to Innovation waves	Sector	Role	Experience in sector (years)	Age range
S2	High	Shipbuilding	Senior engineer—Technology research	13	20–39
S3	High	Shipbuilding	Manager—technology research equipment coordination	12	40–59
S4	High	Shipbuilding	Program manager	13	40–59
S5	High	Shipbuilding	Senior engineer—Digital specialist	12	20–39
S6	High	Shipbuilding	Project Manager—Technology research infrastructure	10	40–59
S7	High	Shipbuilding	Project Manager—Technology research	10	20–39
S8	High	Shipbuilding	Senior engineer—System engineering	6	20–39
S9	High	Shipbuilding	Senior engineer—Digital detail design	10	40–59

5.3 Overview of Data

This section provides an overview of the data (organisational dynamic capability) collected from 24 participants. The exploratory and in-depth interviews with practitioners resulted in the identification of 10 organisational dynamic capabilities (sensing, seizing and reconfiguring). As shown in Figure 23, the identified capabilities included:

1. Sensing: (1.1) Strategic foundation, (1.2) Knowledge and (1.3) Management
2. Seizing: (2.1) Value recognition, (2.2) Implementation-centred approach and (2.3) Understanding resistance
3. Reconfiguring: (3.1) Continuous integration, (3.2) Leadership and communication, (3.3) Cultural transformation and (3.4) Skill transformation.

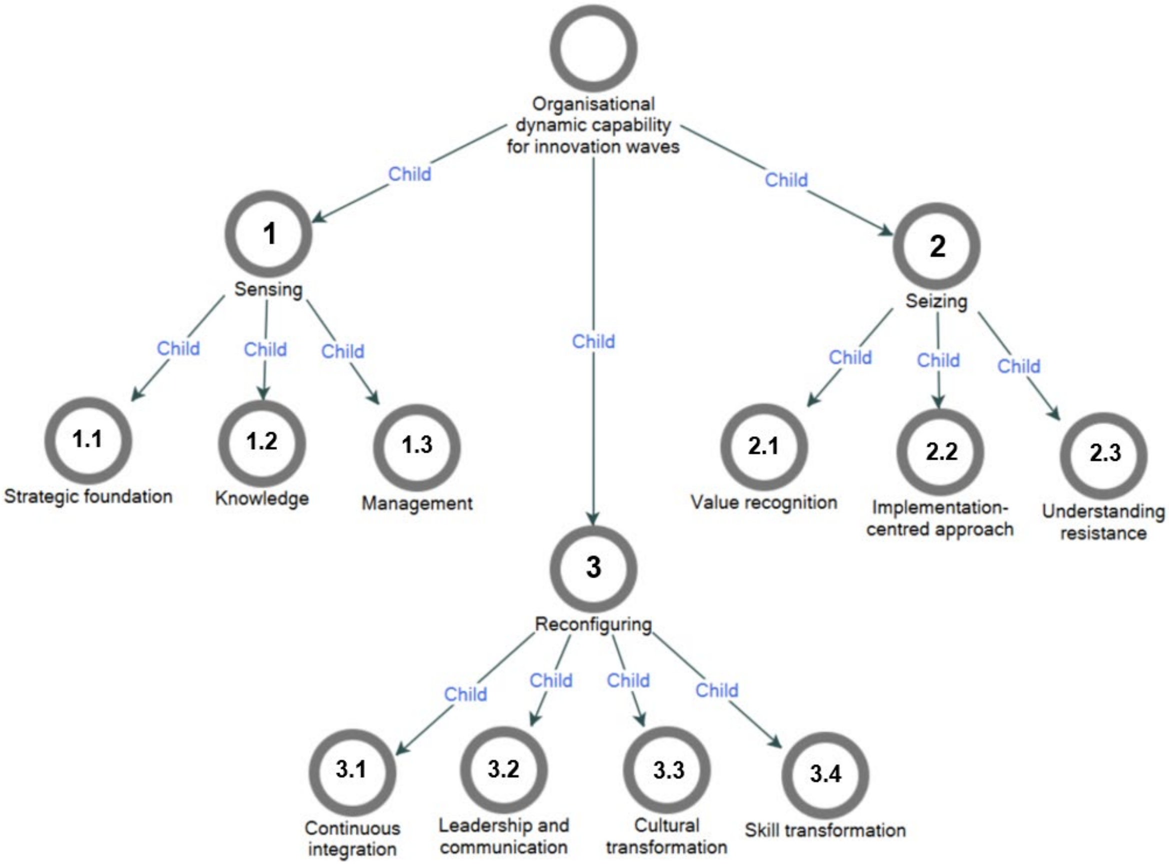

Figure 23: Ten organisational dynamic capability required for innovation waves

All the figures in this chapter were presented to visualise the coding structure that was extracted from the data presentation in NVivo 12. These capabilities were identified through a manual analysis with data from the interviews. These data were re-analysed by thematic and content analysis with NVivo 12. The key data are depicted in Table 28. The first column outlines the three dynamic capability dimensions, the second column shows the 10 organisational dynamic capabilities, the third column provides the attributes of each capability, the fourth column reveals the number of participants who highlighted the importance of each capability and the fifth column outlines the number of codes[6] created for each capability.

Table 28: Key organisational dynamic capabilities, their attributes, number of participants and codes

Dynamic capability dimensions	Organisational dynamic capability	Attributes of the capability	Number of participants	Codes
1. Sensing	(1.1) Strategic foundation	• Long-term goal and vision • Purpose-driven approach • Understanding external and internal factors	17	78

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[6] Codes consist of collections of references derived from interview data pertaining to a particular theme, subject, concept or idea. These references may be either descriptive or analytical in nature.

Dynamic capability dimensions	Organisational dynamic capability	Attributes of the capability	Number of participants	Codes
	(1.2) Knowledge	• Open innovation • Internal assessment • Balancing technology and product knowledge • Human knowledge and insight	21	174
	(1.3) Management	• Management leadership (bridging top, middle and lower) • Management commitment	14	62
2. Seizing	(2.1) Value recognition	• Value translation with end users • Value quantification • Indirect value	18	106
	(2.2) Implementation-centred approach	• Implementation resource • People-centred approach • Methodological implementation	23	165
	(2.3) Understanding resistance	• Resistance and fear • Policy and process for privacy concerns	19	106
3. Reconfiguring	(3.1) Continuous integration	• Customisation • In-house capabilities • Gradual integration	14	108
	(3.2) Leadership and communication	• Diverse leadership • Transparent and effective communication	16	90
	(3.3) Cultural transformation	• Fostering agile culture • Cultivating cultural shift	15	82
	(3.4) Skill transformation	• Reskilling and upskilling • Continuous learning	16	92

Table 28 shows that each organisational dynamic capability was emphasised by at least 14 out of the 24 participants. There was a minimum of 62 individual codes within each capability. The significance of these capabilities was underscored by the large number of participants and codes associated with each capability. However, it is important to note that variations in participants and codes related to each capability should not be interpreted as differences in their importance, owing to the interdependency between these capabilities.

To pinpoint the capabilities, both a priori and empirical codes were applied. The capabilities identified during the analysis were all predetermined categories previously drawn from the existing literature. Although capabilities that were not entirely new emerged during the data analysis, this specific set of attributes and capabilities was unique and did not appear in the literature. Each of these fundamental elements was recognised as comprising a collection of attributes that defined the content of these capabilities.

In this section, each of the identified capabilities and their constituent attributes were detailed for further discussion on why these were important as part of the innovation waves in the Australian heavy industry. The following sections answer the first research question by focusing on sensing capabilities (Section 5.4), seizing capabilities (Section 5.5) and reconfiguring capabilities (Section 5.6).

5.4 Sensing

Sensing refers to the ability to effectively involve scanning, learning and interpreting to identify emerging opportunities in innovation waves trends. Three organisational dynamic capabilities were identified during the thematic analysis, comprising strategic foundation, knowledge and management, as shown in Figure 24.

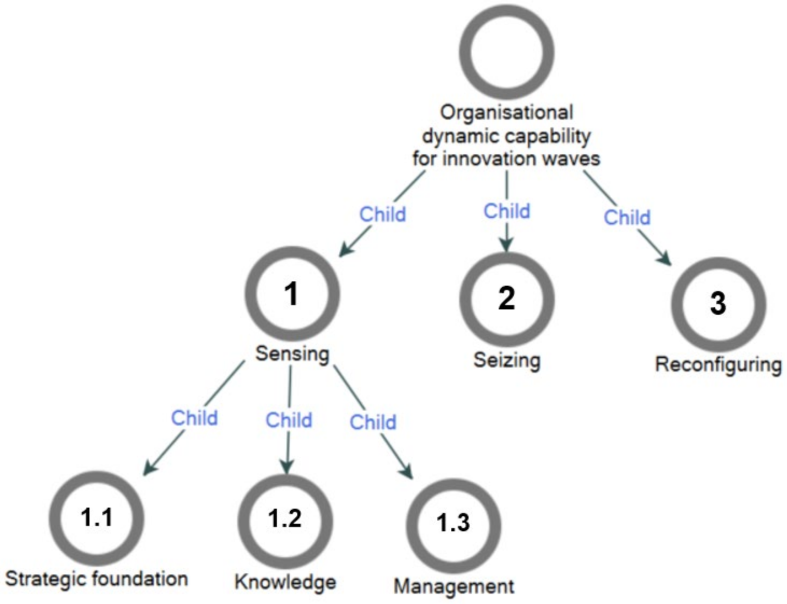

Figure 24: Sensing capability

The following subsections provide a detailed exploration of the three organisational dynamic capabilities (related to sensing): strategic foundation in Section 5.4.1, knowledge in Section 5.4.2 and management in Section 5.4.3.

5.4.1 Strategic Foundation

A strategic foundation serves as the bedrock on which an organisation’s entire operational framework and strategy are built. It encompasses the fundamental elements that define the organisation’s purpose, direction and guiding principles. These include the goal, mission, vision and values that articulate why the organisation exists, where it aims to go and the core beliefs that shape its actions. In the pursuit of innovation waves across the Australian heavy industry, the establishment of a robust strategic foundation serves as a cornerstone of sensing capabilities. These elements not only provide a roadmap for organisational evolution, but also play a vital role in sensing new opportunities and technologies. The existence of a strategic foundation emerged as a central capability in the responses, demonstrating its significance across all three sectors. A total of 17 participants emphasised the importance of a strategic foundation. This common denominator underscored the universal acknowledgment of the pivotal role played by strategic foundations in driving innovation waves across heavy industries.

This in-depth analysis explored the multifaceted elements of a strategic foundation, drawing on detailed data from professionals in three diverse industries. The thematic analysis brought to light three key attributes: long-term goals and vision, a purpose-driven approach, and understanding external and internal factors, as revealed in Figure 25.

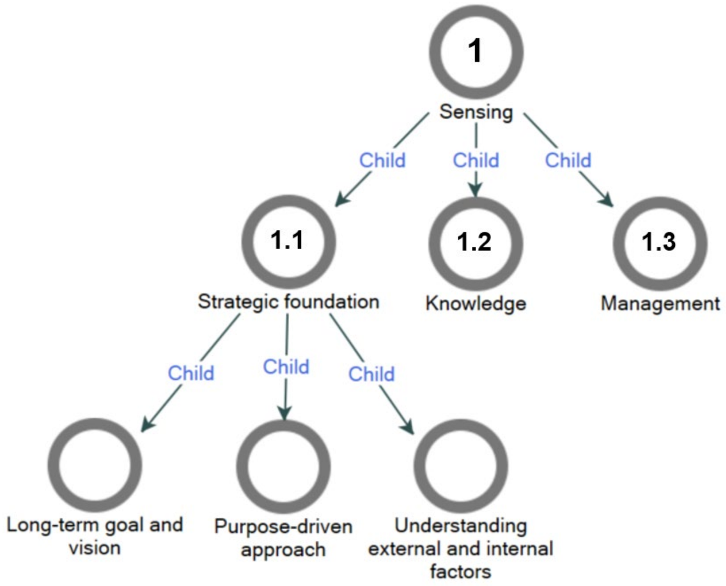

Figure 25: Strategic foundation

5.4.1.1 Long-Term Goal and Vision

The participants unanimously emphasised the pivotal role of long-term goals and vision as the starting point for effective innovation waves endeavours. Having a clear vision of future objectives acted as a guiding beacon, steering organisational strategies amid the complexities of technological advancements and market fluctuations. This is illustrated by participant S5 who asserted:

> In a fast-changing world, it is important to think where we can go. Our long-term goals and visions are like a map, guiding us to new opportunities in the ever-expanding market and technology landscape.

S5 highlighted the indispensable nature of long-term goals and vision in the innovation waves journey. This was echoed by M8 who emphasised how a well-defined vision served as a reference point for aligning organisational efforts and fostering strategic clarity by stating:

> Without a clear long-term vision, it’s sailing without a compass. You may drift aimlessly, unable to identify or capitalise on emerging opportunities.

Moreover, M8 stressed how long-term goals and vision drive strategic alignment, ensuring that digital initiatives are in line with overarching organisational objectives. S9 noted the need to align technology selection with long-term business vision, highlighting the strategic imperative of integrating digital strategies into broader organisational goals by stating:

> Aligning our technology choices with our long-term business vision is crucial. It’s not just about adopting the latest tech trends; it’s about strategically leveraging technology to achieve our organisational goals.

This strongly affirmed the necessity for strategic cohesion for successful transformation for innovation waves. The participants from the shipbuilding sector emphasised the importance of long-term goals and vision as a guiding beacon amid technological advancements and market fluctuations. Their perspective might be influenced by their relatively young age, which may indicate a more forward-thinking approach and greater enthusiasm towards embracing new opportunities in the digital landscape. The perspective of the participants from the mining sector aligned with those from the shipbuilding sector regarding the importance of a clear vision for guiding organisational strategies. However, those in the mining sector specifically mentioned the need for strategic alignment and clarity, indicating a focus on operational efficiency and goal-oriented approaches. Their mid-level commitment to innovation waves suggests that they might have experience navigating digital initiatives but are still seeking to optimise strategies for maximum impact.

5.4.1.2 Purpose-Driven Approach

The participants consistently advocated for a purpose-driven approach. Participant M4 noted the need to align technological advancements with specific organisational needs and challenges. This stressed the significance of identifying and addressing specific problems with advanced technologies rather than adopting technology for its own sake. This approach encouraged organisations to seek out technologies that directly address identified pain points, thereby enhancing efficiency and productivity. This was supported by M8, who stated:

> It’s better to have a problem that you can solve potentially with the technology, rather than having a technology that you try to fit just because it’s new and shiny ...

Moreover, M6 cautioned against a technology-driven approach, emphasising that simply adopting technology without a clear problem-solving purpose is unlikely to yield meaningful results. M6 also referred to the importance of starting with a deep understanding of the challenges and opportunities within the organisation, and then leveraging technology as a tool to address these issues effectively:

> Technology should come later in the process. Understanding challenges should be a priority, and data collection and analysis are essential for identifying and understanding problems, as assumptions may not always be the truth.

Individuals involved in sensing activities play a crucial role in identifying relevant data sources, collecting data and analysing it to extract valuable insights. Their understanding of the organisation's goals and challenges enables them to filter and prioritise information effectively, ensuring that only the most relevant data is used to inform sensing activities. They serve as strategic advisers, providing leadership with insights into emerging opportunities, competitive threats and industry trends.

In contrast to the mining sector's emphasis on a purpose-driven approach to technology adoption, the oil and gas sector participants prioritised internal and external factors. This broader consideration of factors could be attributed to the complex regulatory environment, diverse stakeholder interests and fluctuating market dynamics inherent in the oil and gas industry. Although the mining sector focuses on addressing specific organisational challenges with technology, the oil and gas sector appears to have a wider array of considerations in their adoption strategies. This suggests divergent priorities and approaches between the two sectors, with the oil and gas sector navigating a more multifaceted landscape in their technology adoption decisions.

5.4.1.3 Understanding External and Internal Factors

Participant O7 emphasised the critical importance of organisational adaptability and responsiveness to these external pressures. It was noted that technology adoption decisions were often influenced by client preferences and the potential benefits for contract execution, highlighting the significant influence on sensing capability. Moreover, in the Australian heavy industry, technology opportunity or adoption is often influenced by external factors such as regulations, legislation, shareholder pressure and government mandates. Organisations tend to resist change unless external forces compel them to do so. This was demonstrated by M7 who stated:

> External factors including market demand and regulations are strong drivers for change. Sometimes, these external pressures force organisations to think about a new opportunity.

This underscored that organisations must stay vigilant and adaptive to these external pressures. They should actively monitor market trends, align their strategies with evolving demands and ensure compliance with changing regulations.

The external factors influencing perceptions of the heavy industry's attractiveness were highlighted, revealing the prevailing view that the sector lacked appeal and was perceived as highly conservative. These perceptions contribute to challenges in attracting skilled individuals to the heavy industry. Despite these perceptions, M1 expressed optimism regarding the potential of new technologies, such as Industry 4.0, to revitalise interest in the sector and address skill gaps. This was supported by O3 who asserted:

> I think Industry 4.0 is going to be a good thing because it'll attract people to heavy industry.

Despite the oil and gas, and mining sectors highlighting the significant influence of external factors, such as regulations and market demand, on technology adoption decisions, there was no explicit mention of shipbuilding emphasising external factors in the provided information. This suggests that shipbuilding's approach to technology adoption may be more internally focused or influenced by factors not explicitly mentioned in the analysis section. However, it is important to acknowledge that shipbuilding, similar to other heavy industries, is likely to face external pressures such as market demand and regulatory compliance, but the specific emphasis may differ based on industry-specific dynamics.

Technology advancements hold promise for making the heavy industry more appealing to younger entrants, which leads to reduced skill shortages and fosters innovation. Age emerged as a significant factor influencing technology identification and innovation within organisations undergoing innovation waves. Participant S6 highlighted the impact of age demographics, particularly within leadership and managerial roles, on an organisation's ability to embrace new technologies and drive innovation forward by stating:

> Young people are very familiar with new technologies. If you have a tradesperson or even manager around 40 or 50, they often don't want to or can't use it.

Notably, older technology leaders, typically in their late 50s, exhibited a lower inclination towards innovation and transformation. This was supported by O2 who asserted:

> When you look at the age profile of the leadership, even middle-level management, everybody is in late 50s, so their tendency to innovate is very low.

This reluctance to embrace innovation can hinder an organisation's agility and responsiveness to technological change, potentially impeding progress in innovation waves. Conversely, younger leaders were perceived to be more open to innovation and transformation. Their familiarity with emerging technologies and greater adaptability to change positions them as catalysts to drive organisational agility and innovation forward. Greater diversity in the technology leadership team was identified as a facilitator of innovation, fostering a culture that values creativity, experimentation and forward thinking. This was demonstrated by M7 who stated:

> It's not about just having young or old leader. It's about the dynamic blend of experiences and perspectives they bring to the table.

Age dynamics play a significant role in technology adoption and innovation across sectors, with each sector exhibiting distinct attitudes and responses. In the oil and gas sector, older leadership, typically by those in their late 50s, is perceived as exhibiting a lower inclination towards innovation, potentially hindering the progress of innovation waves. Conversely, in the mining sector, there was recognition of age-related differences in attitudes towards innovation, alongside the openness to innovation among younger leaders. This suggests variability in age-related attitudes towards innovation within the mining sector. Similarly, within the shipbuilding sector, age demographics were acknowledged as influencing an organisation's ability to embrace new technologies, with older managers often exhibiting reluctance or difficulty in adopting new technologies. This implies that age-related attitudes towards technology adoption and innovation may also shape strategies within the shipbuilding industry.

5.4.2 Knowledge

Knowledge as a capability refers to ability of organisations to acquire, utilise, and manage information or expertise effectively to achieve a goal. Knowledge emerged as a pivotal capability needed to identify new opportunities and advanced technologies. Among the participants, 21 emphasised the importance of knowledge; that is, the systematic collection, organisation and dissemination of knowledge within an organisation. A total of 15 participants emphasised the importance of knowledge. The term 'knowledge' was mentioned by 10 participants, while 'insight' was cited by 12 participants. 'Open innovation', mentioned by 10 participants, served as a valuable tool, and 'internal assessment' was mentioned by 13 participants. Additionally, 'learning from others' was mentioned by 12 participants, and 'external expertise' was cited by six participants as providing specialised knowledge and perspectives that can inform decision-making.

The analysis delved into the multifaceted aspects of knowledge, emphasising the in-depth data derived from the participants. Four different attributes were identified in the thematic analysis: open innovation, internal assessment, balancing technology and product knowledge, and human knowledge and insight, as shown in Figure 26.

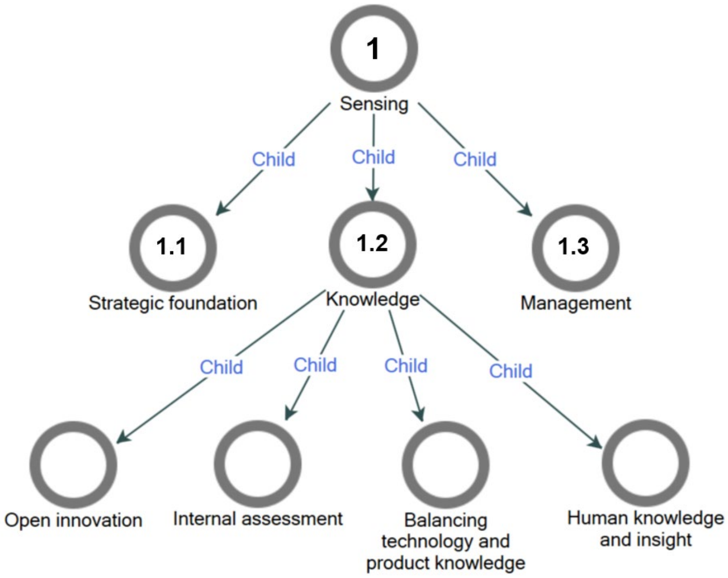

Figure 26: Knowledge

5.4.2.1 Open Innovation

Open innovation refers to the collaborative approach of seeking external ideas, technologies and partnerships to drive innovation and enhance organisational capabilities. Open innovation is critical to augmenting sensing capabilities and driving innovation. Organisations can broaden their understanding of emerging technologies and market trends, and enrich their sensing capabilities by exploring advancements in other industries. However, a lack of open innovation is highlighted by participant M2 who asserted:

> Open innovation can be accelerating the technology innovation, but not much innovation has been done in the heavy industry sector.

Benchmarking enables organisations to gain insights into innovative practices and technological advancements. This was demonstrated by S4 who explained:

> You need to appreciate what others are doing and you need to benchmark other sectors.

Benchmarking and open innovation is needed to acquire knowledge to advance sensing capability. However, participants highlighted the reluctance within the heavy industry to learn from other industries. This insularity can impede progress and hinder the adoption of innovative practices, as articulated by M5:

> The challenge in heavy industry is that it often doesn't see itself as having peers to benchmark against. The idea of going to a winery, or a teacher going to a mining site, or exploring different industries can be met with resistance. Heavy industry tends to be insular and hesitant to seek inspiration outside its sector. This can limit the potential for cross-industry learning and innovation.

By embracing cross-industry learning, organisations can expose themselves to diverse perspectives and approaches to technology adoption, and this type of proactive exploration should be encouraged to break the cycle of insularity. A proactive approach fosters a culture of openness and curiosity, which is essential for effective sensing in a rapidly evolving digital landscape. This cross-industry learning can help in leapfrogging some of the common pitfalls and accelerating sensing activities. This is supported by S5 who emphasised:

> Our organisation looks at other industries. There is much to gain from understanding how different industries handle technology, communication, culture, and productivity.

By actively seeking insights from other industries, organisations can identify potential opportunities and threats early on, bolstering their sensing capabilities. Engaging external consultants further enhances this approach by tapping into specialised knowledge and expertise, accelerating an organisation's innovation waves journey, as noted by O7:

> External consultants play a crucial role in providing necessary skills and knowledge for successful transformation.

Although all sectors recognise the importance of open innovation for augmenting sensing capabilities and driving innovation, differences in execution and perception are evident. Participants from the shipbuilding sector, characterised by a high level of commitment to innovation wave, emphasised the significance of cross-industry learning and benchmarking, acknowledging the value of external insights to advance sensing capabilities. In contrast, the mining sector displayed more scepticism towards open innovation, with participants highlighting a reluctance to learn from other industries and a tendency towards insularity. This reluctance poses challenges to innovation adoption and limits opportunities for cross-industry learning. However, within the oil and gas sector, there was recognition of the role of external consultants in providing specialised knowledge and accelerating innovation waves efforts. Overall, even though the importance of open innovation was acknowledged across all sectors, differences in attitudes and practices underscore the need for proactive approaches to fostering a culture of openness and curiosity, essential for effective sensing and innovation in the digital landscape.

5.4.2.2 Internal Assessment

Internal assessment, a structured process of analysing an organisation's current state of technological capabilities and readiness, plays a crucial role in enhancing sensing capabilities and guiding informed decision-making in the innovation waves journey. By conducting an internal assessment, organisations gain valuable insights into their current technological capabilities, enabling them to sense emerging opportunities and threats in the digital landscape. This was demonstrated by participant S4 who asserted:

> An appropriate assessment tool maps your capability where you measured on a number of things that they analyse you on, and it maps you into a chart.

The structured analysis provided by assessment tools allows organisations to benchmark themselves against industry standards, providing a clear understanding of their relative position and areas for improvement.

Incorporating both technological and organisational aspects, an internal assessment aligns closely with sensing capabilities by providing a holistic understanding of an organisation's digital readiness. By examining digital capabilities alongside organisational readiness factors, such as culture and leadership, organisations can better anticipate and respond to technological disruptions. This was supported by O1 who stated:

> If we only focus on technology area, the transformation is going to fail. Organisational capabilities must be considered as part of digital readiness.

Internal assessments facilitate the identification of gaps in technological capabilities and understanding their underlying causes. This process enables organisations to develop targeted strategies for addressing these gaps, ultimately strengthening their sensing capabilities. By understanding why gaps exist and how they can be filled, organisations can proactively adapt to changing market dynamics and technological trends. This was illustrated by S4 who stated:

> You must recognise the existence of gaps and understand their factors. Identifying these gaps is crucial for understanding why they exist and how they impact our organisation.

Participants from the shipbuilding sector emphasised structured analysis using assessment tools to map technological capabilities and identify areas for improvement. The oil and gas sector participants recognised the holistic nature of internal assessments, which incorporate both technological and organisational aspects to better anticipate disruptions. These differences suggest that, although shipbuilding focuses on a methodical approach to analysing technological capabilities, the oil and gas sector takes a broader view, considering both technological and organisational factors. However, the absence of specific emphasis from the mining sector on understanding the underlying gaps and targeted strategies implies a potential gap in their approach to internal assessments. Overall, this highlights the need for customised internal assessments aligned with each sector's organisational characteristics to effectively enhance sensing capabilities.

5.4.2.3 Balancing Technology and Product Knowledge

In the realm of heavy industry, the integration of advanced technologies is often impeded by a generational gap in knowledge and experience. Participant O6 asserted this with the following statement:

> Technology adoption in heavy industry is a formidable challenge ... the problem arises when the existing workforce, often an older demographic with deep product knowledge, lacks the technological expertise required for modernisation.

This gap presents a significant challenge to successful knowledge acquisition, highlighting the complexity inherent in technology integration within the heavy industry. Despite the importance of human insight and industry-specific knowledge, the gap between product knowledge and technological proficiency poses a considerable obstacle to progress.

Moreover, M5 underscored the distinction between older workers, who hold invaluable product knowledge, and younger, technologically adept individuals, who may lack industry-specific experience. This was demonstrated by M5 who stated:

> There are younger group, technologically adept individuals who lack extensive product knowledge, and older group who have better product knowledge, but less adaptive to technological advancement. This creates a challenge in bridging the gap between these two groups.

Recognising the need to adapt to modern technologies while leveraging the wealth of knowledge within the experienced workforce highlights the complexity of the situation. To address this challenge, it is important to introduce a model that combines the experience of older workers with the technological expertise of younger generations as an effective way to bridge the generational gap and align technology with industry-specific knowledge. This was supported by M5 who asserted:

> Bringing together the seasoned know-how of older workers with the tech-savvy skills of younger generations through a well-designed model is key to bridging the generational gap.

A notable distinction arises between the perspectives from the mining sector and those from the oil and gas sector. The mining sector participants noted the challenge of integrating technology resulting from the perceived disparity between older and younger workers' adeptness with technology. Conversely, participants from the oil and gas sector expressed the belief that older individuals may lack proficiency in technology, suggesting a potential barrier to technological advancement. Although the mining sector appeared to be concerned with leveraging the extensive product knowledge of its workforce, the oil and gas sector is focused on addressing potential deficiencies in technological expertise among older workers. The fact that O6 was younger than M5 added another layer to this analysis, indicating a shift in perspective that was possibly influenced by generational differences. This suggests that age and experience play a significant role in shaping perceptions of technological proficiency and product knowledge within these industries.

5.4.2.4 Human Knowledge and Insight

Recognising the need for human intervention in such tasks is crucial, since technology may lack the necessary knowledge and adaptability. This echoes the idea that technology should complement, rather than replace, human capabilities. This was demonstrated by S7:

> Technology's strength lies in handling repetitive tasks. When faced with complexity, human involvement remains indispensable, even with the advanced technologies.

In heavy industries, preserving and sharing insider knowledge is paramount, as noted by O5. Human insight and knowledge remain indispensable, particularly in labour-intensive and complex processes where technology alone may fall short. Even though technology plays a crucial role, it cannot fully replace the insights and experience of the workforce. This was illustrated by M6:

> We can't disregard the human element. Heavy industries often involve labour-intensive and complex processes where human insight and knowledge are crucial for quality and safety. Technology should enhance human capabilities and provide guidance and support, especially where experience and expertise matter.

Further, human insight and knowledge are critical, particularly in tasks such as welding, where experienced workers possess contextual knowledge that the technology might lack. The effective adaptation of technology requires processes that incorporate human expertise, ensuring that technology complements and leverages human capabilities rather than replacing them. This was supported by M3 who stated:

> To adapt technology effectively, processes need to be well defined and include human expertise and knowledge.

In the context of advancing business processes through technology, the intricate interplay between technology and human insight has become apparent within heavy industries. An example provided was the utilisation of Primavera P6 planning software seamlessly integrated with enterprise resource planning systems such as SAP, affording users real-time access to supply chain information. This integration not only optimised efficiency, but also furnished accurate and timely data, underscoring the importance of human insight in interpreting and utilising technological advancements.

Despite the advancements in technology, human insight remains indispensable, particularly in making pivotal decisions. Participant O1 emphasised the importance of human cognition, especially in navigating complex scenarios where the available data may be imperfect. This was further reinforced by O4 who highlighted the significance of human cognition, especially in the face of unpredictable external circumstances such as the COVID-19 pandemic by stating:

> Even though data integrity has been improved by using the digital technologies, there is always things to be considered by human insight.

The pandemic served as a striking illustration of this principle, wherein the digital system maintained its usual supply chain estimations. Nonetheless, project engineers and planners are compelled to factor in the unpredictability stemming from external circumstances, highlighting the enduring significance of human cognition.

Although participants in all sectors recognised the importance of human knowledge alongside technological advancements, differences emerged in their approaches to technology adoption and the level of emphasis on human cognition. The oil and gas sector participants predominantly emphasised the significance of human cognition alongside technological advancements. In contrast, even though the shipbuilding and mining sector participants also recognised the importance of human knowledge, they did not provide explicit insights regarding human cognition. However, the absence of such statements does not necessarily indicate a lack of recognition of human expertise within these sectors; rather, it suggests a difference in emphasis or possibly a variation in the themes addressed within the analysis.

5.4.3 Management

Management refers to the ability of managers to guide, inspire, and influence their teams or organisations towards achieving common goals effectively. Management is fundamental for organisations in navigating the ever-changing digital landscape, particularly in identifying new opportunities and technologies. It involves setting clear visions, aligning strategies and fostering an environment that is conducive to innovation. Management emerged as a common denominator across the three sectors, with 14 participants emphasising its importance. This commonality underscored the pivotal role this capability plays in the successful transformation for innovation waves. Among the participants, 16 mentioned ‘leadership’ and 14 emphasised ‘management’, indicating a strong consensus on its significance.

The analysis delved into the intricate aspects of management, showcasing in-depth data from practitioners in three varied sectors. Two attributes were pinpointed in the thematic analysis: management leadership (bridging top, middle and lower management) and management commitment, as demonstrated in Figure 27.

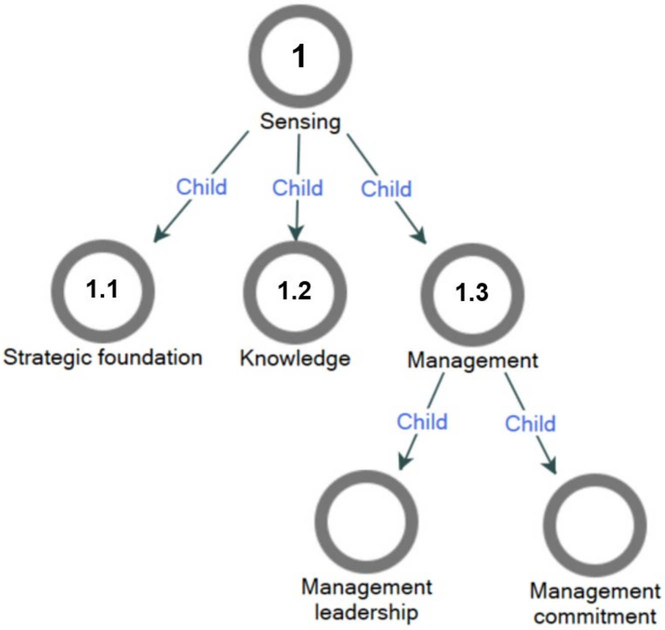

Figure 27: Management

5.4.3.1 Management Leadership (Bridging Top, Middle and Lower)

Bridging top, middle and lower management is crucial for effective organisational leadership. Ensuring alignment and coherence across all levels facilitates the seamless implementation of strategic goals and innovation waves efforts. Management leadership involves being flexible, proactive and capable of driving change and growth within each layer of an organisation from top to bottom. Top-down leadership ensures that strategic goals align with innovation waves efforts, facilitating the identification and pursuit of new opportunities. Endorsement and support from top management are essential enablers for successful bottom-up initiatives. This was explained by S4:

> If you don’t have the top buy in, you can be putting all these initiatives from the bottom up but if you’re not going to get the backing from the management executive, to financially support and provide resource, it cannot happen.

Understanding and appreciation by leadership of the value of innovation waves is crucial in driving effective sensing capability. This fosters a culture of innovation and adaptability throughout an organisation. This was described by S4:

> The cultural shift from management leadership is essential for encouraging employees at all levels to actively engage in sensing opportunities and driving technological changes.

Bottom-up leadership involves employees at lower levels of the organisation driving technological changes aligned with business objectives. Although leadership is necessary for technology adoption, the initial impetus can come from grassroots initiatives within the organisation, as articulated by M7:

> Leadership is required to get it done ... but the drive for technology tends to come from the bottom ...

This bottom-up approach fosters a culture of initiative-taking and empowers employees to contribute to the organisation's sensing capabilities by identifying and capitalising on emerging opportunities. Further, bottom-up leadership complements top-down initiatives by empowering employees to take ownership of technology adoption and innovation. This was echoed by M7:

> When employees feel empowered to drive change from the low level, it leads to greater participation, creativity, and agility in identifying and responding to emerging trends and opportunities.

This bottom-up approach enhances an organisation's sensing capabilities by tapping into the diverse perspectives and expertise of frontline workers.

The middle management group plays a vital part in translating strategic directives into practical applications within manufacturing and production engineering. This group is essential for bridging the gap between innovative designs and efficient production processes, as noted by S6:

> Middle group is critical to translate everything into production.

Their expertise in translating technical concepts into actionable plans enables the effective implementation of digital technologies within operational contexts. This also ensures that digital strategies are refined and adapted based on real-world feedback, enhancing the organisation's sensing capabilities and facilitating the successful identification of new technologies. This was supported by S6 who stated:

> Middle management leadership further enhances capabilities to identify new opportunities by facilitating the translation of strategic directives into actionable plans and processes.

Middle management leadership ensures that innovation wave efforts are effectively integrated into operational workflows, maximising the organisation's ability to sense and respond to changes in the external environment.

The shipbuilding sector exhibits a pronounced emphasis on top-down support, indicative of a leadership strategy that is focused on driving innovation waves initiatives from the executive level. This underscores the importance of a structured and directive leadership style aimed at aligning organisational goals with technological advancements in the shipbuilding sector. In contrast, the mining sector embraces a stronger emphasis on bottom-up empowerment, highlighting a decentralised approach to innovation. This signifies a culture that values employee input and fosters ownership and engagement at all levels of the organisation. The recognition of grassroots initiatives in mining reflects an organisational ethos that encourages continuous improvement and adaptability, allowing diverse ideas to surface, regardless of employees' hierarchical positions. Additionally, in shipbuilding, middle managers serve as crucial liaisons between executive leadership and frontline workers, ensuring effective communication and implementation of strategic directives at the operational level. The differences in leadership dynamics between the sectors illustrate their contrasting approaches to fostering innovation and driving innovation waves. These distinctions underscore the unique organisational cultures and priorities within each sector, shaping their pathways towards innovation waves and organisational success.

5.4.3.2 Management Commitment

Management commitment to sensing new opportunities is intrinsically linked to an organisation's sensing capabilities, playing a critical role in facilitating the identification and exploration of new opportunities and technologies. Management may not fully comprehend the intricacies of a technological advancement. Management commitment plays a pivotal role in amplifying the discovery of a new opportunity by fostering a sense of responsibility in engaging with stakeholders through leadership. Participant S9 asserted this with the following statement:

> The management team's commitment to a new opportunity isn't just desirable. It is indispensable for staying competitive. Their commitment transforms engagement with stakeholders, aligning their vision with the transformative potential of advanced technologies.

Participant M8 emphasised that leadership involvement and hands-on experience enable leaders to better understand the needs and challenges of their teams, fostering trust and alignment. More hands-on experience among management influences their commitment to innovation waves initiatives, since they gain a deeper appreciation for the potential benefits and challenges associated with technology adoption. This heightened understanding enhances management's commitment to allocating resources and supporting initiatives aimed at leveraging new technologies for organisational growth.

Participant O6 noted that top management's commitment to embracing innovation waves was more critical than leadership and communication in driving change. This perspective stressed the significance of top-down support and sponsorship for technology initiatives, reflecting the need for organisational leaders to lead by example and actively champion innovation waves efforts. This was supported by O6 who stated:

> Top management's intention to embrace innovation waves is more critical than leadership and communication.

Participant O5 revealed that some organisations demonstrate a high level of commitment to innovation waves through strategic investments, dedicated product managers and advanced digital technologies. This commitment is important for building the environment and capabilities necessary to identify opportunities effectively. By investing in the development of digital infrastructure, talent and processes, organisations enhance their ability to sense changes in their external environment and capitalise on emerging opportunities. As articulated by O5:

> High level of commitment to innovation waves with strategic investment was crucial for shaping an environment to identify new opportunities.

Ultimately, management commitment to innovation waves was found to be a key organisational capability of sensing, providing the necessary support and resources for an organisation to effectively identify, assess and capitalise on emerging opportunities and technological advancements.

These differences highlight the unique strategies and priorities within each sector regarding innovation waves. In shipbuilding, the top-down approach emphasises the role of leadership in aligning goals with technology, fostering stakeholder engagement. Conversely, the mining sector's bottom-up approach values hands-on involvement, encouraging a culture of collaboration and innovation. In contrast, the oil and gas sector's focus on strategic investments underscores a proactive effort to build digital infrastructure and talent, maximising its sensing capabilities.

5.5 Seizing

Seizing capabilities focus on capturing the value of changes once opportunities have been identified, enabling organisations to exploit these opportunities. Three capabilities were identified as part of the seizing dimension during the thematic analysis, comprising value recognition, an implementation-centred approach and understanding resistance, as shown in Figure 28.

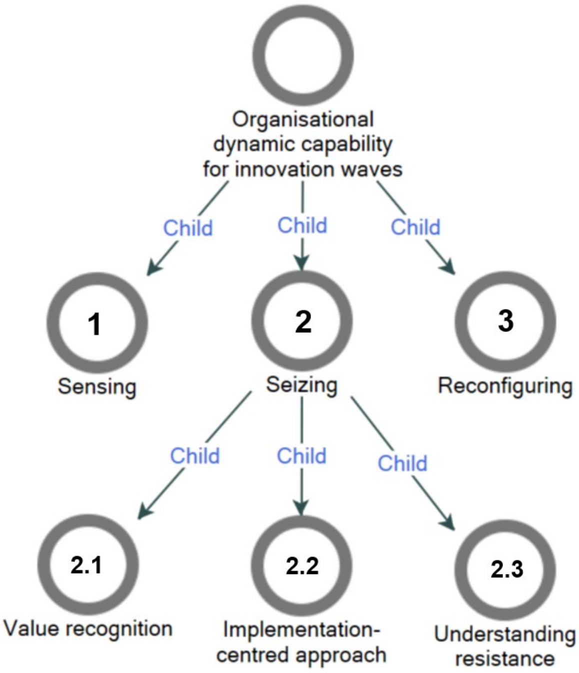

Figure 28: Seizing capability

The subsequent sections provide an analysis of the three organisational dynamic capabilities (seizing): value recognition in Section 5.5.1, implementation-centred approach in Section 5.5.2 and understanding resistance in Section 5.5.3.

5.5.1 Value Recognition

Value recognition refers to the acknowledgment and appreciation of the worth or significance of value from changes (e.g. technology adoption). Value recognition stands as a cornerstone of dynamic capability development for innovation waves. It entails identifying tangible benefits such as cost reduction, enhanced efficiency and improved safety, which are essential for organisational growth. This section explores how value recognition intertwines with seizing capability, reflecting the critical role of recognising opportunities and technologies. The importance of value recognition among the sectors was emphasised by 18 participants. Although the specific priorities, challenges and nuances vary across these sectors, all the participants shared the understanding that recognising value was a critical capability required for innovation waves (‘values’ were mentioned by 17 participants). In essence, participants from all three sectors acknowledged that dynamic capability development efforts should ultimately lead to tangible benefits, including cost reduction, improved efficiency, and enhanced safety (12 participants mentioned ‘cost and safety’, and 10 participants referred to ‘time’). This recognition underscores the central role of value recognition as a driving force behind dynamic capability required for innovation waves.

The analysis provided multifaceted aspects of value recognition, highlighting in-depth data from practitioners in three different sectors. Three different attributes were identified in the thematic analysis: value translation with end users, value quantification and indirect value, as shown in Figure 29.

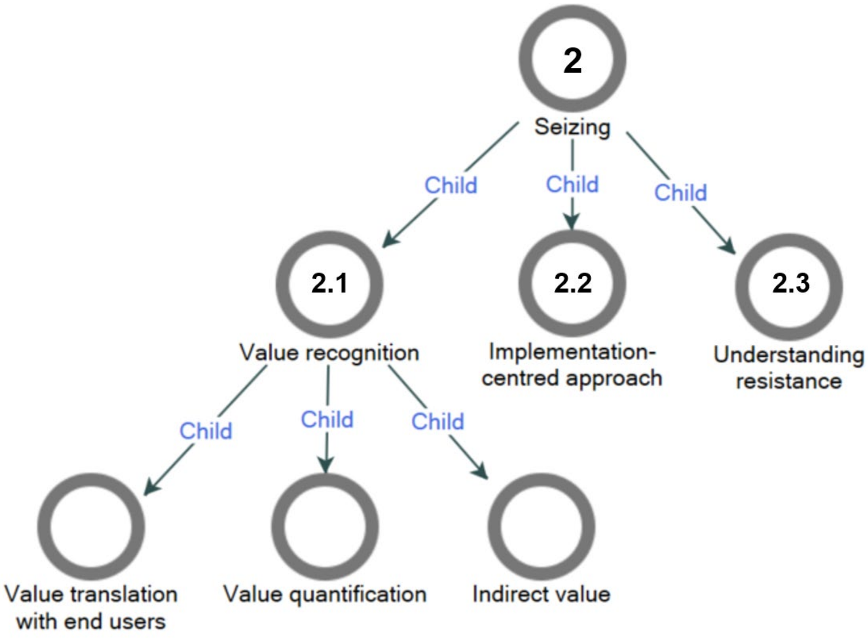

Figure 29: Value recognition

5.5.1.1 Value Translation with End Users

Seizing a new opportunity for innovation waves hinges on the collective understanding of its merits by those tasked with its utilisation. Participant M2 emphasised that organisations must endeavour to demonstrate how the new technology translates to improved safety, health and overall wellbeing, thus reducing workplace incidents. This was supported by O3 who asserted:

> You’ve got to be able to persuade your employees by explaining benefits.

Participant S6 drew attention to the importance of demonstrating how technology can improve the work experience for individuals by stating:

> It is important to illustrate how new technology makes life easier, better, quicker and safer.

Technology, on its own, is of no use, and organisations must identify and extract the true value it can provide. Failure to recognise and leverage this value often stems from a disconnection between a decision-maker and an end user. This was demonstrated by M5 who noted:

> One of the most significant challenges in heavy industry is the failure to recognise the true value of technology. Technology is driven by the latest advancements, but not always by a clear understanding of how it can deliver value. Without the end users' perspective and involvement in the decision-making process, technology may not be properly customised, and its full potential may go unrealised.

It is crucial to involve end users in decision-making processes. Management's engagement with end users not only garners insights into the potential benefits of technology, but also fosters a sense of ownership and alignment with the transformation process. This was confirmed by S4:

> Engagement with end users isn't just about understanding the benefits of technology. It is about cultivating a shared sense of ownership and alignment with the journey of transformation. Success hinges on harnessing the collective support and involvement of management and end users in the implementation process.

The suggestion that tradespeople should be more involved in technology decisions highlights the need for participatory decision-making. Involving end users in technology-related choices can lead to better adoption rates and smoother transitions, as noted by S1:

> Decision-making power regarding technology implementation often rests with management. Tradespeople should be more involved in training and decisions.

Further, M2 highlighted the importance of involving key stakeholders from the very beginning of the seizing process for innovation waves.

There are nuanced perspectives on innovation waves across the three sectors. Participants from the mining sector emphasised the necessity for demonstrating tangible benefits, particularly in terms of safety and wellbeing, reflecting a younger, mid-level experience viewpoint. This suggests a focus on practical outcomes, possibly driven by individuals who are relatively new to the industry but keen on seeing immediate, tangible results. Conversely, the oil and gas sector participants stressed the importance of persuading employees about the benefits of technology, indicating a focus on communication and engagement. This emphasis suggests a strategy aimed at fostering understanding and buy-in among employees, possibly reflecting a mature approach honed through years of industry experience. Participants from the shipbuilding sector prioritised enhancing the experience of work through technology, highlighting a user-centric approach, which may stem from extensive industry tenure and a deep understanding of the importance of user satisfaction. Concerns about recognising the true value of technology in mining suggested a need for greater understanding, indicating a potential gap in awareness or comprehension that could be addressed through education or enhanced communication efforts. These differences in perspectives and strategies underscore the sector-specific priorities and highlight the importance of inclusive approaches to innovation waves.

5.5.1.2 Value Quantification

Transformation with innovation waves often requires significant financial investments in technology infrastructure, software, training and maintenance. Participant O1 noted the significance of value quantification for seizing an opportunity. Organisations change the process and environment with advanced technologies if the technologies save costs. This was supported by O4 who asserted:

> As business is always looking for the cost competitiveness, businesses choose the technology if it saves a lot of money.

Participant S7 highlighted how value quantification helps organisations understand the value of proper technology adoption and enables informed decision-making. However, calculating the value of technology adoption is complex because of its hidden costs, as indicated by S7:

> Quantifying the return on investment for technology acquisitions is a complex task. This complexity arises from numerous hidden costs, such as the necessity of recruiting additional software engineers to ensure smooth functionality.

This suggests that value quantification is critical and should be considered in a broader context that includes potential hidden expenses.

A return on investment (ROI) analysis is a critical step in justifying investments in technology. Participant M8 highlighted the complexity of calculating ROI, especially in contexts related to health, wellbeing and safety. This complexity arises from the challenge of quantifying potential safety improvements and the indirect cost savings associated with technology adoption. Nevertheless, conducting comprehensive ROI assessments is vital for making informed decisions about technology investments. This was illustrated by M6:

> Quantifying the value of digital technologies is challenging. Not all benefits are immediately quantifiable. It’s not just about saving costs or improving quality; it’s about the long-term gains, efficiency, and strategic advantage. Building a solid value proposition requires rigorous data collection and analysis.

Quantifying the value proposition of innovation waves can be challenging, since not all benefits, such as cost reductions or quality improvements, are easily quantifiable. Robust data collection and analysis are essential for building a value proposition. Participant O7 stressed the importance of assessing whether a technology is mature enough for the organisation and aligns with the operational requirements because of its complex change process by stating:

> The transformation journey often involves considerable cultural and technological changes, which can be complex and time-consuming, so it is very important to conduct a careful assessment with new technologies.

This suggests that ROI evaluation is not a one-size-fits-all process but rather involves a consideration of multiple factors, including the readiness of the technology and its alignment with the organisation's goals. Participant O1 observed that evaluating the technology's practicality in the business process and context is important, since every business is different. Participant O3 supported this by stating:

> For instance, weld-data can be uploaded directly as they're doing it rather than all the paperwork. All those things would be massive saving in cost and time. Digitalised data or information could improve a lot of time even be better than human eyes.

It is evident that value quantification is a key attribute of value recognition. This complexity stems from the multifaceted nature of ROI calculations, which must account for significant upfront investments, potential hidden costs and the challenge of quantifying intangible benefits such as safety improvements, quality enhancements and strategic advantages.

Each sector showcased unique approaches shaped by participant characteristics. In the oil and gas sector, a pragmatic emphasis on cost savings and assessment of technology maturity reflects a strategic approach, likely influenced by mid-level commitment to innovation waves and managerial roles. Conversely, the mining sector's focus on the complexity of ROI analysis, particularly regarding intangible benefits such as safety improvements, suggests a thorough and cautious mindset, possibly shaped by mid and high-level commitment to innovation wave. In contrast, the shipbuilding sector prioritises understanding the value of technology adoption and making informed decisions, indicating a strategic approach that is possibly influenced by a high-level commitment to innovation wave. These sector-specific perspectives underscore the need for tailored approaches, with oil and gas emphasising practicality, mining prioritising thoroughness and shipbuilding focusing on strategic decision-making. These differences reflect the diverse priorities and challenges faced by each sector in navigating the complexities of value quantification, emphasising the importance of understanding sector-specific contexts and requirements.

5.5.1.3 Indirect Value

Understanding direct and indirect values is pivotal for seizing new opportunities. Direct values, such as cost reduction and improved quality, are measurable and have a direct impact on the bottom line. Indirect values, such as enhanced health and safety, contribute to employee wellbeing and productivity. Recognising and communicating these values to all stakeholders, from practitioners to management, is essential for garnering support. This was demonstrated by M8 who asserted:

> Understanding both direct and indirect value of the technology is critical.

Direct values have a more significant impact as they directly affect key metrics that organisations track. Indirect values, which take time to materialise, are often undervalued. Organisations prefer technologies that show an immediate impact on key metrics, such as quality and cost. This is because they are less likely to invest in technologies that have a delayed or indirect impact, as articulated by M7:

> If the technology can show immediate impacts on performance metrics ... they are very eager to adopt technologies that help them meet regulatory requirements.

Understanding direct benefits is important as the upfront investment can be significant. However, the importance of indirect value underscores the health, safety, and wellbeing elements for business benefits. There is a reluctance to embrace indirect values, often focusing primarily on direct values such as cost, quality, and performance. Participant S7 emphasised that the industry needs to look at long-term cost savings as technology matures. This was supported by O3 who stated:

> Most people only look at the immediate benefits, but you have to think about the importance of indirect value considering a long-term benefit.

Industry 4.0 technologies have a critical role in automating repetitive and hazardous tasks. Participant S9 expressed a strong belief in the potential of these technologies for improving health, wellbeing and safety that may be considered an indirect value. Safety emerged as a critical consideration, with S8 emphasising that safety was on par with economic considerations in the heavy industry.

Participants in the mining sector placed a strong emphasis on immediate impacts on performance metrics and regulatory compliance, reflecting a focus on direct values driven by mid-career experience. Conversely, the oil and gas sector participants demonstrated a more balanced approach, acknowledging the importance of considering both indirect and immediate benefits for long-term success, possibly influenced by managerial responsibilities and older ages. In contrast, the shipbuilding sector participants showcased a growing recognition of the importance of indirect values, particularly in safety and wellbeing, suggesting a strategic shift. Although safety emerged as a critical consideration across all sectors, there were differences in the extent of emphasis placed on it, with the shipbuilding and mining sectors prioritising it on par with economic considerations, whereas it was not explicitly stated as a comparable priority in the oil and gas sector. These sector-specific perspectives underscore the diverse priorities and challenges faced by each sector in navigating the complexities of value recognition.

5.5.2 Implementation-centred approach

An implementation-centred approach is a method or strategy that places a strong emphasis on the practical execution and deployment of a plan or initiative. This approach prioritises the actual implementation process over conceptual aspects. An implementation-centred approach is a fundamental aspect of seizing capability required for innovation waves. It involves aligning skills and resources to effectively seize opportunities and implement technological changes. The pivotal importance of an implementation-centred approach was recognised by 24 participants. Within this common denominator, the participants' perspectives converged on three key facets: skill, resources and a people-centred approach. 'Skill', denoting the proficiency required to seize advanced technologies, was mentioned by 17 participants. 'Resources', encompassing the necessary personnel, tools and infrastructure, was noted by 16 participants. All the participants shared an understanding of the importance of a people-centred approach ('people-centred' was mentioned by 19 participants).

The analysis investigated deeply into the diverse facets of an implementation-centred approach, highlighting data gathered from practitioners in three different sectors. The thematic analysis uncovered three distinct attributes: implementation resource, people-centred approach and methodological implementation, as presented in Figure 30.

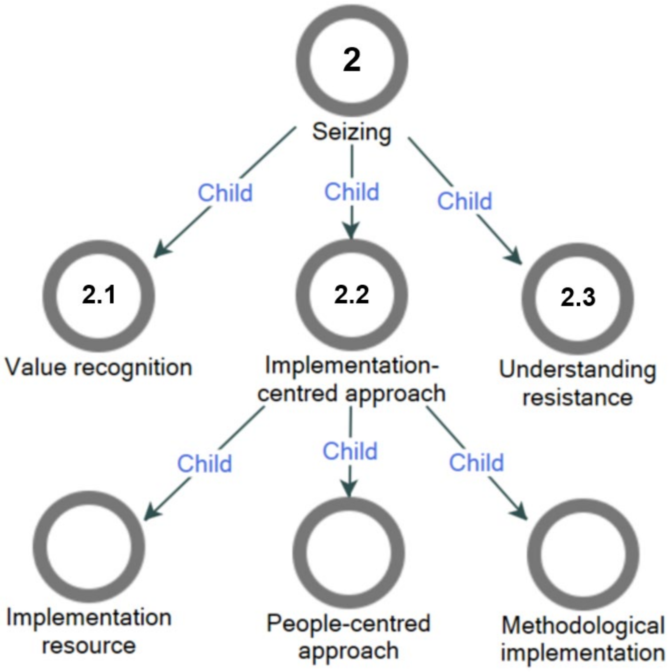

Figure 30: Implementation-centred approach

5.5.2.1 Implementation Resource

Resource allocation is fundamental for organisations seeking to translate opportunities into tangible outcomes. As highlighted by participant S3, significant resources tend to be earmarked for R&D activities, showing the importance of allocating resources appropriately to ensure the effective implementation of innovative projects and initiatives identified through sensing capabilities. The critical role of resource allocation in technology development and implementation was highlighted. For instance, participant S7 stressed the importance of aligning resources with specific needs. This perspective indicates the need for a tailored approach when allocating resources for technology adoption, recognising that different sectors may have distinct requirements, as noted by S7:

> Aligning resources with specific needs is important.

However, there is a limited recognition given to implementation resource allocation across the heavy industry. This was illustrated by O6 who asserted:

> We will end up with a great list of technologies, but I'm not seeing the same level of resources to enable that to actually be implemented. From a broad organisational level, a significant naivety about what are the resource requirements to enable this transformation.

Failure to understand the resource requirements for technology adoption can have a negative impact on the innovation waves process. The requirements include technical support for a variety of digital devices, which may not be readily available without proper resource allocation. This was supported by S3 who stated:

> We actually need lots of people with the basic technical skill to support the end user devices.

Allocating resources is essential not only for technology development, but also for practical implementation and optimisation. This requires comprehensive resource planning to ensure that sufficient resources are available for both R&D activities and on-site support. Neglecting on-site resources can impede success. This was demonstrated by S8 who asserted:

> Overlooking on-site resources can hinder success. It's crucial to ensure that resources are available for both R&D and practical implementation.

Further, management understanding and commitment to resource allocation are important. Top-down support is crucial for providing the necessary financial and human resources for technology initiatives. Without management buy-in, innovation waves efforts may lack the resources needed for successful implementation, as articulated by O5:

> Management understanding becomes crucial to align management's vision with the potential opportunities from advanced technologies.

Transitioning innovative ideas into actionable strategies is challenging, noting the tendency to 'put it on the shelf' after completing projects owing to a lack of implementation resources. This underscores the need for improved strategies for resource allocation. Participant S6 asserted this with the following statement:

> We complete many technology development projects, but often fail to fully utilise their benefits.

Significant resources earmarked for R&D activities indicate the importance of effective resource allocation. By prioritising resource allocation and strategic planning, organisations can enhance their seizing capabilities and realise the full potential of their innovation waves efforts.

The shipbuilding sector, characterised by high-level of commitment to innovation waves and managerial roles, prioritise strategic resource allocation. This involves aligning resources with specific needs to ensure efficient utilisation and avoiding the underutilisation of completed projects. Essentially, they aim to optimise resource allocation for maximum impact, reflecting a proactive and strategic approach to technology implementation. Conversely, the mining sector demonstrate a limited recognition of implementation resource allocation. This suggests a potential gap in understanding or prioritising resource requirements within the sector. This lack of emphasis on resource allocation could indicate a need for improved strategies and management support to ensure successful technology implementation. Essentially, there is room for enhancement in resource planning and utilisation strategies to effectively drive innovation waves initiatives forward. In contrast, participants from the oil and gas sector emphasised the importance of management understanding and commitment to resource allocation. This signifies that top-down support is important in providing the necessary resources for technology initiatives. However, despite this acknowledgment, there were also challenges noted in fully utilising project benefits. This suggests a need for enhanced execution strategies to ensure that technology projects translate into tangible outcomes and deliver maximum value to the organisation. These distinctions among the sectors reveal the unique priorities and challenges they face in the area of resource allocation and technology implementation. Tailored approaches are essential to effectively address sector-specific needs and drive successful transformation with innovation waves.

5.5.2.2 People-Centred Approach

A consensus emerged indicating that people are at the core of successful transformation with innovation waves. People's acceptance, adaptation, and willingness to embrace changes are pivotal in driving transformations forward. It was understood that the transformation journey primarily occurs within the organisational culture, where attitudes and behaviours shift to align with new ways of working. This was illustrated by S2 who stated:

> Ensuring the entire workforce can scale up to this new way of working safely and reliably is a complex endeavour.

Several participants highlighted the initial emphasis on technology over people in their organisations. Participant S7 illustrated their journey as 'semi-mature', noting that technology received significant attention while people were somewhat overlooked. However, efforts were underway to involve employees more actively, recognising the need to strike a better balance. This observation signified the need to align technology with the human element effectively. This was supported by M5 who asserted:

> We encounter scenarios where technology is deemed ineffective, mainly due to the lack of people understanding.

Participant S8 noted that, when individuals understand the purpose behind technological changes, implementation becomes more straightforward. Participant S9 argued that even the most advanced technology was ineffective without the active involvement and support of the workforce:

> The driving force behind successful transformation is the workforce.

Moreover, S6 stressed the paramount role of the human element in any process or technology adoption, noting that:

> If people are not onboard, they can override any process or any rules.

It was also noted that the introduction of novel technologies often entails procedural shifts within a business. Participant M2 underlined that the manner in which these disruptions are perceived and managed holds the key to the success or failure of technological implementation. Acknowledging and navigating human resistance to change emerged as a critical determinant. A mismanaged approach can render the implementation futile, accentuating the significance of recognising the impact of change on business processes. This was supported by S3 who stated:

> If the human factors part is not managed well, it could actually be the reason why a change doesn't happen.

It is important to have a mechanism to connect people with technology with different ways. This was illustrated by M4 who emphasised:

> Appointing champions and involving the right individuals early on is crucial for technology adoption.

Ensuring that people are actively involved in the technology adoption process is essential for its success, with a particular focus on effective communication and support for late adopters.

In the shipbuilding sector, there was acknowledgment of a semi-mature stance, where technology received significant attention while people were somewhat overlooked. Conversely, the mining sector showcased a proactive approach, showing the importance of ensuring the entire workforce can adapt to new technologies safely and reliably. There was recognition of the impact of human resistance to change on the success or failure of technological implementation, indicating that effective management of human factors is required. Notably, participants from the oil and gas sector did not explicitly mention a focus on a people-centred approach, suggesting a potential oversight in acknowledging the critical role of human factors in innovation waves. These distinctions reveal the sector-specific priorities and challenges, signifying that tailored approaches are necessary to address workforce dynamics and organisational culture effectively.

5.5.2.3 Methodological Implementation

Methodological implementation, a systematic approach focusing on aligning technology with people for effective implementation, emerged as a fundamental element of seizing a new opportunity. Participant M1 indicated that this approach places emphasis on the perspectives and experiences of individuals involved in the implementation process, playing a pivotal role in successful technological integration. It is instrumental in preparing end users for the impending changes in their work routines and environments.

Implementation trials, which are integral to methodological implementation, offer invaluable insights for organisations. They facilitate an understanding of what works and what does not work, and identify any necessary cultural adjustments. Participant S4 commented on the significance of such trials, stressing their role in informing decision-making and fostering meaningful discussions:

> Test and trial allow an organisation to understand what works, what doesn't work and what cultural changes are needed. You can then make better decisions on what you go for.

Participant S2 similarly articulated:

> Technology site trial is a good example. Through the trial, people see the value of the technology as well as bringing a conversation.

In heavy industries, where technological adoption carries significant implications, methodological implementation assumes heightened importance. Participant S7 advocated for dedicated digitalisation managers to guide technology implementation, while participant O5 referred to their role in ensuring seamless transitions to digital processes:

> Digitalisation manager is essential for methodological implementation.

Further, collaboration and the active engagement of employees are paramount in methodological implementation. Small pilot runs and prototyping are crucial to validating the effectiveness of technology, as noted by M4:

> Businesses should prove the technology's effectiveness via trials before expecting widespread adoption.

In the mining sector, there is a focus on systematically aligning technology with people, emphasising the importance of individuals' perspectives and experiences in successful integration. Conversely, participants from the shipbuilding sector emphasised the need for dedicated digitalisation managers and technology site trials to showcase benefits and foster discussions, reflecting a proactive stance that is possibly influenced by high-level of commitment to innovation wave. In the oil and gas sector, the focus is on ensuring seamless transitions to digital processes, confirming the role of digitalisation managers. This suggests a strategic approach, also possibly influenced by high-level of commitment to innovation wave.

5.5.3 Understanding resistance

Understanding resistance is crucial since it directly affects how individuals perceive and adopt technological changes within their work environments. It encompasses various factors such as resistance, fear mitigation, job security concerns, misconceptions and privacy. A total of 19 participants commented on the importance of understanding resistance. They recognised that resistance, often stemming from fear, job security concerns or misconceptions, could be significant roadblocks to seizing an opportunity.

This analysis investigated the complex aspects of social foundations, featuring in-depth data from experts in three separate industries. Two attributes emerged from the thematic analysis: resistance and fear, and policy and process for privacy concerns, as seen in Figure 31.

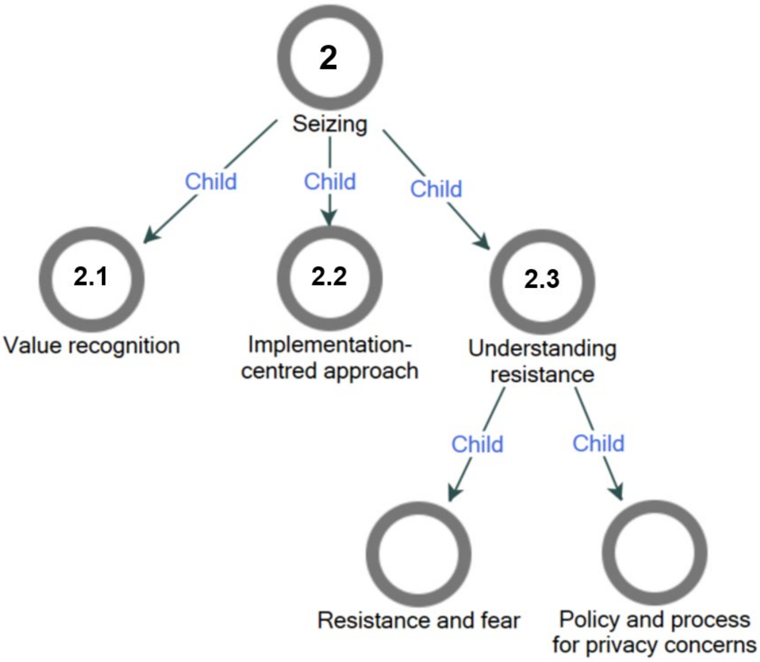

Figure 31: Understanding resistance

5.5.3.1 Resistance and Fear

Participants acknowledged that resistance to technological change often stems from fear, job security concerns and a focus on short-term inconveniences. Participants S6 and S9 both emphasised that understanding resistance is crucial for successfully seizing new opportunities, suggesting a focus on skill transformation rather than job replacement by stating:

> Resistance often stems from the fear that technology will replace their jobs or make their tasks more challenging although there is an opportunity to transform their skills. (S5)

> Fear is a pervasive barrier to innovation in heavy industry. It’s the fear of not knowing, the fear of losing control, and the fear of technology itself. (S9)

Participant M5 noted that overcoming fear necessitated a cultural shift where organisations promote an environment that encourages learning, experimentation and risk-taking. It is about fostering a culture that embraces technology as an opportunity rather than a threat and helps employees develop the confidence to adapt to new technological advancements.

There was a significant concern voiced about the fear of technology within the heavy industry. This fear was attributed to the lack of understanding and familiarity with new technologies. As a result, organisations often opt for technologies they are comfortable with, rather than embracing innovations that could potentially deliver greater value. This was demonstrated by M5 who stated:

> I’ve observed is that companies in heavy industry tend to be led by technologies they are comfortable with, even if it's not the best technology for the job ... Instead of leading with a value-driven approach, they tend to choose technologies they understand ...

Participants S9 and M7 both highlighted that it is important to understand the value gained from new technologies by asserting:

> Automation can remove low-value, repetitive tasks from workers, allowing them to focus on more complex and intricate work. (S9)
>
> Replacing humans with machines isn’t about eliminating jobs but enhancing them. It’s about shifting human labour from repetitive tasks to more strategic and creative roles. (M7)

The introduction of technology faces resistance and cultural challenges in heavy industries. Resistance to new technology may lead to a lack of buy-in from an experienced workforce, since there is often a fear of the unknown. This was illustrated by M5 who stated:

> Cameras were introduced for safety purposes, but they were viewed as an intrusion on privacy rather than a safety measure, leading to a quarter-million-dollar technology being discarded.

This illustrated the struggle involved in implementing technology in an environment that is resistant to change, even when the change brings about substantial safety and efficiency improvements.

The fear of falling behind is a powerful motivating force that encourages organisations to embrace new technologies, as articulated by S5:

> If our organisation doesn’t embrace new technologies and modern practices, we risk being left behind by competitors who are more agile and adaptable.

This underscores the notion that embracing change has evolved from being a choice to becoming a necessity for survival in the evolving business landscape. Such a perspective highlights the competitive pressure that drives innovation waves within the heavy industry.

In terms of the responses to resistance and fear surrounding technological change, notable differences emerged between the sectors. Participants from the shipbuilding sector, predominantly senior engineers with high-level of commitment to innovation waves, emphasised the importance of skill transformation over job replacement and stressed the need to address the fears associated with innovation. They highlighted the potential for technology to enhance productivity and safety within their sector. In contrast, mining participants, comprising a mix of managers and senior engineers with a mid-level of commitment to innovation waves, recognised resistance and fear as barriers to technological adoption. However, they placed greater emphasis on fostering a cultural shift towards embracing technology and acknowledged the benefits of automation in improving job roles. Despite these differences, both sectors share concerns about the fear of falling behind competitors, indicating a common understanding of the competitive landscape and the imperative of innovation waves.

5.5.3.2 Policy and Process for Privacy Concerns

There were concerns regarding individual privacy and the transparent handling of data. Participant O1 expounded on this by stating:

> People immediately raise various concerns in recent media about the use of facial recognition in retail shopping centres have been using the facial recognition for tracking customers. What they're actually attempting to do is identify people that are stealing. However, people say this is terrible that they're now stealing my personal information.

Although technologies such as facial recognition harbour considerable potential, employees must have the utmost confidence that such tools are deployed strictly for well-defined purposes, within boundaries and governed by rules. An instance of this application lies in utilising facial recognition within the heavy industry to quantify personnel congregating at the tool crib. A controlled and secure system can facilitate waste identification for process enhancement. This was elaborated on by S3:

> We could actually figure out how long people spend waiting to get equipment without identified personal information. We just need the software to say that six people were here and we can add up the number of hours work hours that are being lost people waiting to get equipment.

Participants emphasised the importance of addressing privacy concerns when implementing new technologies. Privacy impact assessments, clear policies and processes were highlighted as essential tools used to ensure compliance and instil confidence among employees. Participant S7 noted the requirement for addressing the privacy challenges associated with AI and big data. This suggests that organisations must prioritise data protection and ethical considerations to gain employee trust and maximise the benefits of technology. This was echoed by both S7 and S9:

> Clear policies and processes in technology implementation, especially in addressing concerns about data collection, privacy, and ethical considerations. (S7)

> The importance of strict boundaries, transparency, and legal frameworks when implementing technologies including facial recognition to protect individuals' data and privacy. (S9)

The formulation and enactment of implementation policies and processes was said to be necessary for mitigating the potential for people to misunderstand and misuse emerging technologies. Businesses should establish protocols and frameworks to set limits and identify deviations from the intended course. This was demonstrated by S3 who explained:

> Businesses need to have process and policy around putting boundaries on things to flag when things are starting to go off the rails.

Participant S1 stated that implementation policies and processes must affirm that the business never links personal data, along with the requisite worker awareness. This, in turn, cultivates employee confidence in the incapacity of technology to engage in people tracking. O1 emphasised that, although Industry 4.0 wields substantial transformative potential, a measured approach was imperative regarding its implementation and the delegation of authority over it. This approach safeguards against scenarios in which the technology can be wielded malevolently, resulting in harm to individuals.

Clear communication of the intended purpose of the technology fosters understanding among employees. Participant O6 provided an example of initial resistance to radio frequency identification technology owing to privacy concerns. Clear communication, allowing employees to ask questions and setting specific boundaries were recommended as strategies to ensure responsible technology use. Participant O2 supported this by stating:

> The data collection mechanism of facial recognition should be clearly communicated with all the people involved.

Moreover, these policies and processes must accentuate the technology's value proposition to employees, delineating how it augments their wellbeing, as articulated by O3:

> I think it is critical to show that what they are trying to do is to improve employees' health, make sure they go home every night with no injury. It's important to convince them that they're not trying to monitor them closely, micromanage them.

Shipbuilding participants consistently stated the importance of clear policies and processes, coupled with transparent communication and ethical considerations, to effectively address privacy concerns. This sector's high-level of commitment to innovation waves, along with its focus on technical expertise among senior engineers, revealed a proactive stance towards responsible technology use. In contrast, participants from the oil and gas sector display a more varied response, reflective of the sector's low to mid-level commitment to innovation waves and diverse organisational roles. Although some participants emphasised the need for strict boundaries and transparency in addressing privacy concerns, others stressed the importance of clear communication and demonstrating the technology's value proposition to employees. No participants from the mining sector explicitly prioritised policy and process for privacy concerns, suggesting a potential gap in addressing this aspect of technological adoption within the sector. These differences reveal the varying levels of readiness and approaches to responsible technology use across heavy industries, highlighting that tailored strategies are required to effectively address privacy concerns and ensure ethical technological adoption.

5.6 Reconfiguring

Reconfiguring capabilities involves the ongoing renewal and transformation of organisational routines to ensure sustained profitable growth in evolving markets and technologies. This process encompasses aligning current resources with new strategies, creating new resources and addressing any deficiencies in the resource base. Four capabilities were identified as part of the reconfiguring dimension during thematic analysis: continuous integration, leadership and communication, cultural transformation and skill transformation, as shown in Figure 32.

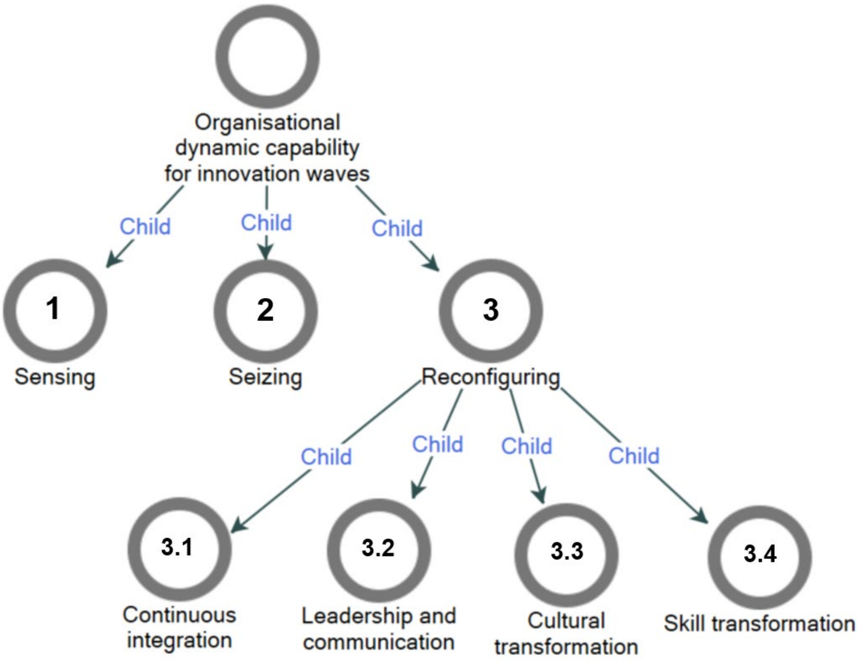

Figure 32: Reconfiguring capability

The subsequent sections provide an analysis of the three organisational dynamic capabilities (reconfiguring): continuous integration in Section 5.6.1, leadership and communication in Section 5.6.2, cultural transformation in Section 5.6.3 and skill transformation in Section 5.6.4.

5.6.1 Continuous integration

Continuous integration refers to the seamless incorporation of new technologies into existing systems, fostering adaptability and innovation. This process is intricately connected to reconfiguring capability, as it involves the dynamic reshaping of organisational structures and processes. Continuous integration emerged as a common denominator emphasised by 14 participants across all three sectors. A total of 11 participants mentioned ‘integration’ and 7 referred to ‘customisation’.

The analysis explored the various dimensions of continuous integration, shedding light on detailed data from professionals. The thematic analysis recognised three key attributes: customisation, in-house capabilities and gradual integration, as depicted in Figure 33.

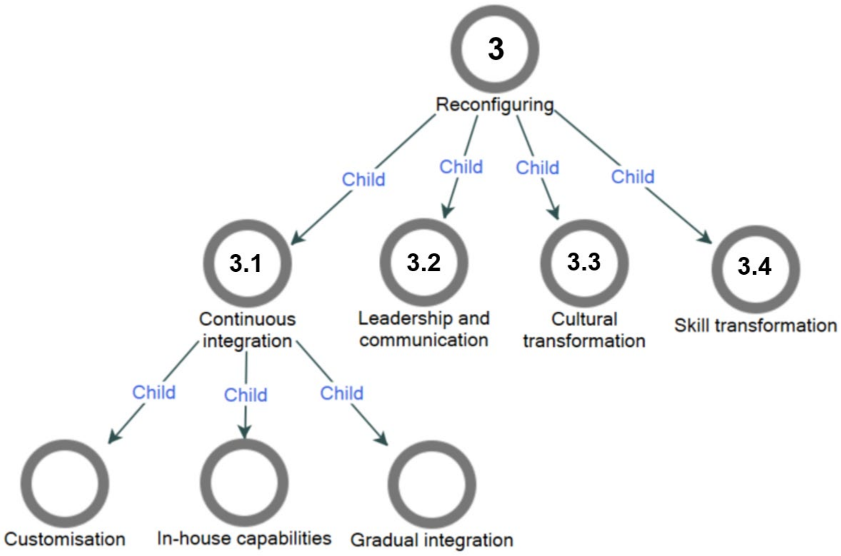

Figure 33: Continuous integration

5.6.1.1 Customisation

Customisation was emphasised as a means to align technology with unique business processes. Participant S1 underscored the uniqueness by stating:

> Every business has unique styles, environments and processes, which require tailored approaches.

The implementation of technology in the heavy industry should not be a one-size-fits-all approach. Continuous customisation by actively involving those who are affected is crucial for successful integration, as noted by M5:

> One of the fundamental challenges is the lack of customisation and the insufficient involvement of end users. It's not just about adopting technology; it's about ensuring it aligns continuously with the specific needs and processes of the organisation. We must actively engage those who will be impacted by the technology because their insights and experiences are invaluable in fine-tuning the technology to make it seamlessly fit into the existing processes.

The age of companies in heavy industries can significantly influence technology customisation, owing to legacy systems and equipment. Older companies tend to have legacy systems and equipment that were not designed for easy integration. In mining, for example, you may have assets with old systems that were built decades ago. This legacy factor adds significant complexity. This was supported by M6 who explained:

> In the heavy industries, numerous data sources are still paper based. You have legacy equipment, machinery, and processes and this diversity makes data integration complex.

When technologies require extensive customisation with other systems or introduce complexity, they face resistance. Industries prefer technologies that simplify their operations. Participant M7 asserted:

> One of the biggest challenges is integrating new machines with legacy systems. It's a complex process, and it's often underestimated.

Autonomous technologies are preferred as they require fewer people to be involved and less customisation since technologies require seamless integration and substantial human effort to be maintained, as noted by M7:

> If technology can stand on its own, it has a better chance of getting adopted. If technologies require a lot of integrations, that's a problem.

The customisation of various systems, such as IoT and networking, and multidisciplinary skill requirements make the transformation a complex endeavour, as articulated by M8:

> There is a lot of smaller parts that take actually a big skill set to get that through... it does come with a lot of layers.

This complexity underscores the importance of having a diverse and adaptable workforce capable of navigating these technological challenges.

Shipbuilding participants, exemplified by a senior engineer with a low-level of commitment to innovation waves, emphasised that there is a need for customisation to align technology with unique business processes. The sector's low-level of commitment to innovation waves may have hindered the effective implementation of customised solutions. In contrast, mining sector participants, characterised by a mix of mid to high-level of commitment to innovation waves and primarily falling within a younger age range (20–59 years), stressed the importance of customisation, particularly because of legacy systems and equipment. Notably, oil and gas sector participants did not provide insights on customisation, indicating a potential disparity in understanding or addressing this aspect of technology integration. These disparities reveal the need for strategies that are tailored to tackle technology integration challenges successfully, considering sector-specific contexts and organisational characteristics.

5.6.1.2 In-house Capabilities

In-house capabilities play a crucial role in driving continuous integration as part of reconfiguring capability required for innovation waves. This involves leveraging dedicated R&D efforts and fostering collaboration both internally and externally.

A dedicated R&D department is instrumental in overcoming the challenges associated with technology integration. Ongoing research and technology development are essential components of innovation waves. Having a dedicated team allows organisations to focus on exploring new technologies, experimenting with innovative solutions and adapting them to suit the organisation's unique needs. This was demonstrated by S5 who stated:

> Having a dedicated R&D department has been instrumental because R&D has the time and expertise to focus on research and tech development.

Moreover, S7 observed that collaboration with contractors who possess industry-specific knowledge is crucial for successful technology integration. These collaborations enable organisations to tap into external expertise while ensuring that the solutions developed align closely with the objectives and requirements of the business.

Additionally, strategic choices regarding suppliers versus in-house capabilities play a significant part in shaping an organisation's approach to technology adoption. Participant M3 provided insights into the diverse strategies adopted by mining companies:

> Industry giants invest heavily in specific suppliers, while others focus on in-house capabilities.

This choice reflects how important it is to modify the approach to suit the organisation's specific needs and goals. By nurturing in-house capabilities and fostering collaboration with external partners, organisations can effectively navigate the complexities of continuous integration and improvement. This strategic approach ensures that organisations remain agile and responsive to emerging technologies and evolving market dynamics, thereby enhancing their competitiveness and long-term sustainability.

Shipbuilding participants, characterised by a high-level of commitment to innovation waves, prioritised dedicated R&D efforts and collaboration, internally and externally. This proactive stance likely stems from the sector's recognition of the need for continuous innovation to stay competitive. Conversely, the mining sector participants, with a lower level of commitment to innovation waves, exhibited a more varied approach that was shaped by factors such as resource availability and strategic priorities. The insights from these participants highlight the sector's struggle with strategic choices, reflecting the complexity of technological adoption within the mining industry. Notably, the absence of perspectives from the oil and gas sector leaves room for speculation. Nonetheless, the observed differences show that customised strategies are required to navigate innovation waves effectively, acknowledging sector-specific contexts and organisational characteristics.

5.6.1.3 Gradual Integration

The interviews revealed the significance of adopting an incremental and structured approach to implementing new technologies, particularly in industries with existing legacy systems. Participant M3 emphasised that this approach involved trials, education and gradual process improvements, recognising that organisations need to navigate the complexities of coexisting legacy systems and new technologies through planning and phased implementation.

Infrastructure and organisational readiness emerged as critical factors influencing the success of gradual integration efforts. Participant S6 emphasised the importance of organisational readiness by stating:

> It's not the hardware that's going to be the problem. It's whether the business is ready to do it and be able to support it.

This suggests that a well-prepared technological foundation, including both infrastructure and organisational processes, is essential for successful technology adoption. Participant S3 highlighted the part played by infrastructure support in accelerating technology implementation, noting that newer and more advanced infrastructure plays a key role in this process:

> We look to what's happening in the UK and in Canada. Australia will lead the UK, purely because of the newly built infrastructure. Whereas to retrofit into an older shipyard is a much greater task.

Participant S3 also emphasised the need to view innovation waves as continuous process rather than a one-time project. M3 supported this by stating:

> Innovation waves in mining should be viewed as an ongoing journey.

Participant M3 also highlighted the importance of maturity in coping with setbacks and adapting to the evolving technological landscape. This perspective reveals the need for organisations to continuously monitor and adapt to changes in technology, and for industry dynamics to remain competitive and resilient.

Shipbuilding participants, in managerial roles and boasting a high-level of commitment to innovation waves, advocated for an approach that features organisational readiness and advanced infrastructure. Their insights reflect a proactive stance towards technology adoption, leveraging existing digital capabilities to navigate complexities successfully. Conversely, the mining sector participants, characterised by a lower level of commitment to innovation waves and extensive managerial experience, underscored the importance of planning and phased implementation to accommodate legacy systems. This cautious approach likely stems from the sector's limited digital maturity and the complexities inherent in coexisting with outdated infrastructure.

5.6.2 Leadership and communication

Leadership and communication encompass the interrelated practices of guiding and influencing others towards common goals while effectively conveying information, ideas and expectations. Leadership and communication stand as pillars supporting reconfiguring capability. This aspect emerged as a common denominator across the three sectors, with 16 participants emphasising its importance. This commonality shows how crucial this capability is in reconfiguring an organisation for innovation waves. Among the participants, 16 mentioned 'leadership' and 15 emphasised 'communication', indicating a strong consensus regarding their significance. Leadership and communication lay the groundwork for reconfiguring capability, enabling organisations to seize opportunities, drive change and thrive in the digital era.

The analysis delved into the intricate aspects of leadership and communication, showcasing in-depth data from practitioners in the three varied sectors. Two attributes were pinpointed in the thematic analysis: diverse leadership, and transparent and effective communication, as demonstrated in Figure 34.

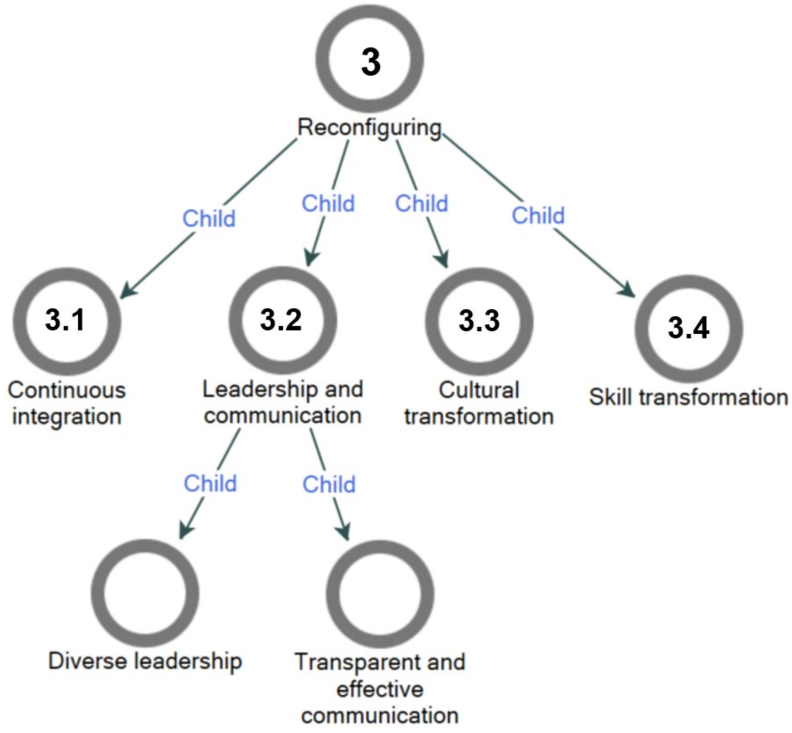

Figure 34: Leadership and communication

5.6.2.1 Diverse Leadership

Leadership styles play a vital role in shaping organisational culture and driving innovation waves initiatives. Although traditional management approaches have their merits, the evolving nature of innovation waves calls for more dynamic and adaptable leadership styles. Diverse leadership goes beyond merely implementing technology to involve creating an environment where people can communicate how technology can improve work processes and enhance efficiency for employees, as noted by S5:

> It's about creating an environment where everyone understands the value of technology and how it can make their jobs easier and more efficient.

Participant O2 highlighted the necessity for agile leadership:

> Agile leadership can be highly effective in managing projects, especially in the software domain.

Agile leaders prioritise adaptability and flexibility, allowing for rapid iterations and adjustments based on feedback. In the context of reconfiguring capabilities, agile leadership enables organisations to respond quickly to changing technological landscapes and market demands. By fostering a culture of continuous improvement and experimentation, agile leaders empower teams to innovate and drive meaningful change.

Participant S5 stressed the need for an environment where everyone understands the value of technology. This aligns with the concept of transformational leadership, where leaders inspire and motivate employees to embrace change. Participant M7 emphasised that the leadership style of the Chief Information Officer (CIO) or Chief Technology Officer is crucial in determining an organisation’s leadership with regards to technological adoption. Transactional CIOs may hinder technology adoption, while transformational leaders drive innovation and technology integration. This was demonstrated by M7 who asserted:

> Some CIOs are very transactional, whereas some are very transformational ... We need a transformational leader to drive technology adoptions.

Participant O5 observed that visionary leadership is important in driving innovation waves initiatives. Visionary leaders have the ability to see the long-term benefits of technology and articulate this vision to their teams. Further, they ensure that technology initiatives align with the broader organisational goals, ensuring that technology investments serve strategic objectives, as noted by O5:

> Visionary leadership is pivotal in fostering an understanding of the significance of innovation waves and its alignment with organisational goals.

The nature of leadership styles is evolving. This aligns with the dynamic nature of innovation waves, where traditional management approaches may not suffice. A visionary leadership style is crucial in fostering an environment where employees are open to adopting new technologies. This was supported M4 who asserted:

> Leaders need to actively engage with their teams, lead by example, and instil a culture of change.

Diverse leadership is essential for driving innovation waves initiatives and reconfiguring organisational capabilities. Agile, transformational, visionary and engaging leadership styles each play a distinct, yet complementary, role in fostering innovation, driving change and ensuring alignment with strategic objectives. By embracing diverse leadership approaches, organisations can navigate the challenges of innovation waves, and emerge stronger and more competitive.

The shipbuilding sector participants prioritised fostering an environment where the value of technology is comprehended and embraced by all employees. This transformational leadership style aligns with the sector's need for innovation and efficiency enhancement, reflecting a proactive stance towards change adoption. Conversely, the oil and gas sector participants noted the importance of visionary leadership in aligning digital initiatives with strategic goals. This approach emphasises long-term benefits and organisational alignment, reflecting the sector's focus on sustainable technological integration to enhance operational efficiency and competitiveness. Additionally, participants from the mining sector stated the importance of transformational leadership in driving technology adoption. Some CIOs are labelled as transactional, while others are deemed transformational, highlighting the need for leaders who inspire innovation and change. These differences underscore the need for tailored leaderships, considering sector-specific contexts and organisational characteristics, to effectively navigate the complexities of innovation waves.

5.6.2.2 Transparent and Effective Communication

Participant S1 underscored the importance of transparent and effective communication as a key driver in enhancing employees' comprehension of the significance of transformation. Participant S3 emphasised that transparency bolsters employees' perception of the changes as beneficial not only to their job security, but also to the organisation, and even the country at large.

Effective communication was observed to be pivotal in helping individuals within the organisation grasp the broader context of innovation waves. The emphasis on open communication throughout the process underscored how vital transparency is in the change management process. This was confirmed by M4 who stated:

> Effective communication is essential for successful transformation for innovation waves, helping employees appreciate the bigger picture and the need for change.

The interviews revealed the integral role of effective communication in navigating the complexities of innovation waves. Communication transcends conveying information, and it serves as a mechanism to prepare employees for impending changes. A tailored and strategic approach to effective communication is essential in recognising the varying degrees of discomfort and apprehension across different organisational tiers. For instance, as highlighted by S3, the negotiations between employees and an organisation for an enterprise bargaining agreement may become incredibly fraught because of resistance from employees. Even if the transformation makes a job better, safer and easier, the benefits can almost become irrelevant if employees feel mistreated and insecure. Therefore, transparent and effective communication with employees was determined to be critical. This was noted by S3:

> I do see the potential for the implementation, but I'm not sure that the business quite appreciates the potential users when we start making radical changes to people's work lives. The level of discomfort needs to be managed by meeting people.

A single message or communication may not resonate with the different levels of an organisation and individuals. The consideration of psychosocial aspects, including human capital development, training and the narrative of the transformation journey, emerged as central features of effective communication. This underscores the imperative for a comprehensive and inclusive communication strategy that addresses employees' multifaceted needs, as explained by O4:

> Management should change to consider human capital development, training and sharing the story of transformation journey.

Convincing employees about the value of new technology is challenging, which confirms the importance of change management and communication strategies. Leaders and managers need to ensure that employees understand not only how technology works, but also how it benefits their day-to-day work and contributes to the organisation's success. This was observed by M3:

> Management should ensure that employees understand how technology enhances their work rather than overwhelming them with its complexities.

Continuous communication is essential for project success. This communication extends to internal teams as well as external stakeholders, including end users. Keeping all parties informed and engaged is critical for achieving project objectives and ensuring that technology solutions align with user needs, as commented on by S5:

> Continuous communication with stakeholders, including end-users, is crucial.

Participants from the shipbuilding and mining sectors prioritised open dialogue and transparency, observing that they are necessary to enhance employee understanding and prepare them for impending changes. Shipbuilding participants emphasised transparent communication to bridge gaps, while the mining sector underscored the role of effective communication in proactive change management. Conversely, the oil and gas sector participants adopted a narrative-driven communication style, focusing on management's role in sharing the journey of innovation waves. This difference likely stems from sector-specific priorities and organisational cultures. Despite these differences, all sectors recognised the importance of continuous communication with internal teams and external stakeholders, indicating a shared understanding of the pivotal role of communication in driving innovation waves.

5.6.3 Cultural transformation

Cultural transformation refers to the intentional and systematic change in the values, beliefs, behaviours and practices of an organisation's culture. It involves reshaping the fundamental aspects of the way in which individuals within an organisation think, act and interact with one another. With regards to organisations striving to reconfigure processes or structures, cultural transformation emerges as a pivotal capability in driving successful transformation with innovation waves, shaping attitudes, behaviours and organisational readiness for change. The concept of cultural transformation resonated strongly with the participants, and this common denominator was acknowledged by 15 participants. The emphasis on cultural transformation (15 participants mentioned 'culture') underlined its significance in driving or impeding innovation waves across various industries.

The provided analysis explored the complex aspects of cultural transformation, illuminating detailed data from practitioners across the three distinct sectors. The thematic analysis identified two attributes: fostering an agile culture and cultivating a cultural shift, as indicated in Figure 35.

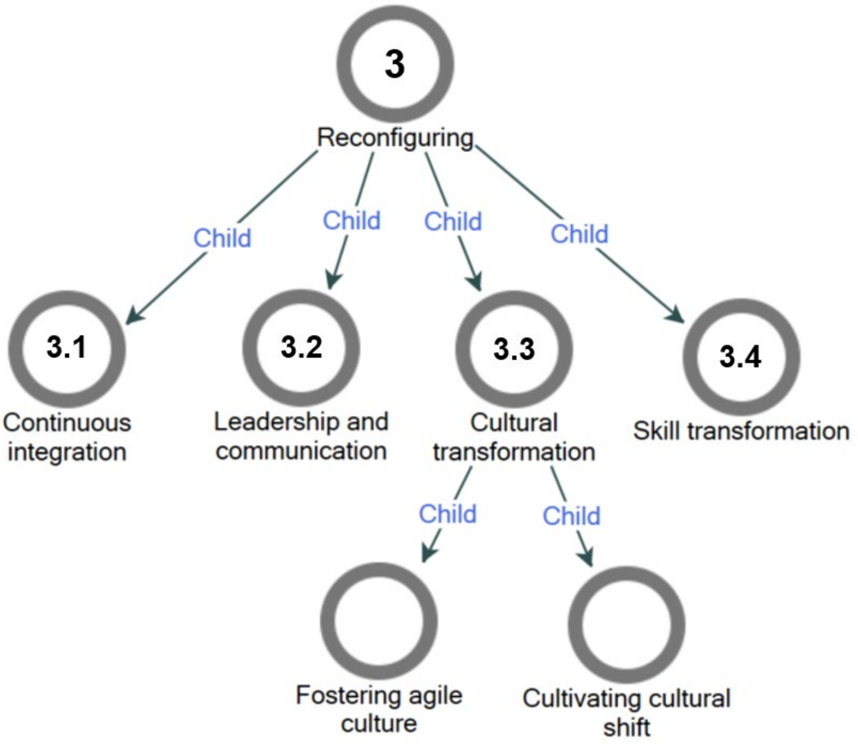

Figure 35: Cultural transformation

5.6.3.1 Fostering Agile Culture

The fostering of an agile culture was not merely a desirable aspect but viewed as an imperative for organisations. This cultural orientation encompasses attributes such as openness, honesty and a willingness to address challenges head-on, as highlighted by O7. As articulated by S5, fostering an environment where individuals feel empowered to voice their concerns and actively engage in problem-solving cultivates a culture conducive to change. Participant O7 further stressed the imperative of instilling a mindset that embraces novel technologies and innovative practices. This cultural ethos, underpinned by effective leadership and communication, serves as a cornerstone for garnering employee buy-in and driving collective efforts towards digital advancement. This sentiment was echoed by M6 who asserted:

> You need a culture that embraces change and new technologies. It starts with effective leadership and communication to help employees understand the purpose and benefits of this transformation.

Although an agile culture is valued in some industries, participant M7 emphasised that heavy industries, at least in Australia, have not yet embraced agile practices. They tend to have functional silos and resist cultural change; therefore, they need to embrace the concept of an agile culture because of the benefits that can be gained in the context of the heavy industry. M7 supported this by stating:

> An agile culture promotes flexibility and adaptability. It encourages experimentation, rapid learning and a willingness to pivot when needed so we need to adopt this culture.

Participant M1 elucidated that an agile cultural framework, rooted in the capability to embrace change, lays the foundation for the seamless integration of transformative technologies. Conversely, S3 issued a cautionary note, warning of the perils of neglecting cultural agility in the face of technological advancement. Industry 4.0 paradigms with agile principles confirm the need to foster an organisational ethos that is characterised by flexibility, rapid iteration and the relentless pursuit of improvement. Participant S3 observed:

> If we don't have the appropriate culture of the people with access to this power, the potential for it to go very wrong is enormous.

An agile culture promotes adaptability, enabling organisations to swiftly respond to market shifts and technological advancements, thus facilitating the reconfiguration of capabilities to meet evolving demands. Participant O5 emphasised:

> The agile approach is seen as crucial in a dynamic environment where interconnected activities require continuous adjustments.

By fostering an environment that is conducive to experimentation and rapid learning, an agile culture encourages innovation. Participant M7 commented that an agile culture is crucial in reconfiguring capabilities to stay competitive and relevant in dynamic markets.

An agile culture promotes collaboration and cross-functional teamwork, which are essential for effective capability reconfiguration. Breaking down silos and fostering collaboration enables organisations to leverage diverse perspectives and expertise to drive meaningful change. Participant S7 highlighted:

> We're seeing some appetite for change, even from senior leadership, but ensuring the entire workforce can scale up to this new way of working safely and reliably is a complex endeavour.

Participants from the oil and gas sector spoke of agility being necessary to adapt quickly to changes and maintain competitiveness. This sector's focus on innovation and flexibility may be influenced by its commitment level to innovation waves (mid to high), where high integration of technology necessitates agile practices to leverage emerging opportunities effectively. Conversely, the mining sector faces unique challenges owing to its traditional organisational structures and resistance to cultural change. This sector tends to have functional silos and a hierarchical management approach, making the seamless adoption of agile practices challenging. The mining industry's slower pace of innovation waves and entrenched operational processes contribute to its cautious approach towards cultural agility. In contrast, participants from the shipbuilding sector acknowledged the importance of cultural agility in embracing technological advancements. However, they also recognised the potential risks of neglecting cultural transformation amid Industry 4.0 paradigms. These differences in approaches to fostering agile cultures between sectors reflect the interplay of organisational factors, leadership styles and industry-specific challenges, and highlight the need for customised strategies to promote cultural agility.

5.6.3.2 Cultivating Cultural Shift

Cultivating a cultural shift towards openness, honesty and a willingness to embrace change was seen to be paramount for successful innovation waves endeavours. This shift, emphasised by S6, required effective leadership and top-down support to ensure that employees understand the purpose and benefits of transformational initiatives. In heavy industries where conservatism often prevails, as highlighted by M7, transforming organisational culture becomes even more critical for adapting to changing environments.

A cultural shift that embraced change was said to be essential for mitigating resistance and facilitating smoother transitions during capability reconfiguration. Participant M3 acknowledged the challenges that large organisations face when it comes to embracing technological change. The larger size of such entities can create resistance owing to entrenched processes and infrastructures, as noted by S5:

> Large organisations tend to be more resistant to change.

When employees are motivated and supported in their efforts to adapt to new technologies, organisations can navigate transitions more effectively. This notion was supported by M8 who asserted:

> There is a need for the skill set of the people coming through ... it is important to have a cultural change where people are motivated and willing to take on these new technologies.

Cultivating a culture that values openness and addresses challenges fosters a mindset of continuous improvement. Embracing failure as a part of the learning process promotes innovation and drives the continuous enhancement of capabilities, as observed by M4:

> Making failure an acceptable part of the process, as long as it leads to learning and continuous improvement.

In conservative industries, bridging cultural differences between traditional and agile environments is crucial for capability reconfiguration. Gradually introducing agile practices and fostering a more flexible work culture helps organisations bridge the gap and adapt to evolving technology landscapes. Recognising and accommodating diverse cultural backgrounds and experiences, as advocated by S6, serves as a basis for tailoring transformational strategies.

Nurturing resilience in individuals is critical for a cultural shift. It is prudent to foster skill development initiatives that indirectly nurture resilience, as articulated by S3:

> It’s difficult to teach resilience into a person, but you can teach them the skills, so they can become more resilient on their own.

Participant M2 emphasised that to gain resilience, an organisation must have a degree of psychological safety. To manage that, an organisation needs to have leaders who have high emotional intelligence. Emotional intelligence is not universally held, so organisations needs to conduct training.

The presence of innovation waves champions within organisations is a vital factor. These champions are not only instrumental, but also indispensable in catalysing broader transformation efforts. Their eagerness to drive change and experiment serves as a driving force for organisational evolution. Participant M4 supported this concept:

> Starting with champions within the organisation who are eager to drive change and experiment. These champions serve as catalysts for broader transformation efforts.

Moreover, S7 noted that these champions play a crucial role in shaping organisational culture by promoting a mindset where failure is viewed as an integral part of the process. By fostering a culture of learning and continuous improvement, they pave the way for innovation and resilience within the organisation.

Even though participants from the shipbuilding and mining sectors recognised the significance of cultural transformation, oil and gas practitioners notably omitted discussions on this aspect. This variance likely stems from sector-specific priorities and organisational cultures, with heavy industries such as mining placing greater importance on cultural adaptation owing to entrenched conservatism. Moreover, the older participants were more immovable in terms of traditional ways of working, highlighting the challenges associated with organisational resistance, whereas the younger participants advocated for agile cultures that are more adaptable to change. Additionally, the level of commitment to innovation waves influences sectoral perspectives, with higher levels correlating with a stronger emphasis on cultural transformation, as seen in the shipbuilding sector.

These factors intersect to shape sector-specific priorities and organisational cultures, leading to differences in the emphasis on cultural shift across sectors.

5.6.4 Skill transformation

Skill transformation refers to the process of evolving and adapting an individual's or an organisation's skill set to meet the changing demands of the workplace or technological advancements. It involves upgrading existing skills, acquiring new ones and sometimes letting go of outdated or less relevant skills. Skill transformation is a linchpin for organisational success, facilitating the adaptation of employees to evolving technologies and methodologies. As organisations strive to reconfigure their processes or structure, skill transformation emerges as a critical component, ensuring the relevance and productivity of the workforce in an ever-changing landscape. A total of 13 participants highlighted the significance of skill transformation. These participants stressed the need for upskilling and reskilling (eight participants mentioned 'upskilling' and seven referred to 'reskilling'), as well as aligning with technological advancements.

The analysis presented here examined the various dimensions of skill transformation, showcasing detailed data from practitioners. The thematic analysis highlighted two notable attributes: reskilling and upskilling, and continuous learning, as depicted in Figure 36.

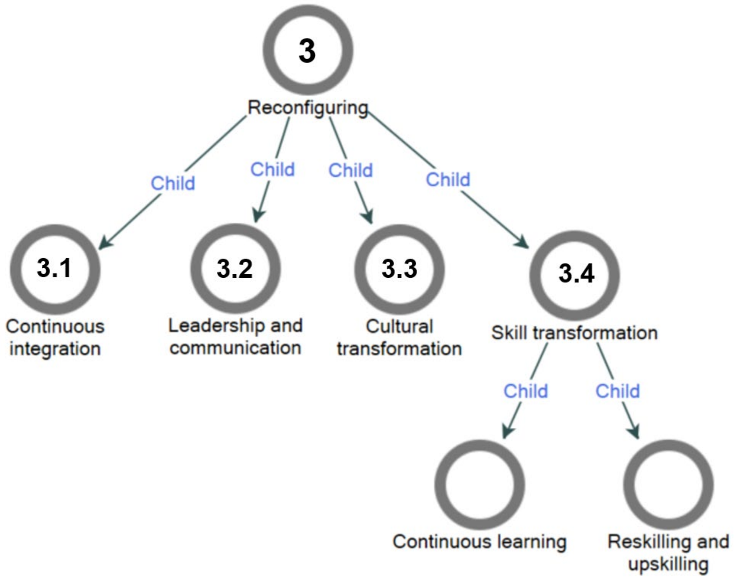

Figure 36: Skill transformation

5.6.4.1 Reskilling and Upskilling

Participants recognised that reskilling and upskilling are necessary to align with technological advancements. Participant O5 emphasised that this involves transitioning employees into roles that complement automation by providing different supports:

> Providing employees with the necessary tools, resources, and training to adapt to the digital environment is fundamental.

The introduction of novel technologies triggers a reassessment of an organisation's skill composition. This prompts a consideration of whether existing competencies align with these new technologies or require enhancement. Participant O3 observed that organisations must consequently evaluate the alignment of current skill sets with the demands of emerging technologies. Participant M1 noted that the adoption of new technologies might lead to a transformation in the skills needed for specific tasks. When technology implementation replaces certain job activities, individuals previously engaged in those tasks may need to transition into different roles. This situation compels organisations to undertake reskilling and upskilling efforts, especially for on-site trade workers. This was illustrated by S2:

> Training and skill are important, and I always think that using robots needs its own trade course. For example, [an] electrician does electrical work, but they won't perform tasks that involve any robotics related work without any robotics training. You should have a trade that knows all different sorts of robots.

The path of reskilling and upskilling may require individuals to acquire new proficiencies previously unfamiliar to them. However, this transformation creates opportunities for employees and is essential for engaging with newly implemented technology. This was confirmed by O3:

> Technology is actually improving your skills, making you more experience for other areas of the business.

Participant S9 remarked that machines lack an understanding of intricacies, such as with welding, so human expertise is needed to complement technological advancements. This approach ensures that technology augments human capabilities rather than replacing them, as stated by S9:

> Workers need to become proficient in operating robotics because machines lack the understanding of welding intricacies.

Participants consistently emphasised the importance of skill transformation. This transformation extends beyond mere upskilling and involves cultivating a diverse skill set that allows individuals to adapt to new technologies and tasks. Participant S5 supported this with the following statement:

> Even in traditionally hands-on fields such as welding, training welders to program robots can lead to superior outcomes.

This underscores the need for a holistic approach to skill development.

Participant M4 commented on the importance of fostering a positive culture around technology and providing adequate training to users. Participant S9 echoed this by asserting:

> Exposing workers to technology and providing them with comprehensive training to eliminate fears associated with automation.

Both participants emphasised that technology should enhance human workers rather than replace them, and that automation can remove low-value, repetitive tasks, allowing employees to focus on higher-value activities.

The oil and gas sector participants focused on transitioning employees into roles that complement automation, emphasising the provision of the necessary tools, resources and training. This aligns with the sector's high-level of commitment to innovation waves, indicating readiness for technological advancements. Similarly, the shipbuilding sector, participants emphasised the importance of reskilling workers to operate alongside technology, highlighting the need for a diverse skill set and training in robotics. The emphasis on enhancing human capabilities alongside technological advancements reflects the sector's high-level of commitment to innovation waves and innovative orientation. In contrast, the mining sector participants observed the need for evaluating current skill sets in light of emerging technologies, especially for on-site trade workers. This suggests a cautious approach, potentially influenced by the sector's slower innovation waves pace and entrenched operational practices.

5.6.4.2 Continuous Learning

Continuous learning is an integral part of the journey of reconfiguring capabilities. The digital divide between generations and age differences was one of the key reasons that continuous learning is required. Participant S7 highlighted its impact on technology implementation by stating:

> The digital divide between generations affects technology implementation.

This confirms the importance of addressing generational differences in technology adoption to enhance organisational readiness for innovation waves. Moreover, S9 provided insights into the limitations of technology, particularly in fields involving intricate tasks such as piping shapes and bends:

> Technology in this field is still 20 to 30 years away from achieving complex tasks

Participant M8 emphasised the need for continuous learning in today's rapidly evolving technological landscape by stating:

> As technology develops, you need a new skill set through continuous learning to stay ahead of the curve.

This shows that employees need to remain adaptable and proficient in leveraging emerging technologies effectively. Continuous training programs and processes are critical to creating an adaptable and proficient environment. This was demonstrated by S3 who underscored the necessity for continuous training:

> Continuous training isn't just about staying up to date It is about building an adaptable and proficient environment. Ongoing training became evident when we realised how quickly we can forget crucial information without it.

This highlights the risk of skill depreciation over time and confirms the need for continuous investment in training programs to ensure workforce proficiency.

Participant S7 advocated for a gradual transition into innovation waves while preserving traditional skills by asserting:

> We can't afford to experiment with the products we're building due to tight timelines and budgets. It's crucial to offer tradespeople a path while maintaining their traditional skills.

This approach balances innovation with the retention of traditional skills, ensuring a smooth evolution without compromising quality or safety standards.

Participant M7 further emphasised the importance of social skills and emotional intelligence in complex work environments by stating:

> People are being priced out of the market ... people with complex contributions are more justified.

This underscores the irreplaceable value of human contributions in decision-making processes, showing that a combination of skills, education and social sophistication are required to navigate the evolving technological landscape.

Continuous learning plays a vital role in driving reconfiguring capabilities required for innovation waves. By fostering a culture of continuous learning and skill development, organisations can empower their workforce to adapt to change, navigate the evolving technological landscape and drive organisational success in the digital age.

Despite all sectors recognising the importance of continuous learning, notable differences emerged in their emphasis and approach. Participants from the shipbuilding sector placed significant value on addressing the digital divide between generations and the need for continuous training to enhance technology adoption and proficiency. This reflects the sector's high-level of commitment to innovation waves and the recognition of technology's impact on traditional skills. Similarly, the mining, and oil and gas sector participants emphasised that continuous learning is required to stay ahead of the technological curve and adapt to rapid advancements. Additionally, while the shipbuilding sector emphasised the need for a gradual transition into innovation waves, the mining sector focused on fostering social skills and emotional intelligence alongside technical proficiency. These differences are influenced by sector-specific priorities, organisational cultures and workforce demographics, reflecting the need for tailored approaches to continuous learning across sectors.

5.7 Summary

This chapter provided a nuanced analysis of the organisational dynamic capabilities crucial for driving innovation waves across three sectors within the Australian heavy industry. The analysis encompassed 10 organisational dynamic capabilities, related to sensing, seizing and reconfiguring, shedding light on the sector-specific nuances and overarching consensus prevalent in these industries.

With regard to sensing, a strategic foundation serves as a cornerstone, guiding organisations' purpose and direction amid technological advancements. Knowledge acquisition and management play a pivotal role in identifying opportunities and fostering innovation, and effective management leadership aligns strategies and fosters an environment conducive to change. Notably, age dynamics significantly influence technology adoption, with each sector demonstrating unique approaches shaped by strategic priorities and workforce demographics.

Seizing capabilities require the recognition and quantification of value while addressing resistance to change. Value recognition, crucial for identifying tangible benefits, varies across sectors, with mining emphasising safety, oil and gas focusing on technology benefits persuasion and shipbuilding prioritising enhanced work experience through technology. Implementation-centred approaches stress resource allocation, aligning technology changes with workforce acceptance and systematic integration methodologies, each sector showcasing unique strategies reflective of their level of commitment to innovation waves and priorities.

Reconfiguring capabilities involves continuous integration, leadership and communication, cultural transformation and skill transformation. Customisation, in-house capabilities and gradual integration are pivotal for seamless technology incorporation, while diverse leadership and transparent communication foster innovation and resilience. Cultural transformation promotes agility and openness, and skill transformation emphasises reskilling and upskilling to adapt to technological advancements.

The analysis underscores the complex interplay of organisational dynamic capabilities across the three sectors within the Australian heavy industry, and highlights that sector-specific challenges and priorities shape approaches to innovation waves. By understanding these dynamics, organisations can develop tailored strategies to effectively drive innovation, adapt to change and thrive in the digital age, ensuring sustainable growth and competitiveness in their respective sectors.

CHAPTER 6: ANALYSIS—RQ2 INTERRELATIONSHIPS AMONG ORGANISATIONAL DYNAMIC CAPABILITIES

6.1 Objective

The objective of Chapter 6 is to address the second research question—*RQ2: How are organisational dynamic capabilities interrelated in the Australian heavy industry?*—focusing on the interrelationships among organisational capabilities within the Australian heavy industry context.

This chapter commences with an overview of the thesis findings regarding interrelationships in Section 6.2. Subsequently, Section 6.3 delves into an analysis of interrelationships with sensing capabilities, followed by Section 6.4, which focuses on interrelationships with seizing capabilities. Finally, Section 6.5 examines the interconnections with reconfiguring capabilities.

6.2 Overview of Interrelationships

The findings from the interview data drawn from 24 Australian heavy industry practitioners identified a total of 25 interrelationships among the 10 distinct organisational dynamic capabilities. Each interrelationship is detailed in the following in Sections 6.3.1 to 6.5.4, and Table 29 illustrates where the interrelationships are discussed. For instance, Section 6.3.1 covers the interrelationships among strategic foundation and knowledge, implementation-centred approach, leadership and communication, and cultural transformation.

Table 29: Matrix of 24 interrelationships[7]

		Sensing			Seizing			Reconfiguring			
		Strategic foundation	**Knowledge**	**Management**	**Value recognition**	**Implementation-centred approach**	**Understanding resistance**	**Continuous integration**	**Leadership and communication**	**Cultural transformation**	**Skill transformation**
Sensing	Strategic foundation		6.3.1		6.4.1	6.3.1		6.5.1	6.3.1	6.3.1	
	Knowledge							6.5.1	6.3.2	6.3.2	6.3.2
	Management								6.3.3	6.3.3	
Seizing	Value recognition						6.4.1		6.5.2	6.4.1	
	Implementation-centred approach						6.4.3	6.4.2	6.4.2	6.4.2	6.5.4
	Understanding resistance		*Redundancy[8]*						6.4.3	6.5.3	
Reconfiguring	Continuous integration										6.5.4
	Leadership and communication									6.5.3	6.5.4
	Cultural transformation										
	Skill transformation										

Note: Each number in the cells indicates the section number where the specific interrelationship is explained in the respective section of this chapter. For example, section 6.3.1 (Strategic Foundation) spans four cells since it explains how strategic foundation relates to knowledge, implementation-centred approach, leadership and communication, and cultural transformation. The table features a central blank space to eliminate duplicate cells. For example, it indicates that there is no interrelationship between knowledge and itself.

Table 29 provides a comprehensive overview of the interrelationships among sensing, seizing and reconfiguring capabilities, but sector-agnostic as sector-specific differences are addressed in depth at the end of each sub-section in Chapter 6. It highlights a notable trend within the core organisational dynamic capabilities—sensing, seizing and reconfiguring. It is evident that reconfiguring capabilities are considerably more interrelated with other capabilities than sensing and seizing, with 17 out of 25 capabilities linked directly to reconfiguring. This observation underscores the intricate nature of the Australian heavy industry, illustrating that, without robust reconfiguring capabilities, the effectiveness of sensing and seizing capabilities is significantly compromised. These findings suggest that reconfiguring capabilities are not only supportive, but also central to

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[7]

[8]

operational effectiveness in a complex industrial environment, where they underpin and enhance the other dynamic capabilities.

Table 29 also shows that a substantial number of capabilities are predominantly interrelated with leadership and communication (8 capabilities), cultural transformation (7 capabilities), strategic foundation (6 capabilities) and implementation-centred approaches (6 capabilities). This pattern reveals the critical importance of leadership, communication and cultural transformation in shaping the strategic and operational landscapes of the Australian heavy industry. The emphasis on leadership and communication suggests that effective management and the clear articulation of goals and strategies are paramount. These capabilities likely reflect the industry’s need to navigate complex regulatory environments and manage diverse stakeholder expectations effectively. Further, the focus on cultural transformation indicates an industry in transition, potentially driven by the need to adapt to technological advancements and global competitive pressures. As Australian heavy industries seek to maintain their competitiveness, transforming organisational culture becomes essential for embracing innovation and change. The significance attributed to strategic foundations and implementation-centred approaches highlights the industry’s approach to operationalising strategy. It suggests that these industries prioritise the formulation of strategic objectives as well as their practical execution, ensuring that strategies are grounded in real-world applications and responsive to dynamic market conditions. These observations may be indicative of the broader economic and regulatory contexts in Australia, where industries are often required to be agile and adaptive in response to both domestic and international pressures. This agility is further necessitated by the need to address environmental concerns, adopt sustainable practices and respond to the rapid pace of technological change.

The following section reports the interrelationship with sensing capabilities.

6.3 Interrelationships of Sensing

In accordance with the prior analysis in Chapter 5, sensing capabilities encompass a strategic foundation, knowledge and management. These capabilities are intricately linked to other seizing and reconfiguring capabilities, as illustrated in Table 30.

Table 30: Interrelationship matrix with sensing capabilities

		Sensing			Seizing			Reconfiguring			
		Strategic foundation	Knowledge	Management	Value recognition	Implementation-centred approach	Understanding resistance	Continuous integration	Leadership and communication	Cultural transformation	Skill transformation
Sensing	6.3.1. Strategic foundation		√			√			√	√	
	6.3.2. Knowledge								√	√	√
	6.3.3. Management								√	√	

Table 30 provides a visual representation of the intricate interrelationships between sensing capabilities and other capabilities, illustrating the respective contributions of various sectors to each interrelationship. The subsequent sections undertake a comprehensive analysis of these findings, delineating sector variances and elucidating nuanced insights. In Section 6.3.1, the analysis delves into the symbiotic relationship between strategic foundation and other organisational capabilities. Similarly, Section 6.3.2 analyses the intricate interconnectivity of knowledge with other capabilities. Further, Section 6.3.3 elucidates the interrelationship between management leadership and cultural transformation, offering detailed insights into their synergistic dynamics.

6.3.1 Strategic Foundation

6.3.1.1 Strategic Foundation and Knowledge (Sensing and Sensing)

The findings showed that the alignment between strategic foundation and knowledge emerges as a pivotal determinant of organisational success in the realm of innovation waves. External factors, such as regulations, market demand, client preferences and government mandates, exert a profound influence on an organisation's strategy for innovation waves. This was illustrated by M7:

> External pressures serve as drivers for change, compelling organisations to embrace digital technologies and adapt their strategies accordingly.

Organisations need to proactively monitor market trends, align their strategies with evolving demands and ensure compliance with changing regulations. A strategy should not only acknowledge these external pressures, but also integrate them into its framework. This was demonstrated by M3 who stated:

> Organisations can refine strategies by leveraging knowledge gained from ongoing monitoring of external trends and market dynamics.

This requires a continuous process of understanding external dynamics, knowledge acquisition and strategic adaptation to navigate uncertainties and disruptions effectively.

Organisational knowledge, encompassing insights derived from internal processes, customer interactions and industry expertise, serves as a valuable asset in shaping strategic decision-making. By harnessing internal knowledge resources, organisations can develop informed strategies that are attuned to both external pressures and internal capabilities. Participant S5 stated:

> Our strategic decisions are informed by our deep understanding of internal processes and external market dynamics.

The interrelationship between strategic foundation and knowledge forms the cornerstone of successful innovation waves initiatives. By aligning strategic decision-making with external influences and organisational knowledge, organisations can navigate complexities and uncertainties with confidence. When organisations embark on an innovation waves journey, leveraging internal knowledge becomes paramount in identifying strategic priorities, allocating resources effectively and mitigating risks. By integrating organisational knowledge into the strategic foundation, organisations can enhance their ability to anticipate and respond to evolving market dynamics.

Although participants from both the shipbuilding and mining sectors recognised the impact of external factors on strategy, those from the shipbuilding sector appeared to take a more proactive and dynamic approach to leveraging internal and external knowledge resources for strategic decision-making, possibly reflecting a higher level of digital readiness and innovation within the sector. No specific responses were provided from the oil and gas sector in this section, limiting insights into their perspective on the interrelationship between strategic foundation and knowledge in innovation waves initiatives. The absence of input from the sector makes it challenging to assess their approach or priorities regarding leveraging knowledge for strategic decision-making. Sharing best practices and insights between sectors, particularly regarding the proactive integration of knowledge into strategic decision-making, could enhance overall readiness for innovation waves. Encouraging cross-sector collaboration and knowledge-sharing platforms may facilitate the exchange of ideas and strategies, ultimately contributing to more cohesive and effective transformation for innovation waves.

6.3.1.2 Strategic Foundation and People-Centred Approach (Sensing and Seizing)

The symbiotic relationship between a strategic foundation and a people-centred approach is critical in driving successful innovation waves initiatives. A well-defined strategy should intricately weave the human element into its fabric, acknowledging that technology implementation is not an end in itself but a means to empower and enhance human capabilities. This was echoed by O3 who remarked:

> Incorporating a people-centred approach into the strategic plan ensures that technology serves as an enabler, rather than a disruptor, of human potential.

By prioritising the human aspect in strategy development, organisations can ensure that technology solutions resonate with users, drive engagement, and foster a culture of innovation and collaboration. This entails understanding user needs, preferences and pain points to tailor technology solutions that enhance productivity, satisfaction and overall wellbeing.

A people-centred approach infuses strategic foundations with purpose and direction, guiding capability development initiatives towards meaningful outcomes. Without consideration of human factors, capability development may lack relevance and fail to drive organisational success, as highlighted by M6:

> A strategy devoid of a people-centred approach is like a ship without a compass drifting aimlessly.

By placing people at the forefront of strategy development, organisations can cultivate a sense of purpose and alignment among employees, fostering a shared vision of innovation waves. This not only enhances employee buy-in and commitment, but also drives innovation, creativity and resilience across the organisation.

A balance between technological advancement and human needs is imperative for sustainable transformation for innovation waves. A strategic foundation serves as a guiding framework for aligning technology investments with human-centric principles, ensuring that technology enhances, rather than supplants, human capabilities, as emphasised by M8:

> Technology should complement, not replace, human ingenuity. A people-centred approach ensures that technology solutions are designed to empower and augment human potential, rather than displace it.

By embracing a people-centred approach in strategy development, organisations can foster a culture of empathy, inclusivity and empowerment. This was noted by M4 who stated:

> People-centric transformation creates an environment where employees feel valued, supported and inspired to embrace innovation waves.

This, in turn, cultivates a resilient and adaptable workforce capable of navigating the complexities of the digital age with confidence and agility. The interrelationship between a strategic foundation and a people-centred approach forms the bedrock of successful transformation for innovation waves. By prioritising human needs and aspirations in strategy development, organisations can harness the transformative power of technology to drive meaningful change and achieve sustainable growth.

The oil and gas sector participants promoted a pragmatic approach, prioritising the seamless integration of human-centric principles into strategic planning. This suggests a focus on operational efficiency and the practical implementation of technology solutions within the sector. In contrast, the mining sector participants articulated a more holistic understanding, emphasising the intrinsic importance of human factors in shaping strategic initiatives. This broader perspective likely arises from the complex and hazardous nature of mining operations, where human considerations are critical for safety and operational success.

6.3.1.3 Strategic Foundation and Resource Alignment (Sensing and Seizing)

The establishment of a robust strategic foundation is closely linked with resource alignment, forming a symbiotic relationship crucial for innovation waves endeavours. Resource alignment, a cornerstone of effective organisational management, faces formidable challenges in the absence of a well-defined strategic foundation. As observed by O7, successful resource allocation hinges on a comprehensive strategic framework. Participant O7 emphasised this synergy by stating:

> Resource allocation should not be limited to technology acquisition but must encompass investments in talent acquisition, development and retention. This can only be achieved if you have a strategic foundation.

Drawing on their expertise and insights, skilled individuals contribute invaluable perspectives to the identification of technological needs, assessments of feasibility and the optimisation of resource allocation strategies. Participant M5 illustrated this by asserting:

> Skilled people not only facilitate the alignment of resources with strategic objectives but bolster the organisational foundation.

Digital technology implementation can be constrained, and a business ultimately cannot achieve its potential if it is not adequately planned and resourced. Participant S3's explanation encapsulates this challenge:

> If the supporting mechanisms resources aren't there, it doesn't reach its potential, or it shines very bright for a short period of time. When you ask about it a year later, everyone will say that it was a nice idea, but this didn't work.

This highlights the importance of considering the broader picture and long-term objectives in innovation waves initiatives, as noted by S3. Hence, a strategic foundation, encompassing long-term objectives, is critical in aligning and acquiring the right resources, ensuring the sustainability and success of innovation waves endeavours. By nurturing a strategic foundation that prioritises resource alignment and leverages the expertise of skilled personnel, organisations can cultivate an environment conducive to innovation and sustainable growth.

Shipbuilding sector participants emphasised operational sustainability, in which the sector's historical volatility necessitates a focus on long-term viability through efficient resource allocation and risk mitigation strategies. Mining, in contrast, values human capital owing to the sector's reliance on skilled labour for optimising operational efficiency and adapting to technological advancements, highlighting a cultural emphasis on workforce development and innovation. Conversely, the oil and gas sector participants prioritised strategic planning and risk management, reflecting the sector's complex regulatory landscape and long investment cycles, in which decisions have significant financial and environmental ramifications. Understanding these nuances is crucial for tailoring the strategies for innovation waves to each sector's specific needs and maximising the success of such initiatives. This requires a deep appreciation of sector-specific challenges, organisational cultures, and the interplay between technological advancements and human capital to drive sustainable growth and competitive advantage.

6.3.1.4 Strategic Foundation, and Leadership and Communication (Sensing and Reconfiguring)

In the journey of innovation waves, the nexus between a strategic foundation, and leadership and communication forms a dynamic and essential framework that shapes organisational success and innovation. Leadership within an organisation plays an important part in shaping the overarching strategy for innovation waves. Importantly, the characteristics and orientation of leaders significantly influence the strategic approach to innovation waves, as articulated by M7:

> Younger leaders and those more open to innovation are more likely to endorse comprehensive strategies that embrace transformation with technologies.

Conversely, a strategic foundation can influence leadership behaviour. When an organisation develops a strategy that prioritises innovation and technology alignment with business objectives, that strategy sends a clear message to employees about the importance of innovation waves. This fosters a culture in which leaders champion transformation efforts and allocate resources accordingly. The synergy between strategy and leadership ensures that transformation initiatives are guided and supported from the top down.

Effective communication acts as a linchpin in translating a strategic vision into actionable steps throughout an organisation. Participants M7 and O5 indicated that transformational and visionary leaders play key roles in shaping these strategies. Tailored communication is essential in conveying these strategies to various organisational tiers. Participant S3 noted:

> Different levels of the organisation require tailored and strategic communication to align their understanding with the overarching transformation goals.

Clear and tailored communication is imperative for gaining buy-in and support for innovation waves initiatives. It involves tailoring messages to different time horizons and priorities within the organisation, ensuring stakeholders grasp the value of technology and its potential impact on achieving strategic goals. This was illustrated by S6:

> The comprehensive strategy might be looking at nine years or 10 years. But that's not enough to communicate, you have to chop it down to five and three and be able to communicate the right piece to the right people.

A strategic foundation encompasses not only the 'what', but also the 'why'. Communication serves as the bridge between these aspects. The strategy should be accompanied by communication approaches that address the unique needs and perspectives of various stakeholders, ensuring alignment with the overall transformation journey. This was noted by M6:

> Developing this strategy must involve stakeholders at various levels, ensuring a balanced approach with input from both top-down and bottom-up perspectives.

Effective communication is a key part of the development and execution of a comprehensive strategy. A well-defined strategy must be communicated throughout an organisation to ensure that all stakeholders understand its purpose, goals and alignment with broader organisational objectives. Without a well-defined strategy, technology adoption may not deliver the desired results. Participant M7 asserted this with the following statement:

> A good strategy aligns digital transformation with the business and communicates the value of transformation ...

Communication does not operate in isolation but is closely tied to leadership, as noted in S3's assertion:

> Leaders must take an active role in conveying the strategy's importance and benefits.

Leaders serve as key communicators who can inspire and motivate employees to embrace innovation waves. Effective communication fosters a shared vision of progress and encourages collaboration among various teams and departments.

Moreover, widespread communication and buy-in from all stakeholders are crucial for successful implementation. Participant S9 highlighted the importance of involving all stakeholders in communication efforts, ensuring that the technology aligns with organisational needs and goals:

> The technology should be fit for purpose, and communication should involve all stakeholders.

The interplay between strategic foundation, leadership and communication forms the centrepiece of successful innovation waves. By fostering alignment between these critical elements, organisations can navigate the complexities of digital disruption with clarity, purpose and resilience.

Although all participants recognised the importance of strategic foundation, leadership and communication in innovation waves, their perspectives varied based on sector-specific challenges, leadership orientation and communication strategies. Participants from the mining, and oil and gas sectors exhibited a strong emphasis on leadership roles and inclusivity in communication, while the shipbuilding sector participants placed particular importance on tailored communication strategies and the alignment between strategic vision and leadership behaviour. These differences reflect the nuanced approaches required to address sector-specific challenges and priorities.

6.3.1.5 Strategic Foundation and Cultural Transformation (Sensing and Reconfiguring)

In the pursuit of innovation waves, the synergy between strategic foundation and organisational culture emerges as the key to success. The findings underscored the pivotal role of long-term goals and vision in cultivating a culture of innovation and adaptability. By providing a clear sense of purpose and direction, organisations can effectively navigate the complexities of digital disruption and seize new opportunities. This was confirmed by O3:

> Our long-term vision serves as a catalyst for innovation. It encourages us to push boundaries, experiment with new ideas, and stay ahead of the curve in a rapidly evolving digital landscape.

This perspective stressed the importance of aligning strategic initiatives with a broader organisational vision, fostering a culture that values creativity, experimentation and risk-taking. Such a culture empowers employees to embrace change, challenge the status quo and drive continuous improvement.

As an ongoing journey, innovation waves demand continuous learning, evolution, and the refinement of strategies and approaches. This necessitates a culture that values flexibility, experimentation and rapid iteration. Participant M3 demonstrated this by asserting:

> Digital transformation is not a finite project; instead, it should be viewed as an ongoing journey of evolution and adaptation.

Organisations that embrace this mindset are better equipped to respond effectively to market dynamics, technological advancements and shifting customer preferences. In an ever-changing technological landscape, organisations must cultivate a culture of learning and adoption. Such a culture needs to be shaped at all levels of the organisation. It requires fostering an environment where employees feel empowered to experiment, fail fast and learn from their experiences. As noted by M3:

> The industry must mature in handling setbacks and adapt to the evolving technological landscape.

This perspective reveals how important organisational resilience and agility are in navigating transformation challenges for innovation waves. Encouraging a culture that values curiosity, collaboration and continuous improvement enables organisations to thrive amid uncertainty and disruption.

Finally, participants highlighted how long-term goals and vision enhance organisational resilience, enabling organisations to navigate uncertainties and disruptions with confidence. By anchoring innovation waves efforts within a broader strategic framework, organisations build resilience and adaptability, positioning themselves for sustained success, as summarised by S5:

> Our long-term vision isn’t just a roadmap; it’s our anchor in turbulent waters. It keeps us focused, resilient, and prepared to overcome whatever challenges lie ahead.

By aligning long-term goals and vision with organisational culture, organisations can foster a dynamic environment of innovation, adaptability and resilience. Embracing innovation waves as an ongoing journey necessitates a culture that values learning, experimentation and rapid iteration.

The oil and gas sector participants highlighted how a clear, long-term vision acts as a catalyst for innovation, encouraging experimentation and staying ahead in a rapidly evolving digital landscape. Similarly, the mining sector participants emphasised the need to view innovation waves as an continuous journey of evolution and adaptation, fostering a culture that values resilience amid setbacks and technological shifts. Participants in the shipbuilding sector commented on the role of long-term goals and vision as anchors in turbulent waters, keeping organisations focused, resilient and prepared for future challenges. These insights highlight the sector-specific nuances in approaching innovation waves, demonstrating the importance of aligning strategic initiatives with organisational culture to drive sustained success in the face of technological disruption.

6.3.2 Knowledge

6.3.2.1 Knowledge and Leadership (Sensing and Reconfiguring)

In the sphere of innovation waves, knowledge and leadership intertwine to shape organisational capabilities. Leaders who are well informed and continuously seek new insights can make more informed decisions and drive strategic change. As M7 noted:

> Leadership effectiveness is closely tied to the depth and breadth of knowledge possessed by leaders. In today's rapidly evolving digital landscape, leaders must stay abreast of emerging trends, technological advancements, and market shifts to navigate complexities and drive organisational growth.

By leveraging knowledge from diverse sources, including industry research, data analytics and employee insights, leaders can gain a deeper understanding of organisational challenges and opportunities. This knowledge empowers leaders to develop innovative strategies, inspire confidence and lead their teams towards achieving strategic objectives in the digital age.

Effective leadership fosters a culture of continuous learning and development, encouraging employees to expand their knowledge and skills. Leaders who prioritise learning create an environment where curiosity is celebrated, experimentation is encouraged and intellectual growth is valued, as highlighted by O3:

> Leadership is about creating opportunities for individuals to grow and develop. By investing in employee education and skill development, leaders can cultivate a highly skilled workforce that is equipped to tackle challenges and seize opportunities in the digital era.

The commitment of leadership to learning sets the tone for the organisation, inspiring employees to embrace lifelong learning and pursue professional development opportunities. By fostering a culture of learning, leaders can nurture talent, drive innovation and position the organisation for long-term success in a rapidly changing digital landscape. Leadership is not just about making decisions; it is about leading by example and inspiring others to follow suit. Leaders who demonstrate a commitment to knowledge acquisition and personal growth set a powerful example for their teams, as observed by S8:

> Leadership is about modelling the behaviour you want to see in others. When leaders prioritise learning, curiosity and intellectual growth, they inspire their teams to do the same.

By demonstrating a thirst for knowledge, leaders create a culture where continuous learning is celebrated and curiosity is encouraged. This not only drives individual growth, but also fosters a collaborative environment where knowledge sharing and innovation thrive. By empowering leadership through knowledge, fostering a culture of learning and development, and leading by example, organisations can build a resilient workforce, drive innovation and stay ahead of the curve in an ever-evolving digital landscape.

In the oil and gas sector, there is a notable emphasis on talent management and skill development, underscoring the sector's recognition of the critical role of human capital in driving innovation waves initiatives. This likely reflects a sector-wide focus on cultivating a highly skilled workforce to address evolving industry demands. Conversely, the mining sector prioritises leadership adaptability and strategic decision-making in response to emerging trends and market shifts. In contrast, the shipbuilding sector places a strong emphasis on fostering a culture of continuous learning and development, reflecting a commitment to innovation and intellectual growth. This indicates a sector-wide recognition of the importance of leadership in inspiring a culture of curiosity, experimentation and adaptation to drive innovation waves efforts forward. Although there is a shared acknowledgment of the critical interplay between knowledge and leadership in innovation waves across sectors, the nuanced differences in emphasis and perspective highlight the need for tailored approaches to leadership and knowledge management.

6.3.2.2 Knowledge and Cultural transformation (Sensing and Reconfiguring)

The fusion of knowledge and organisational culture shapes the adaptive behaviours necessary for success. Organisational culture plays a pivotal role in shaping how knowledge is acquired, shared and utilised. A culture that values continuous learning and knowledge sharing creates an environment where employees feel empowered to explore new ideas, experiment with emerging technologies and collaborate with colleagues, as noted by S1:

> A learning culture is characterised by openness, curiosity, and a willingness to embrace new perspectives. It encourages people to seek out knowledge, share their insights, and contribute to the collective growth of the organisation.

Leadership sets the tone for the organisational culture, modelling behaviours that prioritise learning and development. By demonstrating a commitment to knowledge acquisition and personal growth, leaders inspire employees to embrace lifelong learning and cultivate a mindset of adaptability and innovation. Leadership plays a crucial role in fostering a culture that embraces knowledge acquisition and innovation.

Knowledge acts as a catalyst for cultural evolution, driving shifts in organisational norms, values and practices. As organisations adapt to technological advancements and market changes, knowledge acquisition becomes essential for staying competitive and relevant. A culture that values knowledge acquisition encourages employees to seek out new skills, explore emerging trends and adapt to changing circumstances.

To truly leverage the power of knowledge, organisations must integrate it into their cultural norms and practices. This involves creating processes and systems that facilitate knowledge sharing, collaboration and innovation across all levels of the organisation, as echoed by M5:

> Integrating knowledge into cultural norms involves creating structures and incentives that encourage employees to share their insights, learn from one another, and apply new knowledge to their work.

Leadership plays a central role in fostering a culture that values knowledge integration. By creating opportunities for cross-functional collaboration, promoting transparency and open communication, and recognising and rewarding knowledge sharing behaviours, leaders can embed knowledge into the fabric of the organisation's culture. By aligning knowledge acquisition with cultural values and norms, organisations can create an environment where learning, innovation and collaboration thrive.

Participants from the shipbuilding sector emphasised the importance of a learning culture characterised by openness, curiosity and a willingness to embrace new perspectives. In contrast, participants from the mining sector highlighted the crucial role of leadership in shaping organisational culture. Leadership creates an environment for fostering a culture that values knowledge acquisition, collaboration and innovation, suggesting a focus on leadership-driven cultural change. Even though all sectors recognised the importance of integrating knowledge into cultural norms and practices, participants from the mining sector specifically mentioned the need to create structures and incentives that encourage knowledge sharing and application. This indicates a recognition of the challenges associated with knowledge integration and the importance of organisational mechanisms to facilitate it.

6.3.2.3 Knowledge and Skill Transformation (Sensing and Reconfiguring)

The nexus between knowledge and skill transformation lies at the heart of successful transformations for innovation waves, ensuring that organisations have the right capabilities to thrive in a rapidly evolving digital landscape. It becomes evident that assessing capability extends beyond mere technological competence, as demonstrated by O7:

> Empowering the workforce with the right knowledge and skills is the cornerstone of successful digital transformation. It's not just about adopting new technologies; it's about transforming the way we work and empowering individuals to drive organisational change.

Comprehensive assessment tools highlight the importance of evaluating organisational and people capabilities alongside technical readiness. Technical complexity often necessitates integrating advanced technologies into existing processes, underscoring the need for a workforce equipped with the skills to operate, maintain and adapt to these technologies.

By adopting a holistic approach to internal assessment, organisations can identify skill gaps, anticipate training needs, and tailor reskilling and upskilling programs accordingly. This ensures that innovation waves initiatives account for the human element and organisational dynamics, mitigating implementation risks and enhancing the adaptability of the workforce, as noted by S1:

> A robust assessment of organisational and people capabilities is essential for driving successful digital transformation. It's not just about technology; it's about empowering people to leverage technology effectively.

In the heavy industry, in transitioning towards greater technological adoption, a generational divide often emerges. Younger workers tend to be more receptive to technology, while older workers possess valuable traditional skills and knowledge. The challenge lies in bridging the gap between these two generations and facilitating a smooth transition towards technological adoption.

Skill transformation plays a vital role in bridging this generational gap by helping the workforce understand how technology can enhance their work rather than replace it. By making technology an enabler rather than a threat, organisations can empower employees to embrace digital change and leverage technology to drive innovation and efficiency, as emphasised by M5:

> Bridging generational gaps requires a concerted effort to make technology accessible and relevant to all members of the workforce. It's about fostering a culture of lifelong learning and skill development.

By aligning knowledge acquisition with comprehensive skill transformation initiatives, organisations can empower their workforce to adapt, innovate and thrive in an increasingly digital world.

In the oil and gas sector, there is clear acknowledgment of the importance of equipping the workforce with appropriate knowledge and skills plays in navigating innovation waves successfully. This reveals an industry-wide recognition of the human factor and the imperative for robust skill transformation endeavours to facilitate the effective adoption of technology. In contrast, within the shipbuilding and mining sectors, there is an emphasis on addressing generational disparities in skill transformation. This suggests a recognition of the unique challenges these sectors face in integrating varying levels of expertise and technological proficiency across different age groups. Although there is a common understanding across all sectors regarding the importance of evaluating organisational and personnel capabilities alongside technical preparedness, the shipbuilding sector stood out for its promotion of a more comprehensive internal assessment approach.

6.3.3 Management

6.3.3.1 Management, Leadership and Cultural Transformation (Sensing and Reconfiguring)

The findings revealed that the role of management leadership is paramount in driving cultural change. Heavy industry, particularly those with a security-oriented nature, may face unique challenges in adapting to new ways of working. However, the acknowledgment of top-down support for transformation signals a gradual shift towards aligning the entire organisation with a vision of innovation waves. This was supported by S5 who asserted:

> Top-down management support is critical for cultural transformation. The challenge lies in scaling up and aligning the rest of the business with this ambitious vision.

Effective management leadership involves not only setting a vision for innovation waves, but also championing cultural alignment throughout the organisation. Leadership's commitment to cultural transformation sets the tone for the entire organisation. Leaders must embody the values and behaviours that support cultural change, inspiring employees to embrace new ways of working and adapt to evolving technologies and processes. This was demonstrated by S4 who stated:

> By fostering an environment of openness, collaboration, and continuous learning, leaders can facilitate the adoption of new technologies and practices and drive innovation across all levels of the organisation.

In a heavy industry with a security-oriented nature, such as defence (shipbuilding), cultural transformation may face additional hurdles owing to regulatory constraints and risk aversion. However, effective management leadership can mitigate these challenges by fostering a culture of agility and resilience. By emphasising the importance of adaptability and innovation, leaders can encourage employees to embrace change while ensuring compliance with industry regulations. Through transparent communication and strategic planning, management leadership can navigate industry-specific challenges and pave the way for successful cultural transformation.

By providing top-down support, aligning organisational culture with a vision of innovation waves and overcoming industry-specific challenges, management leadership can foster an environment where innovation thrives and employees are empowered to embrace new ways of working.

Despite there being a shared recognition of the importance of management leadership and cultural transformation across sectors, the shipbuilding sector participants were the only ones that highlighted the unique challenges associated with cultural transformation with a security-oriented nature. This suggests that shipbuilding organisations may face regulatory constraints and risk aversion, which could impede cultural change efforts. In contrast, participants from the mining, and oil and gas sectors may face different challenges specific to their industries, such as environmental regulations, safety standards and geopolitical factors. These sector-specific challenges may require customised approaches to cultural transformation and leadership strategies.

6.4 Interrelationships of Seizing

As demonstrated by the previous analysis using NVivo 12 (Chapter 5), seizing capabilities encompass value recognition, an implementation-centric approach and understanding resistance. These capabilities reveal intricate relationships with other sensing and reconfiguring capabilities, as depicted in Table 31.

Table 31: Interrelationship matrix with seizing capabilities

		Sensing			**Seizing**			**Reconfiguring**			
		Strategic foundation	**Knowledge**	**Management**	**Value recognition**	**Implementation-centred approach**	**Understanding resistance**	**Continuous integration**	**Leadership and communication**	**Cultural transformation**	**Skill transformation**
Seizing	6.4.1. Value recognition	√					√			√	
	6.4.2. Implementation-centred approach							√	√	√	√
	6.4.3. Understanding resistance					√			√		

Table 31 is a comprehensive depiction of the interrelationships between seizing capabilities and other capabilities, attributing contributions from various sectors to each interrelationship. The subsequent sections undertake an examination of these findings, discerning sector-specific differentiations and expounding on nuanced observations. In Section 6.4.1, the analysis probes the mutual dependencies between value recognition and other capabilities. Similarly, Section 6.4.2 explores the intricate intertwining of an implementation-centred approach with other capabilities. Moreover, Section 6.4.3 dissects the interrelationship between understanding resistance and other capabilities, furnishing detailed insights into their intertwined nature.

6.4.1 Value Recognition

6.4.1.1 Value Recognition and Strategic Foundation (Seizing and Sensing)

Value recognition and strategic foundation are intricately intertwined components of successful transformation for innovation waves. To fully grasp the practical value of innovation waves, it is imperative to understand the complex interplay between people and the implementation process. This understanding extends to the significance of clear and comprehensive strategies, as well as a long-term vision, in achieving successful value recognition.

The participants collectively emphasised that value recognition hinges on a well thought out strategy that should be meticulously planned from the very early phases of innovation waves initiatives. This strategy should not only focus on short-term gains, but also incorporate long-term vision and value objectives, as articulated by M6:

> Aligning the strategic planning process with the people centre is crucial for realising the full potential of digital transformation.

This underscores the importance of considering the human element and value realisation in shaping strategic planning.

Further, a robust strategic foundation provides a roadmap for aligning technological investments with overarching business goals and objectives. By incorporating value recognition as a core element of strategic planning, organisations can ensure that digital initiatives are aligned with the broader organisational vision and contribute meaningfully to overall business success, as echoed by S5:

> A well-planned strategy ensures that digital initiatives are aligned with our long-term objectives, driving sustainable value recognition.

Moreover, a strategic foundation plays a critical role in fostering a culture of innovation and adaptability within the organisation. By articulating clear objectives and priorities, leaders can empower employees to embrace change and actively participate in the transformation process for innovation waves. This inclusive approach enhances value recognition and fosters collaboration and engagement across all levels of the organisation, as highlighted by M4:

> A strategic approach encourages a culture of innovation and collaboration.

The interrelationship between value recognition and strategic foundation illustrates the importance of holistic and forward-thinking approaches to innovation waves. By integrating value recognition into strategic planning processes, organisations can enhance their ability to leverage technology effectively and drive sustainable growth.

The mining participants commented on the alignment between strategic planning and a people-centred approach, reflecting a strong organisational culture where human factors are prioritised alongside technological advancements. This also suggests a sector-wide recognition of the importance of inclusivity and collaboration in driving innovation waves. Conversely, the shipbuilding participants emphasised the incorporation of long-term vision and value objectives into strategic planning for innovation waves. This reveals a sectoral focus on sustainable value creation over time, aligning technological investments with broader organisational goals. Although participants from both sectors recognised the importance of alignment with organisational goals, the mining participants stressed fostering a culture of innovation and collaboration, contrasting with shipbuilding's potentially lesser emphasis on this aspect. This implies that the mining sector may be more conducive to innovation and adaptability, fostering a dynamic environment that embraces change.

6.4.1.2 Value Recognition and Understanding Resistance (Seizing and Seizing)

Value recognition and understanding resistance are integral aspects of successful transformation for innovation waves. Effectively communicating the value proposition of such endeavours is paramount. Employees must grasp that acquiring advanced skills through transformation is not only beneficial for their personal growth, but also essential for meeting future industry demands, thereby alleviating concerns about job security. Participant O1 captured this notion by stating:

> It's imperative to openly discuss the organisation's challenges. People need to trust the changes and understand the benefits they bring. Communication must be clear and well managed.

Trust building and transparent communication play pivotal roles in assuaging uncertainties and facilitating the seamless assimilation of transformational changes. Organisations must be forthright about their challenges and effectively communicate the intended benefits of technological changes. Simply imposing changes without adequate explanation or consideration of employees' concerns is counterproductive. This confirms the importance of comprehensive and well-managed communication strategies in change management processes, as expressed by O3:

> To truly understand the impact, examples demonstrating benefits must be communicated clearly.

Individual attitudes towards new technologies significantly influence their adoption and effectiveness. Negative perceptions among users can impede the successful integration of technology into operations, potentially leading to adverse impacts. Therefore, it is imperative for businesses to actively address and mitigate scepticism through effective communication, as noted by S3:

> Human nature inclines us to focus on negatives as a survival instinct. Therefore, communication should emphasise the positive impact and benefits.

Effective communication of the value proposition of innovation waves is essential for overcoming resistance and fostering value recognition. Organisations must engage in transparent dialogue, emphasising the opportunities for growth and efficiency gains while addressing legitimate concerns.

The shipbuilding sector participants emphasised the need to effectively communicate the positive impact and benefits of innovation waves. This indicates a proactive approach to addressing resistance by highlighting growth opportunities and efficiency gains. Conversely, the oil and gas sector participants stressed the importance of open discussion, trust-building and clear communication to overcome resistance and ensure an understanding of the benefits of innovation waves. This signifies a focus on addressing concerns through transparent communication and illustrating tangible advantages. Although specific insights from the mining sector were not provided, considering the mid-level of commitment to innovation waves, it is likely that a similar emphasis on transparent communication and highlighting the benefits would be observed.

6.4.1.3 Value Recognition and Cultural Transformation (Seizing and Reconfiguring)

Value recognition and cultural transformation are intricately linked aspects of successful transformation for innovation waves. Even though technological advancements bring about significant opportunities for innovation, they necessitate a shift in organisational culture to fully realise their potential. The heavy industry often exhibits a conservative mindset. This was demonstrated by O6:

> The heavy industry tends to be conservative due to safety concerns.

This conservatism can pose challenges to implementing transformative changes, revealing the delicate balance between innovation and safety.

The resistance to significant shifts underscores the need to consider indirect values, such as health and wellbeing, in the transformation process for innovation waves. Traditional heavy industries must recognise the importance of these indirect value realisations, particularly safety, which is paramount in high-risk environments. This was echoed by M5 who emphasised:

> The conservative mindset in traditional heavy industries needs to shift towards acknowledging the importance of indirect value realisations such as wellbeing.

This confirms that cultural transformation is required to ensure that organisations leverage technology for operational efficiency, as well as for the wellbeing of their workforce and the broader community.

Crucially, this cultural transformation requires the active involvement of end users and the entire workforce in the technology adoption process. By engaging employees at all levels, organisations can challenge conservative views from the past and foster a culture that embraces technological advancements to their fullest extent, as asserted by M5:

> This shift can only occur when the end-users and the entire workforce are involved in the technology adoption process.

This inclusive approach empowers employees to become advocates for change, driving cultural shifts that align with the strategic goals of innovation waves initiatives. The interrelationship between value recognition and cultural transformation highlights the need for organisations to recognise and address the broader implications of innovation waves beyond immediate economic gains. By fostering a culture that values safety, innovation and inclusivity, businesses can navigate the complexities of technological change while safeguarding the wellbeing of their employees and stakeholders.

Although each sector approaches value recognition and cultural transformation differently based on its specific characteristics and challenges, there are commonalities in how they interrelate. The mining sector participants emphasised the need to recognise indirect value realisations, such as safety and wellbeing, alongside operational efficiency. Cultural transformation in mining involves shifting the conservative mindset towards acknowledging these indirect values and embracing technological advancements to enhance safety and employee welfare. This indicates that value recognition drives cultural transformation by expanding the focus beyond immediate economic gains to encompass broader organisational values. Similarly, in the oil and gas sector, value recognition and cultural transformation are interconnected through the sector’s conservative nature and safety concerns. The recognition of indirect values, particularly safety, drives cultural transformation by necessitating a shift towards prioritising safety alongside technological advancements. Cultural transformation in the oil and gas sector involves fostering a culture that values safety, innovation and inclusivity, aligning with the broader implications of innovation waves beyond economic gains. Even though it was not directly addressed from the shipbuilding sector, it likely shares similarities with the mining, and oil and gas sectors, considering the similar characteristics of these heavy industries.

6.4.2 Implementation-Centred Approach

6.4.2.1 Implementation-Centred Approach, Skill Transformation and Continuous Integration (Seizing and Reconfiguring)

The interrelationship between an implementation-centred approach and continuous integration forms a pivotal axis in the journey of innovation waves. At its core lies the recognition that the successful integration of technology hinges not just on its functionality, but also on its resonance with the people who interact with it.

A human-centred technology trial serves as a potent method for this integration, fostering a sense of ownership and acceptance among users. As S4 noted, empowering individuals to see the benefits for both themselves and the business is paramount:

> A human-focused technology trial enables an organisation to empower and make the people owning what they're going to do and accepting that this is going to be good for them and the business.

This perspective reveals a crucial truth that technology integration is not merely about the tools but about the individuals who wield them. Therefore, a deep understanding of human dynamics becomes essential for any technological endeavour to thrive within an organisation, as noted by O4:

> Technology cannot be implemented without people's support. So, having an excellent understanding of people and technology together is important.

Thus, a symbiotic relationship must be nurtured in which technology enhances human capabilities rather than supplanting them. M8's insight reinforces this notion, highlighting the importance of providing employees with the tools and skills to simplify complex tasks, thereby augmenting their abilities:

> We don't want to replace people in the workforce with technology ... it's giving them the tools and skill sets to make complex things simpler.

Moreover, O5 stressed the significance of feedback mechanisms and a closed-loop approach, advocating for a user-centred design philosophy. This approach ensures that the evolving needs and concerns of employees are continuously addressed, fostering a culture of iterative improvement. By establishing channels for feedback, organisations not only empower employees, but also gain invaluable insights to refine and tailor technological solutions to meet actual needs and goals, as O5 explained:

> Continuous feedback mechanisms and a closed-loop approach to addressing concerns and complaints are crucial for the success of people-focused technology integration.

Participant M5 observed that setting up feedback mechanisms engenders a sense of ownership and empowerment among employees:

> It's essential to set up feedback mechanisms that allow employees to provide insights and suggestions, creating a sense of ownership and empowerment.

This echoes M8's assertion that feedback, particularly from employees across all levels, is essential for continuous improvement. By fostering a culture where feedback flows freely, organisations can identify challenges early, refine solutions and ensure that technology adoption remains aligned with the evolving needs of the workforce.

The interplay between an implementation-centred approach and continuous integration confirms the importance of marrying technological prowess with human understanding. Only by recognising and embracing this symbiotic relationship can organisations truly harness the transformative potential of digital technologies.

Despite participants from all sectors recognising the importance of human-centric technology adoption, their emphasis varied. Participants from the shipbuilding sector stressed empowering individuals and fostering ownership, likely owing to its emphasis on safety and operational continuity. The mining participants prioritised skill transformation to optimise production processes and mitigate safety risks, reflecting the sector's unique challenges in remote and hazardous environments. Conversely, the oil and gas sector participants highlighted the symbiotic relationship between technology and human capabilities, likely driven by the sector's focus on safety, efficiency and environmental stewardship. These differences stem from sector-specific operational contexts, technological requirements and organisational cultures, underscoring the need for customised approaches to innovation waves in each sector.

6.4.2.2 Implementation-Centred Approach, and Leadership and Communication (Seizing and Reconfiguring)

In the dynamic landscape of innovation waves, leadership serves as the compass, steering organisations towards success by understanding and empowering their most valuable asset, people. This was illustrated by S3 who stated:

> Leadership isn't just about leading; it's about inspiring others to become leaders themselves, fostering a culture of empowerment and collaboration.

At the heart of this interrelationship lies the imperative of leadership in championing a people-centred ethos and guiding organisational members through the transformative journey. Effective leadership is not merely about making decisions from the top down, it is also about inspiring, enabling and supporting individuals at all levels to contribute their best. Participant O1 asserted this in the following statement:

> True leadership is about recognising the potential in others and empowering them to realise it, creating a ripple effect of positive change throughout the organisation.

Moreover, effective communication serves as the conduit through which the leadership vision is shared, and organisational alignment is achieved. Clear and transparent communication channels foster trust, collaboration, and a shared sense of purpose, enabling leaders to connect with their teams on a deeper level, as explained by O3:

> Communication is the currency of leadership—it builds bridges, fosters understanding, and creates a sense of belonging that propels organisations forward.

Within the context of a people-centred approach, effective leadership is essential for cultivating an environment where individuals feel valued, heard, and empowered to contribute their unique talents and perspectives. Leaders must prioritise empathy, inclusivity, and transparency to foster a culture of trust and collaboration, as echoed by M2:

> Leadership is about creating a safe space where individuals feel empowered to bring their whole selves to work, unleashing their full potential and driving meaningful change.

In addition, leadership and a people-centred approach synergise to provide guidance and support to employees throughout the transformation journey. Leaders must demonstrate empathy and responsiveness to the needs and concerns of their teams, facilitating a sense of psychological safety that encourages experimentation, learning and growth. This was illustrated by M5 who asserted:

> Effective leadership isn’t about having all the answers; it’s about asking the right questions, actively listening to others, and empowering them to co-create solutions.

By prioritising empathy, inclusivity and communication, leaders can create a culture where individuals feel valued, empowered and inspired to contribute their best, ultimately propelling the organisation towards its digital future.

Shipbuilding practitioners emphasised leadership as a means of fostering empowerment and collaboration. Leadership in shipbuilding was depicted as inspiring individuals to become leaders themselves, indicating a decentralised approach to decision-making and problem-solving. Although effective communication was acknowledged, there was less emphasis on its role in organisational alignment and more focus on empowering individuals to contribute their best. In contrast, the mining sector participants highlighted leadership’s role in creating a safe space for individuals to unleash their potential. The emphasis here was on empathy, inclusivity and creating a supportive environment for innovation. Communication was seen as a conduit for fostering psychological safety, enabling experimentation, learning and growth. Safety and empowerment were central themes in the leadership narrative of the mining sector participants. Conversely, the oil and gas sector participants viewed leadership as recognising and empowering the potential in others. Here, communication was depicted as the currency of leadership, essential for building bridges and fostering understanding. The focus was on aligning stakeholders and driving organisational change through effective communication channels.

6.4.2.3 People-Centred Approach and Cultural Transformation (Seizing and Reconfiguring)

Exploring the intricate interrelationship between a people-centred approach and cultural transformation unveiled the key to organisational resilience and adaptability in the realm of innovation waves. Cultivating a culture that prioritises the needs and wellbeing of employees while fostering a mindset of openness and collaboration is essential for driving sustainable change and innovation.

Central to this interrelationship is the understanding that a people-centred approach goes beyond technological implementation—it encompasses a fundamental shift in organisational values and norms. By placing individuals at the heart of decision-making processes and fostering a culture of inclusivity and empowerment, organisations can lay the foundation for meaningful cultural transformation. This was supported by M7 who asserted:

> In the tapestry of organisational culture, a people-centred approach forms the warp and weft that weave together a fabric of resilience and adaptability, fostering an environment where individuals feel valued, heard, and empowered to contribute their best.

However, the journey towards cultural transformation is not without its challenges. The demands of modern organisational dynamics often place constraints on the comprehensive cultivation of a people-centred culture. Organisations must navigate rapid changes in technology, market conditions and consumer expectations while simultaneously prioritising the wellbeing and development of their employees. This was demonstrated by O1 who stated:

> In the fast-paced arena of digital transformation, a people-centred approach becomes a strategic imperative, requiring organisations to balance the need for agility with a commitment to fostering a culture of trust, collaboration, and continuous learning.

Nevertheless, even in the face of time constraints, there are opportunities to embed a people-centred ethos into the fabric of organisational culture. Participant S3 emphasised that initiatives such as employee-centric policies, personalised development plans and inclusive decision-making processes can empower individuals and foster a sense of ownership and commitment to organisational goals. This was supported by S3 who explained:

> By investing in the well-being and development of employees, organisations can cultivate a culture of resilience that transcends individual projects and initiatives, laying the groundwork for sustained success in an ever-evolving digital landscape.

Moreover, these transformative experiences have the potential to cultivate advocacy from within the organisation. Employees who feel supported and valued are more likely to become champions of cultural change, inspiring their colleagues and fostering a culture of optimism and innovation. Participant O2 demonstrated this by stating:

> In the symphony of cultural transformation, advocacy serves as the melody that reverberates throughout the organisation, inspiring individuals to embrace change and collaborate towards a shared vision of success.

By prioritising the needs and wellbeing of employees and fostering a culture of inclusivity, empowerment and advocacy, organisations can cultivate the resilience and adaptability needed to thrive in an increasingly complex and uncertain business environment.

The shipbuilding sector participants emphasised inclusivity and empowerment, reflecting a focus on teamwork and collaboration inherent in shipbuilding projects. Transformative experiences were seen as catalysts for cultural change, fostering advocacy from within the sector. Conversely, the oil and gas sector participants placed a strong emphasis on advocacy as a driver of cultural transformation, highlighting the importance of mobilising internal support for change initiatives. Balancing agility with trust and collaboration was seen as crucial in navigating the fast-paced and complex environment of the sector. In contrast, the mining sector participants recognised the significance of prioritising employee needs and empowerment for organisational resilience and adaptability, likely because of the physically demanding and often hazardous nature of mining work. Although participants from all sectors recognised the importance of a people-centred approach and cultural transformation in the context of innovation waves, the specific nuances and emphases may vary based on the nature of operations, organisational culture and industry dynamics within each sector.

6.4.3 Understanding Resistance

6.4.3.1 Understanding Resistance and Implementation-Centred Approach (Seizing and Seizing)

The interrelationship between an implementation-centric approach and understanding resistance is pivotal in navigating the complexities of innovation waves. At its core, innovation waves are not just about technology, they are about people. Social foundations, including resistance to change and fear of job displacement, are deeply entrenched within the human resistance and organisational culture. Ignoring or underestimating these factors can impede progress and undermine the effectiveness of any transformation initiative. This was confirmed by M4 stating:

> Change is a journey through the landscapes of human emotions. Understanding resistance is the compass that guides us.

No matter how robust the technological solutions may be, they falter in the face of ingrained resistance. Hence, a comprehensive approach to innovation waves must prioritise understanding and addressing resistance. An implementation-centric approach emphasises the technical aspects of change, focusing on systems, processes and tools. However, the success of these implementations hinges on the acceptance and engagement of those affected by the change, people. This is where understanding resistance becomes imperative. This was echoed by O3 who asserted:

> Resistance to change is not inherently negative; it often stems from concerns about job security, loss of control, or unfamiliarity with new processes.

By recognising these concerns and fostering open communication channels, organisations can create an environment that is conducive to change.

Addressing resistance requires a multifaceted approach that combines empathy, communication and active engagement. Leaders must champion the vision for change while empathising with the challenges faced by their teams. Additionally, providing adequate training and support can alleviate fears and build confidence in embracing new technologies.

Moreover, understanding resistance enables organisations to anticipate potential roadblocks and tailor their change management strategies accordingly. Participant S5 observed that, by proactively addressing concerns and involving stakeholders in the decision-making process, organisations can mitigate resistance and foster a culture of innovation and adaptability. By recognising the human element and actively addressing resistance, organisations can maximise the success of their transformation efforts and unlock new possibilities for growth and innovation.

The shipbuilding sector participants appeared to prioritise understanding resistance and empathetically implementing change, focusing on the human element. They emphasised proactive communication, involving stakeholders, and encouraging a culture of innovation. Generally, the shipbuilding participants demonstrated a higher level of commitment to innovation waves, suggesting that they may have had more experience in rapidly navigating technological changes than those in the other sectors. In contrast, the mining participants generally exhibited a mid-level commitment to innovation waves, indicating that they may have been in the process of adopting digital technologies. The mining sector participants stressed the importance of addressing resistance, but there may have been less emphasis on proactive communication and stakeholder involvement compared with the views of the shipbuilding participants. The perspective from mining participants may have reflected a sector that is somewhat traditional but evolving towards embracing digital changes. Similar to mining, participants from the oil and gas sector generally demonstrated a mid-level commitment to innovation waves. There was acknowledgment of the importance of understanding resistance and fostering open communication, particularly regarding concerns about job security and unfamiliarity with new processes. The focus seemed to be on creating an environment conducive to change rather than actively driving innovation.

6.4.3.2 Understanding Resistance, and Leadership and Communication (Seizing and Reconfiguring)

Clear and transparent communication emerged as a linchpin strategy for addressing behavioural factors across the various sectors, while effective leadership was said to play a pivotal role in enforcing processes, managing change, and reassuring employees about the value of acquiring new digital skills. This was confirmed by M8 who stated:

> Clear and transparent communication is key in helping employees understand that technology is meant to enhance their work, not replace them, emphasising the safety and efficiency benefits of technology.

In alignment with M8’s perspective, M3 explained that integrating technology into the job rather than viewing it as an add-on is important, highlighting the pivotal role of leadership in enforcing processes and managing change. The synergy between leadership and communication becomes apparent in how leaders communicate the purpose and benefits of innovation waves to employees, addressing their concerns and dispelling misconceptions. This interrelationship underscores the importance of leadership’s ability to articulate a clear vision and facilitate an environment of open communication, creating a receptive atmosphere for technology adoption. This was emphasised by S9:

> Communication is key in addressing the fears and concerns that employees may have about new technology.

M5 added:

> It’s about demonstrating the value proposition clearly and showing how the technology benefits not only the organisation but the workforce.

Conversely, communication is empowered by strong leadership, ensuring that messages conveyed are aligned with the organisation’s strategic goals and transformation objectives. By offering ownership in the process and demonstrating how technology can simplify work, organisations can mitigate resistance and foster a culture of innovation and adaptability. S7 stated:

> Leadership without effective communication is like a ship without a rudder.

Stressing the safety and efficiency benefits of technology can alleviate concerns and create a more positive attitude towards innovation waves. By demonstrating the value proposition clearly and showing how technology benefits the organisation as well as the workforce, organisations can address fears and concerns proactively. By encouraging a culture of open communication, empowering leadership and addressing concerns proactively, organisations can navigate resistance and drive successful digital initiatives that benefit both the organisation and its workforce.

Both shipbuilding and mining sector participants prioritised communication and leadership but emphasised different aspects based on their operational contexts. Shipbuilding sector participants were in favour of fostering open communication environments and articulating a clear vision, likely because of the sector’s high-level of commitment to innovation waves. Proactive communication and strong leadership play a crucial role in demonstrating the value of technology and facilitating innovation within an organisation. In contrast, participants from the mining sector recognised the importance of demonstrating the value proposition of technology along with the role of leadership in articulating a clear vision and fostering open communication environments. There was a focus on integrating technology into existing processes while emphasising its benefits to the mining sector and its workforce. No specific statement was provided from the oil and gas sector participants regarding this interrelationship. This could suggest that the oil and gas sector may have different priorities or perspectives on communication, leadership and technology value proposition compared with the mining and shipbuilding sectors.

6.5 Interrelationships of Reconfiguring

As demonstrated in the previous analysis chapter (Chapter 5), reconfiguring capabilities encompass continuous integration, leadership and communication, cultural transformation and skill transformation. These capabilities demonstrate intricate interrelationships with other sensing and seizing capabilities, as illustrated in Table 32.

Table 32: Interrelationship matrix with reconfiguring capabilities

		Sensing			Seizing			Reconfiguring			
		Strategic foundation	Knowledge	Management	Value recognition	Implementation-centred approach	Understanding resistance	Continuous integration	Leadership and communication	Cultural transformation	Skill transformation
Reconfiguring	6.5.1. Continuous integration	√	√								
	6.5.2. Leadership and communication				√						√
	6.5.3. Cultural transformation						√		√		
	6.5.4. Skill transformation					√		√			

Table 32 elucidates the interrelationships between reconfiguring capabilities and other capabilities, delineating the specific sectoral contributions to each interrelationship. The subsequent sections undertake an in-depth exploration of these findings, exploring sectoral differentiations and unravelling nuanced insights. In Section 6.5.1, the interrelationships between continuous integration and other capabilities are scrutinised. Similarly, Section 6.5.2 examines the intricate linkage of leadership and communication with other capabilities. Further, Section 6.5.3 elucidates the interrelationships between cultural transformation and other capabilities, offering comprehensive insights into their synergistic relationships. Last, Section 6.5.4 exhibits the interrelationships between skill transformation and other capabilities.

6.5.1 Continuous Integration

6.5.1.1 Continuous Integration and Strategic Foundation (Reconfiguring and Sensing)

In the landscape of innovation waves, the strategic foundation plays a pivotal role in ensuring the success of continuous integration initiatives. A robust strategic foundation serves as the cornerstone on which continuous integration efforts are built. By aligning transformation endeavours with overarching strategic objectives, organisations can ensure coherence and consistency in their approach. This was illustrated by M4 who asserted:

> You need to have a strategic foundation to integrate new technologies into the process.

A well-defined strategic foundation provides organisations with a roadmap for navigating the complexities of continuous integration. By mapping out clear objectives, milestones and success metrics, organisations can establish a framework for evaluating progress and adjusting strategies as needed, as shown by O7:

> [The] purpose of adopting new technologies needs to be clear so that you can only integrate what you need.

This proactive approach allows organisations to identify potential bottlenecks or areas where readiness may be lacking and take corrective actions in a timely manner. A strategic foundation provides organisations with the direction, alignment and focus needed to navigate the complexities of continuous integration effectively. It ensures that transformation efforts for innovation waves are aligned with the broader organisational goals, thus enhancing the chances of success and maximising the benefits of continuous integration initiatives.

The mining participants emphasised the importance of a strategic foundation as crucial for integrating new technologies into processes. This indicates a recognition of the need for structured planning and alignment with long-term goals in a sector where projects are capital-intensive and have long lifecycles. Their focus on strategic planning likely stems from the risk-averse nature of the mining industry, where operational disruptions can have significant financial and safety implications. Conversely, the oil and gas participants underscored the necessity for clarity of purpose in adopting new technologies. This reflects a pragmatic approach driven by clear objectives and a focus on efficiency, which is characteristic of industries with high capital expenditure and operational complexity such as oil and gas. Their emphasis on targeted technology adoption aligns with the sector’s need to optimise operations and manage risks effectively. Notably, there was no input from the shipbuilding participants. This absence suggests a potential gap in perspectives on the interrelationship between continuous integration and strategic foundation within the shipbuilding sector.

6.5.1.2 Continuous Integration and Knowledge (Reconfiguring and Sensing)

In the realm of innovation waves, the relationship between continuous integration and knowledge is not only complementary, but also indispensable for organisational success. As highlighted by participant M5, the challenge of integrating technology within heavy industry organisations to meet specific needs and processes is daunting. This challenge becomes particularly pronounced in the context of continuous integration, where the pace of technological change is rapid and relentless.

Complex technologies often require customisation to seamlessly integrate with existing workflows and meet the unique requirements of heavy industry organisations. The involvement of end users in this customisation process is crucial. Their insights and knowledge provide invaluable guidance in fine-tuning technology solutions to ensure they not only enhance, but also align with existing processes. Thus, the interplay between continuous integration and people's knowledge is evident, since the complexity of technology frequently necessitates customisation to bridge the gap between generic solutions and the distinctive demands of the heavy industry. This was supported by S5:

> Knowledge has to be improved, challenged and increased constantly, otherwise it will disappear.

This highlights the indispensable role of continuous learning and knowledge enhancement in navigating the complexities of digital integration. In the landscape of innovation waves, continuous integration serves as the bridge between technological advancement and organisational adaptation.

In the heavy industry context, in which processes are often deeply ingrained and specialised, the interplay between continuous integration and knowledge becomes even more critical. As technology evolves, so too must the collective knowledge base of the organisation. Continuous learning ensures that employees remain abreast of the latest advancements and are equipped with the skills and insights needed to effectively integrate and optimise technological solutions within their workflows. This was confirmed by S9 who stated:

> It's not just about adapting to technology; it's about empowering employees with the knowledge and skills to shape its evolution.

By embracing a culture of continuous learning and refinement, organisations can effectively bridge the gap between technology and operations, driving innovation and competitiveness in an ever-evolving landscape. Continuous integration relies heavily on the collective knowledge and expertise of employees to ensure that technological advancements are seamlessly integrated and optimised within organisational processes.

Notable similarities and potential differences emerged in comparing the perspectives across sectors. The shipbuilding sector participants highlighted the imperative of consistent improvement and knowledge enhancement, indicative of a sectoral recognition of the need for ongoing learning and adaptation. Similarly, the mining sector participant's acknowledgment of the challenge in integrating technology within heavy industry organisations resonated with their struggles to customise technology to suit specific operational demands. Although specific references to the oil and gas sector were absent, the complex and dynamic nature of the industry suggests a shared emphasis on the importance of continuous integration and knowledge. However, potential distinctions may arise in the level of intricacy and specialisation within each sector's operations, influencing the degree of customisation required and the depth of end user involvement.

6.5.2 Leadership and Communication

6.5.2.1 Leadership and Communication, and Value Recognition (Reconfiguring and Seizing)

In the domain of innovation waves, the interplay between leadership, communication and value recognition is instrumental in fostering a culture where technology is embraced and its benefits are recognised. Leadership's role in creating an environment in which everyone understands the value of technology cannot be overstated. Effective communication serves as the key in this process, transcending mere information dissemination to become a mechanism for preparing employees for the impending changes. Effective leaders understand the importance of communicating the value proposition of technology to their teams. They must effectively convey how technology can improve work processes, enhance efficiency and ultimately contribute to achieving organisational goals. To illustrate, S3 stated:

> Leadership is about inspiring others to see the value in every step forward, guiding them towards a brighter future.

Moreover, effective communication is essential for ensuring that the value of technology is recognised and embraced across the organisation. By transparently communicating the benefits and potential impact of technology initiatives, leaders can garner buy-in and commitment from employees at all levels. This was echoed by M7:

> Communication is the bridge that connects vision to reality, fostering understanding and appreciation for the journey ahead.

This confirms the pivotal role of communication in shaping perceptions and enabling a culture of value recognition.

Leaders must effectively communicate how technology can improve work processes and enhance efficiency for employees. This involves articulating the tangible benefits as well as addressing any concerns or reservations that employees may have. By actively engaging with employees, listening to their feedback and addressing their needs, leaders can build trust and credibility, thereby facilitating the recognition and adoption of technology-driven solutions. This was shown by O3 who stated:

> Leaders must be very active trying to understand how people feel and think.

Effective leadership involves not only setting a compelling vision, but also actively communicating the value proposition of technology and fostering a culture where its benefits are recognised and embraced.

In the shipbuilding sector, leadership revolves around inspiring others towards a vision of progress. However, the direct link between leadership and value recognition is less explicit, providing an opportunity for improvement. There is a need to stress how effective leadership translates into tangible value for both employees and the organisation. Additionally, although communication is acknowledged as vital, there is a lack of emphasis regarding how it can specifically enhance value recognition. Leaders can benefit from transparently communicating the benefits of technology to cultivate understanding and appreciation among employees, thereby driving its recognition and adoption. Conversely, in the mining sector, leadership prioritises transparent communication to bridge the gap between vision and reality. This pragmatic approach directly contributes to value recognition by ensuring that employees comprehend how technology initiatives align with organisational goals.

Communication is deemed essential for securing buy-in and commitment from employees, directly influencing value recognition. Transparent communication about the benefits and potential impact of technology initiatives facilitates their adoption and recognition of their value across the mining sector. In contrast, leadership in the oil and gas sector emphasises active engagement with employees' thoughts and feelings. This empathetic leadership style fosters trust and credibility, which serve as foundations for value recognition. Communication is perceived as a tool to understand employees' perspectives and concerns regarding technology adoption. By actively listening to feedback and addressing needs, leaders can build trust and facilitate the recognition and adoption of technology-driven solutions, ultimately enhancing value recognition within the sector.

6.5.2.2 Leadership and Communication, and Skill Transformation (Reconfiguring and Reconfiguring)

Skill transformation within heavy industries is closely intertwined with effective leadership and communication strategies. As M3 noted:

> Effective leadership is paramount in driving education and training initiatives within heavy industries.

This underscores the critical part played by leadership in ensuring the success of skill transformation efforts by providing the necessary support, resources and direction.

Participant S1 emphasised that leadership is pivotal in championing the importance of upskilling and reskilling initiatives to align with technological advancements. By effectively communicating the significance of acquiring new digital skills, leaders can motivate the workforce and foster a culture of continuous learning. Participant O5's insights aligned with this perspective:

> Leadership ensures that these initiatives are successful by providing the necessary support, resources, and direction.

Moreover, as highlighted by M3, effective leadership is essential in enforcing processes and change management to ensure that technology implementation follows business processes. Leaders must lead by example and actively participate in the upskilling process, demonstrating their commitment to continuous learning. Their involvement not only reinforces the importance of skill transformation, but also fosters trust and engagement among employees.

Further, leadership's role extends beyond merely enforcing processes; it involves fostering a supportive environment where employees feel empowered to embrace skill transformation. Participant M3's remarks confirm this point:

> Technology adoption can help bridge the gap in industries facing labour shortages.

By promoting a culture where technology complements human skills rather than replaces them, leaders can facilitate smoother skill transformation processes and drive organisational success. By championing the importance of continuous learning, providing support and resources, and fostering a culture of innovation, leaders can navigate the complexities of innovation waves and ensure that organisations thrive in an ever-evolving technological landscape.

From the shipbuilding participants, there was a notable emphasis on leadership's role in driving skill transformation efforts, particularly in championing upskilling and reskilling initiatives. However, explicit recognition of the critical role of communication in facilitating these efforts was lacking. Conversely, the strategic importance of both leadership and communication in driving skill transformation efforts was evident from the comments of the mining participants. Leaders are tasked with driving education and training initiatives, as well as effectively communicating the strategic significance of skill transformation to align efforts with organisational goals. The mining participant's emphasis on clear communication likely stems from the need to navigate complex operational challenges and regulatory environments, where effective communication is crucial for successful technology implementation. Similarly, effective communication is key to motivating the workforce and fostering continuous learning, according to the oil and gas participants. Leaders emphasise the significance of acquiring new digital skills and providing support, resources and direction to ensure the success of skill transformation initiatives. These critical differences highlight how sector-specific challenges and organisational cultures influence the integration of leadership and communication in driving skill transformation efforts. Recognising these differences is essential for tailoring strategies to effectively navigate the complexities of skill transformation within heavy industries.

6.5.3 Cultural Transformation

6.5.3.1 Cultural Transformation and Understanding Resistance (Reconfiguring and Seizing)

Cultural transformation within an organisation is closely intertwined with the phenomenon of resistance to change. As S5 pointed out:

> Addressing employees' fears and concerns about new technology is contingent upon the culture's willingness to embrace change.

People's attitudes and behaviours shift to align with new ways of working, and this shift is heavily influenced by the prevailing organisational culture. An open and receptive culture contributes to a smoother transition to new technology interfaces, mitigating resistance along the way.

The interrelationships among culture, leadership and communication, and the interface between people and technology are intricate and mutually reinforcing. Effective leadership, as highlighted by M4, is crucial for driving cultural change, which in turn shapes the interface between people and technology. As O7 emphasised:

> Communication plays a pivotal role in both addressing concerns related to technology adoption and fostering a culture that embraces change and innovation.

Effective communication, serving as a tool of leadership, not only addresses employees' concerns, but also creates a culture that is conducive to change and innovation. By nurturing an organisational culture that is open, adaptive and supportive of change, leaders can mitigate resistance to technology adoption and create an environment where innovation thrives.

Participants from the shipbuilding, and oil and gas sectors recognised the crucial connection between cultural transformation and understanding resistance. Acknowledging employees' fears and concerns about new technology, participants from the shipbuilding sector emphasised the importance of addressing resistance by fostering an open and receptive organisational culture. However, there might be a need for more explicit strategies to mitigate resistance through effective communication and leadership. Although not explicitly stated, those in the mining sector likely understand the intricate relationship between cultural transformation and resistance to change. Given the sector's hierarchical structure and safety-oriented culture, addressing resistance to change is paramount for successful technology adoption. In contrast, recognising the pivotal role of communication, the oil and gas sector leverages effective communication strategies to address concerns related to technology adoption and fosters a culture that embraces change and innovation. Leaders play a key role in driving cultural transformation by creating an environment conducive to technological innovation while addressing resistance through open communication channels. This critical comparison highlights how each sector approaches the interrelationship between cultural transformation and understanding resistance, emphasising the importance of developing strategies that are tailored to effectively navigate resistance and drive successful technology adoption.

6.5.3.2 Cultural Transformation, and Leadership and Communication (Reconfiguring and Reconfiguring)

Cultural transformation within an organisation is intricately intertwined with effective leadership and communication strategies. Transformational leaders inspire and motivate employees to embrace technological advancements and innovation, supporting the establishment of a climate where change is embraced rather than feared, as stated by S5:

> Leadership plays a pivotal role in instilling a culture of change.

However, the success of cultural transformation relies heavily on transparent and inclusive communication strategies, as noted by S3:

> Transparent and inclusive communication from leadership is crucial in preparing employees for the changes and managing the inherent resistance to change.

Moreover, O7 underscored the importance of effective leadership and communication in fostering a culture of innovation and digital adoption within the organisation:

> Effective leadership and communication are deemed essential to foster a culture of innovation and digital adoption within the organisation.

The journey towards a culture that embraces innovation waves often starts with effective leadership, as highlighted by S5. Leaders must encourage a culture characterised by openness, honesty and a willingness to address problems, nurturing an environment where employees feel empowered to embrace change. This emphasises the clear interdependence between leadership and cultural change, where leadership sets the tone and direction for the organisation’s cultural transformation.

Effective communication is vital in shaping organisational culture. Leaders must communicate the purpose and benefits of innovation waves clearly, creating a shared vision of progress, as noted by M6. This fosters a culture that embraces change and new technologies, driving the organisation towards transformation for innovation waves. As O7 emphasised:

> Shaping culture starts with effective leadership and communication.

By facilitating a climate of change and transparent communication, leaders can create an environment where innovation thrives, and innovation waves becomes ingrained in the organisation’s culture.

The shipbuilding, and oil and gas sector participants emphasised the pivotal role of leadership and stressed the importance of transparent and inclusive communication in driving cultural transformation. Leaders are seen as agents of change who inspire and motivate employees to embrace technological advancements and innovation. The shipbuilding, and oil and gas sectors may have cultures that are more receptive to change and innovation. In such environments, leaders play a crucial role in inspiring and motivating employees to embrace technological advancements and encourage a culture of innovation. The mining sector participants also recognised leadership’s importance in initiating cultural change. However, mining operations often have a more traditional hierarchical structure, where decision-making may be centralised and less influenced by bottom-up leadership initiatives. Consequently, the mining sector participants did not place as strong an emphasis on leadership-driven cultural transformation.

6.5.4 Skill Transformation

6.5.4.1 Skill Transformation and People-Centred Approach (Reconfiguring and Seizing)

Skill transformation within the context of innovation waves in heavy industries confirms the collaborative interaction between human expertise and technological integration. As M2 noted:

> Skill transformation is closely connected with collaborative interaction between human expertise and automated systems.

This collaboration is essential in ensuring that technology augments human capabilities rather than replacing them. In the heavy industry, the application of technology often necessitates a collaborative approach. This was noted by O3 who stated:

> In quality inspection processes, human expertise remains crucial alongside technology-enabled assessments.

Workers must therefore become proficient in operating robots to complement technological advancements, as highlighted by S9. The feedback loop between skilled individuals and education and training initiatives is evident. Organisations with skilled employees are better positioned to provide comprehensive training and development opportunities, while investments in education and training empower employees to become skilled individuals themselves. Participant M8 noted the significance of resource allocation not only for technology acquisition, but also for continuous training and skill development by stating:

> There is a lack of engineers ... we need to get the right people to help develop and then integrate the new system.

This highlights the critical role of resource alignment in facilitating skill transformation and ensuring organisational readiness for innovation waves initiatives. Skill transformation reinforces these efforts, while bridging generational gaps and fostering collaborative interactions are essential for a smooth transition. As O7 emphasised:

> Achieving the right balance between automation and human capabilities relies on skill transformation and education and training initiatives.

This underscores the importance of effective leadership, continuous learning and collaborative interactions in navigating the complexities of innovation waves. By embracing a people-centred approach, organisations can ensure that technology enhances human capabilities and drives organisational success.

The shipbuilding participants highlighted how important it is for workers to become proficient in operating robots to complement technological advancements, indicating a culture of adaptability and collaboration in integrating technology into daily operations. In contrast, the mining sector, as implied by the emphasis on resource allocation for continuous training, may face challenges related to resource scarcity, potentially leading to a slower adoption of new technologies and skill transformation initiatives. Even though all three sectors emphasised common themes, such as the importance of collaborative interactions and people-centred approaches, the differences in organisational cultures and leadership perspectives highlighted the unique challenges and opportunities faced by the shipbuilding, mining, and oil and gas industries in their journey towards innovation waves. Understanding these distinctions is crucial for the development of effective strategies tailored to address sector-specific needs and successful transformation initiatives for innovation waves.

6.5.4.2 Skill Transformation and Continuous Integration (Reconfiguring and Reconfiguring)

Skill transformation and continuous integration are integral components of successful transformation initiatives for innovation waves within organisations. This was supported by S5 who observed:

> The emphasis on integration and connectivity highlights the interconnected nature of modern technology systems, which require holistic skills to implementation.

This reveals the need for upskilling the workforce to support integration efforts, particularly in acquiring new skill sets such as software engineering.

Participant S5 further underscored the importance of skill development and integration in facilitating seamless communication within an organisation’s technology systems. As S2 stated:

> Integration is the key, and given our industry's labour-intensive nature, acquiring the necessary skills and knowledge for our personnel and back-end platforms to facilitate seamless communication is essential.

This illustrates the critical role of skill transformation in enabling organisations to adapt to evolving technological landscapes and drive continuous integration efforts. Skill transformation encompasses acquiring diverse skill sets that enable individuals to adapt to new technologies and tasks. Additionally, technology adoption may lead to the transformation of skills, especially when automation replaces certain job activities, as highlighted by M1. Skill transformation and continuous integration are interconnected elements that are vital in transformation initiatives for innovation waves. By investing in skill development and fostering a culture of continuous learning, organisations can effectively integrate new technologies into their operations and drive innovation.

The shipbuilding sector participants underscored the importance of seamless communication within technology systems, revealing the sector’s emphasis on integration to support labour-intensive processes. Conversely, the oil and gas sector, as implied by the absence of oil and gas participants in the analysis, may have different priorities or perspectives regarding skill transformation and integration, potentially influenced by its unique operational challenges and technological requirements. Further, the sector-specific emphasis on continuous integration reflects varying levels of technological adoption and organisational readiness. The shipbuilding participants stressed the necessity for continuous integration in adapting to evolving technological landscapes, which is indicative of a proactive approach to innovation and adaptation. Conversely, the mining participants acknowledged the transformative effects of technology adoption on skills, suggesting a potential need for ongoing skill development to support continuous integration efforts.

6.6 Summary

This chapter uncovered 24 interrelationships among 10 organisational dynamic capabilities within the Australian heavy industry context. The analysis categorised these interrelationships into connections between sensing and seizing capabilities, sensing and reconfiguring capabilities, and seizing and reconfiguring capabilities. A critical comparison between the shipbuilding, mining, and oil and gas participant responses revealed nuanced differences in approaches to organisational capabilities and innovation waves. Shipbuilding, characterised by a higher level of commitment to innovation waves, exhibited a proactive stance towards leveraging knowledge resources and promoting a learning culture. In contrast, the mining sector emphasised leadership adaptability and skill transformation to optimise operational efficiency, while the oil and gas sector prioritised strategic planning and risk management amid a complex regulatory landscape. These sector-specific nuances highlight the need for strategies to be customised to address unique challenges and priorities in driving successful transformation initiatives for innovation waves. By critically comparing sectoral approaches and considering participant characteristics, this chapter offered valuable insights into fostering innovation and driving innovation waves in the heavy industry sector.

CHAPTER 7: DISCUSSION

7.1 Objective

This chapter discusses the findings outlined in Chapters 5 and 6, linking them with the existing literature introduced in Chapters 2 and 3. It is organised to tackle the two main research questions of the thesis. Section 7.2 discusses the organisational dynamic capability required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0) in the Australian heavy industry, and the discussion in Section 7.3 centres around the interrelationships among the capabilities in the Australian heavy industry.

7.2 RQ1—Sensing, Seizing and Reconfiguring

Chapter 2 (Context) revealed that there are many challenges for innovation waves, implying a prerequisite condition for successful innovation in the heavy industry. However, there was a lack of studies focusing on the organisational capabilities required for innovation waves. The research problem addressed in this thesis pertains to organisational dynamic capabilities, specifically focusing on sensing, seizing and reconfiguring, within the Australian heavy industry. The first research question (RQ1) guiding this inquiry is:

> *What are the key organisational dynamic capabilities (sensing, seizing and reconfiguring) required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0) in the Australian heavy industry?*

The novel findings are the clear categorisation of the 10 capabilities required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0) into three dynamic capabilities:

1. Sensing: Strategic foundation, knowledge and management
2. Seizing: Value recognition, implementation-centred approach and understanding resistance
3. Reconfiguring: Continuous integration, leadership and communication, cultural transformation, and skill transformation.

Further, the thesis findings affirm the validity of 10 capabilities and 26 attributes (RED) identified in the existing literature. A total of 18 new attributes (BLUE) were found in the context of the Australian heavy industry, as shown in Table 33. In addition, the significant findings are nuanced differences in capabilities and their attributes between the shipbuilding, mining, and oil and gas sectors.

Table 33: Attributes of organisational dynamic capability (new, validated, independent)

Organisational dynamic capability	Attributes
1. Strategic foundation	Digital scenario planning and scouting Digital strategy Strategic prioritisation Technology-based strategies Strategic foresight Solution-centric strategy Long-term digital vision Strategic alignment Purpose-driven approach Understanding external and internal factors
2. Knowledge	Knowledge enhancement Collaboration Knowledge management Open innovation Internal assessment Balancing technology and product knowledge Human knowledge and insight
3. Management	Fast decision-making Management commitment Management leadership Bridging top, middle, and lower Management
4. Value recognition	Circular economy Sustainability Value translation with end users Value quantification Indirect value
5. Implementation-centred approach	Human–machine collaboration People-centred approach Resource management Implementation resource Methodological implementation
6. Understanding resistance	Human social capability Ethical consideration Policy and standard Resilience Resistance and fear Process for privacy concerns
7. Continuous integration	Personalisation Process and IT know-how Integration Digital solutions integration Adept integration Seamless integration Continuous improvement Customisation Research and development In-house capabilities Gradual integration
8. Leadership and communication	Digital leadership Proper communication Transparent communication Transformational Leadership Clear communication Diverse leadership styles
9. Cultural transformation	Flexibility Risk-taking culture Digital culture Adaptability Agility Culture of innovation Open culture Fostering agile culture Cultivating cultural shift
10. Skill transformation	Managerial skills Skill training Training mechanism Soft skills Continuous learning and resilience Reskilling and upskilling

In the following sections, the novel findings on each capability are discussed linking to the relevant literature.

7.2.1 Sensing

Sensing capability refers to the adeptness in scanning, learning and interpreting information to identify emerging opportunities within innovation waves. The thesis findings reveal three key organisational dynamic capabilities essential for this process: strategic foundation, knowledge and management. Each of these capabilities is examined in the subsequent sections in conjunction with the existing literature.

7.2.1.1 Strategic Foundation

The purpose-driven approach represents a significant new finding that contrasts sharply with the technology-first mindset often emphasised in the existing literature. Although Chavez et al. (2023) highlighted the human-centric dimension of digital strategies, they did not look into the necessity for aligning technological advancements specifically with organisational needs and challenges. The thesis findings stress that technology should address specific organisational pain points rather than being adopted for its novelty. This perspective introduces a critical shift towards more strategic and problem-solving orientations in transformation initiatives for innovation waves. The emphasis on a purpose-driven approach also reveals sector-specific insights. For example, the mining sector prioritises addressing specific organisational challenges with technology, focusing on operational efficiency and goal-oriented approaches. This sector-specific emphasis highlights a practical shift towards more targeted and impactful transformation efforts for innovation waves, contrasting with the oil and gas sector's broader consideration of factors owing to its complex regulatory environment and diverse stakeholder interests.

The emphasis on understanding external and internal factors is another novel finding, broadening the scope beyond what is commonly discussed in the literature. For instance, even though Feroz et al. (2023) and Ghobakhloo et al. (2023c) discussed the need for rapid adaptation to evolving industry landscapes and the holistic nature of Industry 4.0 principles, they did not explicitly highlight the role of regulatory environments, stakeholder interests or market dynamics in shaping strategies for innovation waves. The thesis findings introduce the significance of organisational adaptability and responsiveness to external pressures. This aspect was less explored in the study by Ghobakhloo et al. (2023c), which tended to focus more on internal organisational dynamics and technological capabilities. By highlighting how external factors such as regulations, legislation, shareholder pressure and government mandates influence technology adoption, the thesis findings suggest that organisations need to stay vigilant and adaptive. This broader consideration of factors is particularly pertinent in sectors such as oil and gas, where regulatory compliance and market demand significantly influence technology adoption. The shipbuilding sector, while not explicitly mentioning external factors in the thesis findings, likely faces similar external pressures such as market demand and regulatory compliance. However, the sector's emphasis might be more internally focused or influenced by factors not explicitly mentioned. This suggests variability in how different sectors prioritise and respond to internal and external factors, reflecting the unique dynamics and challenges of each industry.

The validated finding of a long-term digital vision is consistent with the existing literature but adds practical insights into its implementation. The thesis findings emphasise the importance of having a clear, long-term vision as a guiding beacon for innovation waves. This finding supports the notion presented by Feroz et al. (2023) on the necessity for coherent digital strategies aligned with evolving business objectives. However, the thesis findings add practical insights by illustrating how a well-defined vision helps in aligning organisational efforts and fostering strategic clarity. This practical emphasis on strategic foresight (Vu et al. 2023) and the need for continuous adaptation to market fluctuations reinforces the critical role of a long-term vision in achieving successful transformation for innovation waves. In the mining sector, the specific emphasis on strategic alignment and clarity, as highlighted by S9, indicates a focus on operational efficiency and goal-oriented approaches. This perspective aligns with the broader industry trend of integrating digital strategies into overarching organisational goals, ensuring that technology choices are strategically leveraged to achieve business objectives. This finding supports the assertion by Feroz et al. (2023) regarding the necessity for coherent digital strategies aligned with evolving business objectives and the role of strategic foresight (Vu et al. 2023) in guiding organisational responses to dynamic business landscapes.

The critical role of strategic alignment aligns with the discussion by Yeow, Soh and Hansen (2018) on the iterative nature of strategic alignment. However, our findings provide a more nuanced understanding by illustrating how strategic alignment ensures that digital initiatives are in line with overarching organisational goals. This practical emphasis on aligning technology choices with a long-term business vision supports the findings of Dubey et al. (2024) on the importance of cohesive work environments and strategic initiatives aimed at fostering alignment across diverse age groups.

Age dynamics play a significant role in technology adoption and innovation across the sectors. Younger leaders are generally more open to innovation and transformation, as highlighted by the participants. This openness facilitates greater agility and responsiveness to technological change, positioning younger leaders as catalysts for driving organisational agility and innovation. Conversely, older leaders, typically in their late 50s, exhibit a lower inclination towards innovation, potentially hindering progress in innovation waves. The thesis finding aligns with the emphasis made by Dubey et al. (2024) on the importance of bridging generational divides through strategic alignment and fostering cohesive work environments.

The thesis findings reveal distinct approaches to innovation waves across different sectors. The oil and gas sector's focus on external factors, such as regulatory compliance and market demand, contrasts with the mining sector's emphasis on purpose-driven technology adoption. This divergence reflects the unique regulatory environments and market conditions of each sector. The shipbuilding sector, although not explicitly discussed in terms of external factors, likely faces similar challenges but may prioritise internal factors differently. These sector-specific insights highlight the importance of tailoring strategies for innovation waves to the unique dynamics of each industry. By understanding and addressing the specific needs and challenges of different sectors, organisations can develop more effective and targeted strategies for innovation waves, ensuring that technological investments are aligned with broader organisational goals and industry-specific requirements.

7.2.1.2 Knowledge

The new finding of internal assessments as a critical component of knowledge management provides a novel perspective not extensively discussed in the existing literature. While Vu et al. (2023) and Rangaswamy (2021) emphasised the importance of knowledge management and enhancement, they did not explore the role of internal assessments in this context. The thesis findings highlight how structured internal assessments help organisations map their technological capabilities and readiness. This process enables organisations to benchmark against industry standards and identify gaps, thus enhancing their sensing capabilities. This insight aligns with and extends the work of Rangaswamy (2021) by suggesting that internal assessments provide a holistic understanding of both technological and organisational readiness, which is essential for anticipating and responding to digital disruptions. The sector-specific insights further illustrate this point. For example, the shipbuilding sector's use of assessment tools to map technologies capabilities contrasts with the oil and gas sector's broader approach, incorporating both technological and organisational aspects. This divergence highlights the need for customised internal assessments aligned with each sector's characteristics to effectively enhance sensing capabilities.

The other new finding of balancing technology and product knowledge introduces a significant dimension to the discourse on knowledge management, particularly in the heavy industry. Although the existing literature, such as that by Narkhede et al. (2024), emphasised the importance of collaboration and knowledge sharing, it did not explicitly address the generational gap in knowledge and experience. The thesis findings reveal that integrating advanced technologies is often hindered by this generational gap, with older workers possessing deep product knowledge but lacking technological proficiency, and younger workers being technologically adept but lacking industry-specific experience. This insight is critical since it underscores the need for strategies that bridge this gap, such as combining the experience of older workers with the technological expertise of younger generations. The thesis finding confirms the importance of leveraging both sets of skills through a well-designed model, which is essential for aligning technology with industry-specific knowledge. This finding adds a practical layer to the theoretical discussions on collaboration and knowledge management by illuminating the specific challenges and solutions related to generational knowledge gaps.

Another novel finding is the nuanced understanding of the interplay between technology and human capabilities, revealing the significance of human knowledge and insight. Although technology can handle repetitive tasks, human involvement remains indispensable for complex, labour-intensive processes. This perspective aligns with the literature on knowledge management but adds a critical layer by emphasising that technology should complement, rather than replace, human capabilities. For instance, one of the participants' (M3) assertion about the need for well-defined processes that incorporate human expertise underscores the importance of human cognition in interpreting and utilising technological advancements. This finding extends the work of Sousa-Zomer, Neely and Martinez (2020), and Henriksen and Thomassen (2023), who emphasised the strategic importance of collaboration and stakeholder engagement as a vehicle for knowledge sharing and co-creation by stressing the irreplaceable value of human insight in complex scenarios.

The validated finding of collaboration aligns well with the existing literature and underscores its pivotal role in knowledge management and innovation. Sousa-Zomer, Neely and Martinez (2020), and Mihardjo and Alamsyah (2019) highlighted the need to build digital ecosystems and leverage customer insights through collaboration. The thesis findings reinforce these perspectives by illustrating how collaboration enhances organisational capabilities to sense and respond to technological advancements. However, the thesis finding also reveals sector-specific differences in collaboration practices. For example, the shipbuilding sector's emphasis on cross-industry learning contrasts with the mining sector's reluctance to seek inspiration outside its own industry. This insularity limits the potential for cross-industry learning and innovation, revealing a critical area for improvement.

The role of knowledge enhancement is well documented in the literature, with Vu et al. (2023) and Rangaswamy (2021) emphasising its importance in driving organisational performance. The thesis findings provide practical insights into how knowledge enhancement can be achieved through structured internal assessments and the involvement of external consultants. These insights align with the theoretical discussions on knowledge enhancement but add practical dimensions by illustrating the specific strategies and tools used by organisations.

Knowledge management is the other validated finding that aligns with the existing literature. Rangaswamy (2021) highlighted the multifaceted nature of knowledge management, emphasising its role in creating, refining, sharing and applying knowledge within an organisation. The thesis findings extend this perspective by highlighting the practical challenges and solutions in managing knowledge, such as the generational gap in knowledge and the need for internal assessments to identify and address gaps.

Open innovation, as discussed in the literature, encompasses a broad spectrum of strategies for engaging external ideas and technologies. Lepore et al. (2023) and Naruetharadhol et al. (2022) emphasised the importance of networking and collaboration in fostering innovation. The thesis findings corroborate these perspectives but highlight the practical challenges of open innovation in heavy industries. For example, the interview data (M2 and M5) highlights the reluctance within the heavy industry to learn from other sectors, which impedes progress and innovation. The thesis findings also reveal sector-specific differences in attitudes towards open innovation. Even though the shipbuilding sector embraces cross-industry learning, the mining sector remains sceptical, and the oil and gas sector relies on external consultants for specialised knowledge. These differences underscore the need for tailored strategies to foster a culture of openness and curiosity across sectors, essential for effective sensing and innovation.

7.2.1.3 Management

The new finding of bridging top, middle and lower management introduces a crucial perspective on effective management leadership that has not been extensively covered in the existing literature. Although studies by Dubey et al. (2024) and Ghosh et al. (2022) noted the importance of management commitment and leadership, they did not examine the dynamics of integrating leadership across all organisational levels. The thesis findings reveal that ensuring alignment and coherence across top, middle, and lower management facilitates the seamless implementation of strategic goals and transformation efforts for innovation waves. For instance, the interview data (S4 and M7) highlight that top management’s endorsement of bottom-up initiatives is necessary, emphasising that without financial and resource support from the top, grassroots efforts cannot succeed. This perspective aligns with Chirumalla (2021), who advocated for visionary leadership but added depth by highlighting the critical role of top management in supporting and enabling lower-level initiatives.

Additionally, middle management's role in translating strategic directives into practical applications is pivotal. This finding extends the discussion by illustrating how middle managers act as essential liaisons, ensuring that digital strategies are adapted based on real-world feedback, thus enhancing sensing capabilities. This practical insight complements the study by Tumbas, Berente and Vom Brocke (2020) on the roles of CDOs by highlighting the importance of middle management in operationalising innovation waves. The sector-specific differences further illustrate this point. The shipbuilding sector's emphasis on top-down support contrasts with the mining sector's bottom-up empowerment approach. The mining sector values grassroots initiatives and employee engagement, fostering a culture of innovation and adaptability. These differences underscore the need for customised leadership strategies that align with the unique organisational cultures and priorities within each sector.

The validated finding of management commitment aligns well with the existing literature but adds practical insights into its implementation. Dubey et al. (2024) and Ghosh et al. (2022) emphasised the importance of senior management's commitment to driving innovation waves. The thesis findings highlight that management's hands-on involvement and understanding of technological needs encourage trust and alignment within teams. This practical perspective reinforces the theoretical discussions on management commitment by illustrating how it enhances an organisation's ability to sense and capitalise on new opportunities. The interview data's emphasis on strategic investments and the development of digital infrastructure aligns with the findings of Santos et al. (2023) on the broader cultural implications of management commitment. By investing in digital technologies and nurturing a digital culture, organisations can create an environment conducive to innovation and adaptability. This commitment is crucial for building the capabilities necessary to identify and respond to changes in the external environment.

Management leadership is another validated finding that corresponds with the existing literature. Studies by De Sousa Jabbour et al. (2018) and Vu et al. (2023) noted the importance of effective management leadership in guiding organisations through digital transformation. The thesis findings extend this perspective by emphasising the need for flexible, proactive leadership that bridges top, middle and lower management levels. The interview data illustrate how leadership at all levels fosters a culture of initiative-taking and empowers employees to drive technological changes aligned with business objectives. The shipbuilding sector's emphasis on top-down leadership and the mining sector's focus on bottom-up empowerment reflect the unique leadership dynamics within each industry. These differences reveal the need for customised leadership strategies that address the specific needs and challenges of different sectors, ensuring effective transformation for innovation waves.

The new and validated findings accentuate the critical role of integrated leadership and management commitment in enhancing sensing capabilities. By bridging top, middle and lower management, organisations can ensure that strategic goals are aligned with operational realities, fostering a culture of innovation and adaptability. This alignment is essential for identifying and responding to new opportunities and technological advancements. Sector-specific insights reveal distinct approaches to leadership and management commitment. The shipbuilding sector's structured, top-down approach contrasts with the mining sector's decentralised, bottom-up strategy. These differences highlight the importance of aligning leadership strategies with organisational cultures and priorities to maximise the effectiveness of transformation efforts for innovation waves.

In summary, the comprehensive exploration of sensing capability within the context of digital transformation reveals several critical insights. The findings underscore the importance of understanding both external and internal factors, emphasising the need for regulatory and market dynamics, organisational adaptability and sector-specific responses to external pressures. These insights are encapsulated in Table 34, which summarises the key findings and their implications, highlighting the multifaceted nature of the sensing capabilities required to navigate innovation waves effectively.

Table 34: Key findings and implications of sensing capability

Sensing capability	**Key findings**	**Implications**
Strategic foundation	• The purpose-driven approach contrasts sharply with the technology-first mindset, emphasising the alignment of technological advancements with organisational needs and challenges. • Capability to detect and respond to external and internal changes effectively. • Regulatory environments, stakeholder interests and market dynamics play significant roles in shaping sensing capabilities. • Adaptability and responsiveness are vital for leveraging sensing capabilities to drive innovation and maintain competitiveness. • The importance of a clear, long-term vision as a guiding beacon for innovation waves. illustrates how a well-defined vision helps align organisational efforts and foster strategic clarity.	• Highlights the necessity for organisations to adopt technology strategically, addressing specific pain points rather than for novelty. • Enhances the sensing mechanism to effectively reflect the external and internal changes. • Highlights the importance of integrating regulatory and market intelligence into organisational sensing processes. • Suggests that organisations need flexible and responsive structures to utilise sensing capabilities effectively. • Reinforces the necessity for coherent digital strategies aligned with evolving business objectives, aiding in strategic clarity and alignment. • Highlights the role of strategic foresight and continuous adaptation to market fluctuations for successful transformation initiatives.

Sensing capability	Key findings	Implications
Knowledge	• Internal assessments are a critical component of knowledge management, helping organisations map their technological capabilities and readiness. • Integrating advanced technologies is hindered by the generational gap in knowledge and experience. • Technology should complement, not replace, human capabilities, particularly in complex, labour-intensive processes. • Collaboration enhances organisational capabilities to sense and respond to technological advancements, with sector-specific differences in practices. • Structured internal assessments and the involvement of external consultants are effective strategies for knowledge enhancement. • Sector-specific differences in attitudes towards open innovation affect progress and innovation in heavy industries.	• Enhances organisations' ability to benchmark against industry standards, identify gaps and improve sensing capabilities. • Reveals the need for strategies to bridge this gap by combining the experience of older workers with the technological expertise of younger generations. • Emphasises the importance of human insight and cognition in interpreting and utilising technological advancements. • Highlights the potential for improvement in cross-industry learning and collaboration to drive innovation. • Provides practical dimensions to theoretical discussions on knowledge enhancement, illustrating specific strategies and tools used by organisations. • Suggests tailored strategies to foster a culture of openness and curiosity, essential for effective sensing and innovation.
Management	• Ensuring alignment and coherence across all management levels facilitates seamless implementation of strategic goals and transformation efforts. • Middle managers act as essential liaisons, translating strategic directives into practical applications based on real-world feedback. • Different sectors require tailored leadership strategies aligned with their unique organisational cultures and priorities. • Hands-on involvement and an understanding of technological needs by senior management foster trust and alignment within teams. • Effective management leadership at all levels is crucial for guiding organisations through digital transformation and encouraging a culture of initiative-taking.	• Emphasises the critical role of top management in supporting and enabling lower-level initiatives, enhancing sensing capabilities and strategic clarity. • Stresses the importance of middle management in operationalising innovation waves, ensuring digital strategies are adapted effectively. • The shipbuilding sector emphasises top-down support, while the mining sector values bottom-up empowerment, reflecting diverse approaches to fostering innovation. • Reinforces the importance of strategic investments in digital technologies and fostering a digital culture to create an environment conducive to innovation. • Highlights the need for flexible, proactive leadership that bridges top, middle and lower management levels, tailored to sector-specific needs and challenges.

7.2.2 Seizing

Seizing capabilities are centred on capturing the value of changes once opportunities have been identified, helping organisations to capitalise on these opportunities effectively. The thesis findings show that three distinct capabilities were found, encompassing value recognition, an implementation-centred approach and understanding resistance. These capabilities are further discussed in the subsequent sections, along with the existing literature.

7.2.2.1 Value Recognition

The new finding of value translation with end users highlights a crucial aspect of value recognition that is often underexplored in the existing literature. Although the literature, such as that by

Henriksen and Thomassen (2023), underscored the importance of human-centricity in Industry 5.0, the thesis findings provide a detailed perspective on how value must be effectively communicated to end users to ensure successful technology adoption. The interview data emphasised the importance of demonstrating tangible benefits, such as improved safety and enhanced work experience, to those who utilise the new technologies. This practical approach underscores the necessity for involving end users in decision-making processes to bridge the gap between management and frontline workers. This participatory decision-making process ensures that the technology is not only adopted, but also optimally utilised, thus enhancing overall organisational efficiency and safety. This finding extends the existing literature by adding a layer of practical implementation, highlighting the need for a collective understanding and shared ownership in the transformation journey for innovation waves. It reveals the importance of effective communication and engagement strategies to align technological advancements with end user needs and expectations.

The complexity of value quantification is the other significant new finding. Despite the literature often focusing on the strategic and financial aspects of technology adoption, the thesis findings reveal the multifaceted challenges of quantifying value, particularly when it involves intangible benefits such as safety and wellbeing. The interview data highlighted the importance of robust ROI analyses to justify technology investments, echoing the findings of Narkhede et al. (2024) regarding the need for the evaluation of new technologies. However, the thesis findings add depth by illustrating the hidden costs and complexities involved in these calculations, such as the need for additional resources (e.g. software engineers). The thesis findings further emphasise that not all benefits are immediately quantifiable, which necessitates a comprehensive approach to value assessments that includes both direct and indirect benefits. By highlighting the practical challenges and the need for rigorous data collection and analysis, the thesis findings provide a more nuanced understanding of value quantification in the context of innovation waves.

Understanding and acknowledging indirect value is another critical new finding. Even though direct values such as cost reduction and quality improvement are often prioritised, the thesis findings recognise the importance of also considering indirect values such as enhanced health and safety, which contribute to long-term organisational benefits. The interview data stressed the importance of looking beyond immediate impacts to consider long-term benefits, a perspective that is often under-represented in the literature. This finding reveals the need for a more holistic approach to value recognition, one that balances immediate financial gains with long-term strategic advantages. The sector-specific insights provide additional depth to this finding. For instance, the oil and gas sector's balanced approach to both direct and indirect benefits contrasts with the mining sector's focus on immediate impacts and regulatory compliance. These differences underscore the importance of customising value recognition strategies to the specific needs and priorities of different sectors.

The new findings on value translation with end users, value quantification and indirect value show the critical role of comprehensive value recognition in innovation waves. By involving end users in decision-making processes, organisations can ensure that technological advancements are effectively adopted and utilised, enhancing overall efficiency and safety. The complexity of value quantification highlights the need for rigorous ROI analyses that consider both direct and hidden costs, ensuring that investments are strategically justified. Finally, acknowledging indirect values underscores the importance of a holistic approach to value recognition that balances immediate financial gains with long-term strategic advantages.

The thesis finding reveals distinct approaches to value recognition across different sectors. The mining sector's focus on immediate, tangible benefits reflects a practical approach driven by younger, mid-level experience participants keen on seeing quick results. In contrast, the oil and gas sector's emphasis on persuading employees and balancing immediate and long-term benefits suggests a mature, strategic approach shaped by extensive industry experience. The shipbuilding sector's prioritisation of enhancing work experiences through technology reveals a user-centric approach, reflecting deep industry tenure and a focus on user satisfaction. These sector-specific insights highlight the importance of tailoring value recognition strategies to the unique priorities and challenges of each sector. By aligning practical insights with theoretical concepts, this thesis contributes to a more comprehensive framework for value recognition in innovation waves, underscoring the importance of inclusive approaches that consider both direct and indirect benefits.

7.2.2.2 Implementation-Centred Approach

The new finding of implementation resource allocation reinforces the significance of aligning resources with the specific needs of technological adoption. Although the literature, such as that by Chirumalla (2021) and Ghobakhloo et al. (2023c), highlighted the necessity for resource management in digital transformation, the thesis findings reveal a critical gap in practical resource allocation across the heavy industry. The interview data emphasised that, even though significant resources are earmarked for R&D, there is a notable lack of resources dedicated to the practical implementation and on-site support necessary for successful technology adoption. This adds in-depth insights into the work of Dubey et al. (2024), who highlighted the need for the strategic nurturing and development of human capital. The thesis findings extend the literature by illustrating the specific challenges and shortcomings in resource allocation. For instance, the interview data noted that overlooking on-site resources can hinder the success of transformation initiatives for innovation waves. This insight adds depth to the theoretical discussions on resource management by highlighting the practical implications of inadequate resource allocation. Further, the emphasis on management understanding and commitment to resource allocation underscores the importance of top-down support in providing the necessary financial and human resources for technology initiatives. Sector-specific insights reveal distinct approaches to resource allocation. The shipbuilding sector prioritises strategic resource allocation, ensuring efficient utilisation and avoiding the underutilisation of completed projects. In contrast, the mining sector demonstrates a limited recognition of implementation resource allocation, suggesting a need for improved strategies and management support. The oil and gas sector emphasises management commitment to resource allocation but also notes challenges in fully utilising project benefits, indicating that enhanced execution strategies are required.

The novel finding of methodological implementation highlights the importance of a systematic approach to aligning technology with people for effective implementation. Despite the existing literature, such as that by Henriksen, Røstad and Thomassen (2022), emphasising human-centricity, the thesis findings provide practical insights into how methodological implementation facilitates successful technological integration. The interview data emphasised the importance of implementation trials and the role of dedicated digitalisation managers in ensuring seamless transitions to digital processes. This perspective aligns with the work of Modgil, Singh and Agrawal (2023), who emphasised the importance of talent acquisition, development and retention in the Industry 5.0 landscape. The thesis findings extend the literature by illustrating the practical steps involved in methodological implementation, such as small pilot runs and prototyping to validate technology effectiveness. The thesis finding’s emphasis on proving technology’s effectiveness via trials before expecting widespread adoption underscores the need for systematic planning. This insight adds depth to the theoretical discussions on methodological implementation by highlighting the specific actions necessary for successful technology adoption. Sector-specific insights reveal distinct approaches to methodological implementation. The mining sector stresses systematically aligning technology with people, reflecting a proactive approach. The shipbuilding sector prioritises dedicated digitalisation managers and technology site trials, while the oil and gas sector focuses on ensuring seamless transitions to digital processes. These differences highlight the need for tailored approaches to address the specific needs and challenges of each sector.

The validated finding of a human-centred approach aligns well with the existing literature, confirming its importance in innovation waves. Studies by Henriksen, Røstad and Thomassen (2022) and Chavez et al. (2023) showed the critical role of human-centric digital transformation in enhancing process resilience and flexibility. The thesis findings emphasise the importance of people's acceptance, adaptation and willingness to embrace changes. This perspective reinforces the theoretical discussions by illustrating the practical challenges and strategies involved in aligning technology with the human element. The thesis findings add depth to the existing literature by highlighting the importance of effective communication and support for late adopters. The interview data emphasised the need for appointing champions and involving the right individuals early on to ensure technology adoption. This practical insight complements the theoretical discussions by illuminating the specific actions necessary to foster a human-centred approach in innovation waves. Sector-specific insights reveal distinct approaches to a human-centred approach. The shipbuilding sector acknowledges a semi-mature stance, in which technology received significant attention while people were somewhat overlooked. In contrast, the mining sector showcases a proactive approach, emphasising the importance of ensuring that the entire workforce could adapt to new technologies safely and reliably. The oil and gas sector, however, does not explicitly mention a focus on a people-centred approach, suggesting a potential oversight in acknowledging the critical role of human factors in innovation waves.

The validated finding of resource management aligns well with the existing literature and confirms its importance in enabling innovation waves. Studies by Chirumalla (2021) and Dubey et al. (2024) highlighted the critical role of resource management in recruiting and retaining talent and making strategic investment decisions. The thesis findings emphasise the importance of aligning resources with specific needs and the challenges associated with inadequate resource allocation. The thesis findings extend the existing literature by illustrating the specific challenges and shortcomings in resource management. For instance, the interview data noted that overlooking on-site resources can hinder the success of transformation initiatives for innovation waves. This insight adds depth to the theoretical discussions by highlighting the practical implications of inadequate resource allocation. Sector-specific insights reveal distinct approaches to resource management. The shipbuilding sector prioritises strategic resource allocation, ensuring efficient utilisation and avoiding the underutilisation of completed projects. The mining sector demonstrates a limited recognition of implementation resource allocation, suggesting a need for improved strategies and management support. The oil and gas sector emphasises management commitment to resource allocation but also notes challenges in fully utilising project benefits, indicating a need for enhanced execution strategies.

7.2.2.3 Understanding Resistance

The new finding of resistance and fear highlights the critical role that emotional and psychological factors play in the adoption of technological changes. Although the existing literature, such as that by Narkhede et al. (2024), and Dabić, Maley and Nedelko (2023), touched on the importance of addressing human elements in organisational change, the thesis findings provide a deeper understanding of the specific fears and resistance faced by employees in heavy industries. The thesis findings emphasise that fear of job loss, lack of control and unfamiliarity with new technologies are significant barriers to successful transformation for innovation waves. The interview data's assertion that overcoming fear requires a cultural shift towards embracing learning, experimentation and risk-taking aligns with the broader themes of human-centric approaches discussed by Henriksen, Røstad and Thomassen (2022). However, the thesis findings add practical insights by illustrating how organisations can foster a culture that views technology as an opportunity rather than a threat. This involves promoting skill transformation rather than job replacement and emphasising the value-driven approach to technology adoption. Sector-specific insights reveal differing responses to resistance and fear. The shipbuilding sector, with its high-level of commitment to innovation waves, focuses on skill transformation and addressing the fears associated with innovation. In contrast, the mining sector places greater emphasis on fostering a cultural shift and recognising the benefits of automation in improving job roles. These differences highlight the need for strategies to be customised to address sector-specific challenges and foster a culture of adaptability and resilience.

The other novel finding of addressing privacy concerns through clear policies and processes shows how important ethical considerations are in technology implementation. Despite the existing literature, such as that by Santos et al. (2023) and Vu et al. (2023), highlighting the need for adaptive policy frameworks and effective management involvement, the thesis findings provide practical appreciation of how organisations can address privacy concerns to gain employee trust and maximise the benefits of new technologies. The interview data emphasised the importance of transparency and clear communication in addressing privacy concerns. This perspective aligns with the work of Narkhede et al. (2024), who underscored the need for ethical considerations in Industry 5.0. However, our findings go further by illustrating the specific strategies for implementing privacy impact assessments and setting clear boundaries for data use. This includes ensuring that technologies such as facial recognition are deployed strictly for well-defined purposes and within boundaries. Sector-specific insights reveal varying levels of readiness and approaches to addressing privacy concerns. The shipbuilding sector emphasises clear policies, transparent communication, and ethical considerations, reflecting a proactive stance towards responsible technology use. In contrast, the oil and gas sector display a more varied response, with some emphasising the need for strict boundaries and transparency, while others stressed the importance of clear communication and demonstrating the technology’s value proposition to employees. The mining sector’s lack of explicit prioritisation of privacy concerns suggests a potential gap in addressing this aspect of technological adoption. These differences underscore the need for tailored strategies to address privacy concerns effectively and ensure ethical technological adoption across sectors.

The validated finding of ethical consideration aligns well with the existing literature, reinforcing its importance in organisational dynamic capability. Studies by Narkhede et al. (2024) and Henriksen, Røstad and Thomassen (2022) highlighted the significance of fair labour practices, responsible resource management and ethical considerations in Industry 5.0. The thesis findings emphasise that addressing the ethical concerns related to privacy and data use in technology implementation is vital. This perspective reinforces the theoretical discussions by illustrating the practical challenges and strategies involved in ensuring ethical technology use. The other validated finding of policy and standard is consistent with the existing literature that stresses the need for comprehensive policy frameworks to support digital transformation. Studies by Santos et al. (2023) and Vu et al. (2023) revealed the challenges faced by organisations in navigating policy and regulatory landscapes. The thesis findings underscore the importance of clear policies and processes in addressing privacy and ethical concerns. This practical insight adds depth to the theoretical discussions by illustrating the specific actions necessary to implement effective policies and standards. Another validated finding of resilience aligns well with the existing literature and underscores its importance in enabling organisations to withstand disruptions and adapt to changing environments. Studies by the European Commission (2021) and Henriksen and Thomassen (2023) showed the significance of resilience in industrial production and employee competence. The thesis findings emphasise the importance of fostering a culture of resilience to overcome resistance and fear. This perspective reinforces the theoretical discussions by illustrating the practical strategies for enhancing organisational resilience, such as promoting skill transformation and addressing the fears associated with technological change.

The new and validated findings underscore the critical role of addressing emotional, psychological and ethical factors in innovation waves. By understanding and mitigating resistance and fear, organisations can foster a culture of adaptability and resilience. Implementing clear policies and processes to address privacy concerns is essential for gaining employee trust and ensuring ethical technology use. These insights highlight the importance of a holistic approach to innovation waves that considers both technological and human elements. Sector-specific insights reveal distinct approaches to addressing these challenges. The shipbuilding sector’s proactive stance towards responsible technology use and the mining sector's focus on cultural shift and skill transformation reveal the need for tailored strategies to address sector-specific priorities and challenges. The oil and gas sector's varied response to privacy concerns highlights the importance of clear communication and demonstrating the value proposition of the technology to employees.

In summary, the examination of seizing capability highlights the crucial aspects of value recognition, implementation strategies and addressing resistance to change. The findings reveal the importance of translating value to end users, the complexities of value quantification and the necessity for recognising both direct and indirect benefits. Additionally, the research reinforces the significance of proper resource allocation, methodological implementation, and addressing emotional and psychological resistance to technological changes. Table 35 provides a summary of these key findings and their implications, demonstrating the strategies necessary for organisations to seize opportunities and ensure successful innovation.

Table 35: Key findings and implications of seizing capability

Seizing capability	Key findings	Implications
Value recognition	• Effective communication of value to end users is crucial for successful technology adoption. • Quantifying value, particularly intangible benefits such as safety and wellbeing, presents multifaceted challenges. • Considering indirect values, such as enhanced health and safety, is essential for long-term organisational benefits. • Different sectors have varying priorities in value recognition, with some focusing on immediate impacts and others on long-term benefits.	• Emphasises the need for involving end users in decision-making processes to ensure optimal utilisation and enhanced organisational efficiency and safety. • Highlights the necessity for robust ROI analyses and a comprehensive approach to value assessment, considering both direct and hidden costs. • Stresses the importance of a holistic approach to value recognition that balances immediate financial gains with long-term strategic advantages. • Suggests tailoring value recognition strategies to the specific needs and priorities of different sectors to maximise benefits.
Implementation-centred approach	• Aligning resources with the specific needs of technological adoption is critical for successful implementation. • A systematic approach to aligning technology with people is essential for effective implementation. • A human-centred approach is crucial for successful digital transformation, focusing on people's acceptance and adaptation to changes. • Effective resource management is vital for recruiting and retaining talent, and making strategic investment decisions.	• Highlights the need for practical resource allocation, including on-site support, to ensure the success of transformation initiatives. • Emphasises the importance of implementation trials, dedicated digitalisation managers and systematic planning to validate technology effectiveness. • Reinforces the need for effective communication, support for late adopters and involving the right individuals early in the process. • Stresses the importance of aligning resources with specific needs and addressing the challenges of inadequate resource allocation to enable innovation waves.

Seizing capability	Key findings	Implications
Understanding resistance	• Emotional and psychological factors such as fear of job loss, lack of control and unfamiliarity with new technologies are significant barriers to successful transformation. • Addressing privacy concerns through clear policies and processes is needed for gaining employee trust and maximising the benefits of new technologies. • Ethical concerns related to privacy and data use are essential to address in technology implementation to ensure responsible and fair practices. • Comprehensive policy frameworks are necessary to support digital transformation and address privacy and ethical concerns. • Fostering a culture of resilience is essential for overcoming resistance and fear associated with technological changes.	• Emphasises the necessity for a cultural shift towards embracing learning, experimentation and risk-taking to view technology as an opportunity. • Highlights the importance of transparency, clear communication and ethical considerations in technology implementation to ensure responsible use. • Reinforces the need for ethical frameworks and strategies to manage privacy and data use, aligning with fair labour practices and responsible resource management. • Stresses the importance of implementing effective policies and standards to navigate regulatory landscapes and support ethical technology use. • Underscores promoting skill transformation and addressing psychological barriers to enhance organisational adaptability and resilience.

7.2.3 Reconfiguring

Reconfiguring capabilities entail the continuous renewal and transformation of organisational routines, which is essential for sustaining profitable growth amid changing markets and technologies. This capability includes aligning existing resources with new strategies, developing new resources and addressing any resource gaps. The thesis findings reported four key capabilities: continuous integration, leadership and communication, cultural transformation and skill transformation. These capabilities are examined alongside the existing literature in the subsequent sections.

7.2.3.1 Continuous Integration

The novel finding of in-house capabilities emphasises the importance of developing internal resources and expertise to drive continuous integration for innovation waves. Although the existing literature, such as that by Chirumalla (2021) and Ghosh et al. (2022), highlighted the significance of R&D and collaboration with external partners, the thesis findings provide a deeper understanding of the role of in-house capabilities in navigating the complexities of technology adoption. The interview data emphasised that having a dedicated R&D department allows organisations to focus on exploring new technologies and experimenting with innovative solutions tailored to their unique needs. This aligns with the advocacy of Warner and Wäger (2019) for digital innovation laboratories but extends the discussion by highlighting the practical benefits of maintaining in-house expertise. Moreover, the interview data’s insights into the strategic choices between investing in specific suppliers versus developing in-house capabilities underscore the importance of a tailored approach to technology adoption.

Sector-specific insights reveal distinct approaches to developing in-house capabilities. The shipbuilding sector, characterised by a high-level of commitment to innovation waves, prioritises dedicated R&D efforts and collaboration both internally and externally. This proactive stance reflects the sector's recognition of the need for continuous innovation to stay competitive. Conversely, the mining sector, with a relatively lower level of commitment to innovation wave, exhibits a more varied approach shaped by factors such as resource availability and strategic priorities. The observed disparities underscore the need for strategies to be customised to navigate innovation waves effectively, acknowledging sector-specific contexts and organisational characteristics.

The other new finding of gradual integration reveals the importance of adopting an incremental and structured approach to implementing new technologies. Even though the existing literature, such as that by Ellström et al. (2022) and Szalavetz (2019), emphasised the need for seamless integration and strategic prioritisation, the thesis findings provide practical insights into the challenges and benefits of gradual integration, particularly in industries with existing legacy systems. The interview data highlighted the importance of organisational readiness and advanced infrastructure in supporting gradual integration efforts. This perspective aligns with the work of Vu et al. (2023), who emphasised the need for forward-thinking approaches and continuous technological upgrades. However, the thesis findings add depth by illustrating the specific steps involved in gradual integration, such as trials, education, and phased implementation.

Sector-specific insights reveal differing approaches to gradual integration. The shipbuilding sector, with its high-level of commitment to innovation waves, advocates for organisational readiness and advanced infrastructure to navigate complexities effectively. In contrast, the mining sector emphasises planning and phased implementation to accommodate legacy systems, reflecting the sector's limited digital maturity and the complexities inherent in coexisting with outdated infrastructure. These differences highlight the need for tailored strategies to address sector-specific challenges and foster a culture of adaptability and resilience.

The validated finding of continuous improvement corresponds with the existing literature, which underscores its importance in maintaining organisational agility and competitiveness. Studies by Vu et al. (2023) and Rangaswamy (2021) highlighted the need for continuous technological upgrades and process evaluation to remain relevant. The thesis findings emphasise the importance of viewing innovation waves as an ongoing journey rather than a one-time project. This perspective reinforces the theoretical discussions by illustrating the practical strategies for fostering a culture of continuous improvement, such as ongoing research, development efforts and systematic planning. The other validated finding of customisation is consistent with the existing literature that emphasises the need for tailored approaches to technology adoption. Studies by Ghosh et al. (2022) and Thomas et al. (2023) showed the importance of customisation and flexibility in meeting evolving customer demands and mitigating disruptions. The interview data underscored the challenges of integrating new technologies with legacy systems and the need for continuous customisation to align technology with unique business processes. This practical insight adds depth to the theoretical discussions by highlighting the specific actions necessary for effective customisation, such as actively involving end users in the integration process.

Another validated finding of R&D aligns well with the existing literature that underscores its importance in driving innovation and technological advancement. Studies by Warner and Wäger (2019) and Santos et al. (2023) revealed the role of R&D in fostering collaboration and developing new technologies. The thesis findings emphasise the importance of having dedicated R&D departments to explore new technologies and experiment with innovative solutions. This perspective reinforces the theoretical discussions by illustrating the practical benefits of maintaining in-house expertise and fostering collaboration with external partners.

The new and validated findings underscore the critical part played by developing in-house capabilities, adopting gradual integration strategies and fostering continuous improvement in driving innovation waves. By leveraging internal resources and expertise, organisations can navigate the complexities of technology adoption and maintain organisational agility. Implementing gradual integration strategies allows organisations to accommodate legacy systems and ensure successful technology adoption. Fostering a culture of continuous improvement and customisation ensures that technologies are effectively aligned with unique business processes and evolving market demands.

Sector-specific insights reveal distinct approaches to addressing these challenges. The shipbuilding sector's proactive stance towards R&D and advanced infrastructure reflects a high-level of commitment to innovation waves and a focus on continuous innovation. The mining sector's emphasis on planning and phased implementation highlights the need for tailored strategies to accommodate legacy systems and limited digital maturity. The observed disparities reinforce the importance of understanding sector-specific contexts and organisational characteristics in navigating innovation waves effectively.

7.2.3.2 Leadership and Communication

The new finding of diverse leadership underscores the evolving nature of leadership styles necessary for driving organisation transformation for innovation waves. Although the existing literature, such as that by Thomas et al. (2023), and Huang, Jiang and Chang (2023), revealed the importance of transformational and servant leadership, the thesis findings provide a nuanced understanding of the various leadership styles that can facilitate effective transformation for innovation waves. The interview data emphasised the importance of agile leadership, particularly in managing projects within the software domain. This aligns with the dynamic and adaptable leadership styles discussed by Thomas et al. (2023). Moreover, the role of transformational leadership in driving technology adoption is critical. The interview data's assertion that transformational leaders drive innovation and technology integration aligns with the perspectives of Dubey et al. (2024) and El Sawy et al. (2020), who emphasised the transformative nature of digital leadership. However, the thesis findings extend the discussion by highlighting the importance of visionary and engaging leadership styles. The thesis finding's emphasis on visionary leadership for aligning digital initiatives with strategic goals underscores the need for leaders who can see the long-term benefits of technology and articulate this vision to their teams. Sector-specific insights reveal distinct approaches to leadership. The shipbuilding sector prioritises transformational leadership to foster an environment where the value of technology is comprehended and embraced by all employees. This approach reflects the sector's proactive stance towards innovation and efficiency enhancement. In contrast, the oil and gas sector emphasise visionary leadership to align digital initiatives with strategic goals, highlighting the focus on sustainable technological integration. The mining sector underscores the importance of transformational leadership in driving technology adoption, reflecting the need for leaders who inspire innovation and change. These differences show there is a need for tailored leadership strategies that consider sector-specific contexts and organisational characteristics.

The validated finding of proper communication aligns well with the existing literature, which underscores its importance in fostering clarity, alignment, and engagement during transformation for innovation waves. Studies by Dubey et al. (2024) and Santos et al. (2023) emphasised that transparent and effective communication is needed to facilitate employee acceptance of change. The thesis findings emphasise the role of communication in helping employees understand the broader context of innovation waves and the need for change. This perspective reinforces the theoretical discussions by illustrating the practical strategies for effective communication, such as open dialogue and transparency. The other validated finding of transparent communication is consistent with the existing literature, which highlights the importance of openness and clarity in communication during transformation for innovation waves. Studies by Ghobakhloo et al. (2023c) and Santos et al. (2023) confirmed the need for the clear communication of digitisation objectives to facilitate employee acceptance of change. The interview data underscored the importance of addressing employees' multifaceted needs through comprehensive and inclusive communication strategies. This practical insight adds depth to the theoretical discussions by highlighting the specific actions necessary for transparent communication, such as continuous communication with stakeholders and addressing privacy concerns. Another validated finding of transformational leadership corresponds with the existing literature, which underscores its importance in facilitating innovation waves. Studies by Huang, Jiang and Chang (2023), and El Sawy et al. (2020) confirmed the transformative nature of leadership in rethinking business strategy and fostering innovation. The thesis findings emphasise the role of transformational leaders in driving technology adoption and aligning digital initiatives with strategic goals. This perspective reinforces the theoretical discussions by illustrating the practical benefits of transformational leadership, such as inspiring and motivating employees to embrace change.

The new and validated findings underscore the critical role of diverse leadership and effective communication in driving innovation waves. By adopting diverse leadership styles, organisations can navigate the complexities of technological change and foster a culture of innovation. Implementing proper and transparent communication strategies ensures that employees understand the broader context of innovation waves and feel engaged and supported throughout the process. These insights highlight the importance of a holistic approach to leadership and communication that considers both technological and human elements. Sector-specific insights reveal distinct approaches to addressing these challenges. The shipbuilding sector's focus on transformational leadership and transparent communication reflects a proactive stance towards change adoption. The oil and gas sector's emphasis on visionary leadership and narrative-driven communication highlights the importance of aligning digital initiatives with strategic goals. The mining sector's emphasis on transformational leadership and effective communication underscores the need for leaders who inspire innovation and foster employee acceptance of change. These differences highlight the importance of understanding sector-specific contexts and organisational characteristics in navigating innovation waves effectively.

7.2.3.3 Cultural Transformation

The significant finding of fostering an agile culture reflects the importance of creating a cultural environment that embraces flexibility, rapid iteration and continuous improvement. Although the existing literature, such as Chirumalla (2021) and Agarwal, Seth and Agarwal (2022), emphasised the role of agile teams and capabilities in driving innovation waves, the thesis findings highlight the practical aspects of fostering an agile culture within organisations. The interview data emphasised the need for openness, honesty and a willingness to address challenges directly, which aligns with the principles of agile methodologies. Moreover, the importance of fostering an environment where individuals feel empowered to voice their concerns and actively engage in problem-solving is critical. This corresponds with the concept of transformational leadership, where leaders inspire and motivate employees to embrace change. The interview data emphasised the necessity for fostering a culture that embraces change and new technologies, highlighting the importance of leadership and communication in this process. This perspective extends the discussions by Warner and Wäger (2019), who underscored the need for adaptability and rapid prototyping. Sector-specific insights reveal distinct approaches to fostering agile cultures. The oil and gas sector emphasises agility to maintain competitiveness, reflecting its mid to high-level of commitment to innovation waves and the need for flexibility. Conversely, the mining sector faces challenges owing to traditional organisational structures and resistance to cultural change, underscoring the need for a gradual introduction of agile practices. The shipbuilding sector acknowledges the importance of cultural agility in embracing technological advancements but also recognises the potential risks of neglecting cultural transformation. These differences highlight the need for tailored strategies that consider sector-specific contexts and organisational characteristics.

The other new finding of cultivating a cultural shift underscores the need to reshape organisational values, beliefs and behaviours to align with the demands of technological innovation and changing market landscapes. Despite the existing literature, such as Ghosh et al. (2022) and Santos et al. (2023), emphasising the need for a culture of innovation and open experimentation, the thesis findings provide practical insights into the challenges and benefits of cultivating a cultural shift within organisations. The interview data emphasised the importance of leadership and top-down support in driving cultural transformation, particularly in conservative industries. This aligns with the work of Sousa-Zomer, Neely and Martinez (2020), who highlighted the necessity for a risk-taking culture to support innovation. However, the thesis findings add depth by outlining the specific actions necessary for cultivating a cultural shift, such as fostering a mindset of continuous improvement and embracing failure as part of the learning process. Sector-specific insights reveal varying approaches to cultivating cultural shifts. The mining sector emphasises the need for cultural adaptation because of entrenched conservatism, highlighting the challenges of bridging cultural differences between traditional and agile environments. The shipbuilding sector recognises the importance of cultural transformation in embracing technological advancements but also acknowledges the potential risks of neglecting cultural agility. The oil and gas sector notably omits discussions on cultural transformation, reflecting sector-specific priorities and organisational cultures. These differences underscore the need for strategies to be customised to address cultural transformation effectively, considering sector-specific contexts and organisational characteristics.

The validated findings of adaptability and agility align well with the existing literature, which underscores their importance in maintaining organisational resilience and competitiveness in the face of technological change. Studies by Feroz et al. (2023) and Chirumalla (2021) emphasised the need for strategic agility and cross-functional teams to drive innovation waves. The thesis findings emphasise the role of agile culture in promoting flexibility and rapid learning, enabling organisations to swiftly respond to market shifts and technological advancements. This perspective reinforces the theoretical discussions by illustrating the practical strategies for fostering adaptability and agility within organisations. The other validated findings of a culture of innovation and open culture are consistent with the existing literature that highlights the importance of fostering an environment conducive to innovation and experimentation. Studies by Ghosh et al. (2022) and Cruzara et al. (2023) emphasised the need for an open culture to drive successful transformation for innovation waves. The thesis findings underscore the importance of fostering a mindset of continuous improvement and embracing failure as part of the learning process. This practical insight validates the theoretical discussions by highlighting the specific actions required for fostering a culture of innovation and openness within organisations.

The new and validated findings show the critical role of fostering agile cultures and cultivating cultural shifts in driving innovation waves. By creating environments that embrace flexibility, rapid learning and continuous improvement, organisations can navigate the complexities of technological change and foster a culture of innovation. Implementing strategies to cultivate cultural shifts ensures that organisational values, beliefs and behaviours align with the demands of technological innovation and changing market landscapes. These insights highlight the importance of a holistic approach to cultural transformation that considers both technological and human elements. Sector-specific insights reveal distinct approaches to addressing these challenges. The oil and gas sector’s focus on agility and flexibility reflects its need to maintain competitiveness in a rapidly changing environment. The mining sector’s emphasis on gradual cultural shifts highlights the challenges of bridging traditional and agile environments. The shipbuilding sector’s recognition of the importance of cultural agility underscores the need for proactive strategies to embrace technological advancements. These differences highlight the importance of understanding sector-specific contexts and organisational characteristics in navigating cultural transformation effectively.

7.2.3.4 Skill transformation

The thesis findings reveal how important continuous learning and resilience are in driving successful transformation for innovation waves. Continuous learning ensures that employees remain adaptable and proficient in leveraging emerging technologies effectively. Resilience, conversely, allows organisations to withstand and adapt to disruptions, ensuring long-term sustainability. The significance of these attributes is well supported in the literature, with Rangaswamy (2021) advocating for a focused approach to continuous learning and Modgil, Singh and Agrawal (2023) emphasising the importance of managerial skills alongside continuous learning. The thesis findings show that continuous learning involves not only acquiring new technical skills, but also fostering a mindset of adaptability and innovation. This is essential for organisations to stay competitive in a rapidly evolving technological landscape. Resilience, closely linked to continuous learning, enables organisations to recover from setbacks and persist in the face of challenges, ensuring that technological advancements lead to sustained organisational growth. The emphasis on continuous learning and resilience is evident across various sectors. For instance, in the oil and gas sector, there is a strong focus on transitioning employees into roles that complement automation, underscoring the need for continuous skill development to stay ahead of technological advancements. Similarly, the shipbuilding sector prioritises addressing the digital divide between generations and continuous training to enhance technology adoption and proficiency. The mining sector, while more cautious, also recognises the need for continuous learning to stay competitive.

The necessity for reskilling and upskilling to align with technological advancements is another validated finding. As organisations adopt new technologies, existing competencies may become obsolete, necessitating a re-evaluation of the skill composition within the workforce. Reskilling involves training employees to perform new roles, while upskilling focuses on enhancing current skills to meet evolving demands. The literature supports this need, with Santos et al. (2023) and Lepore et al. (2023) highlighting the importance of aligning human resource management practices with reskilling and upskilling initiatives. Reskilling and upskilling are particularly important in ensuring that employees can transition smoothly into new roles that emerge from technological advancements. For example, when automation replaces certain job activities, individuals previously engaged in those tasks must be retrained to operate new technologies or take on different responsibilities. This not only enhances individual career growth, but also contributes to the overall agility and adaptability of the organisation. The emphasis on reskilling and upskilling is reflected in sector-specific practices. In the oil and gas sector, there is a focus on providing employees with the necessary tools, resources and training to adapt to the digital environment. The shipbuilding sector emphasises the importance of reskilling workers to operate alongside technology, reflecting the sector’s innovative orientation. The mining sector, while cautious, acknowledges the need to evaluate current skill sets in light of emerging technologies, especially for on-site trade workers.

Continuous learning and resilience are universally recognised as essential for navigating innovation waves. In the oil and gas sector, continuous learning aligns with the sector’s high-level of commitment to innovation waves, indicating readiness for technological advancements. The shipbuilding sector's emphasis on addressing the digital divide and continuous training highlights the need to bridge generational gaps and enhance proficiency in new technologies. The mining sector’s focus on fostering social skills and emotional intelligence alongside technical proficiency underscores the irreplaceable value of human contributions in decision-making processes. The emphasis on continuous learning and resilience across these sectors suggests that organisations must invest in creating a learning culture that encourages adaptability and continuous improvement. This involves implementing comprehensive training programs, fostering a mindset of lifelong learning and ensuring that employees have access to the resources and support needed to develop new skills.

The necessity for reskilling and upskilling is evident across all sectors, highlighting the importance of aligning workforce competencies with technological advancements. In the oil and gas sector, the focus is on transitioning employees into roles that complement automation, ensuring that employees are equipped with the skills needed to operate new technologies. The shipbuilding sector’s emphasis on reskilling workers to operate alongside technology reflects the sector’s commitment to innovation and enhancing human capabilities. The mining sector’s cautious approach to reskilling and upskilling suggests a need to balance innovation with the retention of traditional skills, ensuring a smooth transition without compromising quality or safety standards. Organisations must therefore implement strategic reskilling and upskilling programs that are tailored to the specific needs of their industry and workforce. This involves identifying skill gaps, providing targeted training and fostering a culture of continuous learning to ensure that employees can adapt to new technologies and changing job requirements.

In summary, the discussion of reconfiguring capability focuses on the continuous integration of new technologies, leadership and communication, cultural transformation and skill transformation. The findings emphasise the importance of developing in-house capabilities, adopting gradual integration approaches, fostering agile cultures, and cultivating continuous learning and resilience. Further, the thesis highlights the need for diverse leadership styles and transparent communication to facilitate organisational transformation. Table 36 summarises these key findings and their implications, illustrating the critical strategies required for organisations to reconfigure their operations and maintain competitiveness in the face of innovation waves.

Table 36: Key findings and implications of reconfiguring capability

Reconfiguring capability	Key findings	Implications
Continuous integration	• Developing internal resources and expertise is crucial for driving continuous integration and innovation waves. • Adopting an incremental and structured approach to implementing new technologies helps accommodate existing legacy systems. • Viewing innovation waves as an ongoing journey, not a one-time project, is essential for maintaining organisational agility and competitiveness. • Tailored approaches to technology adoption are necessary to meet evolving customer demands and integrate with unique business processes. • Dedicated R&D departments are vital for exploring new technologies and experimenting with innovative solutions.	• Emphasises the importance of dedicated R&D departments and maintaining in-house expertise for tailored technology adoption and strategic flexibility. • Highlights the need for organisational readiness, advanced infrastructure and phased implementation to support successful technology integration. • Reinforces the need for continuous technological upgrades, process evaluation and systematic planning to foster a culture of continuous improvement. • Stresses the importance of active end user involvement and continuous customisation to align new technologies with specific organisational needs. • Highlights the practical benefits of maintaining in-house expertise and fostering collaboration with external partners to drive technological advancement.
Leadership and communication	• Various leadership styles, including agile, transformational and visionary leadership, are crucial for driving organisational transformation. • Different sectors require tailored leadership strategies to navigate technological changes effectively. • Transparent and effective communication is essential for fostering clarity, alignment and engagement during transformation. • Clear communication of digitisation objectives is crucial for facilitating employee acceptance and addressing multifaceted needs. • Transformational leaders play a pivotal role in driving technology adoption and aligning digital initiatives with strategic goals.	• Emphasises the need for leaders who can adapt to dynamic environments, inspire innovation and align digital initiatives with strategic goals. • Highlights the importance of understanding sector-specific contexts to develop leadership styles that foster innovation and employee engagement. • Reinforces the need for open dialogue and continuous communication to help employees understand the broader context and necessity for change. • Stresses the importance of comprehensive and inclusive communication strategies, including continuous stakeholder engagement and addressing privacy concerns. • Illustrates the practical benefits of transformational leadership in inspiring and motivating employees to embrace change and foster innovation.
Cultural transformation	• Creating a cultural environment that embraces flexibility, rapid iteration and continuous improvement is essential for innovation waves. • Reshaping organisational values, beliefs and behaviours to align with technological innovation and changing market landscapes is crucial. • Promoting flexibility and rapid learning enables organisations to swiftly respond to market shifts and technological advancements.	• Emphasises the importance of openness, honesty and empowerment in fostering a culture that embraces change and new technologies. • Highlights the need for leadership and top-down support in driving cultural transformation, particularly in conservative industries. • Reinforces the need for strategic agility and cross-functional teams to drive innovation and maintain organisational resilience. • Stresses the importance of creating an environment conducive to innovation and

Reconfiguring capability	Key findings	Implications
	• Fostering a mindset of continuous improvement and embracing failure as part of the learning process is vital for successful transformation. • Different sectors require tailored strategies to effectively navigate cultural transformation and foster innovation.	experimentation to drive successful transformation for innovation waves. • Highlights the need for understanding sector-specific contexts and organisational characteristics to develop effective cultural transformation strategies.
Skill transformation	• Continuous learning and resilience are crucial for driving successful transformation and maintaining organisational sustainability. • Reskilling and upskilling are necessary to align workforce competencies with technological advancements and evolving demands. • Different sectors exhibit unique strategies for implementing continuous learning, reskilling and upskilling to stay competitive. • Bridging generational gaps and enhancing proficiency in new technologies are essential for successful technology adoption. • Fostering social skills and emotional intelligence alongside technical proficiency is crucial for effective decision-making and collaboration.	• Emphasises the need for fostering a mindset of adaptability and innovation, ensuring that employees remain proficient in leveraging emerging technologies. • Highlights the importance of providing comprehensive training programs, resources and support to ensure employees can transition smoothly into new roles and enhance their skills. • Stresses the need for tailored strategies that address sector-specific challenges and opportunities, ensuring a smooth transition to new technologies. • Reinforces the importance of continuous training and fostering a culture of lifelong learning to bridge the digital divide and ensure all employees can adapt to new technologies. • Highlights the irreplaceable value of human contributions in decision-making processes and the need for a holistic approach to skill development.

7.3 RQ2—Interrelationships Among Organisational Dynamic Capabilities

The second research question (RQ2) is *How are organisational dynamic capabilities interrelated in the Australian heavy industry?* The thesis findings revealed 25 interrelationships among the organisational dynamic capabilities required for innovation waves (20 interrelationships are new findings). Eight interrelationships were identified in the literature and the thesis findings shows that three are independent and five are validated, as shown in Table 37. The new findings show that building organisational dynamic capability relies on understanding the interdependencies among the identified capabilities.

Table 37: Interrelationship matrix (new findings, validated, independent)

🟦 New findings
🟥 Validated
⬛ Independent

		Sensing			Seizing			Reconfiguring			
		Strategic foundation	**Knowledge**	**Management**	**Value recognition**	**Implementation-centred approach**	**Understanding resistance**	**Continuous integration**	**Leadership and communication**	**Cultural transformation**	**Skill transformation**
Sensing	Strategic foundation		🟦	⬛	🟦	🟥		🟥	🟦	🟦	
	Knowledge			⬛			⬛	🟦	🟦	🟦	🟦
	Management								🟦	🟥	
Seizing	Value recognition						🟦		🟦	🟦	
	Implementation-centred approach						🟦	🟦	🟦	🟦	🟦
	Understanding resistance								🟥	🟦	
Reconfiguring	Continuous integration		*Redundancy*[9]								🟦
	Leadership and communication									🟥	🟦
	Cultural transformation										
	Skill transformation										

Table 37 shows that three interrelationships and their attributes are found to be independent in the context of the Australian heavy industry, notably those involving (1) strategic foundation and management (Tumbas, Berente & Vom Brocke 2020), (2) knowledge and management (Saabye, Kristensen & Wæhrens 2022) and (3) knowledge and understanding resistance. The linkage between strategic foundation and management, while theoretically integral, is not materialising effectively in the Australian heavy industry owing to the operational silos and conservatism prevalent within larger, established industrial firms, as illustrated in Section 2.4. These structural barriers hinder the seamless integration of strategic initiatives into daily management practices. Further, the connections between knowledge and management, and knowledge and understanding resistance are similarly undermined by the sector's slow adaptation to technological and process innovations (Fältholm & Norberg 2017). This is compounded by a prevailing culture that typically values operational continuity over innovative risk-taking, leading to a reluctance to fully leverage new knowledge in decision-making processes or in addressing resistance, as discussed further by Ediriweera and Wiewiora (2021).

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[9] The table features a central blank space to eliminate redundancy cells. For example, it indicates that there is no interrelationship between knowledge and itself.

In contrast, five interrelationships are validated by the thesis findings in the Australian heavy industry. These validated interrelationships are (1) strategic foundation and implementation-centred approach (Yeow, Soh & Hansen 2018), which underscores the importance of aligning strategic objectives with practical execution capabilities; (2) strategic foundation and continuous integration (Ghosh et al. 2022), highlighting the necessity for integrating continuous improvement processes within strategic planning; (3) management and cultural transformation (Sousa-Zomer, Neely & Martinez 2020), which are essential for fostering a change-ready organisational culture; (4) understanding resistance, and leadership and communication (Santos et al. 2023), vital for managing change resistance through effective communication; and (5) leadership and communication, and cultural transformation (El Sawy et al. 2020), which emphasise the role of leadership in shaping and directing cultural change initiatives. These relationships underscore the organisational dynamic capabilities necessary for sustaining competitive advantage and driving innovation in a challenging and evolving industrial landscape (Correia, Dias & Teixeira 2020).

The discovery of 20 new interrelationships within organisational dynamic capabilities in this thesis offers significant contributions to the field, enhancing understanding of how these capabilities function within specific organisational contexts. This finding aligns with and extends the existing dynamic capability literature by demonstrating not only the theoretical relevance of integrating various capabilities, but also their practical interdependencies in a real-world setting. The emergence of these new interrelationships underscores the limitations of prior research that often examined dynamic capabilities in isolation. Studies such as those by Wagner et al. (2017), Kump et al. (2019), and Khan, Daddi and Iraldo (2021) provided valuable insights into individual categories of dynamic capabilities. However, the thesis findings suggest that these capabilities do not operate in isolation but are interconnected in complex and previously unexplored ways. This supports the argument by Schilke, Hu and Helfat (2018) that organisations require a bespoke integration of capabilities tailored to their specific operational contexts and strategic objectives, challenging the prevailing one-size-fits-all models in the literature. Moreover, the identification of new capability interrelationships directly engages with the propositions of Helfat and Winter (2011), who argued that the blending of seizing and reconfiguring capabilities could create a strategic complexity that is difficult for competitors to replicate. The thesis findings provide empirical evidence supporting this theory, suggesting that such combinations are not only theoretically viable but also empirically observable in enhancing competitive advantage. Additionally, the work of Di Stefano, Peteraf and Verona (2014), and Yeow, Soh and Hansen (2018) highlighted the significance of a synergistic interaction between sensing, seizing and reconfiguring capabilities. The thesis findings extend this discussion by identifying specific new interrelationships that illustrate how these interactions manifest in practice, thereby providing a clearer roadmap for organisations to leverage these synergies effectively. The significance of the thesis findings also lies in their timing and relevance to current business challenges, particularly in the context of innovation waves and big data, as highlighted by Warner and Wäger (2019). The rapid evolution of digital technologies demands a re-evaluation of how dynamic capabilities are conceptualised and implemented. By revealing new interrelationships, this thesis contributes to a more nuanced understanding of how organisations can more effectively adapt and thrive in rapidly changing digital landscapes.

The interrelationships among the capabilities identified in this thesis, which influence successful organisational dynamic capability building for innovation waves in the Australian heavy industry, are discussed in depth in the following sections.

7.3.1 Interrelationships of Sensing

As outlined in Section 7.2.1, sensing capabilities encompass strategic foundation, knowledge and management. The thesis findings identified seven new interrelationships and validated two existing ones concerning these sensing capabilities, as shown in Table 38.

Table 38: Interrelationship matrix of sensing

🟦 New findings
🟥 Validated
⬛ Independent

		Sensing			**Seizing**				**Reconfiguring**		
		Strategic foundation	**Knowledge**	**Management**	**Value recognition**	**Implementation-centred approach**	**Understanding resistance**	**Continuous integration**	**Leadership and communication**	**Cultural transformation**	**Skill transformation**
Sensing	Strategic foundation		🟦	⬛		🟥			🟦	🟦	
	Knowledge			⬛			⬛		🟦	🟦	🟦
	Management								🟦	🟥	

The specifics of these interrelationships are explored and discussed in detail in the subsequent sections.

7.3.1.1 Strategic foundation

Strategic Foundation and Knowledge (Sensing and Sensing)

The findings present the interrelationship between strategic foundation and knowledge as part of sensing capability in the context of innovation waves. The existing literature highlights the importance of strategic alignment, prioritisation and foresight in guiding organisational responses to external pressures (Ghosh et al. 2022). The findings highlight how external factors such as regulations, market demand and government mandates are significant in shaping organisational strategies for innovation waves. This echoes the literature's focus on the need for organisations to adapt their strategies dynamically to external changes (Chirumalla 2021; Feroz et al. 2023). For instance, the findings revealed that, in the shipbuilding sector, strategic decisions are informed by a deep understanding of market dynamics and internal processes, which is in line with Ghobakhloo et al. (2023c), who emphasised the importance of integrating both technological and structural adaptability into strategic planning.

A notable contribution of the thesis is identifying sector-specific strategic practices, particularly the proactive use of internal and external knowledge in the shipbuilding sector that exhibits a higher level of digital readiness compared with the mining, and oil and gas sectors. This sectoral insight is significant since it offers a new dimension to the literature, which often generalises strategic responses across sectors without accounting for industry-specific challenges and practices. By harnessing internal knowledge, organisations can enhance their ability to anticipate and respond to evolving market dynamics. The findings highlighted a critical oversight in the existing literature, which predominantly accentuates the influence of external factors on an organisation's strategic foundation. Even though these external elements are undeniably significant, this thesis reveals a substantial under-representation of the role of internal knowledge resources in the literature.

Although the thesis findings shed light on the proactive approach adopted by the shipbuilding sector in leveraging knowledge for strategic decision-making, the absence of input from the oil and gas sector underscores the need for further exploration. Cross-sector collaboration and knowledge-sharing platforms could facilitate the exchange of ideas and strategies, ultimately enhancing the overall readiness for innovation waves in the heavy industry. Warner and Wäger (2019) highlighted the importance of developing new capabilities in digital scenario planning and scouting to anticipate technological, customer and competitor-based trends. Encouraging knowledge sharing between sectors could lead to the identification of best practices and insights, ultimately fostering more cohesive and effective transformation efforts for innovation waves. The sector differences underscored in this thesis provide a new, significant understanding of how strategic priorities and knowledge integration can vary, offering a richer narrative that could guide future sector-specific strategies.

The thesis adds to the discourse on strategic foundation by illustrating how organisations can refine strategies in the face of ongoing technological disruptions and market transformations by aligning strategic decision-making with external influences and leveraging internal knowledge. This finding is significant since it aligns with, and expands on, Chavez et al. (2023), who highlighted the role of flexibility and workforce prioritisation in building resilience. By showing how these elements are practically implemented in sector-specific contexts, this thesis provides tangible examples of how organisations can adapt their strategic approaches based on comprehensive knowledge integration. This discussion not only corresponds with the existing literature, but also significantly expands it by providing detailed, sector-specific findings regarding strategic foundation and knowledge interrelationships. The insights into the distinct approaches of the shipbuilding sector, combined with the identified gaps in the oil and gas sector, contribute novel perspectives to the strategic management field, emphasising the need for tailored, informed strategies that consider both external dynamics and internal capabilities.

Strategic Foundation and People-Centred Approach (Sensing and Seizing)

The thesis findings underscore the interconnection between strategic foundation and a people-centred approach, emphasising that successful innovation waves require a holistic consideration of human factors. The findings emphasise that embedding a people-centred approach ensures that technology acts as an enabler rather than a disruptor of human potential. This aligns with Chavez et al. (2023), who stressed the importance of workforce prioritisation in digital strategies to foster organisational resilience. However, this thesis finding extends the literature by showing how this approach is operationalised in specific sectors. For instance, in the oil and gas sector, the strategic emphasis on the seamless integration of human-centric principles for operational efficiency highlights a pragmatic application of digital strategies that prioritise human elements. This sector-specific application contrasts with broader discussions in the literature, such as those by Feroz et al. (2023), who advocated for a general convergence of sustainability goals with digital strategies without taking into consideration industrial nuances.

Further, the mining sector’s approach provides a vivid illustration of a holistic embrace of human factors, driven by the sector’s inherent risks and the critical need for safety and operational success. This sectoral insight is significant because it adds a layer of complexity to the understanding of strategic integration discussed by Ghobakhloo et al. (2023c), who generally highlighted the need for structural adaptability in digital strategies across industries. By detailing the mining sector’s intrinsic focus on human factors, this thesis offers a nuanced perspective that challenges the often one-size-fits-all approach presented in existing studies.

Additionally, the emphasis on technology complementing human ingenuity is a novel finding that resonates with Naruetharadhol et al. (2022), who discussed the potential for SMEs to leverage technology-based strategies. This thesis extends this discussion by demonstrating how strategic foundations that integrate a people-centred approach can enhance the transformative power of technology in larger, more complex sectors such as oil and gas, and mining. The finding highlights a strategic orientation where technology solutions are designed to not only automate, but also augment human capabilities, reflecting a sophisticated application of the principle that technology should empower rather than replace human efforts.

Moreover, the exploration of strategic priorities as they relate to human-centred design in transformation initiatives for innovation waves reveals new insights into the practical application of strategic foresight. Vu et al. (2023) discussed the challenges firms face in capitalising on opportunities with limited sensing capabilities. This thesis builds on that by showing how a people-centred approach can enhance sensing capabilities by aligning technological adaptations with human insights and needs, particularly highlighted by the proactive strategies seen in the mining sector.

This discussion not only corroborates but significantly enriches the existing literature by detailing how different sectors operationalise the integration of strategic foundations with human-centric principles. By providing specific examples from the findings, this thesis reveals the significant contributions to understanding the practical implications of strategic decisions that prioritise human factors in driving innovation waves. This sector-specific exploration offers valuable lessons that could guide future strategic planning and implementation, ensuring that technological advancements genuinely enhance human work life and organisational success.

Strategic Foundation and Resource Alignment (Sensing and Seizing)

The findings highlight the interrelationship between a strategic foundation and effective resource alignment, emphasising their mutual dependence in achieving successful innovation waves. Without a well-defined strategic framework, resource allocation faces significant challenges in optimally supporting digital initiatives. The thesis findings emphasise the pivotal role of comprehensive strategic frameworks in effective resource allocation. This integration is not just about acquiring technology but extends to a comprehensive investment in human capital—talent acquisition, development and retention. This nuanced approach is vital because skilled individuals do not merely align resources; they enhance the strategic foundation itself by contributing their expertise to the technological needs and feasibility assessments of the organisation. Such insights resonate with the literature in which Chavez et al. (2023) emphasised flexibility and workforce prioritisation as central to digital strategies, suggesting that a human-centric approach in resource alignment can significantly bolster organisational resilience.

Further, the findings introduce novel examples from different sectors that illustrate how a strategic foundation influences resource alignment. For instance, the shipbuilding sector's focus on operational sustainability requires a strategic foundation that supports long-term viability through efficient resource allocation and risk mitigation. This approach reflects a strategic response to the sector's historical volatility, aligning closely with the literature's emphasis on strategic foresight and adaptability (Feroz et al. 2023). This sector-specific strategy enhances the discussions found in Feroz et al. (2023), who advocated for rapid adaptation to industry landscapes but often overlooked the detailed approaches needed to ensure sustainability in historically volatile sectors such as shipbuilding.

Conversely, the mining sector's reliance on skilled labour for optimising operational efficiency highlights a cultural emphasis on workforce development and innovation. This sector values human capital highly, aligning resources to enhance safety and operational success—critical factors given the sector's hazardous nature. This approach is notable because it not only aligns resources with strategic goals, but also prioritises workforce development and innovation as central elements of the sector's resource strategy. Such a strategy extends the discussion by Ghobakhloo et al. (2023c), who advocated for holistic principles in Industry 4.0, showcasing how human factors are crucial in the strategic alignment within complex operational paradigms, but did not delve deeply into the specific ways sectors such as mining integrate these principles with human capital considerations.

The oil and gas sector's focus on strategic planning and risk management provides a practical embodiment of strategic prioritisation and foresight. The sector's approach to managing long investment cycles and complex regulatory landscapes through strategic planning exemplifies the critical nature of aligning resources with strategic objectives to manage risks effectively. This sector-specific insight builds on the literature by Yeow, Soh and Hansen (2018), who discussed strategic alignment but missed the detailed, practical implications of such alignment in high-stakes industries (e.g. oil and gas).

By detailing these examples, this thesis not only corroborates the existing literature, but also significantly expands it by illustrating how strategic foundations and resource alignment are practically implemented across different sectors. The discussion provides a more detailed narrative that connects theoretical concepts with practical applications, enhancing the understanding of strategies for innovation waves in complex business environments. These insights offer valuable lessons for both academia and industry, suggesting that effective innovation waves require not only technological adaptation, but also a deep integration of strategic and resource planning tailored to sector-specific needs.

Strategic Foundation, and Leadership and Communication (Sensing and Reconfiguring)

The thesis findings underscore the pivotal role played by strategic foundation, leadership, and communication in shaping organisational success and fostering innovation for innovation waves. By intertwining insights from the findings with the established literature, this discussion reports the nuanced contributions of the findings to the existing body of knowledge, emphasising sector-specific strategies and leadership orientations.

The findings reveal the profound impact of leadership characteristics on the strategic approach to organisational transformation. Younger leaders and those more open to innovation are more likely to advocate for and implement comprehensive digital strategies. This observation extends the discussion in the literature, where Chavez et al. (2023) emphasised the role of leadership flexibility and workforce prioritisation in digital strategies. The specific mention of leadership orientation in the finding adds a layer of depth to understanding how personal traits of leaders can significantly influence strategic decisions, providing a nuanced perspective that enriches the existing discourse on leadership in organisational transformation.

Further, the role of a strategic foundation in shaping leadership behaviour highlights a bidirectional influence in which strategy not only guides but is also shaped by leadership dynamics. This dual influence is critical, since it suggests that strategic foundations are both a driver and a product of leadership actions, a concept that is supported but not extensively explored in the literature. For instance, the influence of a strategic foundation on fostering a culture where leaders champion transformation efforts, as discussed in the findings, aligns with Feroz et al. (2023), who advocated for strategic and leadership goals in strategies for innovation waves.

Effective communication is identified as a pivotal mechanism for translating strategic visions into actionable steps, a theme that is vividly illustrated in the thesis findings. The findings reveal how transformational leaders utilise tailored communication to effectively convey strategic goals across organisational tiers. This detailed exploration of communication strategies significantly contributes to the existing literature by demonstrating practical applications of the strategic communication theories presented by Yeow, Soh and Hansen (2018), who discussed the continuous adaptation and coevolution of strategy and resources. The specific examples of tailored communication provided in the findings—such as breaking down comprehensive strategies into shorter, actionable segments—offer practical insights that expand on the theoretical frameworks discussed in the literature.

Sector-specific variations in the emphasis on leadership roles and communication strategies also enrich the discussion. For instance, the mining, and oil and gas sectors' strong focus on leadership inclusivity in communication strategies contrasts with the shipbuilding sector's emphasis on the alignment between strategic vision and leadership behaviour. These differences not only highlight the sector-specific challenges, but also underline the tailored approaches necessary to address these challenges effectively. This sector-specific discussion enhances the understanding of strategic management in diverse industrial contexts, as highlighted by Ghobakhloo et al. (2023c), who emphasised holistic approaches but often lacked detailed sector-specific analyses.

This discussion not only aligns with the existing literature but also significantly enriches it by detailing how strategic foundations, leadership, and communication interplay to shape transformation initiatives for innovation waves across different sectors. The specific examples and detailed exploration of leadership and communication strategies provide a clearer, more comprehensive narrative that connects theoretical concepts with practical applications, enhancing the understanding of strategies for innovation waves in complex business environments. These insights offer valuable lessons for both academia and industry, suggesting that effective transformation for innovation waves requires not only technological adaptation, but also a deep integration of strategic, leadership and communication planning that is tailored to sector-specific needs.

Strategic Foundation and Cultural Transformation (Sensing and Reconfiguring)

The thesis findings emphasise the interrelationship between strategic foundation and cultural transformation as pivotal in navigating the innovation waves. The thesis finding reveals that this alignment is critical in fostering a culture of innovation, adaptability and resilience, which are crucial attributes in the face of rapid technological changes and market dynamics. The finding's emphasis on long-term vision serving as a catalyst for innovation provides a tangible example of how strategic clarity can drive cultural transformation within an organisation. This specific insight adds depth to the discussions in the existing literature, such as Chirumalla (2021), who focused on continuous improvement strategies without delving into the cultural implications of such strategies. The thesis finding highlights the practical aspects of how a clear, forward-looking vision can encourage risk-taking and boundary-pushing—elements vital for staying ahead in a rapidly evolving digital environment. This adds a practical layer to the theoretical discussions on strategic vision, illustrating how it directly influences organisational culture and innovation capacity.

The finding reports innovation waves as a continuous journey, emphasises the need for a culture that values flexibility and learning. This perspective provides a significant contribution to the literature, particularly enriching the work of Ellström et al. (2022), who cautioned against the lack of strategic focus but did not extensively cover the cultural readiness required to support such strategies. By discussing how strategic initiatives must be underpinned by a culture that is adaptable and open to continuous learning, the finding bridges the gap between strategy formulation and cultural integration, offering a more comprehensive view that is often lacking in the literature.

The finding underscores the importance of cultural resilience and agility in navigating the challenges of innovation waves. The finding also emphasises that innovation waves should be seen not as a finite project, but as a continual process of evolution, necessitating a culture that can quickly adapt and learn from setbacks. This perspective is crucial because it illustrates the practical implementation of adaptive strategies within a culture, which enriches the discussions found in the literature. For example, Ghobakhloo et al. (2023c) discussed the need for holistic adaptation in the context of Industry 4.0, but did not take into consideration how organisations can culturally embed such adaptiveness.

Further, the finding's emphasis on long-term vision as an 'anchor in turbulent waters' (S5) provides an illustration of how strategic clarity supports cultural resilience. This analogy shows that beyond guiding strategic direction, a clear vision also stabilises the organisation during tumultuous periods, allowing it to remain focused and resilient in the face of adversity. This insight contributes to the literature by showing how strategic visions are not just roadmaps for future actions, but also crucial supports that maintain organisational coherence and resilience amid uncertainty. Vu et al. (2023) discussed the challenges of navigating Industry 4.0, but the metaphor adds a new dimension by demonstrating how a well-articulated vision can provide emotional and operational stability.

By integrating these specific findings with broader discussions in the literature, this thesis not only corroborates existing theories but also expands them by providing detailed, practical examples of how strategic visions and cultural transformations are implemented across different sectors. For instance, oil and gas participants highlighted using a clear, long-term vision to foster a culture of innovation and adaptability, crucial in a rapidly changing technological and regulatory environment, as opposed to the mining sector, which focused on viewing innovation waves as an ongoing journey, highlighting the importance of resilience and adaptability in integrating new technologies within safety-critical operations. This illustrates how tailored cultural strategies are essential for the effective integration of transformation initiatives for innovation waves. This sector-specific finding offers a deeper exploration of strategic and cultural alignment than typically discussed, demonstrating the necessity for bespoke strategies that consider the unique environmental and operational challenges each sector faces.

This thesis not only supports existing theories, but also significantly extends them by demonstrating how strategic foundations integrated with cultural transformations practically influence organisational dynamics and successful transformations for innovation waves. The detailed examples from the thesis finding offer valuable enhancements to the literature, providing clarity on the interdependencies between strategy and culture in driving innovation and adaptability in various industrial contexts.

7.3.1.2 Knowledge

Knowledge and Leadership (Sensing and Reconfiguring)

The thesis finding underlines that leadership effectiveness is intricately linked to the depth and breadth of knowledge leaders possess. Well-informed leaders who continuously seek new insights are better equipped to navigate the complexities of the digital landscape and drive organisational growth. This specific example directly contributes to expanding the literature, including work by Vu et al. (2023), who examined the importance of proactive knowledge enhancement in organisational leadership. The thesis finding offers a concrete example of how leaders who actively stay abreast of emerging trends and technological advancements can effectively navigate and lead through the complexities of digital landscapes. This practical insight adds a layer of depth to theoretical discussions by demonstrating how knowledge informs strategic decision-making and innovation in real-world settings.

Moreover, the finding emphasises the role of effective leadership in fostering a culture of continuous learning and development. The finding highlights that leadership is about creating opportunities for growth and development, which is crucial for cultivating a skilled workforce equipped to tackle future challenges. This point is supported by the findings by Rangaswamy (2021) on the multifaceted nature of knowledge management, but it goes further by showing how leaders can operationalise this through specific educational initiatives and skill development programs.

The finding presents how different sectors prioritise and integrate leadership and knowledge to enhance transformation efforts for innovation waves. In the oil and gas sector, there is a notable emphasis on talent management and skill development, reflecting a strategic focus on human capital as a critical driver of digital initiatives. Conversely, the mining sector places a higher priority on leadership adaptability and strategic decision-making to navigate market shifts and emerging trends effectively. Conversely, the shipbuilding sector's strong emphasis on continuous learning and development aligns closely with its commitment to innovation and intellectual growth. These sector-specific insights provide a richer understanding of how leadership and knowledge interplay can be tailored to meet distinct industry demands, which complements and expands the literature by illustrating practical implementations of theoretical concepts.

These findings contribute significantly to the existing literature by not only corroborating the significance of knowledge and leadership in driving transformation for innovation waves, but also providing detailed, real-world examples of how these dynamics are enacted within various organisational and sectoral contexts. The thesis finding bridges the gap between the theoretical importance of knowledge as highlighted across the literature and the practical implications of leadership in fostering a knowledge-driven culture. This enhances our understanding of the strategic integration of knowledge and leadership, offering insights into the development of more effective organisational strategies and practices in the digital age.

This discussion underscores the critical interplay between knowledge and leadership as foundational elements for successful transformation for innovation waves. By detailing how these elements interact within different sectors, the thesis provides valuable perspectives that enrich the academic discourse and offer practical guidance for organisations aiming to navigate the complexities of the digital landscape effectively.

Knowledge and Cultural Transformation (Sensing and Reconfiguring)

The thesis finding identifies that an organisational culture that actively promotes continuous learning and openness leads to more dynamic and innovative practices within an organisation. This finding builds on the existing literature, such as the study by Vu et al. (2023), which emphasised the importance of knowledge in driving organisational adaptability and innovation. The thesis extends these discussions by demonstrating how a culture that prioritises learning not only supports knowledge acquisition, but also encourages its application across different organisational levels, thereby fostering a more resilient and flexible organisational structure.

In addition, the thesis finding discusses how organisations can operationalise knowledge into their cultural norms and practices by establishing structures and incentives that promote knowledge sharing and collaborative learning. This aspect of the findings provides a practical application to the theoretical discussions found in Rangaswamy (2021), who detailed the processes involved in effective knowledge management, including the processes of creating, refining, sharing and applying knowledge. The finding enhances this literature by showing how these structures and incentives can be implemented to encourage employees to integrate new knowledge into their daily practices, thereby enhancing organisational performance and adaptability.

The sector-specific findings provided in the thesis add depth to the literature by illustrating the ways in which different industries implement strategies to integrate knowledge and culture. For instance, in the shipbuilding sector, the emphasis on fostering a learning culture aligns with broader innovation trends in Industry 4.0 and Industry 5.0, showcasing a commitment to continuous improvement and adaptability. In contrast, the mining sector's focus on leadership in cultivating a knowledge-oriented culture illustrates how strategic leadership is critical in embedding knowledge-centric practices within the organisational fabric. These insights demonstrate the variability in how knowledge and culture interplay can be tailored to meet the specific needs and challenges of different sectors, thus providing a nuanced understanding that enriches the existing academic discourse.

By integrating these detailed findings with the broader themes identified in the literature review, the thesis not only proves the recognised importance of knowledge as a dynamic capability, but also offers new perspectives on how knowledge-driven cultural practices can be strategically implemented to enhance organisational resilience and innovation. This discussion thus provides a valuable extension to the existing literature by bridging the gap between theoretical knowledge management concepts and their practical application in various organisational and sectoral contexts.

Knowledge and Skill Transformation (Sensing and Reconfiguring)

The finding stresses the importance of empowering the workforce with relevant knowledge and skills as a cornerstone of successful transformation for innovation waves. This is not simply about technological adoption; it also involves transforming operational processes and empowering individuals to drive organisational change. This insight extends the discussions in the existing literature, such as the work by Vu et al. (2023), which emphasised the proactive enhancement of knowledge within organisations. The thesis finding adds a practical dimension by showing how integrating advanced technologies requires a workforce equipped with the right skills, thus highlighting the need for comprehensive training and development strategies.

Further, the finding highlights the use of comprehensive assessment tools to evaluate organisational and people capabilities alongside technical readiness. This approach is crucial for identifying skill gaps and tailoring reskilling and upskilling programs, ensuring that the workforce can effectively leverage new technologies. This finding enhances the study of Rangaswamy (2021) by providing a concrete example of how organisations can systematically assess and address the human elements of innovation waves, which is often overshadowed by the focus on technological aspects. This practical insight contributes to the literature by detailing the processes that organisations can employ to integrate knowledge and skills within their workforce strategically.

The finding highlights the challenge of bridging generational gaps within the workforce, particularly in the heavy industry where technological adoption varies widely between younger and older workers. The finding provides specific strategies for making technology accessible and relevant to all employees, fostering a culture of lifelong learning and skill development. This sector-specific insight contributes to the literature by illustrating how organisations can address the diverse needs and capabilities of their workforce, enhancing the effectiveness of transformation strategies for innovation waves. In addressing this issue, the thesis extends the work by Ellström et al. (2022), who discussed the need for organisations to adapt their workforce strategies to technological changes but did not consider the intergenerational challenges. The example given in the thesis, where younger workers are more receptive to technology, while older workers possess valuable traditional skills and knowledge, highlights the necessity for customised strategies that facilitate effective technology adoption across all age groups. This sector-specific insight is particularly relevant to the discussions in the literature on lifelong learning and workforce development, such as those by Warner and Wäger (2019), who emphasised the importance of continuous learning within organisations but often overlooked the unique challenges posed by generational divides.

In sectors such as oil and gas, the emphasis on equipping the workforce with appropriate knowledge and skills is highlighted as a critical factor in navigating innovation waves successfully. This sector recognition extends the literature by revealing how industry-specific challenges influence the approach to skill and knowledge integration. The focus in the shipbuilding and mining sectors on addressing generational disparities provides a nuanced view of how different industries tailor their strategies to meet their unique operational and workforce challenges.

These findings provide significant enhancements to the existing body of literature by clearly demonstrating how knowledge and skill transformations are not just theoretical concepts, but vital, actionable strategies that directly affect organisational success for innovation waves. The examples given from within specific sectors provide a richer, more detailed understanding of how organisations can effectively navigate the complexities of integrating new technologies with human factors, thereby offering a practical guide that can inform future research and implementation strategies in the field of innovation waves.

7.3.1.3 Management

Management, Leadership and Cultural Transformation (Sensing and Reconfiguring)

The thesis finding underscores the critical role of top-down management support in cultural transformation. It reveals that management support is essential for scaling up and aligning the organisation with a vision of innovation waves, providing an example of how leadership commitment is crucial in driving cultural change. This specific example enhances the study of Dubey et al. (2024), who stressed the importance of top management commitment. The thesis extends this by showing how management not only needs to be committed, but also actively involved in scaling and aligning cultural practices across the organisation to meet the ambitious goals of innovation waves.

The thesis finding offers detailed insights into the distinct challenges faced by sectors such as shipbuilding, which is heavily regulated and security oriented. It discusses how effective leadership within this sector navigates the tightrope of fostering innovation while adhering to stringent regulatory standards. This specific finding builds on and extends the study by Sousa-Zomer, Neely and Martinez (2020), who investigated the general importance of senior management commitment in fostering a risk-taking culture influenced by emerging technologies but did not consider the complexities of industries with heavy regulatory oversight.

For the shipbuilding sector, the thesis illustrates how leadership strategies are tailored to overcome the obstacles related to regulatory constraints and risk aversion, promoting a culture of agility and resilience. This sector-specific insight is a significant contribution to the literature, adding depth to the discussions found in Saabye, Kristensen and Wæhrens (2022), who emphasised robust top management commitment and a digital culture at organisational levels for successful Industry 4.0 implementation but lacked a detailed exploration of how these strategies are applied in different regulatory environments.

In the mining, and oil and gas sectors, the finding highlights how leadership focuses on bridging generational divides and integrating new technologies with existing practices. These insights enhance the understanding provided by Tumbas, Berente and Vom Brocke (2020), who highlighted the role of CDOs in driving innovation waves but did not specifically address how leadership roles differ across industries with varying technological and operational demands. This thesis enriches the literature by detailing how management leadership directly influences the process of cultural transformation in organisations, especially in sectors with specific operational and regulatory challenges. By using specific examples from the finding, it offers valuable insights into the practical aspects of leadership strategies and their impact on fostering an organisational culture that supports innovation waves.

In summary of Section 7.3.1, the interrelationships with sensing capabilities underscore the critical importance of aligning continuous integration and strategic foundations, as well as integrating technological adaptations deeply into organisational knowledge. These relationships highlight the need for strategic clarity and proactive measures to address readiness gaps, ensuring that digital efforts are not only technically proficient, but also strategically sound. Additionally, continuous learning and knowledge enhancement are essential for successful innovation, with sector-specific dynamics playing a pivotal role. Table 39 summarises the key findings and implications of these interrelationships, illustrating how they enhance organisational capabilities in innovation waves.

Table 39: Key findings and implications on interrelationships with sensing capability

	Interrelationships	Key findings	Implications
Within sensing	Strategic foundation and knowledge	• Aligning organisational strategies with internal and external knowledge enhances sensing capabilities and ensures adaptability to market dynamics and regulatory changes.	• Emphasises the importance of sector-specific strategic practices and cross-sector collaboration to enhance overall readiness for innovation waves.
Sensing and seizing	Strategic foundation and people-centred approach	• Embedding human-centric principles in strategic planning ensures technology acts as an enabler of human potential, enhancing operational efficiency and safety.	• Highlights the need for sector-specific strategies that prioritise human elements in digital transformation, ensuring a seamless integration of technology.
	Strategic foundation and resource alignment	• Effective resource alignment is dependent on a well-defined strategic framework that supports comprehensive investment in human capital and technology.	• Stresses the importance of integrating strategic and resource planning to manage risks and ensure sustainability, particularly in volatile sectors such as shipbuilding and mining.
Sensing and reconfiguring	Strategic foundation, and leadership and communication	• Leadership characteristics and strategic approaches are deeply intertwined, influencing organisational transformation and innovation. Effective communication translates strategic visions into actionable steps.	• Emphasises the importance of sector-specific leadership strategies and transparent communication to foster organisational transformation and innovation waves.
	Strategic foundation and cultural transformation	• Aligning a strategic foundation with cultural transformation fosters a culture of innovation, adaptability and resilience. A long-term vision serves as a catalyst for innovation.	• Highlights the necessity for integrating strategic clarity with cultural readiness, ensuring continuous learning and adaptability to navigate technological changes.
	Knowledge and leadership	• Leadership effectiveness is closely linked to the depth and breadth of knowledge leaders possess,	• Highlights the need for leaders to continuously seek new insights and foster a culture of continuous learning and development within organisations.

Interrelationships	Key findings	Implications
	influencing strategic decision-making and innovation.	
Knowledge and cultural transformation	• An organisational culture that promotes continuous learning and openness leads to more dynamic and innovative practices.	• Emphasises the importance of establishing structures and incentives that encourage knowledge sharing and collaborative learning, enhancing organisational performance and adaptability.
Knowledge and skill transformation	• Empowering the workforce with relevant knowledge and skills is crucial for successful transformation, addressing skill gaps and fostering a culture of lifelong learning.	• Stresses the need for comprehensive training and development strategies, tailored reskilling and upskilling programs, and addressing generational gaps to enhance the effectiveness of transformation strategies.
Management leadership and culture	• Top-down management support is essential for scaling up and aligning the organisation with a vision of innovation waves, navigating regulatory constraints, and fostering a culture of agility and resilience.	• Emphasises the need for the active involvement of management in cultural transformation, tailored leadership strategies to overcome regulatory and operational challenges, and bridging generational divides to integrate new technologies.

7.3.2 Interrelationships of Seizing

As detailed in Section 7.2.2, seizing capabilities include value recognition, an implementation-centred approach and understanding resistance. The thesis findings uncovered eight new interrelationships and validated one existing interrelationship involving these seizing capabilities, as shown in Table 40.

Table 40: Interrelationship matrix of seizing

🟦 New findings

🟥 Validated

		Sensing			**Seizing**			**Reconfiguring**			
		Strategic foundation	**Knowledge**	**Management**	**Value recognition**	**Implementation-centred approach**	**Understanding resistance**	**Continuous integration**	**Leadership and communication**	**Cultural transformation**	**Skill transformation**
Seizing	Value recognition	🟦					🟦			🟦	
	Implementation-centred approach							🟦	🟦	🟦	🟦
	Understanding resistance					🟦			🟥		

These interrelationships are thoroughly examined and discussed in the subsequent sections.

7.3.2.1 Value recognition

Value Recognition and Strategic Foundation (Seizing and Sensing)

This thesis finding highlights the importance of aligning strategic planning with value recognition from the start of transformation efforts for innovation waves. The finding emphasises that strategic planning should integrate both short-term gains and long-term vision to fully realise the potential of innovation waves. This finding extends the work of Henriksen, Røstad and Thomassen (2022), who discussed the role of strategic planning in innovation waves but did not specifically focus on the integration of value recognition strategies. Further, the thesis finding highlights the importance of aligning strategic planning with a people-centred approach, underscoring the necessity for integrating human factors in value recognition processes. This specific insight extends the discussions in the existing literature Narkhede et al. (2024), which emphasised the collaborative and human-centric aspects of Industry 5.0. This thesis finding provides a practical example of how strategic plans that are intricately designed with a focus on value recognition can foster a more inclusive and effective transformation process for innovation waves.

The finding's emphasis on ensuring that digital initiatives align with long-term organisational objectives complement the principles highlighted in the literature on Industry 5.0, particularly those related to sustainability and the circular economy, as discussed by Narkhede et al. (2024). These authors outlined the importance of sustainability in strategic planning, but the finding provided in the thesis adds depth by showing how these sustainability principles can be operationalised within strategic frameworks to drive continuous value recognition and innovation. Moreover, the thesis details how a robust strategic foundation can foster a culture of innovation and adaptability. The specific example is the importance of a well-planned strategy that aligns digital initiatives with long-term organisational objectives, thereby driving sustainable value recognition. This finding contributes to the literature (Narkhede et al. 2024) by showing how strategic foundations are not only about setting goals, but also applicable to creating an organisational culture that continuously seeks to align technology investments with broader business values, as discussed in the principles of a circular economy and sustainability highlighted in Industry 5.0.

The thesis finding provides sector-specific insights, particularly highlighting how the mining and shipbuilding sectors approach the integration of strategic planning and value recognition. In mining, there is a strong emphasis on fostering a culture of innovation and collaboration, suggesting a dynamic environment that is conducive to embracing changes. Conversely, the shipbuilding industry focuses on incorporating long-term vision and value objectives into strategic planning, reflecting a methodical approach to sustainable value creation. These sector-specific examples significantly enrich the literature findings of Sousa-Zomer, Neely and Martinez (2020). Although Sousa-Zomer, Neely and Martinez (2020) focused on the strategic importance of digital ecosystems and collaborations, the thesis finding details how these strategic principles are adapted within specific industries to enhance transformation efforts for innovation waves by detailing how different industries tailor their strategic foundations to not only adapt to technological advancements, but also ensure that these advancements are in line with their core values and long-term objectives.

By integrating these detailed findings from the thesis with the broader themes identified in the literature review, the thesis supports and expands on the recognised importance of value recognition as a critical organisational capability. It provides nuanced insights into how strategic foundations that emphasise value recognition can enhance the effectiveness of transformation initiatives for innovation waves.

Value Recognition and Understanding Resistance (Seizing and Seizing)

This finding in the thesis illustrates the critical importance of clear and well-managed communication in overcoming resistance to transformation for innovation waves. The finding's emphasis on the necessity for open discussions to build trust and clarify the organisation's challenges adds a practical layer to the theoretical discussions found in literature. This approach aligns with the studies by Henriksen, Røstad and Thomassen (2022), which emphasised the need for human-centricity in organisational changes. By providing specific examples of how effective communication can seamlessly facilitate transformational changes, the thesis offers new perspectives on managing employee perceptions and expectations during digital initiatives.

The thesis finding further explores how a robust strategic foundation, which integrates value recognition from the initial stages, can mitigate resistance by aligning digital initiatives with clear, long-term organisational goals. One of the participant's comments about ensuring that digital initiatives align with organisational objectives extend the discussions found in the literature, particularly those by Narkhede et al. (2024), who highlighted the collaborative and flexible nature of Industry 5.0. The thesis builds on this by detailing how strategic clarity in value propositions can ease the adaptation process, providing a concrete example of how strategic foresight in planning enhances value recognition and acceptance among stakeholders.

The sector-specific insights provided by participants in the shipbuilding, and oil and gas sectors emphasise different approaches to addressing resistance through communication. The shipbuilding sector's focus on articulating the positive impacts and benefits of transformation initiatives for innovation waves enriches the discussion on sector-specific communication strategies discussed by Henriksen and Thomassen (2023). Conversely, the oil and gas sector's emphasis on open discussion and trust-building provides practical examples of how industries with high stakes and risk factors manage resistance, extending the existing literature on managing change in complex and regulated environments.

By integrating these findings with the broader discussions from the literature review, the thesis not only supports, but also significantly expands on the recognised importance of effective communication and strategic planning in transformation for innovation waves. It provides nuanced insights into how value recognition intertwined with a comprehensive understanding of resistance can significantly enhance the effectiveness of transformation initiatives for innovation waves.

Value Recognition and Cultural Transformation (Seizing and Reconfiguring)

This thesis finding identifies the inherent conservatism in heavy industries owing to their industry characteristics such as a focus on safety and security concerns. This conservatism poses significant challenges to adopting new technologies and transformative changes. This insight extends the literature on organisational resistance in industries with high safety stakes, such as those discussed by Narkhede et al. (2024), who emphasised the collaborative approach of Industry 5.0 but did not fully explore the resistance from entrenched conservative mindsets. By providing a concrete example of how conservatism can hinder innovation, this thesis enriches the discourse by identifying specific barriers and suggesting that recognising indirect values, such as wellbeing and safety, can facilitate cultural transformation.

The thesis finding highlights the necessity for traditional heavy industries to shift towards recognising indirect values such as wellbeing. Prioritising employee wellbeing reflects a broader trend towards sustainable and responsible business practices. This insight ties directly into the discussions by the European Commission (2021) and Henriksen, Røstad and Thomassen (2022), who highlighted sustainability initiatives that prioritise long-term environmental stewardship and societal wellbeing over short-term, profit-driven strategies. The thesis extends these discussions by applying them to the context of heavy industries, where safety is paramount and often a conservative barrier to innovation. By advocating for the recognition of these values as part of the transformation strategy for innovation waves, the thesis offers a practical example of how industries can align with broader sustainability goals while addressing internal cultural challenges. Moreover, the thesis finding's emphasis on integrating sustainability principles such as the circular economy into transformation strategies for innovation waves aligns with the existing literature that frames these as critical to Industry 5.0. Narkhede et al. (2024) discussed the importance of collaborative and adaptable approaches that include human–robot collaboration and ethical considerations. The thesis builds on this by demonstrating how embracing indirect values such as wellbeing can facilitate a more effective and humane approach to technological adoption, fostering a culture that is both innovative and aligned with the principles of Industry 5.0.

The thesis finding presents an inclusive approach to technology adoption, in which end users and the entire workforce are involved, providing a practical strategy to counter conservative resistance. This strategic emphasis not only aligns with, but also practically applies the principles discussed by Henriksen and Thomassen (2023) regarding the need for inclusivity and collaboration in fostering a sustainable organisational culture within Industry 5.0 settings. The thesis underscores the need for cultural shifts that embrace technological advancements while ensuring the workforce's needs and safety concerns are addressed, thereby enriching the existing models of innovation waves that may focus predominantly on technological and strategic aspects.

In exploring sector-specific insights, the thesis provides nuanced views on the ways in which different sectors within the heavy industry approach the challenges of transformation for innovation waves. The mining sector's emphasis on safety and wellbeing alongside operational efficiency and the oil and gas sector's focus on trust-building through open communication highlight the diverse strategies employed to achieve cultural transformation. These insights are particularly valuable as they illustrate how sectors with similar conservative characteristics can implement varied strategies based on their specific operational contexts and cultural nuances.

7.3.2.2 Implementation-Centred Approach

Implementation-Centred Approach, Skill Transformation and Continuous Integration (Seizing and Reconfiguring)

The thesis finding's focus on a human-centric approach with technology trials underlines the necessity for aligning technological advances with human needs. The finding complements and extends the discussions by Henriksen, Røstad and Thomassen (2022), who highlighted human-centricity as a cornerstone of Industry 5.0. The specific example provided, where organisational members are empowered to own the process through methodological trials, illustrates a practical application of human-centric principles, bridging the gap between theoretical advocacy and practical implementation. It demonstrates the importance of employee involvement in using the technology as well as in understanding and supporting its integration, a critical aspect that is often underexplored in the literature focused on technological specifications and outcomes.

The emphasis of the thesis finding on continuous feedback mechanisms and a closed-loop approach aligns with the literature on continuous improvement processes in innovation waves, as discussed by

Chirumalla (2021). However, the thesis finding provides a nuanced view of how these mechanisms are implemented in practice, highlighting the ongoing nature of adaptation and refinement needed in technology integration. This insight extends the literature by providing a concrete example of how feedback is essential not only for technology optimisation, but also for maintaining alignment with human factors throughout the transformation process.

The finding’s emphasis on providing employees with the tools and skills to simplify complex tasks highlights a key aspect of skill transformation that supports technology adoption. This approach expands on the work by Ghobakhloo et al. (2023c), who investigated the resource management challenges in Industry 4.0. The thesis finding offers a specific example of how organisations can implement skill transformation initiatives to augment human capabilities rather than replace them, stressing skill enhancement as a form of value addition. This detailed illustration shows how empowering employees with new skills can facilitate a smoother integration of advanced technologies.

The differentiation in strategies between sectors such as shipbuilding, mining, and oil and gas underlines the tailored approaches necessary for effective transformation. Each sector adapts the general principles of human-centric technology adoption, skill transformation and continuous feedback to its unique operational and cultural challenges. For instance, the mining sector’s focus on aligning technological advancements with safety enhancements and operational efficiency offers a nuanced view of the ways in which innovation waves can be contextually adapted. This sector-specific insight adds depth to the literature by demonstrating how transformation strategies for innovation waves must be customised to effectively address the distinct needs and challenges of different industries.

Implementation-Centred Approach, and Leadership and Communication (Seizing and Reconfiguring)

This thesis finding that accentuates leadership not just as a directive force, but also as an inspirer of future leaders aligns with and extends the discussions in the literature about transformative leadership. For instance, Thomas et al. (2023) emphasised the need for leadership that fosters continuous learning and adaptation, which is crucial in Industry 5.0 settings. The practical insight from the thesis finding offers a concrete example of how leadership in action can catalyse broader organisational changes, fostering a culture of empowerment and collaboration. This specific case contributes to the literature by bridging the gap between theoretical leadership roles and their practical implications in transformation efforts for innovation waves.

The thesis finding's emphasis on 'communication is the currency of leadership' (O3) reflects the fundamental role of communication in achieving alignment and fostering organisational change. This statement ties directly into the discussions by Dubey et al. (2024) and Santos et al. (2023), who highlighted the importance of transparent and effective communication in managing innovation waves. By offering a detailed example of how communication functions within leadership practices to enhance understanding and drive organisational progress, the thesis finding enriches the literature by providing a nuanced view of how communication strategies are implemented to support transformation initiatives for innovation waves.

The finding's focus on empathy and inclusivity in leadership addresses a significant aspect of leadership that is often underexplored in the literature. Although Henriksen and Thomassen (2023) discussed the importance of human-centric approaches in enhancing employee welfare, the insights from the thesis finding provide a practical application of these theories, revealing how leadership can actively foster an environment where individuals feel empowered and valued. This extends the literature by demonstrating how empathetic leadership can be effectively practiced, enhancing employee engagement and facilitating the adoption of new technologies and processes.

The differentiation in leadership and communication approaches across sectors such as shipbuilding, mining, and oil and gas reflects the contextual adaptability of transformation strategies for innovation waves. For instance, the emphasis in the shipbuilding sector on empowering individuals to become leaders highlights a decentralised approach to leadership that is particularly effective in environments that prioritise safety and operational continuity. This sector-specific insight extends the discussion on leadership in heavy industries, providing a nuanced understanding of how leadership styles can be adapted to meet specific industry challenges and enhance innovation waves outcomes.

People-Centred Approach and Cultural Transformation (Seizing and Reconfiguring)

This thesis finding positions the people-centred approach not simply as a strategy, but as a fundamental part of the fabric of an organisational culture that fosters resilience and adaptability. This aligns with and expands on Henriksen, Røstad and Thomassen (2022), who examined human centricity as a cornerstone of Industry 5.0. By focusing on inclusivity and empowerment, the thesis finding provides examples of how organisations can integrate these principles into their operational ethos, thereby offering a practical application that enriches the theoretical discussions found in the literature. Further, the thesis finding's emphasis on initiatives such as personalised development plans and inclusive decision-making processes illustrates the practical steps organisations can take to foster a culture of resilience and empowerment. This supports the findings from Narkhede et al. (2024) and Mihardjo and Alamsyah (2019), who advocated for a human-centred approach in Industry 5.0. The thesis finding contributes to the literature by showing how these strategies can be operationalised within the context of innovation waves, thereby enhancing our understanding of how to effectively implement such approaches.

The thesis finding also points out that the shipbuilding sector emphasises inclusivity and empowerment, reflecting the collaborative nature required in shipbuilding projects. This practical insight complements the theoretical frameworks suggested by Henriksen and Thomassen (2023), who promoted human-centric approaches that place employee welfare at the forefront. The mining sector's focus on creating a safe space for employees to unleash their potential illustrates a sector-specific application of people-centred approaches, addressing the physically demanding and hazardous nature of mining work. This aligns with discussions in the literature such as those by Chavez et al. (2023), who highlighted the importance of aligning technological advancements with human wellbeing. The example of how mining companies prioritise safety and empowerment provides a nuanced understanding of how people-centred strategies can adapt to sector-specific challenges, enhancing the literature on organisational adaptability and safety management. In the oil and gas sector, the emphasis on advocacy as a driver of cultural transformation highlights how leadership and communication strategies can mobilise internal support for change initiatives. This practical insight extends the findings of Thomas et al. (2023), who discussed the role of leadership in fostering a culture conducive to innovation waves. The specific mention of the way in which the oil and gas sector uses communication as a currency to foster understanding and alignment provides a concrete example of how effective leadership practices can facilitate cultural transformation in industries with high safety and environmental stakes.

This discussion enriches the existing literature by detailing how a people-centred approach can catalyse cultural transformation within organisations undergoing innovation waves. It highlights the importance of integrating this approach into aspects of organisational operations, from strategic decision-making to daily interactions, thereby providing a comprehensive framework for understanding and implementing cultural change.

7.3.2.3 Understanding Resistance

Understanding Resistance and an Implementation-Centred Approach (Seizing and Seizing)

Exploring the interrelationship between understanding resistance and an implementation-centred approach in innovation waves highlights insights for navigating organisational challenges effectively.

This thesis finding underscores that simply deploying technological solutions without addressing the human factors—such as resistance to change because of fears of job loss or disruption—can significantly hinder the success of digital initiatives. This concept aligns with, and expands on, the existing literature, which has often stressed the technological aspects without fully integrating the human response to these changes. For instance, the emphasis on understanding resistance as a dynamic capability within industry contexts, as highlighted by authors such as Narkhede et al. (2024) and Santos et al. (2023), provides a framework for appreciating the depth of resistance beyond mere reluctance, suggesting that addressing these concerns through fair labour practices and responsible management is key to easing transitions in Industry 5.0. These studies suggested that addressing resistance involves more than just overcoming objections, and the thesis finding shows that methodological implementation, such as a technology trial with end users, is crucial to address resistance since it highlights the value of innovation and potential improvement.

Further, the thesis finding suggests that an implementation-centred approach that does not integrate an understanding of resistance is likely to fail because it overlooks the essential human elements that drive successful adoption and integration of new processes. The thesis finding promotes the notion that resistance to change often stems from fears such as job security and control loss; thus, a multifaceted strategy is needed to address resistance. This strategy should not only involve technological adjustments, but also proactive communication and engagement with employees. This approach is supported by the European Commission (2021), which defines resilience as the capability to adapt and thrive despite disruptions, emphasising that fostering employee competence and adaptability is crucial. The practical example of the way leaders in the shipbuilding sector prioritises understanding resistance by focusing on proactive communication and stakeholder involvement illustrates the successful application of these theoretical concepts. It shows that effectively addressing resistance requires acknowledging it as well as actively engaging with it through tailored strategies that consider the specific dynamics of the sector.

By bridging the theoretical gaps identified in the literature—such as the limited focus on human-centric aspects in transformation efforts for innovation waves —the thesis finding contributes to a more holistic understanding of innovation waves. It calls for a balanced approach that considers both the technical execution of strategies and the cultural shifts necessary to ensure that these strategies are embraced at all levels of the organisation. This dual focus is essential for fostering a resilient and adaptable organisational culture that can thrive in the face of rapid technological advancements.

Understanding Resistance, and Leadership and Communication (Seizing and Reconfiguring)

Understanding the interrelationship between understanding resistance, and leadership and communication provides invaluable insights into effectively managing transformation within organisations. For example, the thesis finding's emphasis on clear and transparent communication and helping employees understand the benefits of technology underscores the necessity for addressing human concerns directly. This approach is key to changing perceptions about technology potentially replacing jobs, instead positioning it as a tool used to enhance work efficiency and safety. This aligns with insights from Santos et al. (2023), who discussed the importance of addressing resistance through comprehensive policies that foster innovation while being mindful of regulatory compliance and employee concerns. Moreover, the thesis finding reveals that leadership's role in integrating technology reflects the need for leadership to not only endorse technological changes, but also actively manage the transition by enforcing processes and guiding employees through the change. This is supported by Thomas et al. (2023), who highlighted the evolving requirements of leadership in Industry 5.0, focusing on the necessity for leaders to engage in continuous learning and foster a culture of collaboration and technological understanding.

The thesis finding further illustrates how leadership and communication synergise to address fears and demonstrate value. By effectively communicating how technology benefits the organisation and its workforce, leaders can help to mitigate resistance and enhance receptivity to new processes. This reflects the points raised by Dabić, Maley and Nedelko (2023), who emphasised the impact of leadership values on organisational outcomes and productivity in Industry 4.0 environments. In practical terms, sectors such as shipbuilding and mining emphasise different aspects of leadership and communication based on their operational contexts. Shipbuilding, which requires high levels of precision and safety, focuses on fostering an environment of open communication and clear vision. Conversely, the mining sector, dealing with risks and operational challenges, places a stronger emphasis on leadership's role in creating safe spaces for innovation and addressing concerns related to job security and process changes. These sector-specific approaches reflect the broader themes discussed in the literature, in which understanding resistance is linked to strategic leadership and effective communication. As noted by Ghobakhloo et al. (2023c), managing change effectively requires the clear communication of digital objectives and a leadership approach that aligns these objectives with the organisation's strategic goals and the wellbeing of its workforce.

By combining these practical examples from the findings with the theoretical insights from the literature, a nuanced understanding of the dynamics between resistance, and leadership and communication can lead to more effective transformation strategies for innovation waves. This holistic approach considers the technical aspects of transformation along with the human elements that are crucial for successful implementation and organisational adaptation.

In summary of Section 7.3.2, the interrelationships between seizing capabilities and others focus on the integration of value recognition, understanding resistance and implementation-centred approaches within leadership and communication strategies. These findings emphasise the necessity for clear communication and proactive leadership in managing transitions and fostering an environment that is conducive to technological adoption. By addressing human concerns and aligning technological initiatives with long-term organisational goals, these strategies mitigate resistance and enhance the overall acceptance of new technologies. Table 41 summarises the key findings and implications, highlighting the need for tailored approaches to managing sector-specific challenges and driving successful transformation for innovation waves.

Table 41: Key findings and implications on interrelationships with seizing capability

	Interrelationships	**Key findings**	**Implications**
Seizing and sensing	Value recognition and strategic foundation	• Aligning strategic planning with value recognition from the start of transformation efforts ensures the integration of both short-term gains and a long-term vision.	• Emphasises the need for strategic planning that incorporates human factors and sustainability principles to foster inclusive and effective transformation processes.
Within seizing	Value recognition and understanding resistance	• Clear and well-managed communication is crucial for overcoming resistance and aligning digital initiatives with long-term organisational goals.	• Highlights the importance of open discussions, trust-building and strategic clarity to manage employee perceptions and expectations, facilitating smoother transformation processes.
	Understanding resistance and implementation-centred approach	• Addressing human factors such as fears of job loss or disruption is crucial for the successful innovation and integration of new processes.	• Emphasises the need for proactive communication and engagement with employees, considering both technical and cultural shifts to ensure strategies are embraced at all organisational levels.
Seizing and reconfiguring	Value recognition and cultural transformation	• Recognising indirect values such as wellbeing and safety is essential for overcoming conservatism and facilitating cultural transformation in heavy industries.	• Stresses the importance of integrating sustainability principles and inclusive approaches in technology adoption to align with broader societal and environmental goals, fostering a culture of innovation and safety.
	Implementation-centred approach, skill transformation and continuous integration	• Emphasising a human-centric approach with technology trials aligns technological advances with human needs, supported by continuous feedback mechanisms and skill transformation.	• Highlights the importance of employee involvement in technology integration, continuous feedback for refinement, and empowering employees with the tools and skills needed to simplify complex tasks. Tailored strategies are

Interrelationships	Key findings	Implications
		necessary for different sectors such as shipbuilding, mining, and oil and gas.
Implementation-centred approach and leadership and communication	• Leadership should inspire future leaders, emphasise communication as a key tool and practice empathy and inclusivity to foster a collaborative culture.	• Stresses the need for leadership that empowers and engages employees, transparent and effective communication, and empathetic leadership to enhance employee engagement and technology adoption. Sector-specific approaches reflect contextual adaptability.
People-centred approach and cultural transformation	• A people-centred approach fosters organisational resilience and adaptability, integrating inclusivity and empowerment into the organisational culture.	• Highlights the importance of personalised development plans, inclusive decision-making processes, and creating a safe and empowering work environment. Sector-specific strategies enhance adaptability and safety in industries such as shipbuilding, mining, and oil and gas.
Understanding resistance, and leadership and communication	• Clear and transparent communication, coupled with active leadership, helps employees understand the benefits of technology and addresses human concerns directly.	• Stresses the importance of leadership in managing transitions, enforcing processes and guiding employees through change, while effectively communicating the benefits of new technologies to mitigate resistance and enhance receptivity.

7.3.3 Interrelationships of Reconfiguring

As discussed in Section 7.2.3, the reconfiguring capabilities comprise continuous integration, leadership and communication, cultural transformation and skill transformation. The thesis findings revealed six new interrelationships and validated two existing ones involving these reconfiguring capabilities, as shown in Table 42.

Table 42: Interrelationship matrix of reconfiguring

🟦 New findings
🟥 Validated

		Sensing			Seizing			Reconfiguring			
		Strategic foundation	Knowledge	Management	Value recognition	Implementation-centred approach	Understanding resistance	Continuous integration	Leadership and communication	Cultural transformation	Skill transformation
Reconfiguring	Continuous integration	🟥	🟦								
	Leadership and communication				🟦						🟦
	Cultural transformation						🟦		🟥		
	Skill transformation					🟦		🟦			

Detailed examinations and discussions of these interrelationships are presented in the following sections.

7.3.3.1 Continuous Integration

Continuous Integration and Strategic Foundation (Reconfiguring and Sensing)

Exploring the interrelationship between continuous integration and strategic foundation reveals the fundamental importance of aligning transformation efforts for innovation waves with overarching strategic objectives. The thesis finding's emphasis on the need for a strategic foundation to successfully integrate new technologies into processes offers a practical example of the way in which strategic alignment facilitates effective digital adoption. This reflects findings in the literature, such as those by Chirumalla (2021), who discussed the significance of the strategic integration of digital tools into organisational processes to maintain agility and competitiveness. Additionally, the finding's point regarding the necessity for clear objectives in technology adoption highlights the importance of strategic clarity, which is crucial for successful continuous integration. This is supported by Szalavetz (2019), who underscored the need for seamless technology integration that aligns with strategic business goals to fully leverage technological advancements.

Further, the thesis finding touches on the proactive measures necessary to address potential readiness gaps, aligning with insights from Feroz et al. (2023), who stressed strategic prioritisation and the adept integration of digital solutions to optimise operations and seize new opportunities. This strategic foresight is central to navigating the complexities associated with continuous integration, ensuring that digital efforts are not only technically proficient, but also strategically sound.

In the mining sector, the focus on structured planning and alignment with long-term goals is essential given the industry's capital-intensive and long-lifecycle projects. This sector-specific strategy resonates with the discussion by Feroz et al. (2023) on the need for adept integration and strategic prioritisation to navigate the complexities of innovation waves effectively. The literature suggests that such strategic foundations are vital for ensuring that digital initiatives are not only implemented, but also sustainable and effectively contribute to the organisational goals. The oil and gas sector's focus on clear objectives and efficiency underscores the practical application of the strategic foundation principles discussed by Ghosh et al. (2022), who highlighted the importance of customisation and personalisation in meeting specific industrial needs. The contributions of the findings from the thesis to the existing literature are clear: they reinforce the necessity for a strong strategic foundation as a precondition for successful continuous integration. This alignment supports technological adoption and ensures that such integrations are beneficial and aligned with the long-term strategic goals of the organisation, thereby enhancing the overall effectiveness and sustainability of transformation efforts for innovation waves.

Continuous Integration and Knowledge (Reconfiguring and Sensing)

This thesis finding demonstrates a critical interdependence between continuous integration and knowledge, highlighting that technological adaptations are not merely technical changes, but are deeply embedded in the organisational knowledge. This aligns with the views of Vu et al. (2023) and Rangaswamy (2021), who stressed the importance of continuous improvement and knowledge management as pivotal for sustaining competitive advantage. However, the findings extend these discussions by showing how sector-specific challenges, such as those in the heavy industry, necessitate a more nuanced approach to technology integration and knowledge application. The insights from participants, particularly in the contexts of shipbuilding and mining, illustrate a higher degree of customisation and end user involvement than typically discussed in the literature. This reflects a novel finding that sector-specific dynamics significantly influence the implementation of continuous integration strategies, which may not be as pronounced in more generic organisational models.

Moreover, the thesis finding uncovers a significant variance in the perception and execution of continuous integration across different sectors. Although the literature often presents a somewhat uniform approach to integration and knowledge management (Feroz et al. 2023; Szalavetz 2019), the evidence from the shipbuilding and mining sectors indicates a bespoke adaptation of these strategies, shaped by the intricacies of sectoral operations. This contributes new insights to the literature by illustrating how contextual factors within sectors modulate the interplay between technology and organisational knowledge, a consideration that has been somewhat underexplored. Additionally, the role of continuous learning and knowledge enhancement as indispensable elements of digital integration is significantly highlighted. This is particularly aligned with the theoretical frameworks proposed by Ghosh et al. (2022) and Thomas et al. (2023), who emphasised the strategic importance of customisation and flexibility in technology adoption. The findings here go further, suggesting that continuous learning is both a complementary and a critical capability that enables organisations, especially in technology-intensive sectors, to navigate the complexities of innovation waves. This is a significant extension of the existing literature, which has often focused more on the technological aspects of integration without fully capturing the human and knowledge-oriented dimensions.

The discrepancies observed in the levels of customisation and user involvement across sectors also offer a new dimension to the literature on dynamic capabilities. Even though the literature has recognised the need for technological and process integration (Chirumalla 2021; Ellström et al. 2022), the thesis finding suggests that the depth of integration required can vary significantly across sectors, with heavy industries requiring more profound and nuanced interventions. This finding is novel as it highlights the differentiated impact of sector characteristics on the application of dynamic capabilities, revealing a need for sector-specific frameworks within the continuous integration discourse. The thesis also sheds light on the varied emphasis on collaboration and open innovation across sectors, a theme recurrent in the literature (Henriksen & Thomassen 2023; Sousa-Zomer, Neely & Martinez 2020). The nuanced differences in how collaboration is perceived and enacted across the heavy industry sectors provide new insights into the challenges of implementing open innovation strategies in more insular and traditional sectors. This contributes to the literature by contextualising the strategic importance of collaboration and open innovation within specific sectoral dynamics, thereby enhancing our understanding of how these capabilities can be effectively mobilised in different organisational contexts.

7.3.3.2 Leadership and Communication

Leadership and Communication, and Value Recognition (Reconfiguring and Seizing)

This thesis finding underscores the significant role of leadership in setting a vision that seamlessly integrates technology into organisational processes. This is echoed in the literature, where leadership has been consistently highlighted as crucial for guiding innovation and change (Dabić, Maley & Nedelko 2023; Thomas et al. 2023). However, this thesis provides a significant extension by illustrating the nuances regarding how leadership manifests in different sectors. For instance, although leadership in the shipbuilding sector is noted for its visionary nature, it appears somewhat detached from direct value recognition practices. This contrasts with the mining sector, where leadership explicitly bridges vision with practical outcomes through clear and transparent communication and offers new insights into sector-specific leadership styles and their impact on value recognition.

Communication, identified as a core in the thesis finding, goes beyond traditional roles to act as a strategic tool for aligning employee perceptions with organisational goals. The literature supports the necessity for effective communication strategies in innovation waves (Dubey et al. 2024; Santos et al. 2023), highlighting the need for clarity and transparency. The thesis findings contribute novel insights by showcasing how these communication strategies are implemented across different sectors, affecting the degree to which the value of technology is recognised and accepted by the workforce. In particular, the empathetic communication style in the oil and gas sector, which prioritises the comprehension of employee's acceptance, is highlighted as a key factor in fostering a culture of trust and value recognition.

Additionally, the thesis finding reveals that value recognition is not only about acknowledging the benefits of technology, but also involves a deep understanding of how these benefits align with organisational and sector-specific goals. This is a significant extension of the existing literature, which has often focused on value recognition from a broader, more generic perspective (Henriksen, Røstad & Thomassen 2022). By understanding how value is perceived and communicated within sectors, this thesis presents new, significant findings in that value recognition strategies need to be contextually adapted to maximise their effectiveness and resonance within the organisation.

This discussion aligns with the broader themes of the literature, where the role of leadership and communication as organisational dynamic capabilities has been well established. However, it breaks new ground by detailing how these capabilities are nuanced by sectoral contexts, offering a richer understanding of their implementation and impact. The contrast in leadership and communication styles between sectors such as shipbuilding, mining, and oil and gas, and their differential effects on value recognition, are novel contributions to the literature. These findings underscore the complexity of applying a general leadership and communication style to specific industrial contexts, suggesting the need for more tailored approaches that consider the unique challenges and opportunities within each sector.

Leadership and Communication, and Skill Transformation (Reconfiguring and Reconfiguring)

The thesis findings here highlight the significant role of leadership in advocating and supporting skill transformation initiatives. The importance of leadership in driving skill transformation is well aligned with the literature, which views leadership as essential for guiding innovation and shaping capabilities within organisations (Dabić, Maley & Nedelko 2023). This thesis builds on these studies by demonstrating how leadership in heavy industries not only guides, but also actively participates in and supports the skill transformation process. This active involvement is crucial in fostering a culture that values continuous learning and skill enhancement, which is vital in sectors undergoing rapid technological change. This approach is a significant extension of the literature, which has often highlighted leadership from a more strategic, less hands-on perspective.

Moreover, the thesis finding stressed the essential role of effective communication in skill transformation efforts. The literature has identified clear and transparent communication as a fundamental aspect of successful organisational change (Dubey et al. 2024; Santos et al. 2023). The thesis findings contribute to this discussion by showing how communication strategies are customised within different sectors to meet specific challenges. For example, in the mining sector, where operational complexities and regulatory environments pose particular challenges, effective communication is strategically used to ensure that skill transformation aligns with broader organisational goals. This sector-specific application of communication strategies provides a nuanced contribution to the literature, suggesting that the effectiveness of communication in facilitating skill transformation depends significantly on understanding and addressing the unique needs of each sector.

Further, the thesis finding reveals how leadership and communication intersect to facilitate skill transformation in a way that respects and enhances the existing skills of employees, promoting a symbiotic relationship between technology and human capabilities. This is particularly evident in the shipbuilding sector, where leadership’s role in championing upskilling and reskilling is crucial yet under-communicated. The finding suggests that, even though leadership in the shipbuilding sector effectively drives skill transformation, there is a notable gap in communication, which could further enhance the effectiveness of these initiatives. This finding highlights a novel area where leadership and communication can be better integrated to boost skill transformation efforts, contributing a significant addition to the literature on dynamic capabilities in heavy industries.

7.3.3.3 Cultural Transformation

Cultural Transformation and Understanding Resistance (Reconfiguring and Seizing)

This thesis finding sheds light on how organisational culture, leadership and communication interact to mitigate resistance to technological adoption. The role of organisational culture in facilitating or hindering technological adoption has been emphasised extensively in the literature. The flexibility, adaptability and openness of a culture significantly influence how technology is integrated into organisational processes (Feroz et al. 2023; Warner & Wäger 2019,). The success of integrating new technology depends primarily on the prevailing organisational culture’s openness to change. This notion is supported by the thesis finding demonstrating that, in the shipbuilding sector, addressing employees’ fears and concerns about new technology through an open and receptive culture can significantly mitigate resistance. The thesis finding contributes to this discourse by illustrating how a receptive culture can significantly ease the transition to new technologies, thereby reducing resistance.

Leadership is seen as a critical factor in steering cultural transformation towards greater acceptance and less resistance to technological change. The literature supports this view, suggesting that effective leadership involves not just decision-making, but also embodying the change leaders wish to see within the organisation (Dabić, Maley & Nedelko 2023; Thomas et al. 2023). The thesis finding enhances this understanding by demonstrating that leadership must be proactive in addressing the fears and concerns associated with new technologies, emphasising the role of leaders as facilitators of communication and cultural adaptability. In addition, communication emerges as a fundamental tool through which leaders can shape organisational culture and address resistance. It acts as a bridge between the introduction of new technologies and their acceptance by the workforce (Dubey et al. 2024; Santos et al. 2023,). The thesis finding provides new insights into the specific ways in which communication can be structured to foster a culture that embraces change and innovation, highlighting the importance of transparency and ongoing dialogue in reducing resistance.

These sector-specific findings, particularly from the shipbuilding, and oil and gas sectors, underscore the necessity for tailoring strategies to effectively navigate resistance and drive successful technology adoption. This sector-specific approach is a novel contribution to the literature, which has often focused on more general strategies for managing resistance. By recognising the unique challenges of each sector, this discussion offers a more nuanced understanding of how cultural transformation and resistance to change can be managed more effectively.

Cultural Transformation, and Leadership and Communication (Reconfiguring and Reconfiguring)

This thesis finding elaborates on how transformational leadership and effective communication strategies are key to fostering an organisational culture that is conducive to embracing technological advancements and innovation. Transformational leadership is central to driving cultural transformation within organisations, as highlighted in both the finding and the literature. Leaders play a crucial role in motivating and inspiring employees to adopt new technologies and innovate, thereby fostering a climate where change is embraced (El Sawy et al. 2020; Thomas et al. 2023). For instance, the thesis finding emphasises that leadership instils a culture of change, which is fundamental for organisational adaptability. This aligns with the literature, in which Dabić, Maley and Nedelko (2023) discussed how leadership values significantly influence organisational capabilities and outcomes, especially in high-stakes environments with Industry 4.0. This discussion extends the existing literature by providing detailed examples of how leaders can actively shape the cultural contours of an organisation to better suit the demands of a digital age.

The thesis finding further underscores that the success of cultural transformation is heavily dependent on transparent and inclusive communication strategies. As noted in the thesis finding, transparent communication from leadership is crucial for preparing employees for technological changes and managing resistance. This is supported by the literature, which has emphasised the role of clear and effective communication in digital transformation efforts (Dubey et al. 2024; Santos et al. 2023). For example, the effective communication strategies highlighted in the thesis finding illustrate how leadership can facilitate a culture of innovation and digital adoption by clearly articulating the purpose and benefits of transformation initiatives, thus creating a shared vision of progress.

The sector-specific insights provided in the thesis findings reveal how different industrial contexts—shipbuilding, oil and gas, and mining—approach the interplay between cultural transformation, leadership and communication. In the shipbuilding, and oil and gas sectors, leaders are viewed as agents of change who not only inspire, but also motivate employees through transparent communication. This contrasts with the mining sector, which, owing to its traditional hierarchical structure, places somewhat less emphasis on bottom-up leadership initiatives for cultural transformation. This nuanced understanding offers a substantial contribution to the literature, suggesting that the effectiveness of leadership and communication strategies in driving cultural transformation may vary significantly across different sectoral contexts. The synthesis of these insights with the existing literature highlights the interconnected nature of strategy, digital leadership, communication and cultural transformation in driving organisational change and innovation (El Sawy et al. 2020; Santos et al. 2023). The thesis finding enriches the discourse by showing practical examples of how organisations can implement these theories to enhance their adaptability and competitiveness in rapidly evolving digital landscapes.

7.3.3.4 Skill Transformation

Skill Transformation and People-Centred Approach (Reconfiguring and Seizing)

This thesis finding reports the interrelationship between skill transformation and a people-centred approach within the heavy industry context, highlighting the critical balance between human expertise and technological advancements. One key contribution of the thesis finding to the existing literature is its emphasis on the collaborative interaction between human expertise and automated systems. This interaction underscores the augmentation of human capabilities with technology rather than their replacement. The literature has often discussed technological adoption at a high level, but the specific examples provided here, such as the crucial role of human expertise in quality inspection processes alongside technology, add depth to our understanding of how such collaborations are operationalised within heavy industries. This contributes new insights to studies such as those by Narkhede et al. (2024), and Modgil, Singh and Agrawal (2023), which advocated for adaptable and skilled workforces, but often lack detailed industrial applications.

Another significant contribution is the detailed exploration of sector-specific challenges and strategies in skill transformation. The thesis finding reveals how sectors such as shipbuilding and mining differ in their approach to integrating new technologies, influenced by their unique cultural and operational dynamics. For example, the shipbuilding sector's adaptability contrasts with the challenges around resource scarcity in mining, affecting the pace and approach to technology adoption and skill development. This specificity enriches the literature, which has discussed organisational capabilities generally, by providing grounded examples of how industries adapt to digital transformation challenges (Chirumalla 2021; Sousa-Zomer, Neely & Martinez 2020).

The findings also highlight the critical role of resource alignment in facilitating skill transformation and preparing organisations for innovation waves. This aspect of resource allocation for continuous training and skill development provides a practical dimension to the theoretical discussions on continuous learning and resilience found in the literature (Modgil, Singh & Agrawal 2023; Rangaswamy 2021). By illustrating how investments in education and training empower employees and enhance organisational readiness, the thesis finding offers a strategy that can be adopted by other sectors undergoing similar transformations. This discussion provides a nuanced contribution to the literature by detailing the practical applications and challenges of integrating skill transformation strategies within heavy industries. It extends the theoretical frameworks by adding depth and context, offering industry-specific insights that can guide future research and practice in navigating the complexities of workforce adaptation in the digital age.

Skill Transformation and Continuous Integration (Reconfiguring and Reconfiguring)

This thesis finding emphasises the importance of integrating new skill sets, such as software engineering, within organisations to support continuous integration efforts. This is crucial as modern technology systems require holistic skills for effective implementation. The thesis finding underscores the interconnected nature of modern technology systems, which necessitate a holistic approach to skill implementation, particularly in areas such as software engineering. This was supported by a shipbuilding practitioner, who emphasised the importance of integrating diverse skill sets to facilitate seamless communication within organisational technology systems. This finding enriches the extant literature by demonstrating practical applications of the theoretical concepts discussed in works by authors such as Vu et al. (2023) and Rangaswamy (2021), who observed that continuous improvement and technological adaptability are essential for competitive advantage. The thesis finding's emphasis on acquiring the necessary skills for back-end platform operation provides a grounded example of how organisations can bridge the gap between technological needs and workforce capabilities.

The thesis finding further reveals how different sectors, such as shipbuilding and mining, approach the challenges of skill transformation and continuous integration. For instance, the shipbuilding sector's focus on seamless communication underscores its proactive approach to integrating advanced technologies in labour-intensive processes. In contrast, the mining sector, as suggested by its emphasis on resource allocation for continuous training, faces potential challenges owing to resource scarcity, influencing the speed and effectiveness of technology adoption and skill development. This sector-specific insight adds depth to the literature by illustrating the variability in how industries implement skill transformation strategies to support continuous integration efforts, reflecting the broader themes found in the literature regarding the need for adaptable organisational capabilities in Industry 4.0 and beyond (Chirumalla 2021; Sousa-Zomer, Neely & Martinez 2020).

The literature review positions continuous integration as a crucial organisational dynamic capability, involving the seamless incorporation of new technologies and processes to maintain organisational adaptability. The thesis finding contributes to this concept by linking skill transformation directly with continuous integration efforts, suggesting that the effective integration of new technologies requires a well-prepared workforce capable of managing and utilising these technologies efficiently. This connection is particularly evident in the emphasis on the need for continuous learning and skill upgrading, as highlighted by various authors in the literature review, including Santos et al. (2023), and Modgil, Singh and Agrawal (2023), who advocated for managerial and soft skill development alongside technical training. By synthesising these insights, the discussion not only reaffirms the critical roles of skill transformation and continuous integration in fostering successful transformation for innovation waves, but also enhances the academic discourse by detailing how these elements interact within various industrial contexts.

In summary of Section 7.3.3, the interrelationships among reconfiguring capabilities and other capabilities explore the synergy between skill transformation, continuous integration, leadership, communication and cultural transformation. These relationships emphasise the active role of leadership in advocating for skill transformation and fostering an organisational culture that embraces technological advancements. Effective communication strategies are crucial for aligning employee perceptions with organisational goals and enhancing value recognition. Additionally, the integration of new skill sets, and continuous learning are vital for maintaining organisational adaptability and successfully navigating technological changes. Table 43 summarises the key findings and implications, providing a comprehensive overview of the ways in which these capabilities interact to support capability building for innovation waves.

Table 43: Key findings and implications on interrelationships with reconfiguring capabilities

	Interrelationships	Key findings	Implications
Reconfiguring and sensing	Continuous integration and strategic foundation	- Aligning transformation efforts with overarching strategic objectives is essential for effective digital adoption and continuous integration.	- Highlights the necessity for strategic clarity and proactive measures to address readiness gaps, ensuring that digital efforts are technically proficient and strategically sound. Sector-specific strategies are vital for sustaining long-term goals and navigating complexities, especially in capital-intensive industries such as mining, and oil and gas.
	Continuous integration and knowledge	- Technological adaptations are deeply embedded in organisational knowledge, requiring continuous learning and knowledge enhancement for successful integration.	- Emphasises the importance of customisation, end user involvement and sector-specific dynamics in technology integration. Highlights the need for continuous learning as a critical capability, suggesting sector-specific frameworks to address the unique challenges of different industries, particularly in heavy industries such as shipbuilding and mining.
Reconfiguring and seizing	Leadership and communication, and value recognition	- Leadership integrates technology seamlessly into organisational processes through vision and communication, crucial for recognising and realising the value of technology.	- Stresses the need for sector-specific leadership styles and empathetic communication to align employee perceptions with organisational goals, enhancing value recognition and the acceptance of new technologies.
	Cultural transformation and understanding resistance	- Organisational culture, leadership, and communication interact to mitigate resistance to technological adoption, facilitating smoother transitions.	- Highlights the necessity for a receptive culture, proactive leadership in addressing fears and concerns, and transparent communication to foster openness to change and innovation. Sector-specific strategies are essential for effectively navigating resistance and driving successful technology adoption.
Within reconfiguring	Skill transformation and people-centred approach	- Emphasises the balance between human expertise and technology, with human skills being augmented by technological tools rather than replaced.	- Highlights the need for continuous training and skill development to empower employees, ensuring they can effectively collaborate with and utilise new technologies. Sector-specific challenges, such as resource scarcity in mining, necessitate tailored strategies for skill transformation.
	Cultural transformation, and leadership and communication	- Transformational leadership and effective communication strategies foster an organisational culture conducive to embracing technological advancements and innovation.	- Stresses the role of leaders in motivating and inspiring employees, transparent communication to manage resistance and creating a culture of change. Sector-specific insights suggest the effectiveness of these strategies varies across different industrial contexts, enhancing adaptability and competitiveness.
	Leadership and communication and skill transformation	- Leadership and effective communication are essential for advocating and supporting skill transformation initiatives, fostering a culture of continuous learning and skill enhancement.	- Emphasises the active involvement of leadership in skill transformation, tailored communication strategies to meet sector-specific challenges and the integration of existing skills with new technological capabilities to promote symbiotic relationships between technology and human capabilities.

Interrelationships	Key findings	Implications
Skill transformation and continuous integration	• Integrating new skill sets, such as software engineering, is crucial for supporting continuous integration efforts and maintaining organisational adaptability.	• Emphasises the interconnected nature of modern technology systems, necessitating a holistic approach to skill implementation. Highlights sector-specific approaches to integrating advanced technologies and the importance of continuous learning and skill upgrading to bridge the gap between technological needs and workforce capabilities.

7.4 Revised Conceptual Framework

This thesis aimed to uncover the organisational dynamic capabilities required for innovation waves in the Australian heavy industry. Initially, a theoretical framework (see Figure 37) was developed, informed by the recent literature from 2018 to 2024 on organisational capabilities, specifically focusing on (1) organisational capability for digital transformation, Industry 4.0 and Industry 5.0 and (2) organisational dynamic capability for digital transformation and Industry 4.0.

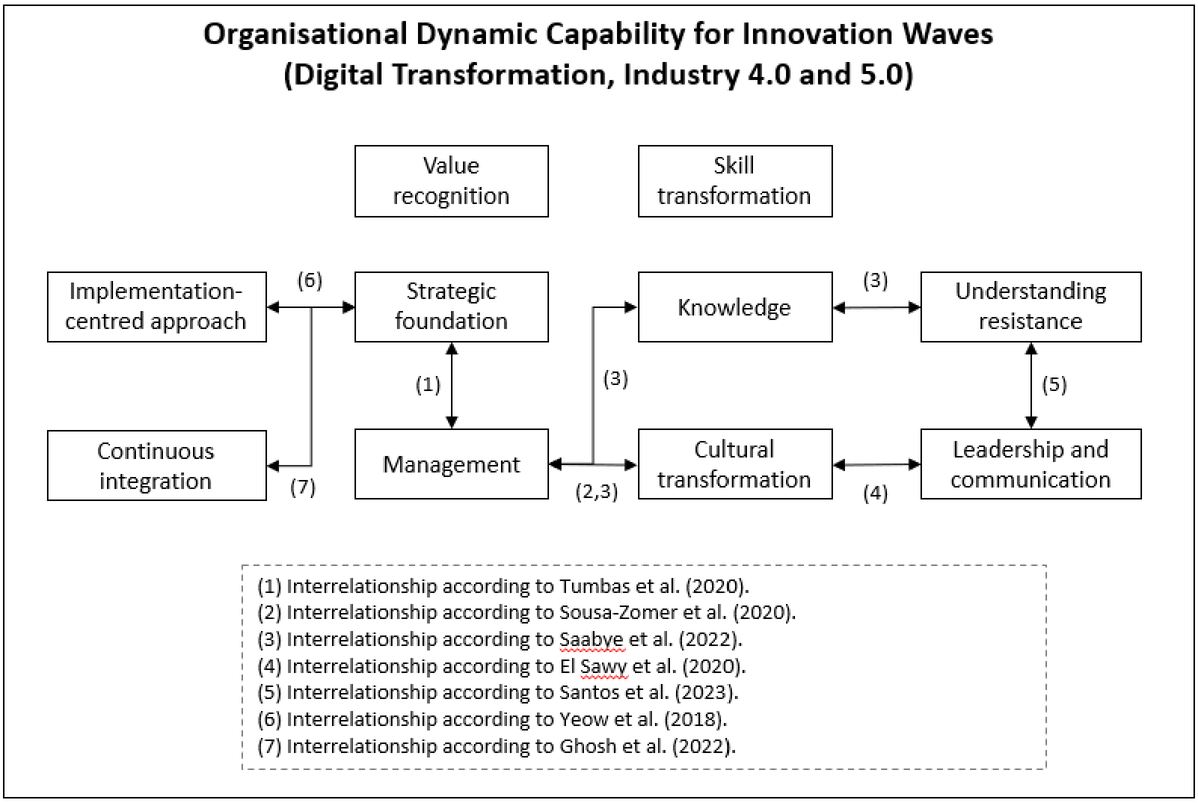

Figure 37: Initial theoretical framework

The initial framework adopted concepts from dynamic capability theory, emphasising 10 organisational capabilities: strategic foundation, knowledge, management, value recognition, implementation-centred approach, understanding resistance, continuous integration, leadership and communication, cultural transformation and skill transformation. This initial framework proposed interrelationships among the capabilities. Drawing from Yeow, Soh and Hansen (2018); El Sawy et al. (2020); Sousa-Zomer, Neely and Martinez (2020); Tumbas, Berente and Vom Brocke (2020); Ghosh et al. (2022); Saabye, Kristensen and Wæhrens (2022); and Santos et al. (2023), eight interrelationships among the capabilities were suggested, as denoted by the arrows in Figure 37. However, the concepts employed in the initial framework were generic, lacking specificity regarding dynamic capabilities among sensing, seizing and reconfiguring.

The revised conceptual framework integrates insights from the existing literature with the significant thesis findings, specifying organisational dynamic capabilities (sensing, seizing and reconfiguring) tailored to innovation waves in the Australian heavy industry. The revised framework retains a subset of attributes proposed in the existing literature on organisational dynamic capability, since many are not aligned with the specific focus of the thesis. Attributes from the literature that align with the thesis findings are incorporated into the revised framework, alongside newly identified attributes. The revised framework encompasses 10 organisational dynamic capabilities under sensing, seizing and reconfiguring capabilities, and builds on the attributes defining each element within the context of the Australian heavy industry, as indicated in Table 33 in Section 7.2. The framework introduces new, context-specific attributes not previously considered in the literature examined in this thesis. An overview of the new framework for organisational dynamic capabilities and their constituting attributes in the context of the Australian heavy industry is presented in Table 44.

Table 44: Attributes of organisational dynamic capabilities identified in the revised theoretical framework

Dimension	Organisational dynamic capability	Constituting attributes
1. Sensing	1.1 Strategic foundation	• Long-term goal and digital vision • Strategic alignment • Purpose-driven approach • Understanding external and internal factors
	1.2 Knowledge	• Open innovation and collaboration • Internal assessment • Balancing technology and product knowledge • Human knowledge and insight
	1.3 Management	• Management commitment • Management leadership • Bridging top, middle and lower management
2. Seizing	2.1 Value recognition	• Value translation with end users • Value quantification • Indirect value
	2.2 Implementation-centred approach	• People-centred approach • Resource management • Implementation resource • Methodological implementation

Dimension	Organisational dynamic capability	Constituting attributes
	2.3 Understanding resistance	• Ethical consideration • Policy and standard • Resilience • Resistance and fear • Policy and process for privacy concerns
3. Reconfiguring	3.1 Continuous integration	• Continuous improvement • Customisation • Research and development • In-house capabilities • Gradual integration
	3.2 Leadership and communication	• Proper communication • Transparent communication • Transformational leadership • Clear communication • Diverse leadership
	3.3 Cultural transformation	• Adaptability • Agility • Culture of innovation • Open culture • Fostering agile culture • Cultivating cultural shift
	3.4 Skill transformation	• Continuous learning and resilience • Reskilling and upskilling

Further, although the initial framework hinted at interrelationships between certain capabilities, these were not elaborated on. Another revised framework below is the product of an examination of the capabilities relevant to innovation waves in the Australian heavy industry, revealing a total of 25 interrelationships among the capabilities. By investigating the interrelationships among organisational dynamic capabilities (highlighted by the arrows in Figure 38), the revised framework offers insights into how the Australian heavy industry senses, seizes and reconfigures its capabilities to embrace new opportunities and navigate innovation waves.

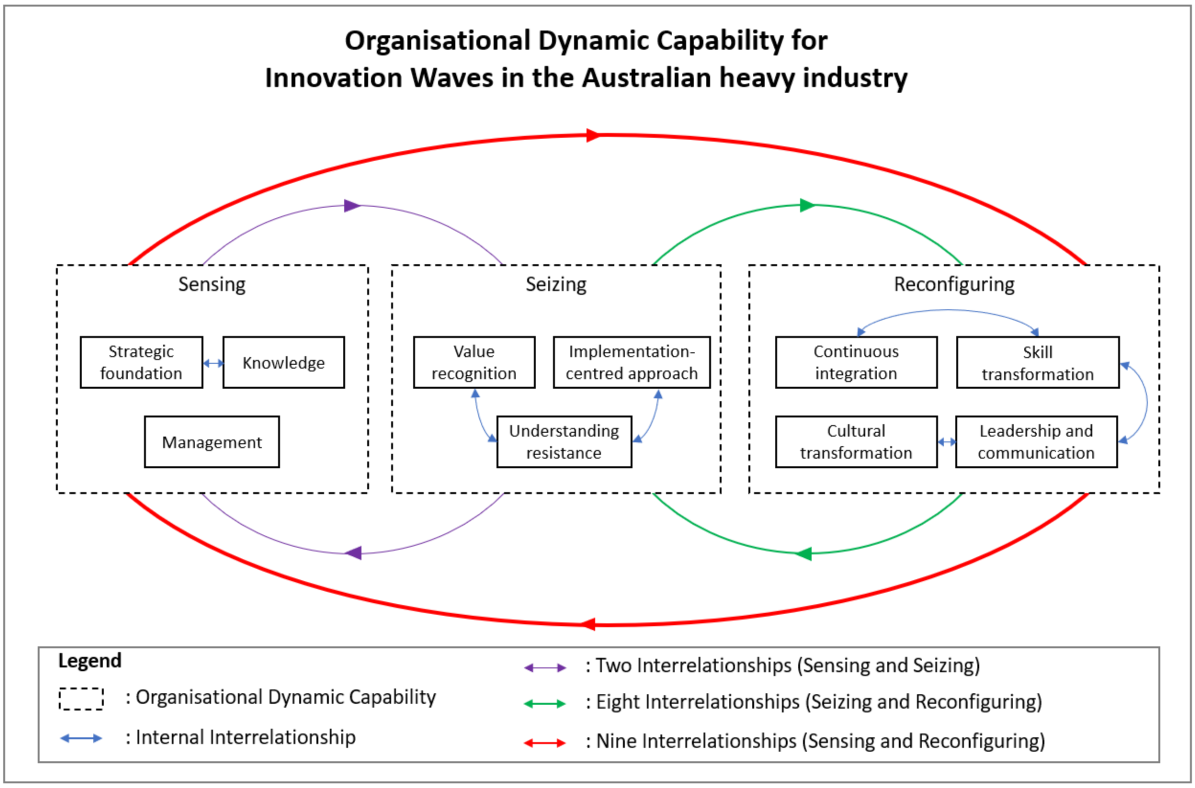

Figure 38: Revised conceptual framework

Figure 38 illustrates the revised conceptual framework with different arrows (blue: internal interrelationships, purple: between sensing and seizing, green: between seizing and reconfiguring, and red: between sensing and reconfiguring). The framework also shows the weight of the interrelationships by differentiating the thickness of the line and specifying it in the legend. Despite showing similarities to the initial framework in terms of organisational capabilities, the revised framework categorises the capabilities into sensing, seizing and reconfiguring, with significant variations in their attributes. Compared with the initial generic framework, the revised version is more intricate and thorough, presenting the interconnections between organisational dynamic capabilities within the context of the Australian heavy industry. The revised framework incorporating the thesis findings significantly contributes to the literature on dynamic capability, particularly concerning the organisational dynamic capability required for innovation waves, Industry 4.0, and Industry 5.0. It accomplishes this by establishing context-specific boundaries within the existing organisational capability literature and refining the concept in the unique context of the Australian heavy industry.

7.5 Summary

Guided by the research questions, this discussion chapter (Chapter 7) examined the findings of this thesis in the context of the existing organisational dynamic capability literature within the Australian heavy industry. Section 7.2 (RQ1) explored the key organisational dynamic capabilities and their attributes for driving innovation waves in the Australian heavy industry, highlighting new, validated and independent findings. This section provided a nuanced understanding of how these capabilities manifest and operate, presenting key findings and their implications in summary tables, offering a clear and structured overview of the insights derived from the research. Section 7.3 (RQ2) addressed the interrelationships between capabilities, emphasising the most interconnected and influential capabilities. It provided summary tables that captured the key findings and implications, demonstrating the interactions among different organisational capabilities. Both sections (7.2 and 7.3) detailed the individual capabilities and their interconnections, providing a holistic view of the dynamic capabilities framework relevant to the Australian heavy industry. The chapter concluded with a revision of the theoretical framework, initially derived from the literature in Chapter 3. By situating the findings within the broader context of the organisational dynamic capability literature, the discussion underscored the significance of the thesis findings and articulated their contribution to the theoretical body of knowledge. This chapter not only reinforced the relevance of dynamic capabilities in fostering innovation within the heavy industry, but also enhanced the existing theoretical frameworks with specific, contextual insights. The following chapter provides a comprehensive conclusion, summarising the significant findings, discussing the implications for practice and theory, and offering future research directions.

CHAPTER 8: CONCLUSION

8.1 Objective

This chapter presents an overview of the significant findings, contributions to the existing knowledge and practical implications. Moreover, it addresses the limitations of the thesis and suggests areas for future research.

8.2 Significant Findings

First, this thesis identified organisational dynamic capabilities for navigating innovation waves (digital transformation, Industry 4.0 and Industry 5.0) within the Australian heavy industry, specifically the shipbuilding, mining, and oil and gas sectors. The thesis identified and categorised 10 dynamic capabilities into three primary areas: sensing, seizing and reconfiguring for the Australian heavy industry. Within the sensing capabilities, strategic foundation, knowledge and management were pivotal, with new attributes such as purpose-driven approach, understanding external and internal factors, internal assessment, balancing technology and product knowledge, human knowledge and insight, and bridging top, middle and lower management. The seizing capabilities highlighted the importance of value recognition, an implementation-centred approach and understanding resistance, with new attributes that included value translation with end users, value quantification, indirect value, implementation resource, methodological implementation, resistance, fear and processes for privacy concerns. Reconfiguring capabilities underscored continuous integration, leadership and communication, cultural transformation and skill transformation as vital components. The significant and new attributes within these areas included gradual integration, in-house capabilities, diverse leadership styles, fostering an agile culture and cultivating a cultural shift. These significant findings contribute to existing literature that has examined the capabilities only in a generic industry context (Dubey et al. 2024; Ghobakhloo et al. 2023c; Vu et al. 2023; Warner & Wäger 2019).

The second significant thesis finding highlighted the contextual differences in organisational dynamic capabilities across the heavy industry sectors of shipbuilding, mining, and oil and gas, with particular attention to sector and age differences. Although the shipbuilding sector benefits from government transformation initiatives, which promote a digital vision, strategic alignment and a culture of innovation, it is essential to consider that interviewee perceptions might not fully reflect the sector's innovativeness. Even though the interviewees in the mining sector emphasised purpose-driven technology adoption, and those in the oil and gas sector highlighted the influence of external factors, the broader context suggests that all three sectors exhibit unique innovative characteristics. Therefore, although shipbuilding may appear more innovative in certain aspects, the mining and oil and gas sectors also demonstrate significant innovation, driven by their respective priorities and external pressures. Age differences also play a critical role in shaping the innovation and transformation processes. The findings indicated that older employees, although more hesitant towards adopting new technologies, possess valuable product knowledge that is crucial for effective transformation for innovation waves. In contrast, younger employees are more open to technological changes but may lack the deep industry-specific knowledge held by their older counterparts.

The third significant thesis finding is the identification of 25 interrelationships among organisational dynamic capabilities, including 20 new interrelationships. These interrelationships underscore the interconnected nature of organisational dynamic capabilities and their critical role in driving innovation waves within the Australian heavy industry. Notably, the reconfiguring capabilities emerged as the most interconnected, with leadership and communication intersecting with eight capabilities, and cultural transformation intersecting with seven. This interconnectedness suggests that reconfiguring capabilities are central to the capability-building process, highlighting their priority in fostering organisational adaptability and resilience. These novel findings contribute significantly to the study of Schilke, Hu and Helfat (2018), and Brewis, Dibb and Meadows (2023), who underscored the significance of interrelationships but did not examine how they are interrelated with each other.

Consolidating the three significant findings, the thesis presented a comprehensive framework of the organisational dynamic capability required for innovation waves in the Australian heavy industry (visualised in Figure 38 of Section 7.4). This framework offers a structured approach to understanding the interconnected nature of these capabilities in the Australian heavy industry. The framework is designed to help organisations develop targeted strategies for capability building, ensuring that technological investments are aligned with broader organisational goals and industry-specific requirements. The coloured arrows in the framework indicate the various interrelationships: blue for internal interrelationships, purple for sensing and seizing, green for seizing and reconfiguring, and red for sensing and reconfiguring, providing a visual representation of the complex and interconnected nature of these capabilities.

8.3 Contribution to the Body of Knowledge

Although the extant dynamic capabilities literature offers a foundation for understanding organisational capabilities required for digital transformation and Industry 4.0, questions remain regarding its validity and transferability. Many studies have examined the organisational dynamic capabilities required for digital transformation (Dubey et al. 2024; Feroz et al. 2023; Ghosh et al. 2022; Warner & Wäger 2019) and Industry 4.0 (Cruzara et al. 2023; Ghobakhloo et al. 2023c; Lepore et al. 2023; Vu et al. 2023) within a generic industry context, but very few have explored the interrelationships among these capabilities. Notably, there is a lack of publications specifically addressing organisational dynamic capabilities for Industry 5.0.

Given that innovation often follows industry contexts (Warner & Wäger 2019), this thesis represents the first academic study into organisational dynamic capabilities for successive innovation waves (digital transformation, Industry 4.0 and Industry 5.0) within the context of the Australian heavy industry. This thesis integrated strategic management, technology management and heavy industry studies, augmented by an empirical investigation. Consequently, this thesis makes significant contributions to the body of knowledge, as detailed in the following sections.

8.3.1 Contribution 1—Organisational Dynamic Capabilities and Their Attributes for Innovation Waves in the Australian Heavy Industry

This thesis, grounded in an extensive literature review and supported by empirical findings, identified the organisational dynamic capabilities and their context-specific attributes for the Australian heavy industry to navigate innovation waves. Specifically, it identified and validated 10 organisational dynamic capabilities: three sensing capabilities (strategic foundation, knowledge and management), three seizing capabilities (value recognition, implementation-centred approach and understanding resistance) and four reconfiguring capabilities (continuous integration, leadership and communication, cultural transformation and skill transformation). Further, it revealed the key attributes of these organisational dynamic capabilities, identifying 18 new attributes and validating 28 existing attributes within the context of the Australian heavy industry, as detailed in Table 44 in Section 7.4 (revised conceptual framework). Additionally, this research uncovered age disparities and sectoral differences between the shipbuilding, mining, and oil and gas industries.

This thesis advances the understanding of organisational dynamic capabilities by identifying and validating dynamic capabilities within the Australian heavy industry. Specifically, it extends current research on dynamic capabilities required for digital transformation (Dubey et al. 2024; Feroz et al. 2023; Ghosh et al. 2022; Warner & Wäger 2019) by providing empirical evidence from a sector that has been underexplored in this context. This includes a detailed examination of how sensing, seizing and reconfiguring capabilities manifest and interact uniquely within the shipbuilding, mining, and oil and gas sectors, offering insights into the sector-specific application of these capabilities.

Further, the thesis builds on research related to Industry 4.0 (Cruzara et al. 2023; Ghobakhloo et al. 2023c; Lepore et al. 2023; Vu et al. 2023) by uncovering new attributes of dynamic capabilities, which are critical for innovation waves. It provides a nuanced understanding of how these capabilities support the integration and optimisation of Industry 4.0 technologies, thus enhancing organisational adaptability and resilience.

Despite significant research efforts over the past decade focused on digital transformation and Industry 4.0, the transition to Industry 5.0 is crucial for addressing key social expectations and emphasising human-centric technology, sustainability and resilience (Horvath 2023). The thesis contributes to the emerging discourse on Industry 5.0 (Chavez et al. 2023; Narkhede et al. 2024) by exploring the transition from Industry 4.0 to Industry 5.0, highlighting the role of human-centric and sustainable practices in this new industrial paradigm. The identification of specific dynamic capabilities necessary for Industry 5.0, such as skills transformation and the balancing of technological and human knowledge, offers a foundational framework for organisations aiming to achieve Industry 5.0 readiness. The thesis findings enhance understanding of organisational dynamic capabilities for Industry 5.0, as well as digital transformation and Industry 4.0, within the Australian heavy industry, paving the way for further investigation into other heavy industries.

The thesis reveals not only the organisational dynamic capabilities, but their interrelated nature. The following section illustrates the novel contribution of the interrelationships among the capabilities.

8.3.2 Contribution 2—Interrelationships among Organisational Dynamic Capabilities for Innovation Waves in the Australian Heavy Industry

This thesis significantly advances understanding of the interrelationships between the organisational dynamic capabilities required for innovation waves in the Australian heavy industry by revealing 25 interrelationships as shown in Section 7.3. Reconfiguring capabilities emerged as the most interconnected, with leadership and communication intersecting with eight capabilities, and cultural transformation intersecting with seven. The discovery of 20 new interrelationships significantly enhances comprehension of how these capabilities function within specific industry contexts. These findings challenge the traditional view of examining dynamic capabilities in isolation, supporting the argument of Schilke, Hu and Helfat (2018) that the bespoke integration of capabilities is crucial for achieving strategic objectives.

The identification of new interrelationships, such as those between sensing and reconfiguring, and between seizing and reconfiguring, provides empirical evidence that supports the theoretical propositions of Helfat and Winter (2011) regarding the strategic complexity created by blending these capabilities. Moreover, these new interrelationships contribute to the broader literature on dynamic capabilities by illustrating their practical interdependencies in real-world settings. This supports the notion that dynamic capabilities must be tailored to specific operational contexts, as suggested by Warner and Wäger (2019) in the context of digital transformation and big data.

The findings align with and extend the work of Di Stefano, Peteraf and Verona (2014), and Yeow, Soh and Hansen (2018), offering a clearer roadmap for leveraging synergistic interactions between sensing, seizing and reconfiguring capabilities. Specifically, this thesis contributes to the studies of Schilke, Hu and Helfat (2018), and Brewis, Dibb and Meadows (2023), who highlighted the significance of interrelationships or combinations of dynamic capabilities. Anchored in the dynamic capability literature and enriched by a qualitative study, this thesis articulated the underlying mechanisms of building organisational capabilities required for innovation waves in the Australian heavy industry, identifying and detailing the interrelated capabilities.

By identifying the organisational dynamic capabilities as well as their interrelationships, this thesis built a comprehensive framework that can be adopted in the Australian heavy industry. The following section details the contribution of the framework development.

8.3.3 Contribution 3—Framework of Organisational Dynamic Capability Required for Innovation Waves in the Australian Heavy Industry

Building on the existing research on organisational dynamic capabilities and incorporating the empirical findings of the thesis, a comprehensive framework for understanding these capabilities in the context of innovation waves within the Australian heavy industry was developed as shown in Section 7.4. This framework is the primary contribution of the thesis, providing a structured approach to the complex process of capability development for innovation waves in the shipbuilding, mining, oil and gas sectors. By synthesising existing research with the empirical findings, it offers a holistic perspective on the interrelationships among these capabilities within the Australian heavy industry.

This thesis extends the discourse on organisational dynamic capabilities by specifically addressing Industry 5.0 in the context of the Australian heavy industry. This extension is particularly pertinent given that much of the existing literature on dynamic capabilities required for digital transformation and Industry 4.0 has focused primarily on their implications for various stakeholders, such as organisations and policymakers (Dubey et al. 2024; Ghobakhloo et al. 2023c; Vu et al. 2023; Warner & Wäger 2019). However, before these implications can be fully realised, organisations must be adequately prepared for them. Thus, this framework highlights the foundational importance of understanding organisational dynamic capabilities and their interrelationships for innovation waves within the Australian heavy industry, making a significant contribution to the existing body of knowledge.

Moreover, this thesis identified the context-specific boundaries of organisational dynamic capabilities. The following section reports the contribution of identifying these context-specific boundaries.

8.3.4 Contribution 4—Contextual Boundaries of Organisational Dynamic Capabilities required for Innovation Waves

The existing literature addressing the organisational dynamic capabilities required for innovation waves has often provided generic insights (Ellström et al. 2022; Feroz et al. 2023; Vu et al. 2023; Warner & Wäger 2019) or focused on industries other than the heavy industry (Dubey et al. 2024; Ghobakhloo et al. 2023c; Lepore et al. 2023). This thesis addresses this gap by identifying the context-specific boundaries of the organisational dynamic capabilities required for innovation waves within the Australian heavy industry as discussed in the end of each sub-section of Chapter 7. The characteristics of the industry led to distinct differences in several key areas: the interrelationships among capabilities, sector-specific approaches to strategic foundations, knowledge management practices, leadership styles, value recognition, implementation approaches and continuous integration practices.

In the shipbuilding sector, strategic foundations are influenced by both internal and external factors, whereas the mining sector adopts a purpose-driven approach. Knowledge management in the shipbuilding sector leverages open innovation and cross-industry learning, contrasting with the mining sector’s more insular approach. Leadership in the shipbuilding sector favours top-down strategies, while the mining sector promotes grassroots initiatives, indicating the need for tailored leadership approaches that align with each sector’s unique cultural and operational contexts. The seizing capability also exhibits sector-specific variations. The oil and gas sector balances immediate and long-term benefits, the mining sector focuses on immediate impacts and the shipbuilding sector prioritises a long-term vision. Implementation approaches also differ, with shipbuilding adopting strategic resource allocation and dedicated digitisation managers, while the mining sector requires improved resource management strategies. Reconfiguring capabilities show differences in continuous integration practices: the shipbuilding sector prioritises R&D and advanced infrastructure, the mining sector advocates gradual implementation, and the oil and gas sector emphasises seamless transitions. Leadership and communication strategies vary as well. The shipbuilding sector emphasises transformational leadership and transparent communication, whereas the mining sector values leadership adaptability. Across all sectors, cultural transformation and skill development are critical, with a universal recognition of the need for continuous learning and resilience. These sector-specific insights underscore the necessity for customised capability-building strategies that cater to the unique characteristics and needs of each industry and workforce demographic, thereby enhancing the effectiveness and sustainability of innovation initiatives within the Australian heavy industry.

By discussing the context-specific findings of the thesis in relation to the existing organisational dynamic capability literature, which has been either generic or specific to other industries, this thesis contrasts the industry-specific boundaries of organisational dynamic capability. Consequently, this thesis makes a theoretical contribution to the body of knowledge on the context-specific boundaries of the organisational dynamic capabilities required for innovation waves.

8.4 Implications

The thesis findings provide significant practical contributions. Based on the insights obtained, recommendations for the Australian heavy industry and policymakers are outlined in the following sections.

8.4.1 Implications for the Australian Heavy Industry

This thesis highlighted the significant role of sensing, seizing and reconfiguring capabilities required for innovation waves in the Australian heavy industry, encompassing the shipbuilding, mining, and oil and gas sectors. For these sectors to effectively develop their organisational capabilities, several key capabilities and their attributes must be developed and tailored to their unique operational contexts and challenges.

8.4.1.1 Sensing Capabilities

For the Australian heavy industry to effectively sense emerging opportunities within the waves of digital innovation, it is imperative that organisations develop a robust strategic foundation that aligns technological investments with long-term sustainability goals and regulatory compliance (Warner & Wäger 2019). This involves a deep understanding of market dynamics and strategically planning technology-sensing activities with both groups who have knowledge of their business process and technologies. Knowledge management is another critical factor. Organisations must foster a culture of openness to embracing external knowledge via cross-industry learning to enhance their sensing capabilities (Ellström et al. 2022). This proactive stance not only facilitates the identification of emerging opportunities, but also promotes a higher level of digital maturity, essential for maintaining a competitive advantage in a competitive market. Management leadership plays a pivotal role in navigating the complex regulatory environments and fostering a culture of innovation (Dubey et al. 2024). Top-down management leadership and commitment are essential for balancing the need for innovation with adherence to regulatory standards, promoting a culture of agility and resilience that is necessary for successful transformation for innovation waves.

8.4.1.2 Seizing Capabilities

To effectively capture the value of identified opportunities, the Australian heavy industry must develop tailored value recognition strategies that balance immediate financial gains with long-term strategic advantages. This involves understanding and aligning technological investments with broader organisational goals and industry-specific requirements. A strategic and methodological approach to resource allocation is crucial for ensuring efficient utilisation and avoiding the underutilisation of projects (Ellström et al. 2022). Organisations must emphasise the importance of dedicated digitisation managers and technology trials to enhance implementation capabilities. Managing resistance to change is also critical. Organisations must develop tailored strategies that address sector-specific challenges, foster a culture of adaptability and resilience, and effectively manage resistance through clear communication and proactive engagement with stakeholders (Saabye, Kristensen & Wæhrens 2022).

8.4.1.3 Reconfiguring Capabilities

The continuous integration of digital strategies is essential for enabling organisations to adapt their resource base, and leverage sensing and seizing capabilities into concrete advantages. This requires a proactive stance towards R&D (Ghosh et al. 2022) and the development of advanced infrastructure (Santos et al. 2023), reflecting a high level of transformation readiness for innovation waves. Leadership and communication strategies must be tailored to foster an environment in which the value of technology is comprehended and embraced by all employees. Transformational (Huang, Jiang & Chang 2023) and visionary leadership (Chirumalla 2021) is essential for aligning digital initiatives with strategic goals and fostering a culture of trust and openness. Cultural transformation is another critical area. Organisations must cultivate cultural agility and flexibility to maintain competitiveness and embrace technological advancements. This involves fostering a learning culture that encourages continuous improvement and adaptability, ensuring that technological investments are effectively integrated and utilised (Vu et al. 2023). Finally, skill transformation is vital for aligning workforce competencies with technological advancements. Organisations must implement strategic reskilling and upskilling programs (Santos et al. 2023) tailored to industry-specific needs, ensuring that employees are equipped to adapt to new technologies and changing job requirements.

8.4.2 Implication for Policymakers

The thesis findings provide insights for policymakers in Australia aiming to advance organisational capabilities required for innovation waves within the Australian heavy industry, specifically the shipbuilding, mining, and oil and gas sectors. The heavy industry is a cornerstone of Australia's economy, contributing significantly to GDP, creating direct and indirect employment opportunities, and generating substantial export earnings. These sectors face unique challenges and opportunities in embracing digital innovation, and strategic policy interventions can significantly support their capability development.

8.4.2.1 Sensing Capabilities

Strengthening the strategic foundations of the heavy industry is essential for aligning technological investments with long-term sustainability goals and regulatory compliance.

Policymakers should develop frameworks that influence and incentivise strategic planning and knowledge enhancement. This includes creating supportive policies that reflect industry-specific dynamics and market conditions, ensuring organisations can dynamically adapt to external changes. Additionally, fostering a culture of openness and cross-industry learning is crucial.

Policymakers should facilitate knowledge-sharing platforms and innovation networks that bridge the gaps between sectors, establishing centralised knowledge databases and promoting cross-sector collaborations to affect organisational capabilities required for innovation waves.

They should also encourage the assessment and development of internal capabilities by supporting training programs and initiatives that enhance technological and organisational knowledge. Given the substantial investments in sectors such as naval shipbuilding and mining, such policies are vital to ensure that technological advancements are effectively integrated and leveraged.

8.4.2.2 Seizing Capabilities

To effectively capitalise on transformation opportunities for innovation waves, policymakers need to support tailored value-recognition strategies. This involves incentivising organisations to develop comprehensive frameworks that balance immediate financial gains with long-term strategic benefits. Policies should encourage practical approaches to value recognition that consider both the direct and indirect benefits of technological investments.

In terms of implementation, policymakers should support strategic resource allocation by providing grants or subsidies for transformation projects for innovation waves, ensuring organisations have access to dedicated digitisation managers and technology site trials.

Supervised industry trials can be incentivised to allow companies to test and evaluate digital technologies, reducing the risk of failure and fostering positive experiences with new technologies. Addressing resistance to change is another critical area.

Policymakers should promote clear communication strategies and stakeholder engagement initiatives that address sector-specific challenges. This could include funding workshops and training sessions focusing on change management and the benefits of innovation waves, thereby fostering a culture of adaptability and resilience.

8.4.2.3 Reconfiguring Capabilities

The continuous integration of digital strategies is vital for leveraging sensing and seizing capabilities into concrete advantages. Policymakers should support R&D efforts and the development of advanced infrastructure through targeted funding and incentives. Policies should facilitate continuous innovation and competitiveness within the heavy industry sectors.

Leadership and communication are pivotal in driving innovation waves. Policymakers should support leadership development programs that emphasise transformational and visionary leadership. This influences initiatives that enhance transparent communication and align digital initiatives with strategic goals.

Cultural transformation requires policies that promote agility and flexibility within organisations. Policymakers should encourage the adoption of agile practices and the development of a learning culture through funding for training programs and organisational development initiatives. Ensuring that organisations can adapt to technological advancements and integrate them effectively is crucial for maintaining competitiveness.

Skill transformation is another essential area where policymakers can make a significant impact. By supporting reskilling and upskilling programs tailored to industry-specific needs, policymakers can ensure that the workforce is equipped to handle new technologies and evolving job requirements. This involves providing grants for training programs and collaborating with educational institutions to develop curricula addressing the skills needed for innovation waves.

8.4.2.4 General Recommendations

To summarise, policymakers should:

1. Strengthen strategic foundations: Develop frameworks that encourage strategic planning with human elements for inclusive and effective transformation, and provide incentives for aligning technological investments with sustainability and regulatory compliance.
2. Foster knowledge sharing: Establish centralised knowledge databases, promote cross-sector collaborations and support training programs that enhance technological and organisational knowledge.
3. Support tailored value recognition: Encourage comprehensive value-recognition strategies and provide financial support for transformation projects for innovation waves through grants or subsidies.
4. Promote clear communication: Fund workshops and training sessions that focus on change management and the benefits of innovation waves to manage resistance effectively.
5. Facilitate continuous integration: Provide targeted funding and incentives for R&D efforts and the development of advanced infrastructure to support continuous innovation.
6. Enhance leadership development: Support programs that promote transformational and visionary leadership, and encourage transparent communication strategies.
7. Encourage cultural transformation: Promote the adoption of agile practices and the development of a learning culture through funding and organisational development initiatives.
8. Invest in skill transformation: Provide grants for reskilling and upskilling programs and collaborate with educational institutions to develop relevant curricula.

By implementing these policy recommendations, the Australian Government can significantly influence the readiness and capability of the heavy industry sectors to engage in and benefit from transformation for innovation waves. This not only improves the competitiveness of these industries, but also contributes to broader economic growth and technological advancement in the country.

8.5 Limitation and Future Research Direction

Despite the rigorous research design and processes employed to enhance data truthfulness and integrity, this thesis has several limitations that could serve as avenues for future research. Given the limited research on the organisational dynamic capabilities required for innovation waves (digital transformation, Industry 4.0 and Industry 5.0), particularly within the context of the heavy industry, this thesis adopted a qualitative research approach involving interviews with a diverse set of subject experts. This approach facilitated a deeper analysis and illuminated the complexity of the topic (Creswell & Creswell 2017). However, the findings may not be fully representative of all sectors within the heavy industry. The focus of this study encompassed primarily the shipbuilding, mining, and oil and gas sectors. Although these sectors are significant within the heavy industry, they may not capture the full spectrum of capabilities and challenges present in other sectors, such as construction. Different heavy industry sectors may require distinct capabilities and approaches to successfully navigate innovation waves. Therefore, further studies are necessary to explore these dynamics in other heavy industry sectors, ensuring a more comprehensive understanding of organisational dynamic capabilities across the entire industry landscape.

Another limitation is the sample size. Following the guidelines from Marshall (1996b), the exact sample size was not predetermined. Instead, empirical data were collected and analysed iteratively, with additional interviews conducted until data saturation was reached and no new information emerged. Future research should build on this work by further specifying and quantifying the developed framework of the organisational dynamic capability required for innovation waves in the heavy industry context, and by testing it quantitatively with a larger sample size.

This thesis focused on the Australian heavy industry within a specific timeframe. However, scholars have highlighted the importance of longitudinal studies in understanding how organisations manage innovation (Van de Ven & Huber 1990). Thus, future research should conduct longitudinal studies to fully capture the long-term transformations and impacts of digital innovation.

Finally, although this thesis aimed to ensure the transferability of its findings, research has indicated that management practices can vary significantly between countries (Teagarden, Von Glinow & Mellahi 2018). Comparative studies in different geographical locations would provide additional insights into national-level organisational capabilities required for innovation waves and the processes of developing these capabilities. Consequently, future research may undertake comparative cross-industry studies to expand the understanding of industry-specific organisational dynamic capabilities for digital innovation.

8.6 Summary

This chapter summarised the thesis by presenting its significant findings, contributions to existing knowledge, practical implications, limitations and future research directions. The significant findings include the identification of 10 organisational dynamic capabilities, categorised into sensing, seizing and reconfiguring, essential for navigating innovation waves within the Australian heavy industry.

Novel attributes within these capabilities were highlighted, such as strategic foundation, value recognition and cultural transformation. Additionally, the thesis revealed contextual differences across the shipbuilding, mining, and oil and gas sectors, and identified 25 interrelationships among the dynamic capabilities, emphasising the interconnected nature of these capabilities. The thesis contributes a comprehensive framework to guide organisations in aligning technological investments with broader goals and offers practical implications for policymakers and industry stakeholders. Finally, the thesis limitations were addressed, such as the qualitative approach and sample size, and future research directions were suggested, including quantitative validation, longitudinal studies and comparative cross-industry research.

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APPENDIX 1: INDUSTRY 4.0 AND INDUSTRY 5.0 COMPARISON (Müller 2020; Xu et al. 2021)

Table 45: Industry 4.0 and 5.0 comparison

No.	Category	Industry 4.0	Industry 5.0	Crossover	Difference
1	Concept	Tech-driven	Value-driven	–	–
2	Origin	In 2011, Germany	In 2021, Europe	–	–
3	Focus	Smart factory, automation, digitalisation	Human-centric, sustainability, resilience	–	–
4	Outcome	Higher efficiency and productivity	Achieve societal goals beyond jobs and growth	–	–
5	Technology	• Cyber–physical system • Internet of Things • Additive manufacturing • Big data • Artificial intelligence (AI) • Augmented reality (AR) • Virtual reality (VR) • Autonomous robots • Cloud computing	• Human-centric and human–machine interaction technologies (e.g. speech and gesture recognition, human intention prediction, mental physical strain tracking technologies, cobots, AR, VR, exoskeletons, decision-support systems). • Bio-inspired technologies and smart materials that allow materials with embedded sensors and enhanced features while being recyclable (e.g. self-repairing, lightweight, recyclable, embedded sensors and biosensors). • Real-time digital twin and simulation (e.g. dynamic modelling and simulation, virtual simulation and testing). • Cybersafe data transmission, storage and analysis technologies (e.g. networked sensors, safe cloud, big data). • AI (e.g. causality detection, dynamic systems leading to actionable intelligence, brain-machine interfaces, person-centric AI, informed deep learning). • Energy efficiency technology.	• Integration • Skill and training • Communication • Enabling technologies (AI/ AR/ VR/ cobot) • Digital twin • System interoperability	• Human–machine interface and integration • Sustainability • Resilience • Mass personalisation

APPENDIX 2: ORGANISATIONAL CAPABILITIES FOR DIGITAL TRANSFORMATION, INDUSTRY 4.0 AND INDUSTRY 5.0

Table 46: Organisational capabilities for digital transformation, industry 4.0 and 5.0

Capabilities and attributes	Digital transformation	Industry 4.0	Industry 5.0
Continuous integration Continuous improvement Customisation Personalisation Process and IT know-how integration Digital solutions integration Research and development Adept integration Seamless integration Continuous improvement	Chirumalla (2021); Ellström et al. (2022); Ghosh et al. (2022); Feroz et al. (2023); Warner and Wäger (2019)	Rangaswamy (2021); Santos et al. (2023); Szalavetz (2019); Vu et al. (2023)	Narkhede et al. (2024); Thomas et al. (2023)
Cultural transformation Adaptability Agility Flexibility Risk-taking culture Digital culture Culture of innovation Open culture Adaptability	Chirumalla (2021); Dubey et al. (2024); Feroz et al. (2023); Ghosh et al. (2022); Sousa-Zomer, Neely and Martinez (2020); Warner and Wäger (2019)	Agarwal, Seth and Agarwal (2022); Cruzara et al. (2023); Santos et al. (2023); Vu et al. (2023)	Chavez et al. (2023); Mihardjo and Alamsyah (2019); Narkhede et al. (2024)
Implementation-centred approach People-centred approach Human–machine collaboration Resource management	Chirumalla (2021); Dubey et al. (2024); Ellström et al. (2022)	Ghobakhloo et al. (2023c)	Chavez et al. (2023); European Commission (2021); Mihardjo and Alamsyah (2019); Henriksen and Thomassen (2023); Henriksen, Røstad and Thomassen (2022); Modgil, Singh and Agrawal (2023); Narkhede et al. (2024); Thomas et al. (2023)
Knowledge Collaboration Knowledge enhancement Knowledge management Open innovation	Ellström et al. (2022); Feroz et al. (2023); Ghosh et al. (2022); Sousa-Zomer, Neely and Martinez (2020); Warner and Wäger (2019)	Agarwal, Seth and Agarwal (2022); Cruzara et al. (2023); Ghobakhloo et al. (2023c); Jiang et al. (2020); Lepore et al. (2023); Naruetharadhol et al. (2022); Rangaswamy (2021); Santos et al. (2023); Ul Zia, Burita and Yang 2023; Vu et al. (2023)	Mihardjo and Alamsyah (2019); Narkhede et al. (2024)
Leadership and communication Leadership Proper communication Transparent communication Transformational leadership Digital leadership	El Sawy et al. (2020); Dubey et al. (2024); Huang, Jiang and Chang (2023)	Dabić, Maley and Nedelko (2023); Ghobakhloo et al. (2023c); Santos et al. (2023)	Thomas et al. (2023)

Capabilities and attributes	Digital transformation	Industry 4.0	Industry 5.0
Clear communication			
Management	Chirumalla (2021); Ghosh et al. (2022); Dubey et al. (2024); Heubeck and Meckl (2022); Tumbas, Berente and Vom Brocke (2020); Warner and Wäger (2019)	de Sousa Jabbour et al. (2018); Ghobakhloo et al. (2023c); Saabye, Kristensen and Wæhrens (2022); Santos et al. (2023); Vu et al. (2023)	Mihardjo and Alamsyah (2019)
Fast decision-making			
Management commitment			
Management leadership			
Skill transformation	Chirumalla (2021); Sousa-Zomer, Neely and Martinez (2020)	Ghobakhloo et al. (2023c); Lepore et al. (2023); Rangaswamy (2021); Santos et al. (2023); Szalavetz (2019); Vu et al. (2023)	Mihardjo and Alamsyah (2019); Modgil, Singh and Agrawal (2023); Thomas et al. (2023)
Continuous learning and resilience			
Managerial skills			
Reskilling and upskilling			
Skill training			
Training mechanism			
Soft skills			
Strategic foundation	Chirumalla (2021); Dubey et al. (2024); Ellström et al. (2022); Feroz et al. (2023); Ghosh et al. (2022); Warner and Wäger (2019); Yeow, Soh and Hansen (2018)	Ghobakhloo et al. (2023c); Naruetharadhol et al. (2022); Vu et al. (2023)	Chavez et al. (2023)
Digital scenario planning and scouting			
Digital strategy			
Long-term digital vision			
Solution-centric strategy			
Strategic alignment			
Strategic prioritisation			
Technology-based strategies			
Strategic foresight			
Understanding resistance		Dabić, Maley and Nedelko (2023); Lepore et al. (2023); Santos et al. (2023); Vu et al. (2023)	European Commission (2021); Henriksen, Røstad and Thomassen (2022); Henriksen and Thomassen (2023); Modgil, Singh and Agrawal (2023); Thomas et al. (2023); Narkhede et al. (2024)
Ethical consideration			
Policy and standard			
Resilience			
Human social capability			
Value recognition		Ghobakhloo et al. (2023c)	European Commission (2021); Henriksen, Røstad and Thomassen (2022); Henriksen and Thomassen (2023); Narkhede et al. (2024)
Circular economy			
Sustainability			

APPENDIX 3: INTERVIEW GUIDE AND QUESTIONS

1. Rationale

Informed by a literature review, the approach adopted here uses qualitative research to delve into the Australian heavy industry practitioners' experience and perspectives. These qualitative interviews represent a single and comprehensive phase of the research where a researcher seeks to understand and explore the nature of the phenomenon the researcher is investigating. This phase is also used to validate the findings from the comprehensive literature review to answer the research question:

Research question: "What are the key organisational dynamic capabilities and their interrelationships that enable the Australian heavy industry to build and support innovation waves (digital transformation, Industry 4.0, and Industry 5.0)?"

This overarching question is expanded into the following three sub-research questions (RQs):

- *RQ1: What are the key organisational dynamic capabilities (sensing, seizing and reconfiguring) required for Innovation waves (Digital Transformation, Industry 4.0 and 5.0) in the Australian heavy industry?*
- *RQ2: How are organisational dynamic capabilities interrelated in the Australian heavy industry?*

2. Introduction and interview

First, an interviewer confirms if a participant read a participant information sheet and consent form and then start the interview process below.

[***read to participants after reading the information sheet and achieving consent***] Thanks for reading through the participant information sheet before this interview. First of all, as I indicated in the consent form, I will need to record the conversation for my data analysis. Are you happy for me to start recording? As mentioned in the recruitment letter, the PhD title is the organisational dynamic capabilities required for Innovation waves in the Australian heavy industry (Shipbuilding, mining, oil and gas). I am going to provide a background and objectives before moving into the interview questions.

This study aims to explore the aspects of sensing, seizing opportunities, and reconfiguring to adapt to the rapidly changing environment when adopting advanced technologies as well as their interrelationships. Sensing involves the capacity to scan, learn, and interpret information to identify new opportunities within innovation waves trends. Seizing focuses on capturing the value from these opportunities once they are identified, allowing organisations to exploit them effectively. Reconfiguring, or transforming, is crucial for implementing digital strategies, as it enables organisations to adjust their resources and capabilities to turn sensing and seizing into concrete benefits.

This research addresses these gaps and underscores the necessity for a more thorough examination of organisational dynamic capabilities tailored specifically for innovation waves in diverse industrial contexts. This interview will contribute valuable insights, helping me better comprehend your experiences and perspectives on innovation waves within the heavy industry.

3. Demographic questions

1. What is your business area (Shipbuilding, mining, oil and gas)?
2. What is your role?
3. What is your age range (20-39 or 40-59 or 60+)
4. How long have you been working in the Australian heavy industry?
5. Have you worked in any other countries (Not in Australia)? Y/N where?
6. Has your company embarked on the innovation waves (digital transformation) journey?
7. What is a level of commitment on the innovation waves (your organisation)
   - Low: where the organisation has implemented basic digital technologies but hasn't initiated a strategic transformation journey for innovation waves
   - Mid: where the organisation has implemented advanced digital technologies and has initiated a strategic transformation journey for innovation waves with an allocated fund
   - High: where the organisation has implemented advanced digital technologies and has a highly strategic transformation journey for innovation waves with substantial funds with long-term digital innovation programs

4. Interview questions

1. Sensing:
   a) How does your organisation identify and interpret new opportunities related to digital transformation and Industry 4.0/5.0?
   b) Business must make sure that technologies are strategically sensed, implemented and integrated into a management process. What are the key sensing capabilities required for innovation waves? Can you tell me about your thought on this? (how can we have a better sensing capability for transformation with advanced technologies?)
   c) Can you provide examples of how your organisation has successfully sensed opportunities in the past?
   d) What processes or tools do you use to scan the external environment for technological advancements and market trends?
   e) As the heavy industry has a unique characteristic which includes complex, labour-intensive and long processes dealing with heavy objects, the technology will still require human insight and knowledge to sense right opportunities. Do you have any thoughts on this? And how can we successfully sense an opportunity with human insight and knowledge?
   f) Management leadership has been highlighted as sensing capabilities. Top management's engagement, formulating technological visions, leadership skills were emphasised. Any thoughts on this?

2. Seizing:
   a) Once an opportunity is identified, how does your organisation go about capturing its value?
   b) Business must make sure that technologies are strategically seized (implemented and integrated) into a management process. What are the key seizing capabilities required for innovation waves?
   c) Can you describe a specific instance where your organisation effectively seized an opportunity related to advanced technologies?
   d) What challenges do you face when trying to exploit these opportunities, and how do you overcome them?
   e) Without understanding the practical value of technology, it is hard to seize an opportunity. There are direct (Cost, Quality) and indirect (Health, safety, well-being)

values highlighted for ROI. Do you have any thoughts on this? Which one do you think it most important? How can we successfully understand the ROI?

f) A lack of recognition of required resources was highlighted in literature. Appropriate resource allocation was important highlighting the importance of implementation resources. Can you tell me about your thought on this?

3. Reconfiguring:
   a) How does your organisation adapt its resources and capabilities to implement digital strategies effectively? And What are the key reconfiguring capabilities?
   b) Can you share an example where reconfiguring your organisation's structure or processes was crucial for leveraging an innovation wave?
   c) What are the main obstacles in reconfiguring your organisation to adapt to Industry 4.0 and 5.0 technologies?
   d) In your experience, how does leadership play a role in reconfiguring process? Please elaborate on the impact of strong leadership and effective communication related to reconfiguring capabilities.
   e) People’s appreciation of the bigger picture for innovation waves can be improved by leadership or effective communications. What kind of leadership and communication business should have as a reconfiguring capability? Do you have any other thoughts on better leadership and communication?
   f) Agile and cultural transformation were highlighted in literature for reconfiguring capabilities. What do you think about the cultural transformation in organisational capability development? Do you have any other insight on factors affecting organisational capability development (e.g. how can we have a better culture?)
   g) Education and training have been important to reconfigure processes with changes. Skill development and alignment and continuous learning have been emphasised. Any thoughts on this?

4. Interrelationship:
   a) In your experience, how are the sensing, seizing, and reconfiguring capabilities interrelated within your organisation?
   b) Can you provide an example where the interplay of these capabilities led to a successful innovation or transformation?
   c) How does your organisation ensure that these capabilities are developed and maintained cohesively?
5. Closing (if possible)
   a) What are the most critical factors for building and sustaining dynamic capabilities in your organisation?
   b) How do you foresee the future of digital transformation and Industry 4.0/5.0 impacting the heavy industry in Australia?
   c) Is there anything else you would like to add regarding your experiences with organisational dynamic capabilities and innovation waves?

APPENDIX 4: PARTICIPANT INFORMATION SHEET

INFORMATION SHEET

for *Interviews*

Title: Organisational Dynamic capabilities for Innovation waves in the Australian heavy industry (Shipbuilding, mining, oil and gas)

Researchers:

Ryan Jang
College of Business, Government and Law
Flinders University

Prof Adela McMurray
College of Business, Government and Law
Flinders University

A/Prof Ann-Louise Hordacre
College of Business, Government and Law
Flinders University

Dr Tim van Erp
College of Science and Engineering
Flinders University

Description of the study

This study aims to explore the organisational dynamic capability including sensing, seizing and reconfiguring concerning innovation waves (digital transformation, Industry 4.0 and Industry 5.0) within the Australian heavy industry, with a specific focus on shipbuilding, mining, and oil and gas sectors. `

The progression from digital transformation through Industry 4.0 to the emerging Industry 5.0 represents successive waves of innovation. Each wave aims to enhance organisational efficiency, productivity, and innovation through the strategic deployment of advanced technologies. Industry 4.0 set the stage by incorporating advanced technologies and digitalisation. Building on this foundation, Industry 5.0 focuses on human-centric approaches, integrating intelligent systems with human capabilities. Understanding these revolutions as interconnected rather than isolated is crucial to grasp their cumulative impact on the industrial landscape. This comprehensive view can be termed 'Innovation Waves.'

The dynamic capability framework is conceptualised as a firm's ability to construct, modify, and integrate internal and external competences in response to dynamic environmental shifts. The investigation will particularly examine individual and managerial levels to gain insights into the detailed components that contribute to the overall organisational capabilities for the innovation waves, which provides a nuanced understanding of the attributes of the capabilities on a broader scale. While previous studies have touched upon certain organisational capabilities, these inquiries have predominantly focused on the aspects of sensing, seizing opportunities, and reconfiguring to adapt to the rapidly changing environment when adopting advanced technologies as well as their interrelationships. Sensing involves the capacity to scan, learn, and interpret information to identify new opportunities within digital transformation trends. Seizing focuses on capturing the value from these opportunities once they are identified, allowing organisations to exploit them effectively. Reconfiguring, or transforming, is crucial for implementing digital strategies, as it enables organisations to adjust their resources and capabilities to turn sensing and seizing into concrete benefits.

This research addresses these gaps and underscores the necessity for a more thorough examination of organisational dynamic capabilities tailored specifically for the innovation waves in diverse industrial contexts. This interview will contribute valuable insights, helping me better comprehend your experiences and perspectives on innovation waves within the heavy industry.

Purpose of the study

The study focuses on investigating organisational dynamic capability (sensing, seizing and reconfiguring) required for innovation waves (digital transformation, industry 4.0 and 5.0) with the goal of validating new model that supports a successful transformation with advanced technologies in the Australian heavy industry.

What will I be asked to do?

You are invited to attend a one-on-one interview with a researcher who will ask you a few questions regarding your views about your:

- Insights on the organisational dynamic capabilities required for innovation waves (digital transformation, Industry 4.0 and 5.0)
- Experiences of working in the heavy industry and need of transformation with advanced technologies
- Expectations of the contributions of transformation with advanced technologies to business outcomes
- Insights on the key sensing capabilities for the innovation waves
- Insights on the key seizing capabilities for the innovation waves
- Insights on the key reconfiguring capabilities for the innovation waves
- Ideas for how transformation could be successfully performed to support the workforce

Participation is entirely voluntary, and you may withdraw at any stage without disadvantage to your relationship with Flinders University and its staff and students. The interview will take about 40-60 minutes and be conducted either by face-to-face or tele/video conference via computer at a time that is convenient for you.

With your consent, the interview will be audio recorded using a digital voice recorder to help with reviewing the results. Once recorded, the interview will be transcribed (typed-up) and stored as a computer file. If you would like to review and edit interview transcripts, please indicate it after an interview so that a researcher can organise it.

What benefit will I gain from being involved in this study?

Sharing your experiences and insights will help the researcher understand how innovation waves can be successfully introduced to the heavy industry that includes your organisation Your input may positively shape new capability maturity and readiness model that can be used to support innovation waves in your workplace in the future.

Will I be identifiable by being involved in this study?

Individual interviews will always keep you anonymous. All data will be stored in a de-identified format (i.e. name and contact details not linked to your responses). The findings may be reported in conferences and journal publications and will not identify individuals. All information and results obtained in this study will be stored in a secure way, with access restricted to relevant researchers.

Are there any risks or discomforts if I am involved?

The researchers anticipate few risks from your involvement in this study beyond a time commitment. However, if the interview unintentionally triggers distress relating to workplace incidents, please contact your EAP provider or Lifeline on 13 11 14, free of charge to all participants. If you have any concerns regarding anticipated or actual risks or discomforts, please raise them with the researcher.

How do I agree to participate?

Participation is voluntary. You may answer 'no comment' or refuse to answer any questions, and you are free to withdraw from the interview at any time without effect or consequences. A consent form accompanies this information sheet. If you agree to participate, please read and sign the form and send it back to us at ryan.jang@flinders.edu.au. Where this is not possible, verbal consent will be gained and recorded prior to the interview commencing.

How will I receive feedback?

The results will only be used in the PhD thesis or journal paper so the researcher will be able to share the completed thesis or journal paper if you indicate that you wish to receive the information.

Thank you for taking the time to read this information sheet, and we hope that you will accept our invitation to be involved.

This research project has been approved by the Flinders University Human Research Ethics Committee in South Australia (Project number: 5455). For queries regarding the ethics approval of this project please contact the Executive Officer of the Committee via telephone on +61 8 8201 2543 or email human.researchethics@flinders.edu.au

APPENDIX 5: CONSENT FORM

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(Interview)

Organisational dynamic capabilities for innovation waves (digital transformation, Industry 4.0 and 5.0) in the Australian heavy industry

(Oil & Gas, Mining, Shipbuilding)

I …..

being over the age of 18 years hereby consent to participate as requested in **an interview** for the research project with the title listed above.

1. I have read the information provided.
2. I am aware that I should retain a copy of the Information Sheet and Consent Form for future reference.
3. I understand that I am free to withdraw at any time during the study and that my withdrawal will not affect my relationship with Flinders University and its staff and students.
4. I understand that I can contact Flinders University's Research Ethics & Compliance Office if I have any complaints or reservations about the ethical conduct of this study.
5. I agree to audio recording of my information and participation.
6. I may ask that the audio recording be stopped at any time that I may withdraw at any time from the session or the research without disadvantage.
7. I understand that I have an opportunity to review and edit interview transcripts and I will indicate this after an interview if I need.
8. I understand that only the researchers on this project will have access to my research data and raw results; unless I explicitly provide consent for it to be shared with other parties. If the need to seek my consent to share my research data with other parties does arise, I will be contacted by the researchers via email.

Participant's name……………………………….……………………..........................

Participant's signature……………………………………………Date…………………...

CONSENT FORM FOR PARTICIPATION IN RESEARCH

(Interview)

Organisational dynamic capabilities for innovation waves in the Australian heavy industry (Oil & Gas, Mining, Shipbuilding)

I certify that I have explained the study to the volunteer and consider that she/he understands what is involved and freely consents to participation.

Researcher's names… Ryan Jang **……….................**

Researcher's signatures……………………………………....Date…………………….

This research project has been approved by the Flinders University Human Research Ethics Committee in South Australia (Project number: 5455). For queries regarding the ethics approval of this project please contact the Executive Officer of the Committee via telephone on +61 8 8201 2543 or email human.researchethics@flinders.edu.au

APPENDIX 6: RECRUITMENT LETTER

Dear [name]

I would like to inform you of the opportunity to participate in the research study titled **"Organisational dynamic capabilities for innovation waves in the Australian heavy industry (Shipbuilding, mining, oil and gas)"**. The purpose of this study is to investigate organisational dynamic capability (sensing, seizing and reconfiguring) required for innovation waves in the Australian heavy industry.

This study is conducted by Ryan Jang and supervised by Professor Adela McMurray from Flinders University in Adelaide, South Australia.

We would like to invite you to take part in this research (interview) because you possess industry expertise in innovating the Australian heavy industry with Industry 4.0 technologies. We hope you will be able to spend approximately 60 min for an interview (via remote or in-person) with us and tell us about your perceptions on the organisational dynamic capabilities required for innovation waves in the Australian heavy industry.

We believe your insights will be valuable in determining a comprehensive model of the organisational dynamic capability required for innovation waves to enhance innovation in the Australian heavy industry. Your contribution is important since you are a major stakeholder and a pioneer in the industry sector.

If you are interested in participating in this research, please contact the researcher of this project via email. If you are located in Adelaide, kindly advise on a suitable time and place to meet. If you are located outside Adelaide, please advise on a suitable time along with your telephone number or video-call details (or email address). Please also let us know your preferred interview time, so we can try our best to suit your requirements. We have attached the participant information sheet and consent form, which detail the research study objectives and the processes involved.

Please note that participating in this project is entirely voluntary. You do not have to participate if you don't feel like so, and you can withdraw anytime during the study. In addition, the interview data will be kept strictly confidential. The researchers are ethically bound to keep all data confidential.

Please do not hesitate to contact us for further information. The contact details of the responsible researcher can be found below. Please be assured that request for more information does not obligate you to participate in the study.

On behalf of the entire research team, I thank you for your thought on being part of this important study and look forward to hearing back from you soon.

Regards,

Ryan Jang

PhD Candidate, College of Business, Government and Law, Flinders University, Adelaide