Gordon Institute of Business Science
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Factors that influence the successful implementation of digitalisation in South African manufacturing firms

(22964259)

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i. Abstract

Digitalisation has been shown to be a game-changer for manufacturing companies, leading to increased productivity and operational performance. Over and above the economic benefits, manufacturing firms have benefited from digitalisation throughout the value chain. For example, digitalisation has been shown to improve the firms' product development cycle by eliminating the need for physical trials and prototypes and using digital solutions like digital prototyping, digital twins, and augmented reality, thereby simplifying product design. However, there is evidence that technology adoption in developing economies has been uneven and primarily dependent on available resources, making technology adoption relatively difficult.

The objective of this study is to explore the factors that influence digitalisation in the South African manufacturing industry. The goal is to understand the factors that impact successful digitalisation and uncover the methods that organisations that have digitalised their manufacturing operations have used to digitalise successfully as well as the capabilities that have enabled successful digitalisation.

A phenomenological qualitative approach is used as the research strategy to expand the organisation's application of phenomenological studies and offer a structured method for exploring the digitalisation phenomenon. The study's outcomes offer a qualitative textual and structural definition of digitalisation within a South African context founded on TOE and PBV. This adds to the existing knowledge and provides a conceptual strategic framework for digitalisation in the form of a digitalisation house to guide practitioners on their digitalisation journey.

ii. Keywords

Digitalisation

Industry 4.0

Technical adoption

Digitalise

Manufacturing digitalisation

iii. Plagiarism declaration

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

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Signature Date

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1 Introduction to the research problem

1.1 Introduction and background to the study

Digitalisation has transformed the manufacturing industry, allowing developing nations to innovate and enhance their technologies, thereby playing a crucial role in securing firm-level growth and innovation and by implication a contribution to overall economic growth and global competitiveness (Bag et al., 2021; Gillani et al., 2020; Wen et al., 2022). This transition to digitalisation has been driven by technological advances, such as the Internet of Things (IoT) and artificial intelligence (AI), which have enabled automation and data-driven decision-making. Empirical research suggests a significant association between the adoption of technology and the financial performance of firms (Bhatia & Kumar, 2022; Raj & Jeyaraj, 2022).

As such, manufacturing companies have increasingly adopted digitalisation to improve their operational efficiency, productivity, cost management and overall profitability (Björkdahl, 2020; Buer et al., 2021; Chauhan et al., 2021; Y. Yang & Yee, 2022). By digitising their processes, manufacturing companies have been able to eliminate manual errors, reduce production time, and increase overall productivity. Additionally, the use of digital tools has allowed for real-time data monitoring and analysis, enabling companies to make more informed decisions and quickly identify areas for improvement (Bhatia & Kumar, 2022; Raj & Jeyaraj, 2022; Sharma et al., 2023).

Overall, digitalisation has been shown to be a game-changer for manufacturing companies, leading to increased productivity and operational performance (Buer et al., 2021). Over and above the economic benefits, manufacturing firms have benefited from digitalisation throughout the value chain. For example, digitalisation has been shown to improve the firms' product development cycle by eliminating the need for physical trials and prototypes and using digital solutions like digital prototyping, digital twins, and augmented reality, thereby simplifying product design (Björkdahl, 2020; Roscoe et al., 2019).

However, there is evidence that technology adoption in developing economies has been uneven and primarily dependent on available resources, making technology adoption relatively difficult (Raj et al., 2020). The pandemic also brought challenges

to the manufacturing sector. The United Nations' Industrial Development Report of 2022 (UNIDO, 2022) indicates that the firms with lower levels of digitalisation and technology adoption were impacted more by the pandemic when compared to more technologically advanced firms (Appendix 1).

1.2 Problem statement

Despite the plethora of new technologies, manufacturers are prioritising productivity and efficiencies over advanced technology adoption due to the absence of immediate returns on investment from digitalising (Björkdahl, 2020). Meanwhile, Sustainable Development Goal number 9.2 (SDG 9.2) seeks to boost the manufacturing industry's employment and GDP share, promote inclusive and sustainable industrialisation, and adapt to national circumstances by 2030 (UNstats, 2023). SDG 9b and c are targeted at promoting local technological development and innovation and elevating access to information and communications technology by 2030. This is measured by the share of medium-high and high technology industries to the Manufacturing Value Add (MVA).

Sub-Saharan Africa's proportion of medium-high and high-technology manufacturing in 2020 was 21.7%, compared to 47.7% in Europe and Northern America(United Nations, 2023; UNstats, 2023). It has been indicated that higher-technology industries recovered faster and exhibit higher values of MVA, highlighting the importance of innovation, technology transfer, and advanced technology investment in LDCs and developing countries(UNstats, 2023). South Africa is classified as a developing country yet, in the indicators for SDG 9.2, (MVA) as a percentage of GDP has declined by more than half from 1990, when it was 24%, to the current value of 11.4%, compared to 14.03% among least developed nations (StatsSa, 2023b; World Manufacturing Foundation, 2023; Worldbank, n.d.). Manufacturing enterprises in South Africa are lagging in digitalisation compared to those in developed economies and are at risk of facing challenges that will continue to impede their growth, and by implication their manufacturing value added to the economy. Furthermore, the country's expenditure on research and development has decreased from 71% of GDP in 2015 to 61% of GDP in 2021 with the business expenditure on research and development dropping from 42% to 30% of gross domestic expenditure in the same period (StatsSa, 2023b). Expenditure on research and development has been shown

to be one of the indicators and requirements for digital advancement (Zangiacomi et al., 2019).

It is therefore evident that manufacturing firms in South Africa are slow in digitalising when compared to manufacturing companies in developed economies. As such as the manufacturing sector needs to prioritise digitalisation to increase productivity and the MVA, this has the added benefit of reducing the income inequality gap (Berlingieri et al., 2024) while moving the country closer to achieving the SDG 9.2 deliverables.

1.3 Purpose of the study

The objective of this research is to gain a better understanding of the factors that would promote successful digitalisation in manufacturing companies based in South Africa. The plethora of digital technologies that come with the era of Industry 4.0 and the speed at which these solutions are coming make it critical for organisations to have a clear selection strategy or method in order to avoid being overwhelmed or lagging. This study's objective is therefore threefold:

- To understand the factors that influence digitalisation within a South African context
- To understand how manufacturing firms select, deploy, and successfully integrate digital technologies within their organisations
- To understand what capabilities or practices are required to enable successful digitalisation

1.4 Significance of the study

1.4.1 The academic need for the research

Recent digitalisation studies have focused on understanding technology adoption antecedents and managing these barriers, enablers and critical success factors to adoption (Bhatia & Kumar, 2022; Chatterjee et al., 2021; Pozzi et al., 2023; Raj et al., 2020; L. Yang et al., 2023; Zangiacomi et al., 2019), the importance of developing technological capabilities (Giotopoulos et al., 2017; Peerally et al., 2022), the key role of implementation facilitating factors, implementation frameworks and strategies (Hughes et al., 2022; Van Zeebroeck et al., 2023; Zangiacomi et al., 2019). In manufacturing specifically, studies have focused on the impact of digital technologies

and the implementation of Industry 4.0 (Gaglio et al., 2022; Guo et al., 2021; Jones et al., 2021; Mishra et al., 2023; Sharma et al., 2023; Stark et al., 2023).

Several of these studies have been conducted in particular geographic and economic contexts, including developing economies such as Brazil and India (Buer et al., 2021; Mishra et al., 2023; Stark et al., 2023; G. L. Tortorella et al., 2023; Zangiacomi et al., 2019). However, there has been limited research conducted on the subject of manufacturing digitalisation in the specific context of South Africa, which is influenced significantly by cultural and country-specific factors (Bag et al., 2021; Gaglio et al., 2022).

Some of the studies have been conducted using qualitative methods, which has the limitation of not being generalisable and hence the findings might be different in a South African context (Berlingieri et al., 2024; Peerally et al., 2022; Y. Yang & Yee, 2022). The findings from these qualitative research studies have either corroborated one another or contributed additional perspectives or dimensions to the existing theory. Several quantitative studies have also been conducted to verify the validity of these qualitative findings. However, the results have been equivocal. Typically, these quantitative studies have focused on validating the relationship between the enablers, inhibitors and consequent factors and measuring their strength, in relation to the successful implementation of digitalisation (Bhatia & Kumar, 2022; Chatterjee et al., 2021; Gillani et al., 2020; Raj et al., 2020; Sharma et al., 2023).

This study's academic contribution is both contextual and methodological. Further research is needed in South Africa to identify the factors that contribute to successful digitalisation, considering the changing socioeconomic conditions and slow technology adoption. The study will enhance qualitative research and expand the understanding of digitalisation by utilising a unique methodology that aims to address the knowledge gap on how digitalisation is experienced within a South African manufacturing context. This will support future studies by offering a current perspective on factors influencing digitalisation that can be verified through quantitative approaches and providing academics with an additional qualitative viewpoint on the phenomena.

1.4.2 Practical business need for the research

Given the rapidly evolving and widespread adoption of new technologies, it is imperative for manufacturing firms in South Africa to avoid falling behind in digitalisation. The advantages enjoyed by those who successfully integrate and adopt digital technologies further underscores the urgency for these firms to embrace digitalisation (Björkdahl, 2020; Buer et al., 2021; Stark et al., 2023). The urgency lies in the need to identify the optimal strategy for the local manufacturing sector to effectively initiate, implement, and derive value from the digitalisation.

In their study, Gaglio et al. (2022) concluded that digitalisation efforts must consider the types of digital technologies that are most accessible and beneficial to the organisation. South Africa possesses a knowledge base that is sufficiently complex to enable "opportunities" to diversify manufacturing through technological development (The Atlas of Economic Complexity, n.d.) (Appendix 2) and the overall adoption of technology, using internet usage as an indicator, is above the global average (Share of the Population Using the Internet, n.d.) (Appendix 3). Therefore, South Africa has the technological base and Gaglio et al. (2022)'s recommendation can be achieved through a structured and pre-defined framework aimed at pursuing accessible and beneficial digitalisation. This study therefore aims to provide a practical tool for practitioners by providing a structural framework that can guide and enable successful digitalisation in manufacturing firms.

1.5 Outline of the study

This chapter provided background information for this study, as well as the research problem statement and purpose. The chapter emphasised the importance of digitalization and the economic value of manufacturing, as well as the challenges of digitalization in developing countries such as South Africa and the need for local manufacturing digitalisation skills development. The identification of a gap in the literature provided an opportunity to contribute new knowledge, including practical applications and policy implications.

The remainder of this paper will provide the context and theoretical background through the literature review in chapter two. In chapter three, the research questions will be articulated. The conceptualisation of the study is demonstrated by the conceptual framework in Figure 1 below. Chapter four will focus on the research

design and research methodology and the findings, their analysis and triangulation to theory as well as the final conclusion will be detailed in chapters five, six and seven, as demonstrated in Figure 1.

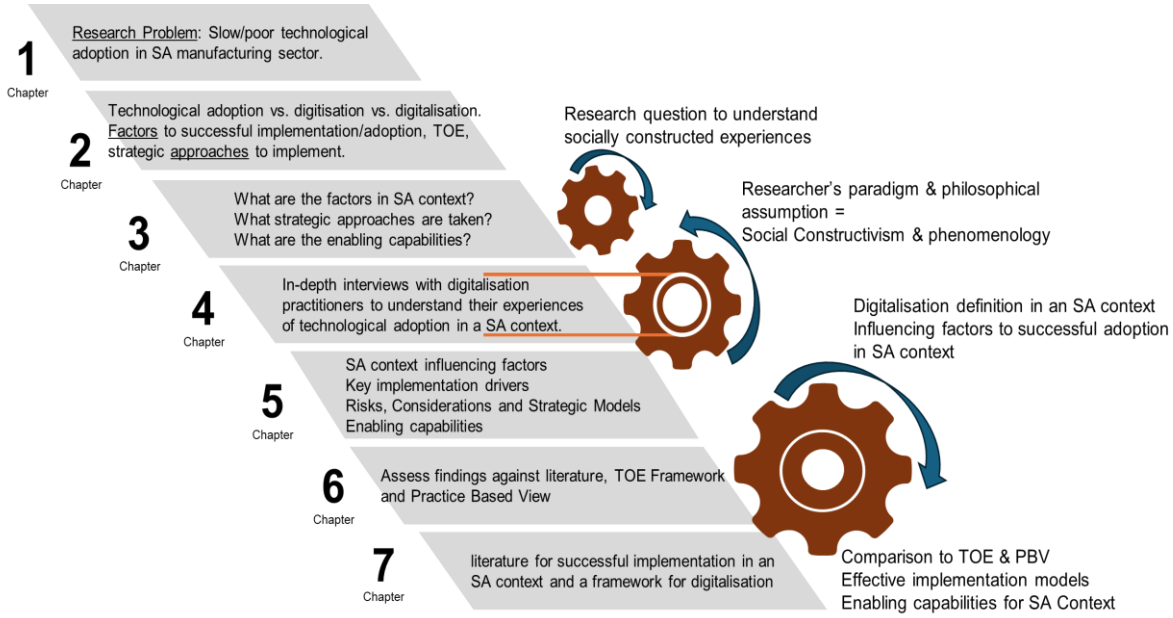

Figure 1: Outline of the study

2 Literature review

This section provides a review of the current body of literature pertaining to digitalisation, specifically in a manufacturing context. A description of digitalisation as found in literature is provided and compared to Industry 4.0, technology adoption and digitisation to bring about synergy and a clear description of digitalisation. This is followed by an assessment of existing theories that apply to digitalisation and then a focus on the core studies that discuss factors that influence digitalisation, strategies that have been used to implement and adopt digitalisation and technology enabling capability frameworks. A contextual and methodological research gap is then established from the assessed literature as the contribution of this study, leading to the research questions that are posed in chapter 3.

Figure 2 below represents the structure of this chapter.

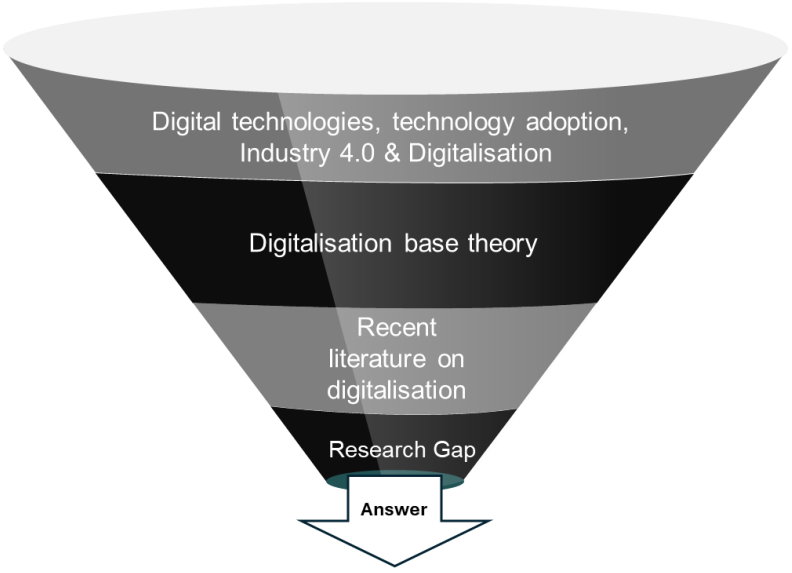

Figure 2: Literature review structure

It should be highlighted that half of the literature was intentionally reviewed after data collection and midway through the analysis. This was done to guarantee that the inductive process of identifying influencing factors was not biassed by what the researcher already knew, as this may limit the outcomes of the study (Bloomberg & Volpe, 2012) based on the selected research strategy.

2.1 Industry 4.0, technology adoption, digitisation and digitalisation

2.1.1 Industry 4.0, technology adoption and digitisation

Industry 4.0, or 4IR, is a term that applies to manufacturing technological applications. In their Industry 4.0 systematic literature study, Liao et al. (2017) discovered that the first presentation of 'The fourth industrial revolution' occurred in 1988. They note that the concept was later utilised to describe the creation and use of nanotechnology. It became more widely known as the application of IoT in industrial processes with the three most frequently cited proposals being the 'Industrie 4.0' from Germany, the 'Industrial Internet' from the United States, and the 'Factories of the Future' from the European Commission (Liao et al., 2017). These informed the coining of Industry 4.0 which was formally established by the Economic Development Agency of Germany as I4.0 in 2011 (Liao et al., 2017; Raj & Jeyaraj, 2022). Raj and Jeyaraj define it as a revolution that links digital and physical systems to facilitate real-time information by integrating multiple technologies and in their systematic literature review, Liao et al. (2017) concur with this view as they list all the different technologies that were investigated and associated with Industry 4.0. Guo et al. (2021) define Industry 4.0 as an advanced technology-driven industrial revolution that integrates the physical and digital domains, transforming the way manufacturing activities are controlled. Throughout their papers, Guo et al., Liao et al. and Raj and Jeyaraj use technology adoption interchangeably with Industry 4.0. This is evidence that technology adoption, especially in recent years, is directly associated with Industry 4.0.

2.1.2 Digitalisation and digitalisation in manufacturing

Buer et al. (2018) argue that there is ambiguity in defining digitalisation. Some define it as an enabler of Industry 4.0 while others define it as one of the core elements of Industry 4.0. Chauhan et al. (2021) and Ivanov et al. (2019) create an association to digitalisation in their paper regarding Industry 4.0 barriers as they use the words interchangeably and include Industry 4.0, digitalisation, and manufacturing digitalisation as part of their search terms in a systematic literature review search. They further define digitalisation as the process of providing real-time data on manufacturing activities through the integration of smart technology and smart value chains. According to Björkdahl (2020), digitalisation is synonymous with industry 4.0, however, digitalisation has wide-ranging effects on various aspects of operations,

extending beyond the realm of manufacturing. Ivanov et al. (2019) effectively delineate the comprehensive scope of digitalisation through their proposed digitalisation framework. This framework highlights the incorporation of Industry 4.0 and other technological disruptors such as big data, additive manufacturing, and advanced trace and track systems in the domain of digitalisation as depicted in Figure 3 below.

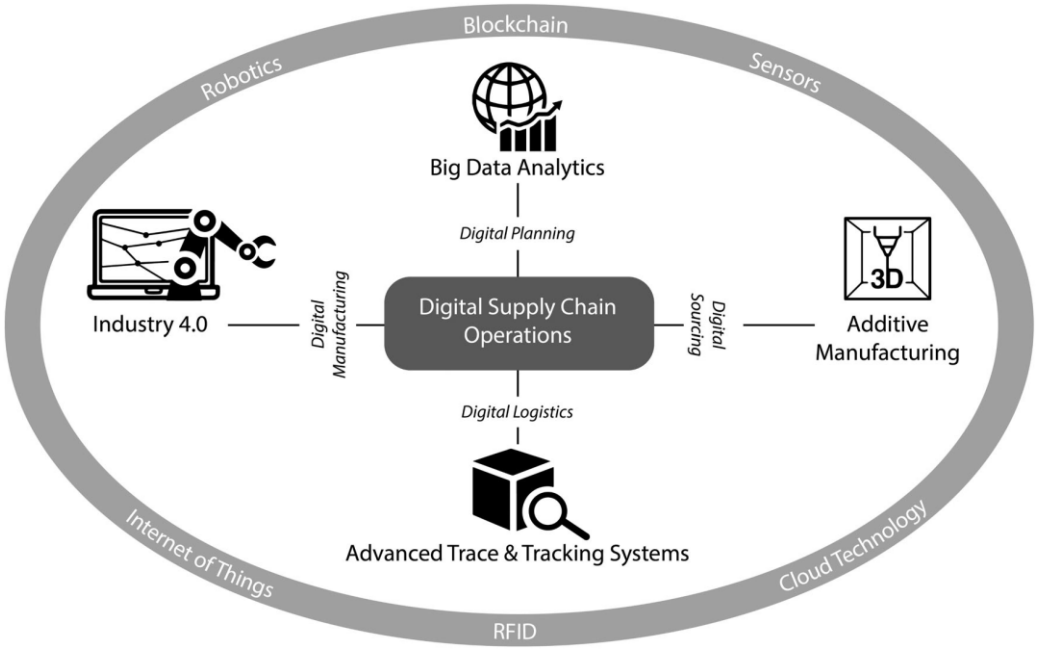

Figure 3: Digitalisation framework of SC risk management

Adopted from Ivanov et al. (2019).

Wen et al. (2022) argue that both digitisation and digitalisation involve the use of digital technologies and although the terms are occasionally interchanged, they have distinct meanings. Digitisation uses technological advances to collect, store, evaluate and share both physical and economic data for linked, decentralised, and adaptive human-machine-application interfaces. The concept of digitalisation is broader and more inclusive. It encompasses the use of digital tools, data, and automation to streamline workflows, improve efficiency, and facilitate new capabilities to enable optimisation and enhancement of processes and products. Mishra et al. (2023) simplify the definition to simply say digitalisation is the use of advanced technologies to improve organisational interactions and consumer satisfaction by rendering processes more accessible and transparent. Several authors distinguish between digitisation and digitalisation and propose that digitisation is the conversion from analogue to digital while digitalisation is using digitisation to optimise processes

(Björkdahl, 2020; Buer et al., 2018; Holmström et al., 2019; Mishra et al., 2023; Wen et al., 2022). Holmström et al. (2019) goes on to say digitalisation merges digital tools within product design and production processes.

According to Wen et al. (2022), digitalisation within manufacturing refers to the use of digital technology in all stages of the manufacturing value chain. Björkdahl (2020) further elaborates that this involves transforming business processes and organisations by integrating digital technologies into value chain activities, thereby creating a digital ecosystem that enhances overall efficiency within the manufacturing process while Mishra et al. (2023) expands on the specifics in noting that some of the manufacturing technology adoptions include product life cycle management integrated with product development, integrated processes for managing numerous operations, additive manufacturing, cloud-based data storage to increase data availability, and big data analytics. Digitalisation has changed the way manufacturing uses technology, bringing about a new way of thinking about technology and the economy that makes developing countries less dependent on technologies from other countries (Björkdahl, 2020; Mishra et al., 2023; Wen et al., 2022). Studies conducted into digitalisation in manufacturing have focused on specific digital transformation elements like IoT, Big Data, machine automation, and data transfer (Roscoe et al., 2019; Stark et al., 2023; L. Yang et al., 2023).

In view of the prior studies and conclusions stated above, this study proposes a segregation of terms and the definition of digitalisation based on Buer et al. (2018), where digitisation is defined at the data level of technology adoption, digitalisation is defined at the process level, integrating all business and external processes, and digital transformation refers to the overall business transformation level.

2.2 Theoretic frameworks that apply to digitalisation

Numerous frameworks, such as the Technology Acceptance Model (TAM) (Davis et al., 1989), the Technology-Organisation-Environment (TOE) framework (Raj & Jeyaraj, 2022), the Task-Technology-Fit model (TTF) (Goodhue & Thompson, 1995), the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003), the Capability Based View (CBV) (Antonucci et al., 2020), and an emerging 4IR Framework (Peerally et al., 2022), have been commonly used and explored in studies pertaining to digitalisation. TAM is the most widely used and cited

when it comes to technology adoption studies. TAM aims to understand the processes behind technology acceptance and to determine its successful implementation by representing the outcome predicted by perceived ease of use, perceived usefulness, and behavioural intention (Davis & Venkatesh, 1996). TAM has enabled the evaluation of user motivation to adopt various technologies. Advanced versions of TAM provide a comprehensive framework for explaining and predicting technology acceptance in organisational settings. TAM3, the latest version robustly explains information system use and offers a list of interventions with direct implications for decision-making in IT implementation and management (Venkatesh & Bala, 2008). However, it is more individually and internally focused and lacks integration with other organisational and external elements and more applicable to a specific technology at a time. The critique by Lee et al. (2003) highlights the perceived limitation of the TAM in terms of its ability to offer practical recommendations for organisational implementation.

Close to the TAM, is the Task-Technology-Fit model, which was originally developed by Goodhue and Thompson (1995). This model investigates the use of technology by aligning it with the tasks and requirements of users. The objective was to validate and substantiate the claim that enhanced performance occurs solely when technological functionality aligns with the task requirements of users in the context of information system usage. Goodhue and Thompson investigated the influence of technological acceptance on performance and post-adoption factors. Yet, similar to TAM, the model is limited to addressing task specific technology when used independently in comparison to other theories, this necessitated its integration with the TAM and other models (Dishaw & Strong, 1999).

The Technology-Organisation-Environment (TOE) framework has technological, organisational, and environmental dimensions, which make it a robust model for firm-level process digitalisation. This framework classifies theories such as TAM and Task-Technology constructs into the three dimensions, which is considered appropriate for analysing digital adoption and addressing significant differences in organisations' theoretical perspectives.

In their quantitative study, Raj and Jeyaraj (2022) found that all the aspects related to the TOE framework had a favourable influence on the adoption of Industry 4.0 and consequently, digitalisation. The results obtained provide support for the importance

of technological, organisational, and environmental aspects in the context of digitalisation. (Raj & Jeyaraj, 2022) intended to provide support for organisations to effectively mobilise resources for the successful implementation of Industry 4.0 by emphasising the identification and understanding of key drivers. This deeper understanding of the digitalisation factors can enable successful implementation in an organisation. The TOE framework has been recognised as a model that provides more comprehensive and insightful perspectives on factors that influence technology adoption by considering the internal and external factors that impact an organisation. Compared to other models, it also takes into account and analyses the elements of value creation resulting from digitalisation (Chittipaka et al., 2023).

Due to the TOE framework's comprehensive incorporation of the technology adoption factors in the three dimensions and its applicability at an organisational level, it serves as the basis for this study, enabling a broad assessment of the factors that enable digitalisation in South African manufacturing firms (Gillani et al., 2020; Jere & Ngidi, 2020; Raj & Jeyaraj, 2022; Sharma et al., 2023). Although they do not refer to the TOE specifically, Holmström et al. (2019) agree with its comprehensive applicability in recognising that technology, organisation and environmental changes stimulate digitalisation.

2.3 Core recent studies on digitalisation

A plethora of studies have been conducted in recent years on Industry 4.0, digitalisation and digital transformation efforts in the manufacturing industry across different contexts (Bag et al., 2021; Bhatia & Kumar, 2022; Guo et al., 2021; Huang, 2020; Jones et al., 2021; Pozzi et al., 2023; Sharma et al., 2023; L. Yang et al., 2023; Zangiacomi et al., 2019). Contrary to what Pozzi et al. (2023) claim, more than a few of these have queried the factors that either enable or inhibit digitalisation (Bhatia & Kumar, 2022; Mukherjee et al., 2023; Raj et al., 2020; Raj & Jeyaraj, 2022) while others focused on the strategies and strategic frameworks used (Björkdahl, 2020; Mukherjee et al., 2023; Van Zeebroeck et al., 2023; Wen et al., 2022) and a few more focused on the capabilities required to ensure successful digitalisation efforts (Antonucci et al., 2020; Bag et al., 2021; Peerally et al., 2022).

The aim of this section is to evaluate recent studies to identify the theories and models that have generally influenced the knowledge base and identify gaps that

could potentially be closed, especially in the South African manufacturing context. The section is divided into the three focus areas.

2.3.1 Studies on factors that influence digitalisation

Raj et al. (2020) conducted a mixed-methods study to evaluate the barriers that hinder the adoption of Industry 4.0 technologies in the manufacturing sectors of developed and developing economies. The main barrier that they identified as prominent was the absence of a digital strategy accompanied by scarcity of resources. They also identified capital investment needed to implement Industry 4.0 as a significant barrier. Their study was later supported by Mukherjee et al. (2023), who added and brought about additional barriers, with cost and funding coming up as the prominent barriers in their study, in contrast to digital strategy and resources from Raj et al. (2020). Mukherjee et al. (2023) also notes that organisations in developing economies that are dealing with other priorities tend to have cost and funding as their major barrier to digitalisation.

A different approach was taken through a meta-analysis study conducted by Raj and Jeyaraj (2022) which utilised the TOE framework to determine the most important factors that contribute to the successful implementation of Industry 4.0 and, by extension, digitalisation. The study validated that the TOE factors had a positive impact on digitalisation but contrary to the factors drawn out by Raj et al. (2020), they found that strong infrastructure and perceived usefulness had a stronger impact on digitalisation efforts and that compatibility and ease of integrating the new technology to the organisation was significant, supporting Mukherjee et al. (2023) who noted scalability as the second prominent barrier. The view on strong infrastructure was also supported by Mukherjee et al. (2023) who noted suitable infrastructure or lack thereof as an influencing barrier and Gillani et al. (2020) who posits that base technology provides the infrastructure support required for advanced front-end technology.

A continuous learning and lean culture and meeting stakeholder expectations also stood out as important in Raj and Jeyaraj (2022)’s study. This view is supported by Pozzi et al. (2023). The importance of top management involvement and management support in digitalisation initiatives has become a relevant and prevalent discussion as authors and practitioners realise the key role, they play in ensuring digitalisation success and leading the implementation vision for the organisation and

this has been proven to be a significant factor (Giotopoulos et al., 2017; Pozzi et al., 2023; Raj & Jeyaraj, 2022). Raj and Jeyaraj (2022) noted the of government and external support as significant environmental factors impacting on an organisation's digitalisation efforts.

Bhatia and Kumar (2022) undertook a literature review and identified 26 critical success factors for digitalisation. Their study focused on assessing the success factors against impact on performance outcomes and they listed data governance and usage the most critical to performance, followed by legal aspects such as information security and regulatory compliance, to which Mukherjee et al. (2023) also attests and emphasises it as a key influencing factor. Collaboration and teamwork also came up and this correlated to the findings by Pozzi et al. (2023) who found that establishing cross functional teams was key in enabling successful digitalisation adoption. IT infrastructure and workforce involvement in the form of communication, training and empowerment were also noted as critical by Bhatia and Kumar (2022). The elements noted in workforce involvement relate to effective change management, a subject that is also inferred in Mukherjee et al. (2023)'s findings on acceptance and adaptability as an influencing factor that talks to acceptance of the technology by the workforce and the organisation being able to adapt its internal resources through upskilling and reskilling to eliminate the fear of loss of human jobs.

2.3.2 Studies on strategic approaches to digitalisation

Raj et al. (2020) completed a comparative study of both developed and developing economies and found that in both contexts, the main barriers hindering technology adoption was the absence of a well-defined digitalisation strategy and the limited availability of resources. These factors directly impede the progress of digitalising processes. It is therefore imperative for companies to develop strategies that effectively direct their actions and investments in the resources necessary to facilitate the digitalisation of processes. To ease the transition to Industry 4.0, they suggested that managers participate in strategic planning to guide organisational activities, allocate resources, and develop internal competencies. This gap has also been highlighted by practitioners, with an article in Forbes calling for purposeful business digitalisation strategies that are inward-looking (Garrett, 2021).

This literature review attempts to support Raj et al. (2020)'s finding that the main contributor to unsuccessful implementation and adoption is the failure to develop a

well-defined digitalisation strategy. From a Resource Based View standpoint, Chauhan et al. (2021) assert that digitalisation provides organisations with competitive capabilities that can enhance their performance. Their research shows that companies can benefit from creating a digitalisation strategy and vision to guide the company's internal resource mobilisation and digitalisation efforts.

Björkdahl (2020) argues that leaders must advocate for digitalisation and foster a culture of coordinated, precise practices if they want their firms to succeed in the long run. Leaders are responsible for sharing the digitalisation vision and coordinating efforts to achieve it and as such, they need to be more agile, creative, and strategic in their approach to digitalisation. According to Björkdahl, companies that have trouble integrating digitalisation often operate under the assumption that digitalisation is something that can be handled by a single department, that is not supported financially or in terms of allocating resources and there is no apparent ownership which in turn leads to tensions within that organisation. Roscoe et al. (2019) and Zangiacomi et al. (2019) propose establishing central internal structures that enable cross-functional collaboration, flexible learning processes and approvals for technology deployment as this will promote continuous learning, exploitation of technology and cross-functional engagement in organisations. Roscoe et al. (2019) further found that structures and processes enable people to deliver on digitalisation requirements while building operational capabilities but also emphasised that the type of digitalisation output will be influenced by the structures in place, whether they are hierarchical or collaborative.

Sharma et al. (2023) propose that companies should have a well-defined strategy to implement digitalisation. Raj et al. (2020) substantiates that to achieve successful digitalisation with a focus on capturing value, firms need to undertake a comprehensive reengineering of their current strategies and make significant investments in human resources, operational procedures, and technological infrastructure. Very few studies have been done on the firm level strategy for digitalisation. Studies on firm-level decision making for digitalisation indicate a significant positive correlation between the degree of strategy shift and the adoption of digital technologies, signalling a close relationship between digitalisation and strategy Van Zeebroeck et al. (2023). Björkdahl (2020) emphasises that these strategies must enable the creation and exploitation of value from digitalisation. The

question is whether the type of strategy selected by firms is the driver or is driven by digitalisation. Wen et al. (2022) put forward that the strategies pursued by manufacturing firms are indirectly affected by digital transformation. They argue that the digital transformation of the manufacturing industry encourages businesses to implement differentiated competitive strategies as opposed to the adoption of a cost-competitive strategy.

This study builds on Björkdahl's (2020) finding and attempts to unearth insights into the tactical approaches within the digitalisation strategies that enable coordinated digitalisation efforts with a clear vision and accountabilities.

2.3.3 Studies on digitalisation enabling capabilities

As organisations begin their digitalisation journey, over and above daily operations, it introduces new demands, challenges, and requirements for new technological capabilities. This implies that organisations need to become more skilled at using technology over time so that they can adopt more advanced technologies. One of the most recent frameworks in the digitalisation space is the development of the technological capability framework by Peerally et al. (2022). According to their findings, they posit that technological capabilities at the firm level are a set of organisational activities and resources that are enhanced by the adoption of more complex technologies required by firms to manage the digitalisation process. These activities and resources enable the firm to gain a competitive advantage. According to Barney (1991)'s Resource Based View (RBV), these activities and resources must be rare and immobile, however, with digitalisation being at the centre as the revolution of focus, Bromiley & Rau (2014) propose a Practice Based View (PBV) as an alternative to the Resource based View (RBV) for operations on the premise that PBV advocates capabilities that are transferable and common across firms but required to enable achievement of desired goals and that the differentiator would be the efficient and proficient usage of the practices.

The practices, their application, and their interplay with other practices within the firm are the primary foci of the PBV (Bromiley & Rau, 2014). To this, Peerally et al. (2022) propose that, to adopt more complex technologies, firms must invest in developing their technology skills and enable continuous learning over time, thus enhancing their practices with regards to digitalisation. Even though Kaplinsky and Kraemer-Mbula

(2022) assert that the development of digital skills should be addressed at country level through policies that address poor education outcomes, Peerally et al. (2022) declares that it can be done at firm-level by encompassing all the methods by which firms acquire the knowledge, skills, and resources.

Bag et al. (2021) argue through PBV that digitalisation itself, is a practice that enhances advanced manufacturing capabilities of a firm, as the firm continuously adopts new technologies, their ability to digitalise improves. A view that Gillani et al. (2020) concurs with in that companies with existing digitalisation capabilities find it easier to adopt new technologies compared to less technologically adept firms, which face challenges in integrating new technologies. Therefore, the firm's digitalisation ability is directly influenced by its technological competence, and this is in line with Peerally et al. (2022)'s proposal. According to Giotopoulos et al. (2017), these technological competencies can be classified into the technological and organisational domains of the TOE. They position innovation, research and development and benchmarking and collaboration competencies as technological competencies while technologically skilled personnel, decentralised decision making and visionary leadership are noted as organisation competencies that have direct impact on the organisation's digitalisation capability.

The benchmarking and collaboration practices are essential in keeping up to date with industry trends. Organisations need to keep up to date with current developments in digitalisation by investing in the research of future technologies. According to Berlingieri et al. (2024), government should support through research and development in digitalisation to foster innovation and enable companies to bridge the productivity gap, especially the smaller enterprises but bigger corporations should be able to invest in their own research and grow the competence internally. Giotopoulos et al. (2017) refers to visionary leadership within the organisation domain of TOE and G. Tortorella et al. (2023) recorded the role of leadership behaviours in influencing the digitalisation outcomes, they posit that change-oriented leadership behaviours have a significant impact on digitalisation maturity.

Peerally et al. (2022)'s proposed technological capability framework is depicted in Figure 4 below and this can be used by firms to assess where they need to invest their time and resources.

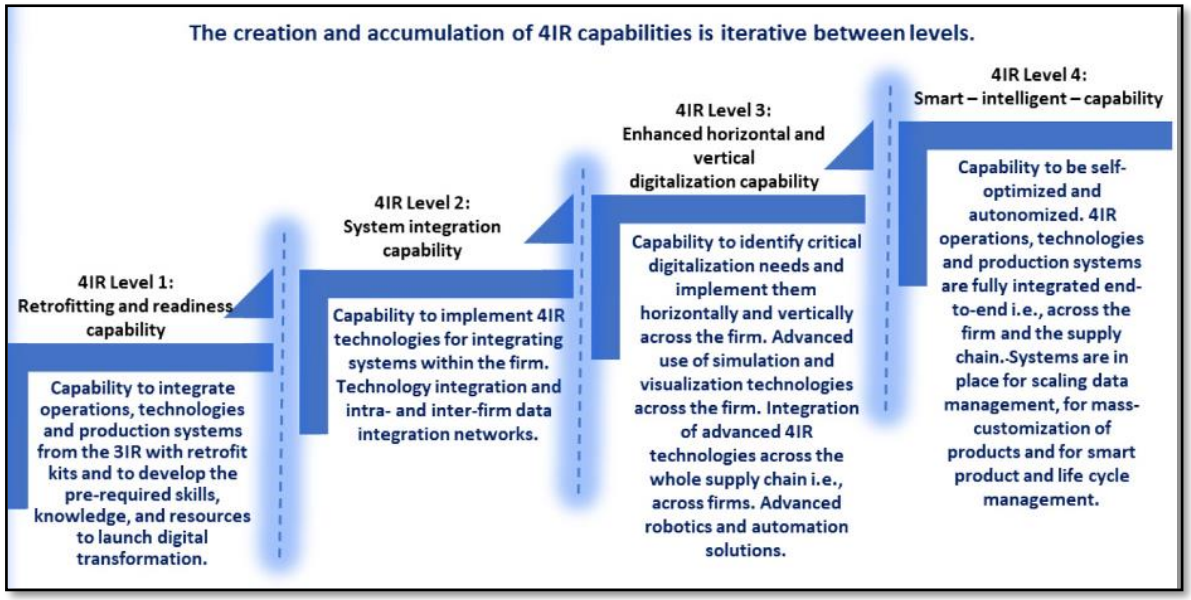

Figure 4: 4IR technological capability framework

Adopted from Peerally et al. (2022, p12)

The framework references four levels of technological capabilities: retrofitting and readiness, system integration, enhanced digitalisation, and smart-intelligent. Within each capability, they discuss six themes that indicate the level required to attain that level of capability. Thus, combining this framework with the PBV to identify capability building practices of a firm, this study can explore the current level of capability according to Peerally et al. (2022)'s framework and identify required practices to get to the next level of capabilities.

Moving from one capability level to the next is highly dependent on the organisational culture. Tortorella et al. (2023a) found that the type of organisational culture profile can positively or negatively influence digitalisation success depending on the targeted digitalisation output. A collaborative culture that encourages teamwork and employee involvement for example, is a positive conduit for most digitalisation efforts. This type of culture is usually exemplary of a continuous improvement culture and Buer et al. (2021) found that there is a correlation between lean or a continuous improvement culture and digitalisation that enables operational performance. They emphasised that manufacturing firms that have not implemented continuous improvement should reconsider their digitalisation path, especially if their driver is operational performance, as their findings indicated that without continuous improvement, digitalisation efforts will yield very little performance improvement while Roscoe et al. (2019) accentuated that such processes enable people to deliver

on digitalisation requirements while building operational capabilities. Yang and Yee (2022) on the other hand found that continuous improvement has a substituting effect in that you can either have continuous improvement or digitalisation to improve performance, however, it should be noted that Y. Yang and Yee (2022) based their assessment from a return on asset view, where a big investment is required for digitalisation while continuous improvement requires little upfront capital and advocates for reduced operating cost.

In summary, it is evident that the practices, structures, processes and organisational culture are important capability inputs or considerations for successful digitalisation. In this research, we make use of a combination of the technological capability framework as presented by Peerally et al. (2022) and the Practice Based View to explore the capabilities that currently exist in the sampled manufacturing firms, identify where they are positioned in the capability levels and what capabilities are required for firms to successfully digitalise their operations to the next level (Bromiley & Rau, 2016b; Peerally et al., 2022).

2.4 Research gaps

Table 1 below provides a summary of major studies that have been referenced and inspired this research. All remaining studies are cited in the reference list located at the conclusion of the study.

Table 1: Summary of the key studies that informed this research

Reference	**Context**	**Methodology**	**FRIN**	**Journal Rating**
Bhatia and Kumar (2022)	Developing economy	Quantitative	Method: Qualitative to reinforce findings	AJG 3
Peerally et al. (2022)	Developing economies	Qualitative	Context: explore the accumulation of 4IR technological capabilities in low and medium technology sectors	AJG 4*
Raj et al. (2020)	Developing and developed economies	Quantitative	Context and method: explore various enabling factors from various manufacturing industries could be collected and studied to generalise the current findings.	AJG 3
Raj and Jeyaraj (2022)	Meta Analysis	Quantitative	Method: exploring other theories like the resource-based	AJG3

Pozzi et al. (2023)	Developed economy	Case Study	Context: companies belonging to different sectors, to confirm the evidence emerging from this study	AJG 3
Mukherjee et al. (2023)	Developed economies	Quantitative	Method: longitudinal study and further statistical methods to validate factor dependencies.	AJG 3
Stark et al. (2023)	Developed economy	Case Study	Method: cost-benefit realisation of implementing advanced technologies	AJG 4*
Björkdahl (2020)	large multinational firms	Multi Case Study	What enablers and capabilities are needed to support digitalisation efforts? How is the firm approaching identification of an operating model?	AJG 3
Mishra et al. (2023)	Developing economies	Mixed	Context: samples from different geographical locations and/or conduct investigations in diverse cultural contexts.	AJG 3
Tortorella et al. (2023)	Developing economies	Quantitative	Context: target the services sector as there are more digitalisation initiatives.	AJG 3
Zangiacomi et al. (2020)	Developed economy	Multi Case Study	Method: involve a larger sample of organisations from other industries.	AJG 3
Y. Yang & Yee (2022)	Developing economy	Qualitative	Method: explore how external factors impact the effectiveness of digitalisation.	AJG 3
Bag et al. (2021)	Developing economy	Qualitative	Method: extend the sample size and target other sectors and industries.	AJG 3
Roscoe et al. (2019)	Developed economy	Case Study	Method: Identify what different structures and processes enable what types of technology	AJG 4*
Berlingieri et al. (2024)	Developing and developed economies	Qualitative	none recommended	AJG 4*
Chatterjee et al. (2021)	Developing economy	Quantitative	Context: tested in the context of other developing countries.	AJG 3
Buer et al. (2021)	Developed economy	Quantitative	Method: how continuous improvement can be effectively combined with digitalisation to yield operational performance	AJG 3
Gaglio et al. (2022)	Developing economy	Quantitative	Context: Future research can extend the study to holistic digitalisation and not just ICT.	AJG 3
Giotopoulos et al. (2017)	Developed economy	Quantitative	Context: Extend the context of study to other countries and bigger firms.	AJG 3
Gillani et al. (2020)	Developing and developed economies	Quantitative	Method: identify other factors that impact digitalisation within the TOE framework, especially the environmental context in developing countries	AJG 3

The main themes that have been studied in the digitalisation context include barriers and enablers (Chauhan et al., 2021; Jones et al., 2021; Mukherjee et al., 2023; Raj

et al., 2020), factors that influence adoption (Chatterjee et al., 2021)(Bhatia & Kumar, 2022), and the impact of digitalisation on manufacturing and the supply chain (Ivanov et al., 2019).

Studies into the capabilities required to digitalise processes have developed frameworks and themes to guide adoption. The authors acknowledge that this transition shifts the organisation's focus from merely adopting digital technologies to implementing digitalisation. A few studies have attempted to statistically test and provide empirical evidence based on existing models (Bag et al., 2021) but limited studies were found that were qualitative in nature, to further the identification of the factors as listed in the literature in different and varying contexts (Pozzi et al., 2023; Raj et al., 2020). There is an opportunity to carry out additional qualitative research in South Africa that makes use of the TOE model and that explored the key drivers of digitalisation in the current context.

Most research on digitalisation in the manufacturing sector has primarily examined the sector in either developed nations or developing nations in South America and Asia (Mukherjee et al., 2023; Stark et al., 2023; Zangiacomi et al., 2019). However, there is a limited body of literature that specifically addresses Africa, including South Africa (Peerally et al., 2022; Pereira et al., 2019). Bhatia and Kumar's (2022) research highlights successful factors in a developing country context, but it focuses primarily on the automotive industry and does not examine other industries; thus, there is an opportunity to assess other manufacturing industries or the manufacturing sector as a whole and to compare the results. The study utilises a quantitative technique but gives room for a qualitative approach to examine manufacturing firms' experiences and validate the conclusions or report any differences. Another issue is that the study was conducted in India, a developing country, but one that is very different from South Africa.

Raj & Jeyaraj (2022)’s research included a South African study, but they pointed out that other viewpoints, such as the resource-based view, were lacking. Manufacturing companies require a competent labour force that can rapidly adapt to new technologies. Managers and employees with the necessary skills can leverage the advantages of technology and digital tools (Kossaï & Piget, 2014). Giotopoulos et al. (2017) emphasises that technological competencies, and a skilled workforce are a

key determinant to digitalisation. Giotopoulos et al. (2017) note that technological knowledge and skills development should be a priority consideration for strategic decision-makers as a lack thereof will impede digitalisation implementation and adoption. Raj et al. (2020) further asserts that to effectively address the issues associated with the implementation of digitisation, it is imperative for firms to give due consideration to the development of internal skills within their organisations.

The literature gap identified is contextual. There is a need to examine these factors within a South African context, which might be different given socio-economic conditions and other contextual factors (Chauhan et al., 2021). It is therefore necessary to compare the factors in a South African context with the factors identified by previous studies and then to explore the strategic and mitigating components to enable successful digitalisation implementation in a South African context. In particular, this research builds on a gap identified by Peerally et al. (2022) on the exploration of digitalisation technological capabilities for low and medium tech industries to identify the level of technological skills, experience and knowledge that has been accumulated. The methodology used will add to the body of knowledge in that only a few studies have applied the phenomenological approach at an organisation level and the outcomes of the study will enable the development of a framework that practitioners can use to guide the steps they need to take to advance in their levels of technological capabilities.

3 Research questions

Biddix (2018) viewed the identification of the research question as the most significant decision in the research process. A research question serves as the foundation of a research project, guiding all phases and the research methodology used, from literature review to reporting on findings. A good research question will be guided by an efficient literature search technique to ensure the construction of a logical argument and should guide the research process, leading to an approach that effectively answers the research question.

In considering the academic gaps as identified in section 2.4, this study utilised Björkdahl (2020)'s multi-case study to address these academic gaps by establishing a set of questions to assess for successful digitalisation. Firstly, the questions explore why digitalisation is important for the firm and how it will help them solve their main problems. Next, where to focus their attention to avoid costly and unproductive digitalisation outcomes, Björkdahl emphasises that firms that are successful in digitalisation are clear about where they will invest their effort. He also notes that firms must define what capabilities they need to enable successful digitalisation. An example is one of the firms in the case studies emphasised data management and utilised sophisticated analytics and business intelligence to make informed decisions. Finally, companies require strategic frameworks that dictate decision-making processes, identify decision-makers, and outline their primary responsibilities. The research questions for this study were thus formulated as follows:

3.1 Research question 1: Key drivers of digitalisation

What are the key drivers of digitalisation in the South African manufacturing sector?

According to Raj et al. (2020), developed and developing nations alike face the same 15 main challenges to digitalisation, The authors note that their findings may be more broadly applied if future studies looked at digitalisation enabling factors and collected additional data from a variety of industries and sectors. This guided the research question, with the aim of eliciting participants' first-hand accounts of digitalisation as well as their overall impressions of the phenomenon to identify the factors that facilitate its implementation within the South African manufacturing context. Raj & Jeyaraj (2022) provided a lens of reviewing these factors within the TOE framework

and this lens was used in answering the research question to ensure a strong theoretical foundation for the study. As such, the results are compared to the previously stated key drivers in the TOE literature.

3.2 Research question 2: Strategic frameworks for digitalisation

Do South African manufacturers use strategy frameworks to drive digitalisation in their organisations?

This question was based on Björkdahl's (2020) reference to the role of the leaders in sharing the digitalisation vision and coordinating digitalisation efforts. The question aimed to extract the tactical approaches to a digitalisation strategy that enabled these coordinated digitalisation efforts and how they were managed or executed by the manufacturing firms.

3.3 Research question 3: Pre-requisite requirements for digitalisation

What are the pre-requisite requirements for a strategic approach to digitalisation?

In their paper, Peerally et al. (2022) create an updated framework of firm-level technological capabilities. This framework considers the capabilities, practices and resources that firms will need to adopt 4IR technologies as they progress through their digitalisation journey. Their research shows that developing economies' technological capability frameworks for firms need an extensive rethink, not just incremental upgrades, as it might take years to account for the digitalisation changes and the rapid advancement of smart technologies happening in firms and industries. Their proposed updated framework serves as a foundation for developing digitalisation capabilities at the firm level. This study aimed to expand and use their framework to elicit from manufacturers, the prerequisite capabilities required for successful digitalisation and advancing to the next level of capabilities within this framework.

Through these questions, this study addressed the existing literature gaps for the digitalisation phenomenon by exploring the application of the Technology-Organisation-Environment framework (TOE) in a South African manufacturing context.

4 Research methodology

This chapter provides a description of the research strategy employed for this study, as well as the underlying philosophical assumptions. The qualitative technique utilised in the approach to the research methodology demonstrated congruence between the identified literature gaps, the research questions, and the research findings derived from the collected data. Data was gathered using open-ended, semi-structured interview questions, with careful planning to ensure that research delivery dates were met. A phenomenological research methodology was utilised, involving a purposive criterion-based sample of 16 participants. The individuals were specifically chosen because of their ability to offer reliable insights on the digitalisation process, as well as their pertinent roles within various manufacturing industries. The next sections give the detail and rationale for the research strategy employed.

4.1 Research paradigm

The researcher's philosophical paradigm was based on ontological, epistemological, and axiological assumptions, with the goal of understanding the nature of reality and acquiring new knowledge, in this case, about the digitalisation phenomena in the manufacturing context, while acknowledging underlying personal values and biases (Creswell & Poth, 2018). The ontological assumption was founded on the researchers' ability to accept the concept of many realities as experienced by each participant in the study, recognising that there is no single true north. The epistemological assumption was the acceptance of the participant's subjective experiences gained through in-depth engagements as a sufficient form of knowledge acquisition (Merriam & Tisdell, 2016). With the researcher's background as a manager in various manufacturing organisations, the axiological assumptions included the researcher's personal experiences and perspectives on the sluggish or unsuccessful implementation of digitalisation and the researcher's appreciation of and value placed upon process-driven digitalisation. These axiological assumptions introduced biases into the study, and Creswell and Poth (2018) endorse Husserl’s view and highlight the importance of declaring them upfront to ensure they are bracketed so as not to influence the validity of the study unknowingly (Creswell & Poth, 2018; Gill, 2014). However, Heidegger (1996, as cited in Gill, 2014) argues that every individual is inherently grounded within a culturally and historically influenced context, rendering them unable to transcend its boundaries. He posits that an

individual's culture and traditions have a significant impact on how they interpret an experience and as such, it is impossible to separate one's preconceptions completely, and therefore, attempting to do so through the exercise of bracketing is pointless.

Gill (2014) argues that phenomenological methods inspire studies that embrace a social constructivists stance, which views organisational identity as fluid and shaped by the common understandings of its members. According to Bloomberg and Volpe (2012), the social constructivists see research as a value-bound process in which the research's values are fundamental. The different meanings derived from the participants' socially constructed views give rise to multiple meanings that the researcher employs to gain knowledge of the phenomenon without separating themselves as their own background shapes their interpretation; as a result, they inductively develop meaning from the collected data. Consequently, this research employed the social constructivism framework to inductively develop understanding regarding digitalisation meaning and implications based on the participants' experiences when implementing it within their different organisations (Creswell & Poth, 2018; Merriam & Tisdell, 2016). The constructivism framework was applied under the premise that, in contrast to other qualitative approaches, knowledge is not discovered but constructed through participants' subjective perspectives within their social context (Merriam & Tisdell, 2016). The study interpreted and built the knowledge regarding digitalisation based on the firsthand experiences of individuals within the chosen manufacturing organisations (Saunders & Lewis, 2018). The goal was to avoid making predictions about the outcomes of these experiences and instead concentrate on the variances and the factors behind those variances (Creswell & Poth, 2018; Tomaszewski et al., 2020). This perspective acknowledged the existence of multiple interpretations in support of the ontological assumption and acknowledged the diverse viewpoints of different actors within the manufacturing sector. Social constructivism also took into account the unique contextual backgrounds and characteristics of each organisation's approach to digitalisation. Furthermore, it was acknowledged that the identified resultant findings would be inherently relative and subjective (Creswell & Poth, 2018; Given, 2023).

4.2 Research design

This research study had a human-centric orientation, as its objective was to carefully examine the experiences, perspectives, and behaviours of the chosen participants. The study aimed to analyse the decision-making influencers of individuals who determine digital choices for their organisations, specifically in the manufacturing sector. By examining their experiences, this research sought to shed light on the underlying factors and strategies behind the digitalisation efforts in manufacturing firms (Given, 2023).

A qualitative inquiry is an investigative approach that facilitates an in-depth understanding of a phenomenon, as perceived from the participants' perspectives (Bloomberg & Volpe, 2012; Lunenburg & Irby, 2008; Merriam & Tisdell, 2016). This method allows for the definition, exploration, and finding of multiple facets related to the subject under study. Creswell and Poth (2018, p42-43), further posit that a qualitative inquiry is characterised by the integration of assumptions and theoretical frameworks in research enquiries aimed at exploring the subjective interpretations individuals assign to social or human issues. This approach involves the inclusion of participant perspectives, the researcher's reflective analysis, and the interpretation of the problem, ultimately contributing to existing theory or advocating for a paradigm shift. To Marshall and Rossman (2016) and Saunders and Lewis (2018), a qualitative inquiry is distinguished by its exploratory or descriptive nature. Both sources highlight the significance of considering the context and perspective of the participants. Given the objective of this study, which aimed to gain an in-depth understanding of the perspectives and lived experiences of individuals involved with the decision-making related to digitalisation from a social constructivist perspective, the most appropriate research strategy to employ, according to these definitions, was determined to be a qualitative inquiry.

The study exhibited several key features of a qualitative inquiry as revealed by Creswell and Poth (2018) and Merriam and Tisdell (2016). Firstly, it employed data-gathering methods that involved direct interaction between the researcher and participants, thereby drawing the researcher into the participant's natural setting. Secondly, the study prioritised the exploration of meaning and understanding, rather than simply examining the frequency of events or phenomena. Thirdly, the researcher assumed the role of the principal instrument in the research process by

being personally involved, and finally, the study provided an all-encompassing and nuanced representation of the viewpoints of the participants, presenting a holistic yet intricate picture.

Flick (2018)points out that deduction in qualitative research is analysing data using an established theoretical framework to interpret it rather than test it against the theory. He suggests that this should aid researchers in explaining the data by highlighting features and nuances that could otherwise be overlooked. He recommends that researchers should move between deduction and other forms of reasoning, to effectively employ deduction in qualitative research, as this can guide and aid them in analysing the data, enabling them to obtain a better understanding of what they are studying. Flick (2022) further argues that qualitative research that is interpretive or constructivist based, views the experiences of the participants as interpreted data, as opposed to flawless unadulterated data as in pure induction, therefore, induction is an interpretive process that is subject to the researcher's biases, assumptions, and historical context. As such, this study employed an inductive approach to interpret the gathered information. This involved identifying and interpreting patterns, categories and themes to formulate a holistic view of the data to be analysed. The study thereafter employed a deductive approach to enable a guided analysis and explanation of the data based on existing literature.

For the deductive approach, the study expanded on the reviewed literature that investigated existing literature and theories that offered a general explanation of the current antecedents and areas of interest pertaining to the digitalisation phenomenon. The study analysed the factors that have been identified in prior research as being pertinent to the digitalisation phenomenon in the manufacturing industry, the strategic methods involved with its execution as the discussions regarding capabilities required to successfully adopt the technologies. The literature review established the TOE as the core theory in this context. Consequently, exploratory data collected from participants within the interpretive framework of social constructivism facilitated the construction of a knowledge base specific to the South African context and this knowledge base, derived from the research findings served to validate, enhance and introduce new knowledge and approach to the TOE framework.

4.2.1 Research methodology

In line with the selected qualitative research design and guided by the researcher's philosophical paradigm, a phenomenological research methodology was used as the research blueprint. According to Moustakas (1994), phenomenology is a field of study that centres on understanding and interpreting the meaning of the subject under investigation, taking into account the researcher's deep curiosity in the subject as the researcher is intimately connected to the phenomenon. Lunenburg and Irby (2008) assert that phenomenological research is centred around understanding particular phenomena from the participants' perspective, employing inductive and qualitative instruments such as interviews. This approach exhibits affinity to descriptive research, as it primarily focuses on providing comprehensive and detailed descriptions of a phenomenon rather than delving into its underlying causes or explanations. Its main objective is to offer in-depth and nuanced portrayals of the phenomenon under investigation. Van Manen (1990, as cited in Bloomberg & Volpe, 2012) goes on to say that the goal of a phenomenological investigation is to determine what the participants have in common when they experience the phenomenon and to define the universal essence based on these experiences.

Gill (2014) validates this view by stating that a descriptive phenomenological methodology aims to illuminate the basic elements of personal experiences, thereby providing a comprehensive description of their essence. Converse (2012) proposed that this study would adopt a phenomenological emphasis that focuses on the description of the digitalisation phenomena with an intent to develop descriptive categories that capture the factors and strategic insights derived from the data. According to Bloomberg & Volpe (2012), phenomenological research is characterised not only by its descriptive nature but also by its interpretive aspect, as it enables researchers to interpret the meaning of participants' perspectives, a view that is supported by Creswell and Poth (2018). These descriptive and interpretive aspects of phenomenology support the social constructivism approach that was adopted in this study.

Sanders (1982) presented a compelling argument in favour of employing phenomenological qualitative analysis in the fields of social sciences and organisational research. The argument posits that it is applicable in the context of organisational research, specifically with respect to understanding the factors that

contribute to organisational success and the characterisation of organisational behaviours and norms, a view that Tomkins & Eatough (2013) revisited and confirmed. Creswell and Poth (2018) suggested that phenomenology is particularly appropriate when a researcher aims to understand the common experience of a phenomenon among several individuals, with the goal of enhancing practices or gaining a broader knowledge of the underlying features of the phenomenon in question. The methodology was therefore applied in the study to promote an understanding of the inherent factors of digitalisation based on the perspectives and experiences of the selected participants (Tomaszewski et al., 2020). This enabled an examination of the multiple facets of digitalisation to identify its fundamental factors, without which, its implementation would be a challenge in the South African manufacturing sector.

4.3 Research universe

4.3.1 Population

The target population for this research consisted of manufacturing firms operating inside South Africa. The research objectives and research questions presupposed a certain degree of digitisation as a prerequisite for this study in the firms that were chosen for this qualitative investigation. Consequently, the target population for this study consisted of South African manufacturing organisations that have adopted or are currently in the process of adopting digital technology within their organisations. Given the large number of South African manufacturers and the exploratory nature of the investigation, it was neither plausible nor necessary to gather data from the entire target population. A non-probability sampling technique was therefore applied for selecting a sample from the target population, this eliminated the need for a thorough population list as a prerequisite.

4.3.2 Unit of analysis

The primary unit of analysis for this study was the manufacturing organisational level. Guided by the phenomenological strategy disposition of this study, the primary participants for this study were individuals who could provide credible information on the digitalisation efforts and who held key positions in the various manufacturing organisations. What was important was that they held senior organisational positions in respect of implementing digital solutions, digitalisation and making related decisions. As such, the interviews primarily concentrated on senior and executive

management personnel employed in the organisation to obtain valuable, useful, and reliable information (Sanders, 1982). This approach aligned with prior research on digitalisation, wherein the organisation was chosen as the primary unit of analysis and the individuals within these organisations were recruited as participants (Björkdahl, 2020; Govindan & Arampatzis, 2023; Zangiacomi et al., 2019). As such, since the participants represented the organisation, the terms participant, organisation and organisation participant were used interchangeably in the study to all refer to the unit of analysis, which is the organisation.

4.3.3 Sampling method and size

Sampling in qualitative research is predominantly purposive; the samples are typically smaller and non-random to emphasise an in-depth description of the perspectives and contexts of the participants. It is more important to devote adequate time working with a limited number of participants rather than superficially involving large numbers (Lunenburg & Irby, 2008). Bloomberg and Volpe (2012) suggest that criterion-based sampling should be used for phenomenological research where the selected individuals have experienced the same phenomenon. As such, purposive sampling was used in the selection of the study's participants, satisfying the specific requirement of participants having experienced and implemented digitalisation in manufacturing directly. The methodology employed maximum variation sampling to determine which organisations will be included in the research, while purposive criterion sampling was utilised to select participants from within those organisations. (Given, 2023; Lunenburg & Irby, 2008).

According to Saunders and Lewis (2018), the recommended sample size ranges from 15 to 60, as observed in high-ranking journal papers. However, they acknowledge that the generally acceptable sample size can be as low as 12, depending on the sampling method employed and the specific research questions asked. On the contrary, Sanders (1982) argued that when employing a phenomenological approach inside an organisational setting, it is recommended that researchers engage in in-depth interviews with a small number of participants, often ranging from three to six participants as this strategy is believed to provide sufficient and reliable insights. Sanders posits that an increase in the number of participants does not necessarily result in a corresponding increase in the quality of information, emphasising the importance of not confusing quantity with quality. She further posits

that too many participants can be overwhelming, and that the researcher is required to acquire the skills necessary for conducting comprehensive and thorough investigations with a restricted sample size of participants.

Given that the emphasis was placed on manufacturing companies, there was a degree of homogeneity within the target demographic, hence the employment of the maximum variation sampling approach at an organisational level. This provided a heterogeneous sample, encompassing the various industries within the manufacturing sector, as defined by Statistics South Africa (StatsSa, 2023b). To ensure an equitable representation of the manufacturing sector industries, a minimum sample size of 10 companies and participants were initially selected for this research. The aim of this approach was to attain maximum variation in the data collected. However, consideration was given to the size of each industry within the manufacturing sector and bigger industries were allocated more participants, resulting in 16 firms being included and one very small industry, the Communication, medical and optical equipment industry was excluded due to restricted access to participants.

Table 2 below presents the sample organisations that were included in the study. The selection of the organisations was contingent upon the level of convenience in establishing contact with individuals within each organisation through existing professional networks.

Table 2: Sampled organisations

Company Pseudonym	**Manufacturing Industry**	**Contact**
C1	Food & Beverages	Finance Manager
C2	Glass and other non-metallic mineral products	Operations Manager
C3	Transport equipment	Engineering Director
C4	Coke, petroleum products, chemical products, rubber and plastic products	Group Finance Manager
C5	Coke, petroleum products, chemical products, rubber and plastic products	Managing Director
C6	Wood products, paper products and printed matter	Group Financial Manager

C7	Textiles, clothing and leather products and footwear	General Manager
C8	Transport equipment	Plant Manager
C9	Food & Beverages	Supply Chain Director
C10	Coke, petroleum products, chemical products, rubber and plastic products	External Consultant
C11	Electrical machinery and apparatus	Customer
C12	Wood products, paper products and printed matter	Managing Director
C13	Electrical machinery and apparatus	Board Member
C14	Transport equipment	Supply Chain Manager
C15	Metals, metal products, machinery and equipment	Customer
C16	Metals, metal products, machinery and equipment	Managing Director

4.4 Measurement instrument

Open-ended, semi-structured phenomenological one-on-one interviews were the primary source of data collection, and these were used as the tool to allow for in-depth interrogation of the digitalisation phenomenon. The interviews were conducted with the purposively selected participants who held the positions that are responsible for making decisions pertaining to the implementation of digitalisation.

Schneider & Fuller (2018) pointed out that, in qualitative phenomenological research, interviewees examine the meaning and interpretation of a phenomenon within their experience. As such, the questions within these interviews were designed to facilitate a comprehensive understanding of the lived experiences by the participants and draw out factors that affect digitalisation decisions within the manufacturing organisations that have been selected for this study. Schneider and Fuller further proposed that, by promoting introspection, the interviews elicit in-depth responses, which facilitated a more comprehensive collection and interpretation of data as the thoughts and responses were extensive and specific to the individuals.

Furthermore, the questions aimed to provide valuable insights into the approaches employed in the digitalisation strategic requirements and planning. Each question throughout the interview served a specific objective aimed at collecting the necessary data to successfully address the research questions of the study. Sanders (1982)

recommended fewer question and in-depth probing on each question to enhance the quality of the collected data. Appendix 5 contains a schedule of the interview questions for this study.

4.5 Data gathering

Considering the research's adoption of the Interpretivism philosophy, the utilisation of semi-structured interviews was deemed appropriate for the purpose of extracting meaning and comprehending the phenomena as perceived by the individuals being interviewed (Creswell & Poth, 2018; Saunders & Lewis, 2018). During the data collection process, study participants were contacted via email and WhatsApp instant massaging with the purpose of requesting their involvement in the study.

The research topic was explained through a brief introductory request email, and thereafter supplemented with a detailed email after the participant agreed to take part in the study. The scheduling of meetings for the interviews was determined by the availability of the individuals being interviewed. The participants were provided with a Teams meeting request and it was explained that the interview will be virtual for convenience. The duration of the interviews were generally less than 60 minutes, except for one interview that lasted for 110 minutes as the participant was generous in sharing information.

The meetings were recorded using Microsoft Teams, and the interviews were instantly transcribed using the built-in Microsoft Teams transcriber. Using the instant transcriber in Microsoft Team had the benefit of not requiring the researcher to take notes, which allowed them to conduct thorough and systematic probing without interruption. Researchers sometimes must fill in gaps in understanding when taking notes; however, in this instance, the researcher was able to record and transcribe participants' exact words and phrases, which were then used for analysis.

The verification process involved a first read through of the transcribed interviews while listen to the recordings to correct any incorrect phrases and update grammatic errors. This was followed by a read through of the now corrected transcripts while taking note of key ideas that were standing out and words that stood out. Next, the transcripts were coded to anonymise participant names and organisational identities before being loaded onto Atlas.ti for further analysis.

4.6 Analysis approach

An effort to commence the formal data analysis concurrently with the data collection process by analysing the data following each interview to promptly determine the point of saturation and subsequently adjust the sample size accordingly was unsuccessful due to the consecutive nature of the interviews. Consequently, the official commencement of data analysis was delayed until the total of sixteen interviews had been concluded.

The data for analysis were derived from the transcribed narratives. The process of reviewing and analysing the data was completed by following the phenomenological analysis methodology of exploring the data to identify significant statements, generating initial codes from the data, generating themes and patterns from the coded data, and finally formulating findings based on the observed patterns (Bloomberg & Volpe, 2012; Creswell & Poth, 2018), as shown in Figure 5 below. The goal was to reduce the data from the intimidating, overwhelming volume provided by the interviews to patterns of data that provide a description and structure for the digitalisation phenomenon.

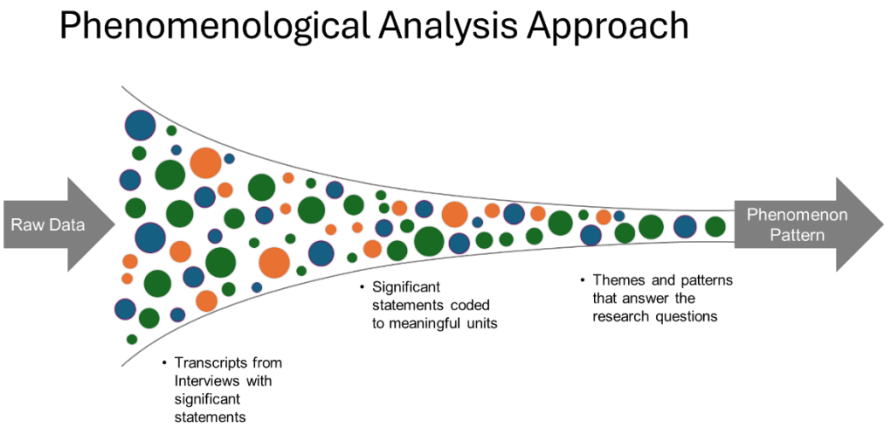

Figure 5: Phenomenological analysis approach

The transcribed interviews from the recording programme (Microsoft Teams) were evaluated and validated by listening to the recording while reading them, then fixed for grammar while retaining the participants' verbatim terms. The transcripts were then reread, and the significant statements relating to the research questions were captured as initial codes. The codes were deduced using a combination of the template analytic approach, with the research questions providing the foundation; in vivo coding directly from the data using the first read-through, and the editing

approach, based on the participants' significant statements and allocating meaning based on the researcher's interpretation of the statements (Bloomberg & Volpe, 2012).

The interviews were transcribed and coded before the completion of the remainder of the literature review. This measure mitigated the researcher's preconceptions and guaranteed that the information obtained from the literature did not introduce additional bias. Undertaking the literature review before data collection and analysis in this phenomenological study would have contributed to additional preconceived prejudices (Bloomberg & Volpe, 2012). As such, the balance of the literature review was concluded after the initial coding of the data.

The detail of the analysis after the initial coding in contained in appendix 6. The analysis of the data employed a combination of codifying, interpretation, categorising and thematic techniques to identify patterns that served to substantiate the findings relevant to the research questions (Tomaszewski et al., 2020). Themes were selected for each research question and subsequently formulated into findings. Given that the collection and analysis of phenomenological data is influenced by and contributes to existing theoretical frameworks (Schneider & Fuller, 2018), theory triangulation was used to validate the data by incorporating the TOE into the data analysis process. This involved a comparison between the participants' perceptions, as interpreted through the lens of social constructivism, and the theory documented in the TOE.

4.7 Quality controls

Dependability, trustworthiness, and credibility were assured by ensuring that there was cohesion throughout the research design, with appropriate techniques and tools applied that were congruent to the research strategy to ensure relevance to the research questions and type of study undertaken (Baxter & Jack, 2008). This congruence was emphasised and demonstrated through presentation of the study layout and alignment in the relevant sections of the study. The process followed during the data analysis method also ensured dependability by capturing the initial summary of each interview and then later comparing it for congruence with the summary of the analysed data. Data triangulation with existing theory provided the trustworthiness and credibility lens (Bloomberg & Volpe, 2012).

Given the researchers' inherent epistemological biases and the phenomenological approach employed in this study, it was acknowledged that an objective analysis is unattainable. The researchers' cultural background and personal traditions were likely to shape the researcher's understanding of participants' experiences and subsequently impact the interpretation of the collected data (Heidegger,1996, as cited by Gill, 2014). The researcher selected this topic because of the cognitive impact of unexamined preconceptions regarding the definitions, classifications, and attitudes around digitalisation and its implications in the manufacturing sector. Therefore, it was imperative to momentarily disregard any personal biases, preconceived notions, or assumptions in order to obtain a clear and unbiased understanding of the fundamental nature of digitalisation in the South African Manufacturing context.

The utilisation of bracketing was employed as a method to enhance the dependability of the study outcomes by momentarily suspending the researchers' pre-existing assumptions concerning digitalisation in the manufacturing sector. This was achieved by the researcher answering the research questions and bracketing the responses until post the analysis of the collected data. This procedure helped maintain the researcher's assumptions as a constant factor and excluded them from consideration throughout the study (Giorgi, 2008; Sanders, 1982). The bracketed items were not permanently suspended, however, and they did not result in exclusion of participant statements that shared the same sentiment, instead – these shared sentiments were revisited to ensure that no bias had entered into the researcher's interpretation.

4.8 Limitations

As this is a qualitative study, the results and findings could be generalised, but due to the efforts in making the sample heterogeneous, a logical but limited generalisation was applied to the manufacturing sector sample as defined in this study. A larger sample will be required to make it more generalisable. It was also not fitting to make generalisations that extend beyond the South African manufacturing sector, but the findings can provide a basis for subsequent research that extend the knowledge base.

The other limitation was that, although the study, being a phenomenological study, was looking at the one phenomenon, digitalisation, it pulled in other possible

constructs and moderators like the factors, the strategic models, and technological capabilities. Its nature of being qualitative meant we could not test the strength of the relationship or quantify the correlation; however, this is an opportunity for future research.

4.9 Ethical considerations

Throughout the design, data collection, analysis, and reporting phases of this research, ethical considerations were upheld. The purpose was to secure the rights of research participants, guarantee confidentiality, and safeguard the research process.

Participants were properly informed about the purpose of the study, their role, the risks and benefits, and were reminded that their participation is entirely voluntary. Participants were given a consent form to sign, which was signed and sent to the researcher for record keeping.

To protect the confidentiality and privacy of participants, their identities were kept private and any identifying information was removed or anonymised from the research findings to prevent the disclosure of sensitive information. Due to the analysis method that was applied, only aggregated information generally included in the report. The research data has been securely stored and maintained to prevent any unauthorised access or breaches of confidentiality. The data will be retained for a minimum duration of 10 years in the researcher's personal cloud-based storage provided by the institution. Additionally, it will be backed up in a secure secondary cloud storage account. Once the maximum storage period is reached, the data will be either securely destroyed or archived.

4.10 Time horizon

Data was gathered from the multiple participants concurrently. The researcher employed a cross-sectional time horizon in this study (Saunders & Lewis, 2018) due to time limitations for the completion of the master’s program. The process of data collection commenced promptly following the acquisition of ethical clearance and continued until conclusion at the in the second week of December 2023. This timeframe was allocated to facilitate the validation, analysis, and consolidation of the obtained results, ensuring their accuracy and reliability with the final submission of the research findings scheduled for the 5th of March 2024.

4.11 Methodology summary

This chapter provided a description of the research strategy employed for this study, as well as the underlying philosophical assumptions. The qualitative technique utilised in the approach to the research methodology demonstrated congruence between the identified literature gaps, the research questions, and the research findings derived from the collected data. Data was gathered using open-ended, semi-structured interview questions, with careful planning to ensure that research delivery dates were met. The overall result of this methodical approach were the findings, which are detailed in the next chapter.

5 Research findings

5.1 Introduction

This chapter presents the findings from the data gathered from the 16 in-depth interviews with participants representing 90% of the divisions of the manufacturing sector in the South African context, as categorised by StatsSa (StatsSa, 2023a). The data is presented in a systematic and structured manner using an inductive process of delving deeper into the data and unearthing insights from the participants.

Five findings emerged from the research and as per the selected methodology, the findings were structured as textual and structural descriptors (Bloomberg & Volpe, 2012; Moustakas, 1994). Finding 1 is a textual descriptor for digitalisation in a South African context while Finding 2 to 5 are structural descriptors that address the research questions.

The layout of how the findings link back to the research questions is presented in **Error! Reference source not found.** below.

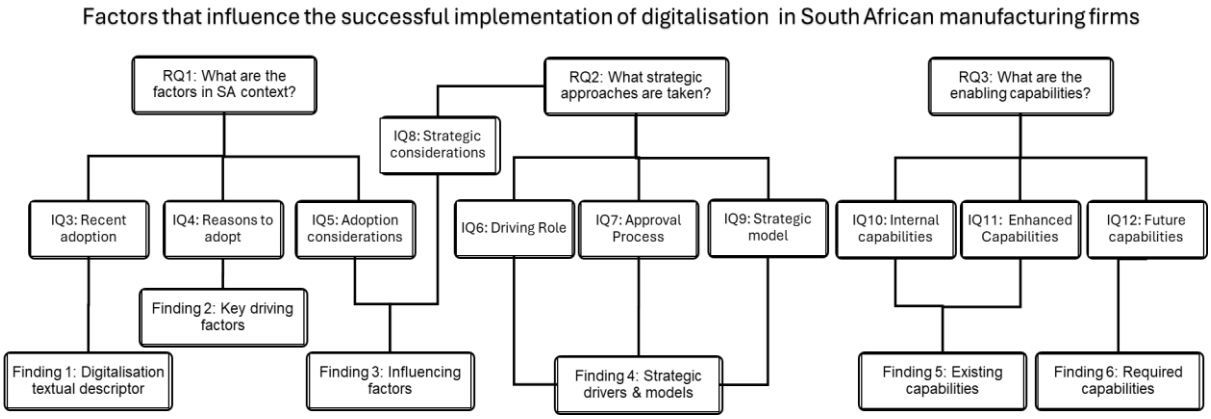

Figure 6: Findings link to the research questions

The findings are summarised in Table 3 below.

Table 3: Findings with related research questions

Findings and Research Questions
RQ 1: What are the key drivers of digitalisation in South African manufacturing sector?
Finding 1 - *Digitalisation descriptor* Digitalisation involves an effective combination of Information Technology (IT), Operational Technology (OT), and Advanced Technologies that allows for

seamless integration of manufacturing processes and the business planning systems (ERP) supported by efficient data storage solutions, robust connectivity, and collaboration technology infrastructures.
Finding 2 - *Key driving factors of digitalisation in a South African context* The key driving factors that influence digitalisation within the sample of firms are the perceived operational and business benefits underpinned by data analytics capabilities and the need to achieve technical advantage and meet regulatory and customer requirements.
Finding 3 - *Factors that influence digitalisation in a South African context* The sampled firms take into consideration the strategic alignment and financial implications of the technology while being cognisant of the sustainability, complexity, and competitiveness of the technology being adopted.
RQ 2: Do South African manufacturers use strategy frameworks to drive digitalisation in their organisations?
Finding 4 - *Effective strategic drivers and models for digitalisation in South African manufacturing firms* The key drivers of digitalisation in the sampled firms include the active involvement of the executive team as sponsors, the IT department as enablers and advisors, the end-users as initiators, users, and owners, and in some cases, a specialised future technology team serving as researchers and experimenters for emerging technologies. All of these are channelled through a collaborative approval system that allows for governance and interactions.
RQ 3: What are the pre-requisite requirements for a strategic approach to digitalisation?
Finding 5 - *Existing capabilities for digitalisation in South African manufacturing firms* Firms are citing a continuous improvement culture, basic digitalisation capabilities, either internally or through global expertise links, and reliable foundation infrastructure as key existing practices and capabilities to have.
Finding 6 - *Required capabilities for digitalisation in South African manufacturing firms* *South African manufacturing companies need to develop digitalisation change management capabilities, digitalisation technical skills, digitalisation leadership, data literacy, and a digitalisation resourcing model.*

Before exploring the evidence gathered, a summary of the participant sample is first presented.

5.2 Sample summary

Purposive criterion sampling was used to choose the participants, who had to meet the special requirement of directly experiencing and implementing digitalisation in manufacturing. The methodology used maximum variation sampling to determine which organisations would be included in the research, with the goal of representing an organisation from each manufacturing industry categorised by StatsSa (StatsSa, 2023a). Purposive criterion sampling was used to select participants from those organisations. The study comprised 16 organisations. Some of the divisions were covered by more than one organisation and two divisions (radio, television and communication apparatus and professional equipment and furniture and other manufacturing) were dropped from the list because of difficulty in engaging firms in these divisions.

Table 4 below contains the participant demographics and the organisations represented. The participant positions ranged from a Process Engineer, who had oversight and implementation responsibilities in the local organisation, with the head office driving the digitalisation plan, to executives such as Head of IT or Group Managers, who had complete authority and oversight over the digitalisation agenda. The companies involved ranged in size with the smallest one having a total staff complement of 130 employees and the largest enterprise, a multinational with over 18,000 employees in Africa. Interestingly, per Table 5 which tables digitalisation summaries from the sampled organisations, the smallest enterprise, with 130 employees was one of the more advanced in digitalisation applications in that they were also implementing advanced manufacturing technologies as compared to some of the largest firms that were still busy with basic technologies like industrial sensors, visual reporting tools and ERP systems.

The sample was made up of a combination of exclusively local firms and multinationals. Most of the firms have been around for more than a couple of decades, while the two companies that had been operating for ten years or less had context. I9 had recently been merged with other companies, forming the new conglomerate eight years ago. I11 is part of a multinational that has been around for decades. They are the one of the latest additions to the portfolio.

Table 4: Participant organisations and demographics

Participant Ref	Industry	Participant Role	Size (No. of employees)	Firm age (Years)	Multinational or Local
I1	Food & Bev	Information Systems Manager	3300	90	Multinational
I2	Glass & non metallic	Process Engineer	400	65	Multinational
I3	Auto Parts	Group Infrastructure & DT Manager	2000	50	Local
I4	Rubber & Chemical	IT Manager	950	50	Multinational
I5	Rubber & Chemical	Head of IT and OT	2500	80	Multinational
I6	Printing	Group IT Manager	1800	40	Local
I7	Clothing	Head of IT and Business Systems	1200	88	Local
I8	Automotive	General Manager for Production Control	8500	63	Multinational
I9	Food & Bev	Production Improvement Specialist	>18000	8	Multinational
I10	Rubber & Chemical	Head of Group IT	4000	70	Multinational
I11	Electronic	Engineering Manager	130	10	Multinational
I12	Printing	Head of ICT	500	69	Local
I13	Auto Accessories	IT Manager	500	25	Multinational
I14	Auto Parts	Mechatronics Manager	700	61	Local
I15	Metal	Business Improvement Projects	4000	80	Multinational
I16	Metal	Head of IT	460	35	Local

Table 5 provides a summary of the data collected from each interview, highlighting a key significant statement from each interview. This table was generated from the initial review of the recorded transcripts. The intention was to secure a high-level view and storyline from each participant. It also allowed comparisons between the

responses of participants. This permitted a congruence and dependability check later on.

Table 5: Summary of sample firms digitalisation focus

Participant Reference	Industry	Digitalisation Summary
I1	Food & Bev	The company uses PLCs, warehouse management systems, Wi-Fi, and reporting tools and is migrating to SAP ERP. Efficiency, cost management, standardisation, infrastructure enhancement, and faster decision-making drive technology implementation. Corporate participation, production and efficiency needs, technology ageing, and competitiveness affect adoption. Strategic and risk factors include manufacturing, brand reputation, and customer service issues.
I2	Glass & non metallic	To boost productivity and data integrity, the company implemented a new ERP and MES. Productivity and operational excellence drive these implementations. Initiatives are led by IM and Digital Transformation. Data availability, integrity, process control and governance, cost handling, production planning, and traceability have influenced digital technology adoption.
I3	Auto Parts	The organisation has prioritised cloud storage and document digitisation to enable workflow management. They focus on AI in decision support and production systems. They want to employ AI to increase insights. They are also investigating prescriptive manufacturing, which uses AI to optimise production and eliminate rejects. The company is leveraging AI platforms from cloud and AI service providers and their ERP vendor.
I4	Rubber & Chemical	The company implements digital technology to improve traceability, quality, Kaizen, and business intelligence. Implementation is driven by quality because the company must meet OEM customer and global quality standards. The company considers current systems and competencies when choosing technology. An approval committee checks proposed technologies for compliance with company strategy and needs. IT serves as a supporting role in understanding and implementing the appropriate technology.

Participant Reference	Industry	Digitalisation Summary
I5	Rubber & Chemical	The organisation aims to improve operational efficiency through digitalisation. Security, data availability, and redundancy drive their technological adoptions. External issues, including limited technological access and industrial system complexity, have affected technology adoption. IT leader skills and recommendations are considered in decision-making and the goal is to deploy technologies that benefit the business and support the strategic goals.
I6	Printing	The primary motive for the company is to remain competitive and meet the needs of its customers. The key considerations are the return on investment (ROI) and the complexity of the technology. They also consider the product's cost and its fit with the organization's broader strategy. They also analyse the business's strategic concerns and how the technology will fit into their long-term goals.
I7	Clothing	The company implemented technologies alongside WCM or Continuous Improvement. They've prioritised basic technology that boosts productivity and efficiency through visibility and traceability. They use video calling and PLM software to boost efficiency and product development. The participant stressed leadership, vision, and progressive digital transformation for successful implementation.
I8	Automotive	This organisation prioritises identifying faults and taking effective corrective steps as a key driver of digitalisation. Access to data is identified as the primary motivation. they note that effective implementation requires training and change management, as well as considerations for business benefits and costs.
I9	Food & Bev	The company deployed Flow, a system for recording and tracking downtime in the manufacturing process, which enables more accurate recording and analysis of downtime and has made operators more comfortable working with a paperless system. The decision to implement Flow was motivated by the requirement for an online system that could record and report downtime.

Participant Reference	Industry	Digitalisation Summary
I10	Rubber & Chemical	I10 is digitising paper-based operations and applying automation to reduce lead times. Drivers of digital technology implementation include push and pull influences. Technology vendors pushing new technologies, clients pulling for relevant solutions. The company prioritises IT, business, and risk management strategies that align. In general, the company plans to use technology to expand globally and meet client needs.
I11	Electronic	I11 has employed cloud migration, automatic continuity testing, 3D printing, CAD software, custom applications, and a wireless network. Cloud migration was driven by the need for more control and security. The decision to adopt technology involves research, cost analysis, and simulation. Management and related departments must approve implementation. Planning, training, and simulation help implement successfully. Thus far, technological improvements have improved working conditions.
I12	Printing	I12 has introduced communication and collaboration tools, plant management systems, and employee mobility features with focus on workflow management. Improving operational efficiency and becoming data-driven are key motivators to implement digital technology. They plan to focus on cloud computing and advanced analytics to help the organisation become more data-driven. They prioritise adopting technologies that will improve efficiencies and boost business capabilities.
I13	Auto Accessories	I13 has adopted cloud computing, wireless networking, and tablets to increase efficiency and communication. These technologies were implemented to improve speed, data accessibility, and customer feedback. Technology underpins traceability and accurate manufacturing at the plant. Internal capabilities and external training allow them to implement and adapt to new technologies in line with the company's strategy.
I14	Auto Parts	I14 has introduced cobots, AGVs, augmented reality, and virtual reality. To improve their data-driven approach, they employed a data engineer and are already incorporating industrial and plastic 3D printing. Their motivators include a competitive advantage in terms of technological drive as well as consumer demands.

Participant Reference	Industry	Digitalisation Summary
I15	Metal	I15 has focused on implementing a scheduling system and digitising quality complaints. Internal factors that affect digital technology adoption include recognising a problem, resources, finances, and senior management support. External factors include industry and group benchmarking, funding, and availability of resources and capabilities. The firm strategy focuses on sustainability, preventative measures, and safety and green steel initiatives in line with digitalisation.
I16	Metal	I16 has implemented cloud migration and security improvements. Although the company has good infrastructure, its systems need updating. Replacement plans and end-of-life factors drive technology adoption. Supplier advice and company affiliation to group are external influencers. Business strategy influences IT decisions, including security and ease of use.

5.3 Findings

A detailed explanation of the process followed in reducing the raw data to meaningful statements that led to the findings presented in the following subsections is included in Appendix 6. The process followed was an inductive process, as such, the data led to the findings that subsequently answer the research questions. Table 6 below summarises the data reduction and demonstrates the link to the research questions.

Table 6: Findings link to the research questions

Code Categories	Theme/Findings	Research Question
* Information technology * Operational technology * Advanced technologies * Data storage * ERP * Collaboration technology * Connectivity * Communication technology	Digitalisation textual descriptors	**RQ 1:** What are the key drivers of digitalisation in the South African manufacturing sector?

* Operational benefits * Data analytics capability * Business benefits * Achieving technical advantage * External requirements	Reasons to adopt (Perceived benefits)	
* Strategic alignment * Financial implications * Technology sustainability * Competitive pressure * Technology complexity	Digitalisation considerations	
* Executive sponsorship * IT Department * Head office * End user * Future technology team	Strategic drivers	**RQ 2**: Do South African manufacturers use strategy frameworks to drive digitalisation in their organisations?
* Strategic enabler * Strategic focus * Strategic advisor * Business Strategic partner * Approval Structures	Strategic model	
* Existing capabilities * Required capabilities	Enabling capabilities	**RQ 3**: What are the pre-requisite requirements for the strategic approach to digitalisation?

The subsections that follow explore the findings and provide an outline of their significance to the study. Related and relevant evidence, in the form of participant statements, is inserted into the text to highlight specific arguments made. In most situations, these remarks best capture the sentiment of the participants.

5.3.1 Finding 1: Digitalisation textual descriptor

Digitalisation involves an effective combination of Information Technology (IT), Operational Technology (OT), and Advanced Technologies that allows for seamless integration of manufacturing processes and the business planning systems (ERP) supported by efficient data storage solutions, robust connectivity, and collaboration technology infrastructures.

The foundation and departure point of the research was to understand how participants describe digitalisation. The textual descriptors drawn from the significant

statements they used in describing recent digitalisation in their firms, provided a valuable description from their perspective. These statements were reduced to meaningful units that enabled the compilation of a comprehensive description of the digitalisation phenomenon (Moustakas, 1994).

Figure 77 below displays the themes that emerged from the participant's descriptions, and Figure 88 deconstructs the categories within these themes to further describe digitalisation.

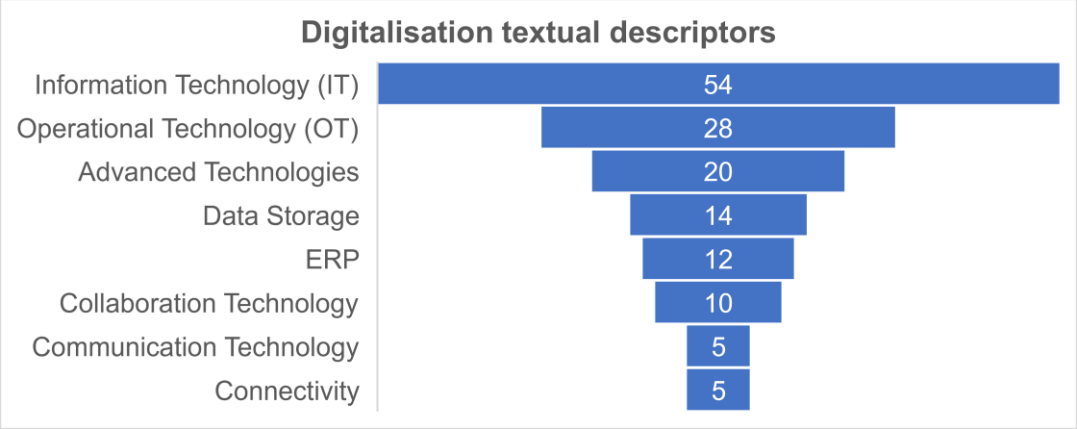

Figure 7: Digitalisation textual descriptors

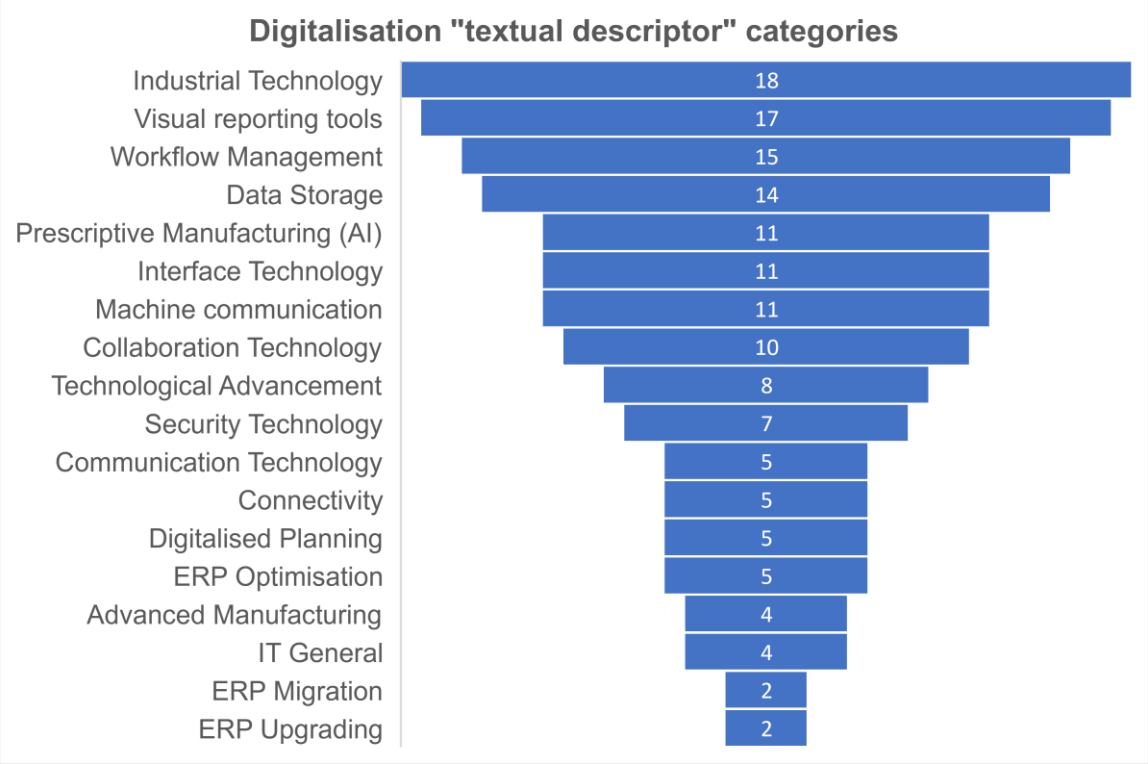

Figure 8: Digitalisation textual descriptor categories

In giving examples of current digitalisation efforts, participants mainly referred to basic technology, tools the researcher later grouped as basic Information Technology(IT). From the participant statements, this entailed visual reporting, workflow management tools, interface technology and some security related technology. Nine out of sixteen participants listed visual reporting tools like Power BI, Qlikview, Qliksense and general dashboarding with trends. Seven out of the sixteen participants identified workflow management tools, in particular, electronic workflow management like e-signatures, document management, workflow approvals with customers and product lifecycle management from concept to realisation. The interface technology referred to in the interviews included easy input screens or applications for users and drop-down screens for human-error-elimination selection of downtime categories. Other technologies that came up in this theme were security technology like user login verification and authentication applications.

The second highest theme that came through was Operational Technology (OT), with mainly two categories as recent digitalisation efforts: industrial technology and machine communication. A few of the technologies that were being adopted by the different organisations were more geared towards ensuring machine information visibility and machines transferring information between each other and with the overall manufacturing execution system and ERP for example. There were some participants that did not mention any operational technology initiatives at all, like I7, being a clothing and textile organisation that is predominantly driven by manual intensive labour, hence more focus on workflow management and visual reporting tools to enable the workforce. I5 and I10 were also of interest, both being from the rubber and chemical industry. I5 focused on eliminating hierarchical damage to infrastructure and building network redundancy. As such, most of their digitalisation efforts are aimed at establishing a strong infrastructure, while I10 was more focused on external partnerships from the perspective of both their suppliers and their clients.

Advanced technologies came up as the third most frequently stated theme where participants referred to areas where they are focusing digitalisation efforts such as the use of 3D printing and artificial intelligence to enable predictive manufacturing. A good example was I14, where they started with focus on 3D printing of plastic moulds but now want to advance to metal 3D printing. I14’s sentiment is captured.

"We started with the plastic injection moulded 3D printing to build the capability like our drawing office, our engineers and so on to understand how the things would, how their products would change and how designing would change based on now being able to 3D print. But we now want to investigate 3D printing with metal and other types of additive manufacturing. I'm thinking like mixed reality. We investigating digital twins at the moment… " - I14 - Automotive Parts

Other firms spoke of advanced technologies but more as an aspiration rather than as current digitalisation initiatives. Data storage in the form of cloud technology and ERP upgrades and optimisation, specifically to enable digitised and automated planning also featured in several participant statements.

5.3.2 Finding 2: Key driving factors

The key driving factors of digitalisation for the organisations in this study are the perceived operational and business benefits underpinned by data analytics capabilities and the need to achieve technical advantage and meet regulatory and customer requirements.

Interview question 4 directly contributed to answering research question 1: "What have been the key drivers for digital technology implementation?" The question drew out from the participants the reasons why they opted to pursue the indicated digitalisation journeys and what benefits they anticipated. Five categories emerged from the participant responses in articulating the anticipated benefits and reasons why they adopted certain technologies. These categories are detailed in Figure 99, in order of most frequently referred quotations.

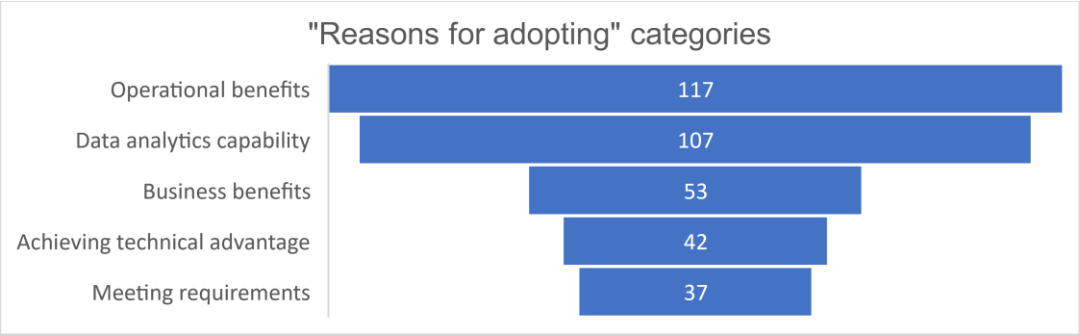

Figure 9: Digitalisation key drivers - Reasons for adopting digitalisation

5.3.2.1 Operational benefits

This finding indicate that a number of surveyed firms have been influenced by factors that deliver on operational benefits such as visibility, productivity, agility, operational efficiency, traceability and cost reduction. In some cases, software systems such as Product Lifecycle Management (PLM) and Enterprise Resource Planning (ERP) have been implemented to enhance traceability and production planning. In others, technology solutions such as cloud systems have been instrumental in enhancing agility and achieving cost savings. Several digitalisation efforts in the operational space were motivated by customer issues that were encountered, and so, to prevent future human errors, a digitalisation solution was implemented.

> *"…but what that software has allowed us to do despite fairly slow and painful beginnings, is to develop, uhh, traceable pipeline of where are you at in your pre production process flow? Are you at the concept stage? Are you still looking at colours? Are you working with, Uh, new a new design and it's also serves as a content management system. So while a designer can, let's say do a design and Adobe illustrator, that file could be living on a shared folder. Or on their desktop if they've forgotten to dump it on the shared folder. Whereas this forces a check-in and a check-out of a design or product. So the work in progress design is actually saved into the PLM" - I7 - Clothing & Textile*

5.3.2.2 Data analytics capability

The participants highlighted the significance of a data analytics capability as the next emergent factor. Some indicated that real-time data is important for making informed decisions. I2, in particular, said the utilisation of data and the benefits of operating as a data-driven organisation and also emphasised the importance of relying on data to make decisions:

> *"… So being a data driven site that is that that utilise a lot of data to make decisions, it makes it easier to actually lay out how you want the data and yeah how you want the data and how you want the data to be utilised. So with that, then it sort of lays blueprint of any digitisation or digitalisation initiative that you want to undertake." - I2 - Glass & non-metallic*

Some of the participants indicated that their organisations use real-time data to monitor the efficiency of their machines. Some responses also highlighted the importance of data analysis capability, with some stating that it aids in identifying trends, inefficiencies, and improvement opportunities. Some, like I8, make use of Business Information (BI) tools like Power BI and AI tools to visualise data and analyse it faster as it gets integrated from different sources:

> *"So I think through the data management and digitisation and Power BI and all of these tools, it's actually enabled us to pin-point where our problems are. It's visualised and it's easy to see the trends, you know and the and also the information is shared through to the masses, you know, so everyone has access to it." - I8 - Automotive*

Some participants claimed that implementing strategies like dropdown displays and reducing reliance on manual input reduced errors and resulted in advantages such as improved visibility of production information and increased data accessibility.

5.3.2.3 Business benefits

Some participants remarked on the need to stay competitive or to gain an advantage in the manufacturing sector by adopting technological advancements. Most organisations cited being involved in transformation initiatives to convert manual processes into digital workflows with the intent to automate and digitise processes that used to rely on paper and manual labour. One participant revealed their concentrated effort on the elimination of repetitive tasks by encouraging employees to submit requests for digitisation of these tasks:

> *"So what they've done is they've actually created the awareness where the end users, you know, doing the repetitive tasks will actually raise their hand and say, OK, this is a repetitive task, can I submit it as a proposal to this IT team to digitise? And through that we started to see a huge amount of improvement come through." - I8 - Automotive*

Some organisations have integrated digital workflows and real-time monitoring systems to enhance productivity and foster accountability at all levels. I7 *stated "This type of tool, even though it was somewhat free-form, enforced more rigidity and structure and certainly accountability" - I7 - Clothing & Textile.*

5.3.2.4 Achieving technical advantage

When it comes to gaining a technical advantage, participants emphasised the importance of seamlessly integrating various systems into a single industrial network and integrating the different data sources, including integration with the ERP. They noted the realised benefits of data availability and accessibility, enabling data analytics. Some participants identified the focus on introducing a Manufacturing Execution System (MES) as a key integration system for their operations. A key focus has been the integration of MES with ERP, being able to feed machine output information directly into the ERP so that it can generate useful input into the planning system. This includes aspects of process performance and linking it to transaction data.

Another important factor that came up from several participants, was the need to replace ageing and outdated technology, with some participants admitting to only digitalising as part of their replacement plans versus having a planned technology adoption roadmap. So, when the time comes for the technology to be replaced, only then do they test the market to see what technology is presently available. This then also provides the opportunity to explore other supporting newer technologies that complement the technology that is being replaced.

One participant was adamant that their organisation wanted to guarantee uninterrupted operations and data availability by implementing redundant network capabilities as a foundation. His position was that redundancy will create reliability and ensure that data is always available. According to I5, when you have redundancy in your network or infrastructure, it creates a buffer for other exploratory technological initiatives. I12 also agreed with this view, noting that without baseline capacity, they would not be able to achieve the targeted operations efficiencies through technology.

5.3.2.5 Meeting Requirements

Nine out of the sixteen organisations acknowledged the importance of understanding and meeting customer requirements and seven affirmed the need to ensure regulatory requirements are met, including ISO certification and data protection and security requirements. Participants also identified the requirements of the original equipment manufacturer (OEM) and the necessity to satisfy customer expectations as the driving forces for the digital transformation in their companies. Some stated

that one of the most important motivating factors was to fully understand the requirements of their customers and to be able to offer a suitable solution to every customer segment. For C7, engaging regularly with the customer was built into their process through product life cycle management.

5.3.3 Finding 3: Influencing factors

The sampled firms take into consideration the strategic alignment and financial implications of the technology while being cognisant of the sustainability, complexity, and competitiveness of the technology being adopted as factors that influence their digitalisation efforts.

Interview question 5 also contributed to answering research question 1: “What internal and external factors have influenced your level of technology adoption as an organisation?” Interview question 5 further expanded on the factors that influence the digitalisation decisions of South African manufacturing firms by attempting to ascertain any other factors, internal or external, that tend to influence these digitalisation decisions. The five themes that came from the participant responses, which gave a view of the factors that are taken into consideration when assessing digitalisation options, are presented in Figure 10 below.

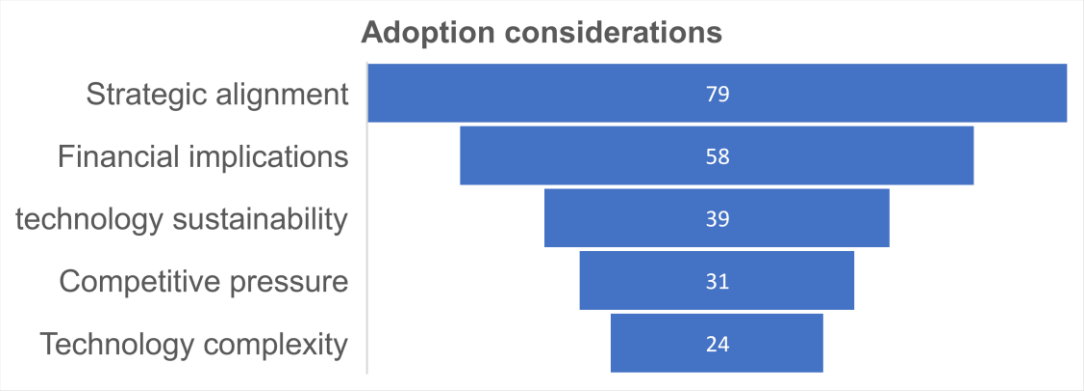

Figure 10: Digitalisation key drivers - Adoption considerations

5.3.3.1 Strategic alignment

When considering digitalisation options, organisations underlined the necessity of aligning technical decisions with organisational objectives and considering business-related results such as the organisation's financial standing and internal business unit alignment. All but three participants stressed the need to establish adoption objectives based on business requirements and impact. They stated that the primary

factors to be taken into consideration include the necessity for digitalisation initiatives to be in line with the organisation's vision, capabilities, and strategic objectives, as well as the importance of digitalisation initiatives aligning with priorities such as customer-centricity, operational excellence, and productivity, according to business strategy. Other factors include the impact on operations, customer relationships, labour, and brand reputation.

The necessity of determining whether the adoption of a particular technology is essential or whether alternative solutions exist was also revealed by participants as an important factor in ensuring strategic alignment. They emphasised the significance of evaluating the current environment prior to implementing new technology and the necessity of compelling reasons to digitise or automate processes. Several participants indicated that when determining whether to implement a particular technology, they consider cost, labour, and functionality, among other factors. They stressed the importance of conducting planning, research, and an assessment of the advantages and disadvantages of various technologies as part of the technology screening process. Other participants referred to a digitalisation roadmap for the implementation of technology that is aligned with the overarching business strategy.

A statement by I5 covered most of the sentiments shared by participants:

> *"Digitisation. So obviously we have EXCO's and then when we deciding on the strategy of the organisation. So for example, I will take a look at what the business strategy is, say it is the, the business strategy is to grow, OP, right, operational profit. What can we do and how can we digitise to? According to… in the road map, in the IT roadmap that meets the business strategy, because you know digitalisation is a buzzword, it's an innovative word. It is a buzzword, but not all the time. Is it? Should, should you be digitising? right, there's 10 steps in a process, for example, right? Digitisation, people tried and they overkill. They tried to, to digitise the entire process, but that's not the way you should be doing things right. Because and I'll give you an example of why I say that, but you should pick things that give you the most value, the most benefit in that ten-step process that you now make it a four-step process…" - I5 - Rubber & Chemical*

5.3.3.2 Financial Implications

The participants emphasised the significance of return on investment (ROI) and argued that business benefits and value should motivate digitalisation, as opposed to it being merely a trendy term. They argued that the implementation of a digitalisation strategy should yield a return on investment and emphasised the importance of a positive impact on the bottom line. An instance is provided in which a participant stated that they would not advise investing in a product with a price tag of R5 million that yields a value of only R1 million. When investors are faced with the decision of whether to invest in a manufacturing facility that yields a 3% return or a bank that offers a 7% return, profit and the bottom line will invariably take precedence. Therefore, when evaluating digitalisation alternatives, it is critical to account for the return on investment.

Additionally, some participants noted that the initial investment in technology and associated costs is a significant factor, as businesses require a return on their investment and may not invest in a product that is too costly or unsuitable for their budget. The bigger organisations and multinationals seemed to have less concerns with funding when compared to the smaller and local companies.

One participant stated that in the South African context, the labour consideration is quite unique in that there is the advantage of cheap labour that must be considered when evaluating the cost implications of digitalisation. I6 stated that if the same task that could be completed by costly technology can still be accomplished by our labour force, with the added benefit of saving jobs, especially in a country with high unemployment rates, then one would opt to forego the technology and keep the labour intensity of the task.

> *“So sometimes it doesn't always make sense to go the whole automated robotic digitalisation route. If you have a labour force which is really available and fairly cheap, so yeah, it's also in too much because it does provide job. So if you can make a profit and a good profit out of not spending a hell of a lot of money on capital, why not do it?” - 6:58 ¶ 70 in I6 - Wood & Printing*

5.3.3.3 Technology sustainability

Participants noted a few factors related to technological sustainability. Some were concerned that they may not have the necessary capabilities in the organisation to use technology to avoid insufficient use or poor adoption, resulting in technology abortion. It was asserted that in many cases, digital transformation projects are driven by the IT function, resulting in low adoption. Participants also noted a disparity in employees' technological proficiency, stating that older workers may find new technologies intimidating. As a result, some organisations were implementing employee awareness initiatives such as digitisation weeks and gamification to make technology more enjoyable, increase awareness and adoption, and improve employees' tech savvy.

The other consideration that came from the participants was the adequacy of internal and external support to maintain the technology. Participants noted a lack of local companies supplying and servicing these technologies, resulting in a small market with little government support. A few participants stated that their suppliers, with whom they had partnerships, had an influence on what digitalisation they should pursue. Where long-term relationships with strategic partners have been established, organisations receive regular updates on the latest technological trends and upgrades as part of the support. The lack of specialised internal resources, specifically skilled IT personnel was also noted as a barrier and a factor to take into consideration. One participant said that the global companies he works with have specialists who specialise in specific areas of digital transformation rather than generalists, as is common in South Africa.

Compliance with regulatory requirements also emerged as an important consideration. Participants emphasised the importance of technology providers offering data storage and verification capabilities while maintaining high compliance standards as regulatory requirements, such as data hosting in the country of origin, must be met. Some participants believed that South African manufacturers are underinvesting in technology due to other pressing issues such as water supply and electricity shortages. The macroeconomic situation and infrastructure issues are seen to be overshadowing the potential for technological advancement as noted in I10’s statement below.

“I think we are finding ourselves with unfortunately dealing with so much other issues that is taking the opportunity away from us as specifically in South Africa to really get deep and technology. If you think about where investment is currently happening, we are investing in water supply. We are investing in electricity. We not investing, well, we were investing in uh, operational efficiencies in which technology can play a part, but I think there's so much noise in our macro economy currently where we are with our export markets where we all with our infrastructure that it's taking away the opportunity for us to think freely.” - I10 - Chemical Industry

5.3.3.4 Competitive pressure

Only six of the organisations in the sample of sixteen were exclusively local, the rest were multinationals that are globally affiliated. Participants from organisations that are part of a globally affiliated network emphasised the importance of aligning with global standards and strategies. They highlighted that adhering to these standards is crucial for their organisations to ensure the production of high-quality products. As a result, they need to align their processes and systems with global standards and regulations. Some participants asserted that standardisation was a major driver because it ensured consistency in tools, suppliers, and technologies around the world. It also encourages the development of cross-functional skills and the flexibility to transition individuals between different environments. Overall, participants stated that when digitalisation is pushed globally, the company becomes actively involved in its digital transformation.

Participants like I12 stated that other external factors that they consider when evaluating technology adoption options include activities such as benchmarking, research, and keeping up with industry developments. I15 shared a similar sentiment as well in that adapting to market changes and focusing on interactions within the industry and globally within the company group allowed them to choose more current and competitive technology options.

Some participants admitted that their organisations conduct ongoing research on available technologies, relying on objective sources such as Gartner. Some have regular meetings where they discuss where technology is going in the next five years and how it will affect their business and customers. I6 confirmed that they talk about future trends, such as artificial intelligence, and their global impact.

“So we have a we have a business strategy and we have IT Steerco meetings every two months where we discussed the ideas, we discussed the future, we discussed what's happening in the world, you know AI, the big one. Everyone's talking about the changes that are happening globally. How does it affect us? And yes, we do.” - I6 - Wood & Printing

5.3.3.5 Technology complexity

The last theme that emerged as an essential consideration from the participant’s perspective was the complexity of the technology or digitalisation efforts and whether the firms have the time, processes, and skills to manage it. Participants stated that the process of digitalisation in manufacturing is time-consuming and complex, particularly for an 80-year-old company with outdated machines. Upgrading equipment to the latest technology requires digitising and replacing machines one at a time, which cannot be done overnight. One participant stated that this is due to the firm's limited time and resources, as well as the plant's short shutdown, which usually occurs in December. The complexity of the technology may necessitate more thorough research and an investigative approach to integrate the new technology within the organisation, which takes longer due to the need for extensive research and proof of concept.

One participant emphasised the importance of matching technology with people and processes, stating that having the right technology alone is insufficient for success if the right people and processes are not in place. This was a shared sentiment because six of the participants believed that process flows, as well as process governance or compliance, were critical to technology implementation success. One participant compared Japan's disciplined culture to South Africa's culture, noting that the latter requires more extensive interlocks to ensure that tasks are completed correctly and in the correct sequence, thereby reinforcing discipline and process adherence. Having defined processes that force discipline, reduced the complexity of the technology.

I16 provided an example in which complexity was brought about due to a lack of alignment between business processes and systems, resulting in gaps and reliance on spreadsheets rather than the implemented system - *“…So in the C16, umm, why we've got so many gaps is because business processes and the system separated and that's because business will change their process. But then they don't go to IT*

or they don't go to their system and align it to their new process. And then it just gets further and further away and that is why everyone ends up on spreadsheets." - I16 - Metal & Metal Products

The other complexity element noted from the statements from participants was the ease of use of the technology, which came as an effect of complex technology as evidenced when I1 stated that many businesses only use a portion of the technology's capabilities and fail to fully utilise it.

5.3.4 Finding 4: Strategic drivers and models

The key drivers of digitalisation in the sampled firms include the active involvement of the executive team as sponsors, the IT department as enablers and advisors, the end-users as initiators, users, and owners, and a specialised future technology team serving as researchers and experimenters for emerging technologies. All of these channelled through a collaborative approval system that allows for governance and interactions.

A combination of interview questions six to nine contributed to answering research question 2: Do South African manufacturers use strategy frameworks to drive digitalisation in their organisations? The themes that emerged from the participant responses articulated the strategic drivers and the strategic models used by South African manufacturers.

5.3.4.1 Strategic drivers

The first theme related to research question 2 was categorised as detailed in Figure 11, in order of most frequently referred to in quotations.

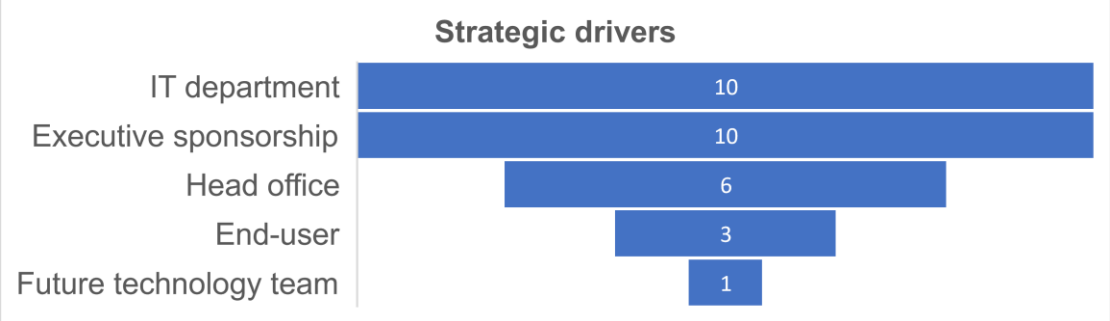

Figure 11: Strategic framework - Strategic drivers

Most participants reported that the IT department or equivalent team led the digitalisation efforts. In particular, when it came to IT for IT technologies, the IT department's experience was critical in making intelligent choices. I16 captured this sentiment well in their statement:

> *"The capability of ICT and of course we do collaborate with the business owner in identification of that technology. There are some technologies that, you know. Are the sole prerogative of ICT to determine, things like the network technology that, and server architect and all of that I mean that is in the domain of ICT expertise and that kind of a technology will therefore be driven, the technology decision will be driven from ICT." - I12 - Wood & Printing*

Several participants stated that having IT drive technology implementation resulted in difficulties obtaining buy-in from the business.

According to participants, the decision-making process for digitalisation projects is typically led by executives or board members who shape the organisation's vision and direction. These individuals also provide sponsorship and approval for digitalisation initiatives as they have sight of the budget. Some declared having a global initiative where the digitalisation solutions are typically determined at the head office level and then implemented across other plants. The participants noted that local sites may not be involved in making these decisions, but instead they follow the direction set by the business at the corporate office. In most cases, participants confirmed that end-users have the freedom to initiate and put in requests as needed. I14 noted a dedicated future technology team that can see future technologies and recommend these to the organisation.

> *"It does come from specific areas, you know, but supported from the from the parent company as well as from our executive. But the initial key drivers are going to be like the mechatronics team and the future technology team, the engineering teams, you know as they see these new technologies, they basically have to see it, justify it, show what the benefit is going to be" - I14 - Automotive Parts*

5.3.4.2 Strategic models

The second theme; strategic models, was categorised as detailed in Figure 12, in order of most frequently referred to in quotations and the outcomes are detailed below.

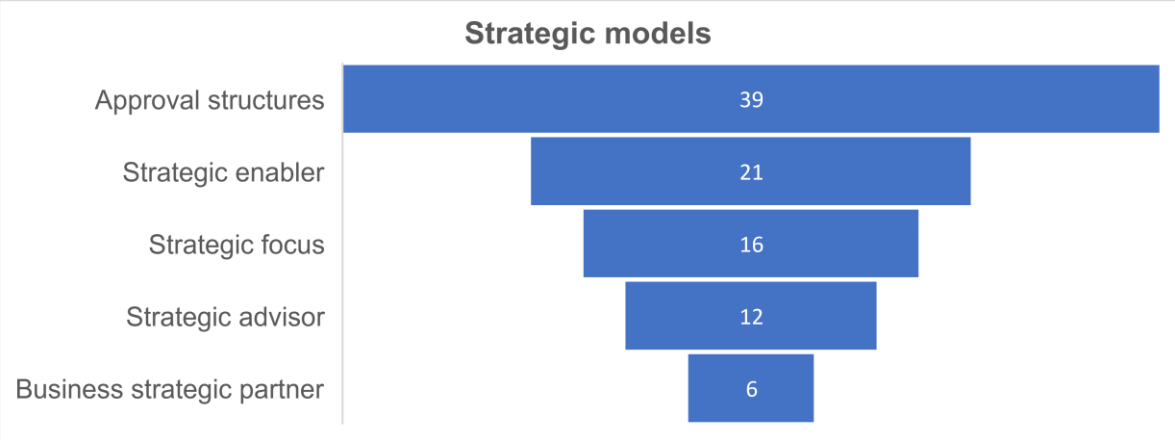

Figure 12: Strategic framework - Strategic models

5.3.4.2.1 Approval Structures

All participants concurred that some sort of governance structure for approval or vetting is in place for digitalisation decisions. While methods differed, they all culminated in a form of digitalisation approval structure. In most organisations, the decision-making process involves committees and approvals that consider elements such as the defined business case and Capex (capital expenditure) or Opex (operating expenditure) requirements. Participants stated that overall, the structures ensure that digitalisation efforts take into account the business needs, budgetary considerations, current technology trends, evaluation of vendors to comply to organisational requirements. Some participants had IT governance frameworks and change management policies put in place to facilitate transparent decision-making, technology onboarding, and process enforcement.

5.3.4.2.2 IT's role in a digitalisation strategic model

This represented the role that IT or the digitalisation team played in the business to illustrate the business model followed. Some of participants were convinced that digitisation and technology play a crucial role in driving the business forward and as such, should go beyond being mere IT projects. One participant asserted that IT

should have a clear understanding of the technology requirements, but they should not take ownership of the project. According to some participants, IT supports different departments in accomplishing their specific goals and objectives through the use of technology. This is achieved by enabling the business to access technologies. Some participants highlighted the importance of technology as an enabler rather than the primary focus of the business strategy and as such, the IT function being an enabler to the business strategy. They emphasised that digitalisation must not stand as its own pillar within the business strategy but should rather work across the different pillars to enable the delivery of those objectives but can stand as it won pillar only within the IT strategy. Some provided the digitalisation through focused projects, where the target would be improving productivity through digitalisation, manual migration through automation or moving towards being a data driven organisation.

Participants stated that business leaders rely on the IT leader for guidance on what technology is required and how it should be implemented. They underlined that the IT leader's responsibility is to act as a business advisor and to integrate technological initiatives with overall strategy. One participant stated that he collaborates with other important stakeholders to identify solutions and bring them to the board. Some stated that they also analyse future technology trends to ensure that the organisation is digitally future-fit, and that they work with technology providers to uncover technologies that can have a substantial influence on the business. The shared perspective is captured below in a statement by one of the participants.

> *"…so our push demands obviously from the technology providers themselves with the plethora of new technology available to IT. And how do we distil it again, what are the tech that we feel will and could potentially make a big impact in the business and how do we, be the conduit as an IT department to the business of a specific technology: A new AI module gets released in Microsoft, possibly marketing and communication can benefit from that. To provide that linking role." - I10 - Chemical Industry*

A successful model was explained by I3 who noted that they have a fully technically capable, multi skilled team within the IT function that acts as the business strategic partner in both enabling the business through solutions that are designed developed

and executed internally, but also supplying strategic capabilities within the organisation.

5.3.5 Finding 5: Existing capabilities

The firms cited a continuous improvement culture, basic digitalisation capabilities, either internally or through global expertise links, and reliable foundation infrastructure as key existing practices and capabilities to have.

Research question 3 stated: “What are the pre-requisite requirements for a strategic approach to digitalisation?” The question sought to understand, from the participant’s experiences, what they viewed as capabilities that enabled them to be able to successfully adopt and implement digitalisation and their perspective on what they viewed as required capabilities to enable current and future digitalisation efforts. Interview questions ten to twelve were geared towards answering this research question.

Two themes emerged for the participant responses, and these resulted in two findings. The first finding, finding 5, was derived from the theme – “Existing capabilities” and was further categorised as depicted in Figure 13 below.

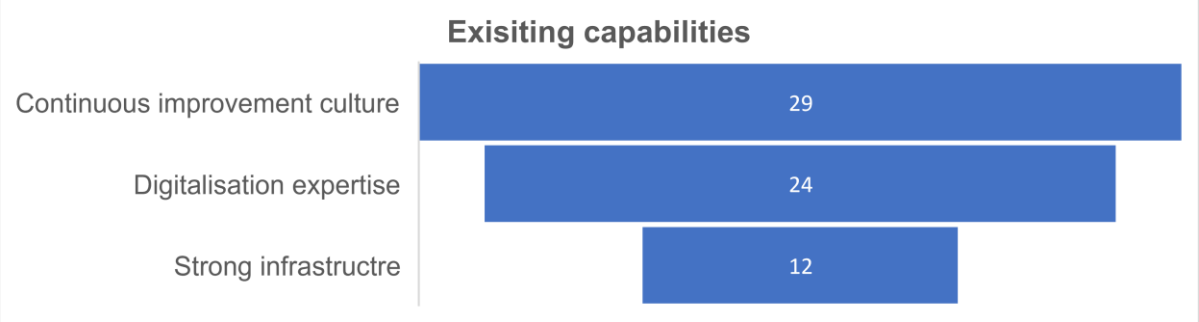

Figure 13: Pre-requisite requirements - Existing capabilities

5.3.5.1 Continuous improvement culture

Six organisations indicated that they have employed continuous improvement to promote a culture of problem solving, team collaboration and accountability. These organisations associated their success in digitalisation to the continuous improvement culture with some giving examples of the Toyota production system philosophy and how it helps instil process discipline. Participants appreciated the benefits of these programmes in facilitating technology adoption by instilling

discipline and promoting communication, accountability, and ownership. Participants such as I14 noted the significance of continuous improvement in enabling digitalisation.

> *"So the main thing that that that helped us was building the internal, you know, technical capacity, technical capabilities and, and just that desire for continuous improvement. So there's a lot. There's a strong link to the, to Toyota and the Japanese philosophies, and that desire for continuous improvement is kind of what's driven this." - I14 - Automotive Parts*

Linked to the continuous improvement culture, participants noted the innovation culture with one participant affirming that innovation was one their values and a driver for digitalisation efforts as the company encouraged it. Six of the participants discussed how process understanding, process capabilities and overall understanding of the organisation impact on the culture of continuously improving and how in-depth process knowledge enabled improvements and digitalisation.

5.3.5.2 Digitalisation expertise

The subcategories that emerged under this category were internal technical capacity and global expertise. Seven of the sixteen organisations declared having strong internal technical abilities for digitalisation, with several participants stating that they had had these skills for years as they evolved with the organisation. Only one participant confidently declared that their organisation had digitalisation skills that cover the whole spectrum of digitalisation skills and were continuously upskilling and learning; the rest admitted to outsourcing some core activities but having the basic skills internally. A few emphasised the shortage of software development skills and that this was one of the skills they outsourced. Some added that they are consciously focused on increasing technical capability and upskilling through continuous training and one participant noted that their organisation was not necessarily focusing on building skills as digitalisation was not their core business. The participant who stated that they had various technological talents within the organisation had the following to say:

> *"Yeah. So uh in our case we actually very fortunate we've got an extremely strong insourced skill and it's a very interesting characteristic of the business itself. It's very technically capable of supporting its own processes, so like for*

instance, so we've got an IT department and the individuals employed there, they are highly skilled and they actually we've got a whole software development team, we've got a whole ERP team that actually looks after our financial side and business MRP systems and we obviously got our infrastructure team and so on" - I3 - Automotive

The global expertise subcategory was noted from some of the multinational organisations, with some participants admitting to relying on their global office connections, claiming that having a global knowledge base allows them to overcome obstacles and achieve their digitalisation objectives.

5.3.5.3 Strong IT infrastructure

Seven organisations in the study declared having a strong, well established IT infrastructure, including modern and up-to-date hardware and a stable platform that allows for connectivity. Some have also implemented new technology for backups. One participant emphasised the importance of focusing on the infrastructure of digitalisation to have a strong foundation for further growth. I13 for example, indicated that overall, they feel that their facility is equipped to compete with others and fulfil their needs – *"… But at this stage we are there, we can compete with other plants and we have everything that we need." - I13 - Automotive Accessories*

However, the other organisations that did not have infrastructure as an existing capability noted the challenges of outdated infrastructure and battling with hierarchical damage that has accumulated over the years that is not easy to unbundle, making it difficult to accumulate newer stronger infrastructure that would be compatible.

5.3.6 Finding 6: Required capabilities

South African manufacturing companies need to develop digitalisation change management capabilities, digitalisation technical skills, digitalisation leadership, data literacy, and a digitalisation resourcing model.

The second finding related to research question 3: "What are the pre-requisite requirements for a strategic approach to digitalisation?" was finding 6 which came from the theme – "Required capabilities". The categorisation of this theme is depicted in Figure 14 below.

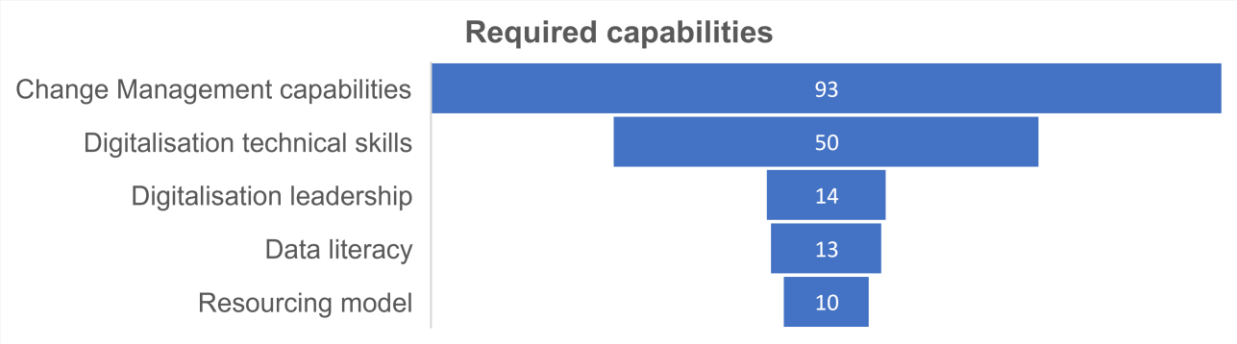

Figure 14: Pre-requisite requirements - Existing capabilities

5.3.6.1 Change Management

All participants emphasised the importance of change management when integrating new technologies. Some were explicit, emphasising the importance of proper change management capabilities in the organisation to guarantee efficient technology adoption, as it takes time to get everyone on board. Participants pointed out the crucial role of continuous learning, training, and empowerment in change management. They underlined the value of allowing employees to learn and educate themselves in order to remain competitive in the age of digital technologies. One participant said that the younger generation tends to be more comfortable with technology and willing to learn new technologies, whereas the older generation will be resistant and hence require a different approach. They stated that their resistance to change originates from a lack of digitalisation abilities and understanding. Some participants acknowledged making an effort to educate staff and use gamification to increase technological interest and adoption. Some are training people to become more tech-savvy as they are introducing new technology.

Participants also emphasised the significance of prioritising stability before moving on to the next technology, as well as having clear ownership and accountability for technology inside the organisation. They stressed the importance of striking a balance and not rushing to introduce new technology without first ensuring stability and ownership.

Another important factor that came up consistently was collaboration and regular updates between IT and the business; participants stated that these are critical in closing the gap. I11 expressed a couple of these sentiments in their statement:

"uhm, getting all departments on the same page. I think would be key from the start that also kind of tallies into the planning where you know you have to get everyone on the same page. If people are not willing to adopt the change that you know obviously affect the performance of the technology in the field…" - I11 - Automotive Accessories

5.3.6.2 Digitalisation technical skills

The other capability that was stated by all participants and noted as lacking in a South African context was digitalisation technical skills. Only one participant (I3) was fully confident that they had sufficient internal skills, and only a few alluded to current efforts of technical upskilling (I13 and I14). The other participants spoke of the need for technical upskilling, for both the IT function and the business. They pointed out the need for skilled employees, particularly in software development, which is frequently outsourced and unavailable in South Africa - *"but there is also other capabilities because we have a significant resource constraints in, OK, umm, we being in Ladysmith, also being in South Africa with this technical skills, the excess exodus of skills out of the country also makes it very difficult to do attract software developers into the department. There's always vacancies, so that is a challenge. having enough skills inside of the organization. It's a continuous struggle that you have, to, you know, get developers into the into the department." - I4 - Rubber & Chemical*

One concern raised was the shortage of specialised digitalisation skills compared to general IT abilities. A participant observed that overseas partners tend to excel in a specific area of expertise rather than having a broad skill set.

5.3.6.3 Digitalisation leadership

Participants believed that leadership needs to have a forward-thinking approach, some stating that in the future, businesses will require a strong IT-savvy workforce, and even CEOs will require programming abilities. The observation is that the leader's attitude towards adopting new technology and the decisions made to support it significantly impact the success of digitalisation. They stressed the importance of executives acknowledging the significance of digitalisation and adopting innovation and leadership 4.0 with a willingness to take risks, as substantial investment is necessary with unpredictable results.

5.3.6.4 Data literacy

A few participants established that the capacity to employ any advanced manufacturing technologies like machine learning and artificial intelligence depended on the maturity and integrity of data. They noted that the business requires the ability to interpret, visualise, and analyse data in order to draw insights; consequently, some have recognised skill gaps in data analysis and data science within their organisations and are taking steps to rectify them. Some are implementing strategies to enhance their data management capabilities and identify insufficient data utilisation within the company as a potential obstacle. A participant emphasised that data usage is crucial for digitalisation to progress efficiently, stating that poor data usage or lack of data literacy can hinder the pace of digitalisation. He observed that their ability to digitalise more easily is because they are a data-driven organisation.

5.3.6.5 Digitalisation resourcing model

Participants indicated the need to have a clear resourcing model to support the digitalisation efforts. This included people resources in the form of specialised skills and digitalisation tools like handheld devices or additional screens where required. Some participants noted that technological advancements and a lack of skilled staff make it difficult to invest in and support certain new technologies like Artificial Intelligence, limiting the opportunities to experiment with new technologies; some, like I15, even recommend having a dedicated new technologies team - *“With all the new technologies available for digitalisation and, for example, open AI, I think, uh, skill set, resources inhouse is also currently, it's something that needs to be constantly updated. So we basically need a team that's dedicated to new technologies.” - I15 - Metal & Metal Products.*

Sustaining digitalisation is also dependant on the resourcing model, participants noted lack of dedicated support and constant knowledge base upgrading as the reasons for failure to sustain digitalisation efforts.

5.4 Findings conclusion

Overall, this chapter presented the six findings that came from the data collected during the in-depth interviews of participants from sixteen manufacturing organisations. The chapter gave an overview of the sample and explained the process of reducing raw data to meaningful statements, which were then used to

compile the findings, including a comprehensive description of digitalisation in the context of South African manufacturing gleaned through finding 1 from the sampled participants.

Finding 2 and 3 had a direct link in answering research question 1 and provided the key factors that drive digitalisation as well as the factors that influence the digitalisation decisions. Finding 4 provided insights from participant responses on the drivers and models they use and how these enable their digitalisation efforts. From the participant perspectives, the strategic models typically used in their organisations focus on technology as an enabler rather than the primary focus of the business strategy with the IT leader acting as a business advisor who integrates technological initiatives with the overall strategy.

Finding 5 presented participant perspectives on the current capabilities that they have that enable the successful adoption and implementation of digitalisation in their organisations. The finding indicated that a continuous improvement culture and reliable infrastructure are the prevalent digitalisation-enabling competencies that manufactures claim.

Finding 6 emphasised the importance of digitalisation change management capabilities, technical skills, leadership, data literacy, and a digitalisation resourcing model with change management being highlighted as critical for integrating new technology in the organisation.

Chapter 6 will provide a discussion of these results and how they support, contrast or add to what has been revealed by the literature in chapter 2.

6 Discussion of research findings

The purpose of this research was to gain a better understanding of digitalisation and the factors that promote successful digitalisation in the South African manufacturing sector. Additionally, the study sought to explore the tactical strategies applied and identify the enabling capabilities that facilitate the successful execution of digitalisation initiatives. Through the application of a phenomenological research strategy, it was anticipated that the structured method would enable different and deeper insights into the phenomenon. The analysis approach applied in this chapter draws from Merriam and Tisdell (2016) who describe findings as descriptions, themes, or categories. Furthermore, the phenomenological analysis method proposes that the phenomenological findings can be structured into textural and structural descriptors, to enable analysis and discussion (Bloomberg & Volpe, 2012; Giorgi, 2008; Sanders, 1982).

The findings formulated from the collected data were presented in the previous chapter and these were based on what the participants said, which was then themed, grouped, and organised into textual and structural descriptions. The textual descriptors provide a description of the phenomenon from the participant's perspective, drawn from the significant statements they declared when describing recent digitalisation efforts. These statements were reduced to meaningful units that enabled the compilation of a comprehensive textual description of digitalisation within a manufacturing context. These textual descriptors focused on the "what" and described what digitalisation in manufacturing is according to the participants. The structural descriptors focused on the "how" to give the essence of how digitalisation was experienced and from this inference can be drawn on "how" digitalisation should be experienced to enable successful digitalisation and provide answers to the research questions. This will enable the formation of a structured framework that answers these research questions holistically.

The preliminary construction of the conceptual framework, based on the findings from the previous chapter and the phenomenological analysis structure explained above is displayed in Figure 15 below. The phenomenological analysis provides a structured approach with the textual descriptor providing the foundation. As such, the conceptual framework takes the form of a digitalisation house with the textual descriptor (Finding 1) providing the foundation of the house and the structural

descriptors (Finding 2 to 6) providing the main structure with the pillars as capabilities and roof of the house as the overall digitalisation objective for the organisation. The building blocks of the house answer the research questions and align with the purpose of the study in providing a different but structured method as a guide to execute digitalisation through the key building blocks that will be defined through this conceptual framework.

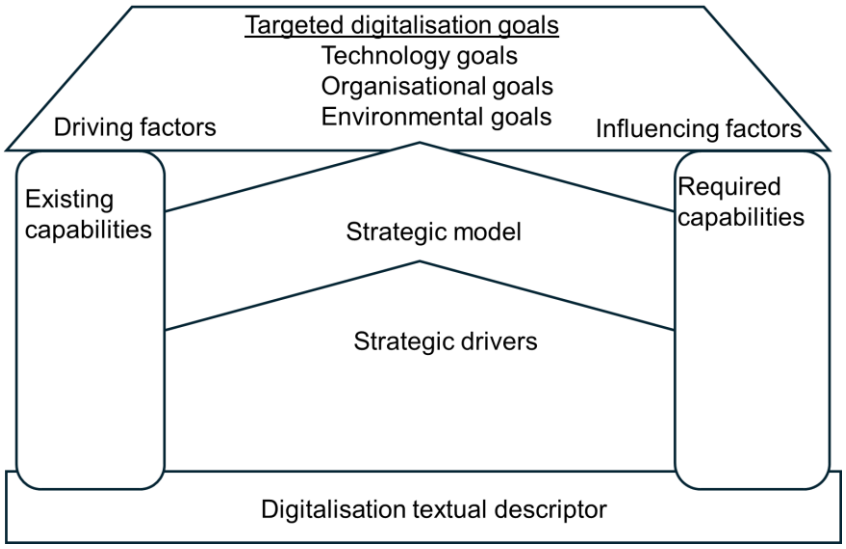

Figure 15: Digitalisation house conceptual framework

6.1 RQ 1: Key drivers of digitalisation

What are the key drivers of digitalisation in the South African manufacturing sector?

Research question 1 sought to secure first-hand accounts from participants of the factors that drive their digitalisation efforts as well as their overall impressions of the phenomenon within the South African manufacturing context. This was achieved by answering interview questions about what the recent digitalisation efforts had been embarked upon by their organisations, what motivated these digitalisation efforts and what internal and external factors influenced these efforts. The overall research question was based on a gap raised by Raj et al. (2020) on soliciting additional data on barriers to digitalisation from other industries. This is supported from a theoretical framework point of view by a study that assessed the impact of the factors within the TOE framework to performance outcomes by Raj & Jeyaraj (2022).

6.1.1 Finding 1: Digitalisation textual descriptor

The participants in the study described digitalisation as the effective combination of Information Technology (IT), Operational Technology (OT), and Advanced Technologies. The expansion of which indicated that the combination of these technologies allows for seamless integration of manufacturing operations and business planning systems, supported by efficient data storage solutions, robust connectivity, and collaboration technology infrastructures. A lot of the focus on digitalisation among the participant organisations are still on basic technology that would be classified as the base technology or base industrial technology (Peerally et al., 2022; Roscoe et al., 2019). These included tools like reporting tools to enable visibility of business process performance, workflow management tools to enable productivity to optimise flow within processes, and interface technology that also links in to enable visibility of machine performance, directly linking to process performance. A few of the firms are focussed on ensuring connectivity and data collection and storage. Björkdahl (2020) notes that this is what is required to enable digitalisation that enables the firm's business strategy and ability to meet customer requirements, supporting the firm's capacity to fulfil consumer needs, but it lacks the innovation needed to distinguish the firm from its competitors.

What was of interest was the fact that some of the smallest companies, were one of the more advanced in digitalisation applications in that they are implementing advanced manufacturing technologies as compared to some of the largest ones that are still busy with retrofitting and readiness technologies (Peerally et al., 2022), the first level of capability in Peerally's framework. But a majority are still embedding basic technology. Only two of the participant organisations declared current initiatives on advanced technologies like 3D printing and robotic process automation (RPA). The rest of the organisations are either upgrading their ERP system or looking at enhancing data handling capabilities like cloud storage or enhancing their internal data management skills as evidenced in the participant summary Table 5 of section 5.2.

Wen et al. (2022) 's definition of digitisation and digitalisation indicates that digitisation uses technological advances to collect, store, evaluate and share data, creating human-machine-application interfaces whereas digitalisation encompasses the use of digital tools to streamline workflows and enable optimisation and

enhancement of processes and products. From the observation of the descriptions offered by the participants, there is still a few basic activities that are focused on digitising but the overall focus on visual reporting tools and workflow management indicates that the overall aim is to digitalise the processes and products of the organisation. Some of the focus on connectivity, reliable networks, and data access through the cloud support Mishra et al. (2023)'s definition of digitalisation being the use of advanced technologies to improve organisational interactions and consumer satisfaction by rendering processes more accessible and transparent but Stark et al. (2023) argue that, until strategic paradigm shifting examples occurs in manufacturing, digitalisation in the form of advanced manufacturing will remain a vision rather an operationalised strategy. This is truer in a South African and developing economy context where a lot of the digitalisation is still focussed on the basic technology that would still be recognised as information technology, an industry 3.0 deliverable (Peerally et al., 2022).

Product life cycle management implementation by I7 that integrates processes from conceptualisation to realisation, including soliciting customer input is an example of the type and description of digitalisation that some companies in South Africa are engaging in and reflects what other countries are focusing on (Holmström et al., 2019; Mishra et al., 2023). The focus on the recent technologies adopted by some of the participant organisations were geared towards streamlining workflows, a focus that Wen et al. (2022) stated as the focus in the Chinese manufacturing companies.

The definitions offered by prior literature align with the descriptions by the participants, including the framework offered by Ivanov et al. (2019), though in a supply chain context, it includes elements of manufacturing that feature the technologies declared by participants including 3D printing, digitalised planning and digital manufacturing that encompasses industrial technologies. It can therefore be surmised that the textual descriptors offered in literature that applies to other economies also applies in a South African context where digitalisation is seen as technology adoption efforts that are geared towards optimising business processes and streamlining workflow to achieve operational and business benefits. Even though it is also noted that the majority of the firms represented are yet to attempt advanced manufacturing technologies.

In light of the categories listed in Figure 8 of subsection 5.3.1 in the findings and the descriptions from the participants to digitalisation definitions as observed in prior studies (Chauhan et al., 2021; Holmström et al., 2019; Ivanov et al., 2019; Mishra et al., 2023; L. Yang et al., 2023), the researcher consolidated the groups to reveal a pattern that indicates that the outcome is a representation of the technologies that integrate products, processes and people with key consolidated descriptors as listed in Table 7 below.

Table 7: Resultant digitalisation descriptors

Consolidated descriptor	**Original categories**
Integrated industrial technology	Industrial technology Machine communication Technological advancements Advanced manufacturing
Integrated visual reporting	Visual reporting tools Interface technology
Streamlined workflow management	Workflow management Security technology
Integrated data analytics	Data storage Prescriptive manufacturing
Connected Firm	Connectivity Collaboration technology Communication technology
Integrated ERP	Digitalised planning ERP optimisation/upgrading/migration

As such, the recommendation is that a clear and aligned description of what digitalisation is must form the foundation at firm level. This is represented by the foundation of the digitalisation house that begins to build the conceptual model using the descriptors in Table 7. This foundation is represented by Figure 16 below.

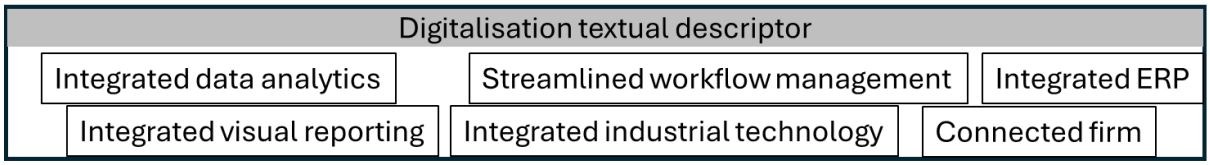

Figure 16: Digitalisation house – the foundation

6.1.2 Finding 2: Key driving factors

The factors derived from the continuation of the textual descriptors as offered by participants when they responded to the question of what motivated these digitalisation efforts. The study revealed five categories of factors that drive the digitalisation decisions within the sampled organisations: operational benefits, data analytics capability, business benefits, achieving technical advantage and meeting requirements.

6.1.2.1 Operational benefits

The participants cited operational benefits as the most significant driver. This is directly related to their most significant digitalisation efforts, which were industrial technology, visual reporting tools, and workflow management, as these provide productivity, visibility, and agility, which were identified as driving factors under operational benefits. Other perceived results under the operational benefit driving factor included increased operational efficiency, traceability, and cost savings. According to the TOE framework (Raj & Jeyaraj, 2022), operational benefits fall into the "perceived usefulness" category since participants recognised the usefulness of the technology in providing the desired outcomes. The validity of the impact of digitalisation to operational performance has been qualitatively established by various studies (Buer et al., 2021; Gillani et al., 2020; Raj & Jeyaraj, 2022; Y. Yang & Yee, 2022) and as such, the claims that it is a factor that drives the motivation for digitalisation is a valid claim that manufacturing organisations embarking on a digitalisation path can pursue.

6.1.2.2 Data analytics capability

The second driving factor that was revealed in this study was data analytics capability. This is contrary to where researchers usually discuss data analytics capability as it normally features when discussing capabilities (Antonucci et al., 2020; Bag et al., 2021; Peerally et al., 2022; Y. Yang & Yee, 2022) but a number of participants in this study stated that due to the use and need of data in decision making and overall execution of all activities in the organisation, being able to collect, analyse and use the data is the reason why they digitalise their processes. This was evident in the list of recent digitalisation efforts they presented where there is emphasis on cloud and data storage technologies. The study findings revealed the

importance of having real-time data to make educated decisions with emphasis on developing data analysis capabilities.

The study also found that the availability utilisation and integrity of the data was a concern for most organisations due to a lack of data literacy. It was evident that the data integrity difficulties stemmed from human error, prompting the motivation for use of interface tools and the shift to automated data extraction solutions. Peerally et al. (2022). argued that to attain digitalisation readiness, organisations need to be able to collect and connect existing data with data from newer digitalisation sources, which adds to the data issues being experienced by the organisations in that, as they introduce solutions to the data analytics problem, they need to make sure they are ready to integrate it into the existing data while enhancing the data analytics capabilities.

Bhatia and Kumar (2022) concluded in the study that data exploitation had a substantial impact on performance results, therefore the reliance on data and data capabilities, as well as the anticipated benefits of developing data analytics capability, make it plausible for organisations to use data analytics capability as a driving factor for their digitalisation efforts. The capability can be classified as an organisational context factor within the TOE framework, in the form of internal organisational skill (Raj & Jeyaraj, 2022). This means that organisations will want to implement certain technology to improve their data handling and analytical skills.

6.1.2.3 Business benefits

The other motivating aspect indicated was business benefits. This is closely related to operational benefit because it is a perceived outcome with a broader perspective on overall business benefits such as being able to automate all aspects of the business through digitisation, being able to make informed decisions as a business, driving accountability through transparency, and achieving a competitive advantage as a company. Some authors would refer to this as an economic benefit (Raj et al., 2020), but the phenomenological approach drew out the business benefits as stated by the participants, who saw other benefits that impact the overall business, such as manual migration, as business benefits, over and above just the economic gains. As a result, all perceived business outcomes, including economic gains, are viewed as aspects that would help the business as a whole.

6.1.2.4 Achieving technical advantage

According to the findings, achieving a technical advantage through seamless system integration, uninterrupted operations, and compatible technology appears to be one of the primary drivers for digitalisation. Being able to integrate across systems gives businesses better access to their data and the ability to combine it for analytics. Björkdahl (2020) describes two types of integration: one in which firms focus on basic internal integration, which allows for the collection of data from various sources within the organisation and the integration of different equipment, and another in which more advanced firms can integrate with their customers' production systems and link in to see their inventory levels. None of the studied organisations cited this capability, hence it is assumed that most firms are currently focusing on internal integration initiatives.

Providing platforms that assure uninterrupted operations was also a significant motivator, particularly in the context of the possibility of interrupted operations due to energy shortages; removing any other potential disruptions is a sufficient motivator to extend and digitalise your operations. It was interesting to note, however, that a few organisations did not take a proactive stance when it came to innovatively digitalising, but rather digitalised in accordance with an outdated technology replacement plan, implying that they waited until the technology was obsolete before embarking on digitalisation, at which point one could argue they are simply patching digital solutions to outdated technology, rather than digitalising.

6.1.2.5 External requirements

The final main driving factor is meeting customer and regulatory needs. Companies are finding themselves required to adhere to numerous regulatory obligations pertaining to data management and other standard body compliance standards, both for legal compliance and for competitive advantage. South African enterprises are no exception, and the firms that participated in the study stated that this is now a factor driving their digitalisation choices, as they must consider the technology's ability to assure compliance and meet such standards. Raj et al. (2020) noted the risk of breaches in security and lack of regulations as deterrents to digitalisation; therefore, where there are regulations and minimum requirements imposed to reduce the risks, organisations will be motivated to digitalise; however, the firms in this study digitalise in order to meet these requirements because the benefits include meeting

operational performance, boosting product performance, and profitability (Bhatia & Kumar, 2022).

6.1.3 Finding 3: Influencing factors

As part of Finding 2 and in response to research question 1, the study found that organisational participants identified strategic alignment, financial implications, and the sustainability, complexity, and competitiveness of the technology being adopted as key factors to consider when deciding on the direction of digitalisation. These factors will either boost or harm the organization's digitalisation path.

6.1.3.1 Strategic alignment

The results indicate that strategic alignment ensures that digitalisation is geared towards achieving key business objectives and improving the company's reputation. As such, digitalisation options must be screened and a needs assessment performed to ensure alignment, followed by the development of a strategy aligned digitalisation roadmap. According to Bhatia and Kumar (2022), companies must set strategic goals before commencing on a digitisation journey to ensure that they prioritise accordingly. Björkdahl (2020) contends that digitisation aimed at a specified purpose, such as cost reduction, is more focused and objective than digitalisation intended at growth, which typically lacks specific goals and is hence haphazard and uncertain. A claim that may not be justified, as some participants emphasised growth as a potential business objective and can be explicitly articulated as such. This is proven by I5's comment, in which he highlighted having an IT roadmap in place to ensure they can meet their growth targets.

6.1.3.2 Financial implications

The study also revealed that the financial implications play a key role and was one the first factors that organisations took into consideration before embarking on a digitalisation journey. It emerged that financial implications impact on the business benefit key driver and feeds into ensuring strategic alignment as negative financial implications cannot be strategically aligned to business objectives. Most organisation had to take financial implications into consideration as investment into digitalisation can be costly, more so in a South African context where the cost of labour is cheaper and some organisations may opt not to digitalise because it’s cheaper to use labour

and it ensure employment, this was stated explicitly by I6 in the findings section 5.3.2.7, that if the same task that could be completed by costly technology can still be accomplished by our labour force, with the added benefit of saving jobs, especially in a country with high unemployment rates, then one would opt to forego the technology and keep the labour intensity of the task.

Peerally et al. (2022) predict a decrease in low-skilled jobs and overall human intervention as firms become more digitalised. This would not be favourable in a South African context with its high unemployment rate (StatsSa, 2023b). Raj et al. (2020) mentions this consideration as a barrier to digitalisation, especially in economies where cheap labour is an economic resource. South African manufacturing will need to balance the need to grow the digitalisation footprint without worsening the employment statistics of the country, and this is where technological capability building can play a role, as will be discussed later.

6.1.3.3 Technology sustainability, complexity and competitiveness

The study revealed the other key driving factors to ensure a successful digitalisation journey are the sustainability, complexity and competitiveness of the technology being adopted.

6.1.3.3.1 Sustainability of the technology

From a technology sustainability consideration, the data showed that the organisations are struggling to sustain the technology mainly due to poor user adoption, inadequate internal IT resources, inadequate external support, regulatory compliance issues and in South Africa in particular, external macro-issues that take away the funding and focus from digitalisation. The technological capability issue comes up again, where in the previous section, the data revealed the risk of job losses if technological capabilities are not enhanced, here it is the employee tech savviness and IT personnel technical skills resulting in unsustainable attempts at digitalisation. The employee tech savviness relates to the ease of use within the TOE and Raj and Jeyaraj (2022) confirmed the positive association of ease of use with technology adoption.

The focus on the macro-economic issues that comes from the findings not only takes away the funding from digitalisation efforts, but also from the investment that would have been made on developing the required technical skills and creating a

technology continuous learning culture within organisations. Even though it was noted that some organisations are investing in creative ways of embedding technical savviness, still more could be done from government and other external support (Bhatia & Kumar, 2022; Buer et al., 2021).

6.1.3.3.2 Complexity of the technology

And lastly, the aspect of technology complexity can discourage digitalisation efforts as it might take too long to implement new technology when trying to digitalise in an environment with old equipment that are not easy to adapt. The data also revealed that it is important to ensure internal business processes align with the digitalisation efforts as a misalignment will result in unsustainable digitalisation efforts and impact on ease of use due to employees struggling to make the system work for the process.

6.1.3.3.3 Competitiveness of the technology

On the technology competitiveness, of interest from the data was that the globally affiliated companies were able to digitalise more readily due to pressure from their global head office from a standardisation or strategic point of view or due the expected high standards from their global customers whereas the local firms went out to identify the pressure through benchmarking and doing research to understand industrial trends of which, implementation, or attempts thereof, varied, depending on internal capabilities.

6.1.4 Consolidation of the answer to research question 1

Finding 1 provided the textual descriptor of digitalisation that consolidated how the participants in the study understand it to be and what current literature describes it to be. This provided the foundation of understanding the digitalisation phenomenon. The insights gained from finding 2 and 3 aligned with the TOE framework in addressing the technological, organisational, and environmental (external) driving and influential factors. This provided the answer to research question 1 and is demonstrated in figure 17 below when mapping the driving factors and influencing factors into the digitalisation house, forming the roof of the house, where the organisation’s digitalisation goals are captured.

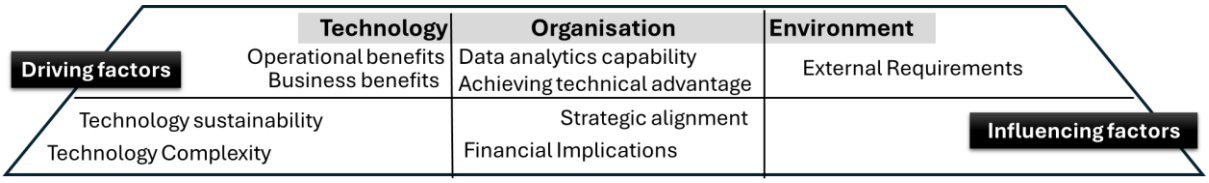

Figure 17: Digitalisation house - the roof

6.2 RQ 2: Strategic frameworks for digitalisation

Do South African manufacturers use strategy frameworks to drive digitalisation in their organisations?

This question sought to shed light on the tactical approaches employed by manufacturing firms within their strategies to enable coordinated digitalisation efforts and their execution. The question was based on the prior literature by Björkdahl (2020) who asserts the importance of the role of the leaders in sharing the digitalisation vision and coordinating digitalisation efforts. The four interview questions related to this research question that were posed to the participants were: who is the key driver of technology adoption within your organisation, how does your organisation decide on which technology to adopt, what strategic concerns do you take into account when considering which technology to adopt and what aspects of technology and technology adoption are included in your organisational strategy?

In retrospect, these interview questions could have been framed differently to allow for more detail of the tactical aspects of strategy as opposed to the pure strategic framework questions as participant tended to focus on the overall business strategy or the IT strategy in their responses, which was not the intended outcome. Nonetheless, the results were sufficient to give detail into the key roles and responsibilities of the strategic executors for digitalisation. Hence, the results described the strategic drivers and models that were employed and worked for the sample organisations used in this study.

6.2.1 Finding 4: Strategic drivers and models

6.2.1.1 Strategic drivers

The findings showed that a majority of the organisations signalled that the IT function or equivalent drove the digitalisation efforts. Specifically, seven of the organisations exclusively identified the IT function as the key driver while five organisations

identified the head office, who, in the context of the multinationals is the central IT team. The difference were two organisations where the strong drive came directly from the user with IT playing the mediator role between the user and service providers and the one organisation where they had a specialised future technology team that does the research and assesses application and proof of concept for the business.

The study also found that some of the organisations that had IT as the driving role battled with user adoption and system ownership and the digitalisation was seen as an IT initiative. To curb this, one organisation confirmed the use a partner engagement model to ensure leadership engagement and ownership. This insight supported Björkdahl (2020)'s assessment that companies that have trouble integrating digitalisation often operate under the assumption that digitalisation is something that can be handled by a single department. What was also interesting to note from the study was the generally uniform role the executive team and board members played in the digitalisation efforts, the consensus was that they sponsor and advocate for the digitalisation and approve the budget and execution thereof.

6.2.1.2 Strategic models

6.2.1.2.1 Approval structures

This study found that manufacturing organisations generally have governance structures like Capex committees, IT steering committees and other IT governance structures to facilitate consensus and due diligence regarding digitalisation decisions. These structures ensured the effective deployment of digitalisation and promoted cross-functional engagement across the organisation. This aligns with the recommendations made by Roscoe et al. (2019) and Zangiacomi et al. (2019) on establishing internal structures for approval of digitalisation deployment. They indicated that this enables cross-functional engagement and easy exploitation of technology.

6.2.1.3 IT's role in a digitalisation strategic model

The study found that the role that the IT function or digitalisation function played in the business was a good indicator of the strategic model being followed, even when this was not exclusively stated but though the response to the research questions

the study was able to deduct four main strategic models that this function implemented in order to enable digitalisation. They were either the business enablers, provided the strategic digitalisation focus by applying a project approach, provided guidance on what technologies will enable efficient digitalisation or being strategic business partners by playing a holistic role.

The observation from the study was that a majority of the organisations are using the digitalisation strategic enabler model where either the business user will initiate requests for service and IT would fulfil this request by driving the digitalisation for the user or IT would seek out solutions to enable the business and push these into the organisations. This results, noted in the previous subsection, in IT being the overall digitalisation driver with poor adoption outcomes. This does not mean that the model does not work, but the observation from the study also indicated the critical role of the end user as the owner of digitalisation being noted as a lacking aspect. This could be the key to unlocking efficient adoption by the end-user, if they take ownership of the digitalisation and be in partnership with IT and a technology subject matter expert represented in the form of a future technology team, as presented by one of the organisations but this will require a change in the overall organisation strategic direction regarding digitalisation (Van Zeebroeck et al., 2023).

6.2.2 Consolidation of the answers to research question 2

In response to research question 2, finding 4 illustrated that a digitalisation strategy framework comprises the important strategic drivers within the company supported by an empowered approval governance structure with clear roles and responsibilities that enable digitalisation implementation throughout the organisation. This is then the structure of the digitalisation house, representing the “who” and the “how” building blocks as demonstrated in Figure 18Figure 1 below.

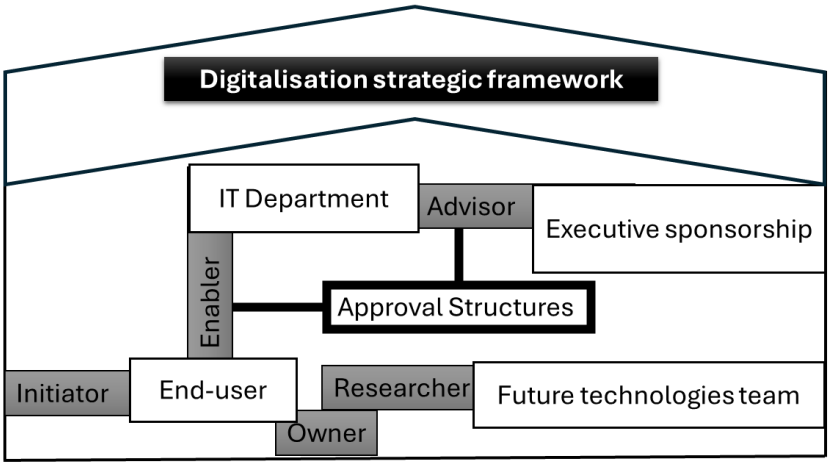

Figure 18: Digitalisation house - the structure

6.3 RQ 3: Pre-requisite requirements for successful digitalisation

What are the pre-requisite requirements for a strategic approach to digitalisation?

The question's overall aim was to elicit a list of digitalisation capabilities that are required to enable firms to achieve their digitalisation objectives. The interview questions asked in the regard were: what are the pre-existing internal capabilities or abilities that have enabled your digitalisation success, have the technologies you have adopted so far further enhanced your overall technological capabilities and based on your learnings to date, what interventions have you undertaken or plan to undertake to enhance your technological capabilities?

The framework employed in triangulating the findings to research question 3 came from a high-ranking journal by Peerally et al. (2022) that used a systematic literature review of 115 documents as their research method. The framework is intended to serve as a useful aid to organisations navigating the digitalisation path. It presents a roadmap for the firm-level practices and resources required by firms to develop more advanced 4IR capabilities. The responses to the research question in this study were divided into two findings, one listing what organisations viewed as existing capabilities and the second one listed what they viewed as capabilities they need for future digitalisation efforts.

Both findings were synthesised with Peerally et al.'s technological capability framework to understand what level of capability the organisations were in currently based on their existing capabilities and a comparison of what they viewed as required

capabilities to what Peerally et al. (2022) indicated as required capabilities to advance to the next levels of digitalisation. The discussion was supported by the theory on practise-based view by (Bromiley & Rau, 2014, 2016a, 2016b).

6.3.1 Finding 5: Existing capabilities

6.3.1.1 Continuous improvement culture

The study also found that organisations with a continuous improvement culture easily digitalised as the culture encouraged process discipline, communication, ownership, and accountability. G. L. Tortorella et al. (2023) confirmed that a culture of collaboration and teamwork positively impacted digitalisation efforts and Buer et al. (2021) confirmed that continuous improvement complements digitalisation to improve operational efficiencies and as a result, operational benefits. An underlying culture of innovation and having a deep understanding of the business processes were also discovered to have influenced successful digitalisation efforts among the organisations sampled, a view that both Roscoe et al. (2019) and Tortorella et al. (2023) agreed with as they state in their studies that a creative and innovative culture promoted digitalisation efforts.

6.3.1.2 Digitalisation expertise

The study found that the existing expertise in digitalisation amongst the firms was either a certain level of developed internal technical capacity or global support in the globally affiliated organisations. Where there was internal capacity, it pertained to one or two areas of strength and generally, complex technical skills like software development were outsourced. Some organisations actively engage in training and upskilling to build on their capabilities, which Peerally et al. (2022) encourage as a means of advancing capabilities to the next level. The multinational organisations were found to be reliant on and supported by their global affiliation where, in some cases, the digitalisation skills were centred at the head office but shared across the organisation.

6.3.1.3 Strong IT infrastructure

The study found that not all organisations had strong infrastructure as an existing capability due to legacy outdated and complex irreparable infrastructure that had accumulated with time, but where it was found to be an existing capability, the

organisations were able to seamlessly digitalise or with less difficulty due to an established foundation of solid infrastructure, which places these organisations at the level of “retrofitting and readiness capability” according to Peerally et al. (2022, p12)’s framework.

However, more is to be said about infrastructure as Raj and Jeyaraj (2022) argue that technological infrastructure is required to promote digitalisation in developed countries. Although strong infrastructure has been found to be an existing capability in some of the organisations, Raj and Jeyaraj’s argument may still be in support of the findings of this study as the majority of the organisations indicated a deficiency. Gillani et al. (2020) stated that base technology can prove to be a strong infrastructure for future advanced technologies, this is possibly the case for the organisations that have strong infrastructure as an existing capability, it could possibly be base technology infrastructure. Furthermore, noting that Raj and Jeyaraj (2022) indicated the strong infrastructure as a requirement for developed economies having evaluated it at a national level so far, developing nations have only achieved digitalisation at the company level due to a lack of integrated national policy, this then might have been an incentive in developing nations to have a strong infrastructure at firm level to support the digitalisation initiatives, in the absence of robust integrated national policies.

Peerally et al. (2022) adds to the view on the drive for manufacturing firms to have strong infrastructure by noting that capital goods suppliers and Original Equipment Manufacturers (OEMs) are not the only ones who innovate their equipment, as the process of adapting old systems to the new manufacturing ecosystem within firms is complex and hampered by the risks associated with investing and a lack of technical skills. Manufacturers, as users of the equipment, frequently play active roles, sometimes taking the lead, in developing and upgrading technology and equipment supplied from others to establish a strong infrastructure base.

6.3.2 Finding 6: Required capabilities

This study identified five capabilities that were classified as required capabilities by the participating organisations. These were change management capabilities, digitalisation technical skills, digitalisation leadership, data literacy and a digitalisation resourcing model.

6.3.2.1 Change Management capabilities

In this study, change management was one term that all participants listed as a required capability in their organisation. The study observed that all the participating organisations noted change management as a capability that was lacking but required to enable effective digitalisation. The capability materialised in different formats in the results, from lack of training, employee engagement and empowerment to ensuring entrenchment before moving to the next digitalisation effort and ensuring ownership and accountability.

What was interesting to note was that prevalence of change management as a required capability in the sample assessed was contrary to prior literature in that, although mentioned or inferred through requirements for training and upskilling, change management did not come up as a critical concern or strong factor in the quantitative studies when compared to how it is exclusively stated in the current context (Bhatia & Kumar, 2022; Mukherjee et al., 2023; Pozzi et al., 2023; Zangiacomi et al., 2019). This is unique to the manufacturing companies assessed and would be a key area to research further to understand the extent of the impact of pro-active change management to digitalisation.

6.3.2.2 Digitalisation technical skills

In as much as some organisations declared internal technical capability as an existing capability, the general observation was that digitalisation technical skills were not sufficient to enable successful digitalisation in manufacturing firms. This was more pronounced for advanced technologies like artificial intelligence capability and specialised skills like software development. This finding was in line with the findings in the literature in that the lack of digitalisation skills was noted and came up as a prominent factor in a number of studies (Bhatia & Kumar, 2022; Chatterjee et al., 2021; Pozzi et al., 2023; Roscoe et al., 2019).

6.3.2.3 Digitalisation leadership

The results from the participant responses indicated the need for a digitalisation mindset from the leaders, recommending a leadership 4.0 mentality as this has a strong effect on the success of the digitalisation efforts. Giotopoulos et al. (2017)referred to visionary leadership that enables digitalisation change maturity and

G. Tortorella et al. (2023) confirmed the criticality of the leader's role in enabling digitalisation in manufacturing organisations.

6.3.2.4 Data literacy

The study observed that data was one of the strong variables that came up a lot within the different research questions, as it was also one of the strong drivers for digitalisation with manufacturing firms. The study surmised that there is a requirement to develop data literacy capabilities throughout the organisation for capturers, collectors, users, and processors of data to the decision-makers in the organisations. Peerally et al. (2022) determined that to achieve digitalisation maturity, firms must develop capabilities to collect, manage, protect and analyse the data.

6.3.2.5 digitalisation resourcing model

The results from this research gave insights into the need for a revised resourcing model to enable better uptake of advanced and emerging technologies as the speed at which these are coming cannot be accommodated by current resource models; as such, the manufacturing firms are generally lagging.

Overall, these capabilities as identified from the data, are consistent with what Peerally et al. (2022) discovered in their research regarding firm level capabilities. They argued that firms must be intentional and invest in technology upskilling and continual learning to be able to adopt more complex technologies. They stated that this entails the ways in which firms acquire the knowledge, skills, and resources needed to ensure a successful digitalisation drive that has the right structures and processes to enable people to deliver on digitalisation requirements while building operational capabilities (Bag et al., 2021; Peerally et al., 2022; Roscoe et al., 2019).

6.3.3 Consolidation of the answers to research question 3

Finding 5 and 6 provide the pillars of the digitalisation house while answering research question 3. They provided the existing and required capabilities as accounted for by the participants. These capabilities are enabling the digitalisation efforts as what should be in place and what the organisations need to strive for in order to reach the next level of capability within their journeys. Consequently, these

capabilities are represented as the pillars of the digitalisation house, represented by Figure 18Figure 1 below.

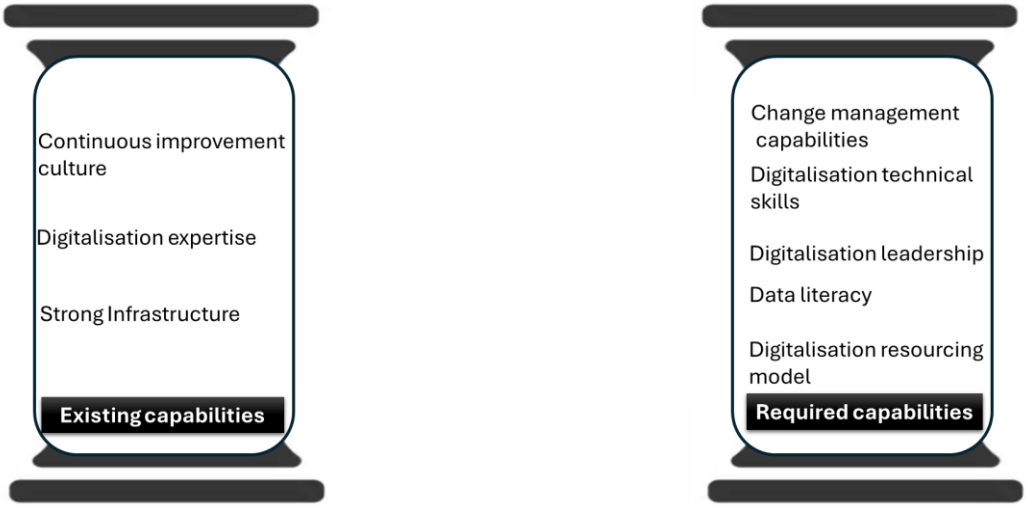

Figure 19: Digitalisation house – the pillars

6.4 Conclusion

This chapter consolidated and triangulated the findings as represented in chapter 5 with the literature as presented in chapter 2 in order to support or refute the participant's claims. This was guided by the phenomenological approach which allowed for a systematic consideration of foundational textual elements and structural elements.

A conceptual framework in the form of a digitalisation house was formulated as part of the discussion, and the findings from the data formed the foundation and structural building blocks of the digitalisation house. The consolidation and relevance of the digitalisation house form part of the conclusion in the next chapter.

7 Research conclusion

7.1 Motive for the research

The purpose of this study was to explore the use of digitalisation in the context of South African manufacturing industry. In particular, it intended to get an understanding of the factors that impact effective digitalisation, taking into consideration the setting of the South African country, and sought to discover the methods that organisations who have digitalised their manufacturing operations have utilised to digitalise successfully. According to Bag et al. (2021), Bhatia and Kumar (2022), and Raj and Jeyaraj (2022), digitalisation has been shown to have a significant impact on the manufacturing industry, including manufacturing in developing nations. This transformation has enabled organisations to enhance their productivity and operational performance by utilising both fundamental and advanced technologies, such as cloud technologies, advanced connectivity, and advanced manufacturing technologies like 3D printing.

Evidence has also indicated that technology adoption in developing economies such as South Africa has been slow and lacking the required investment in research and development, both from a government support perspective and investment by businesses. The continued reduction in the manufacturing value add has also made digitalisation relatively difficult as manufacturing firms had to prioritise survival over innovation (Raj & Jeyaraj, 2022; StatsSa, 2023b; UNIDO, 2023).

As such, manufacturing organisations in South Africa needed to prioritise digitalisation to prevent lagging and the increasing gap between income and productivity distribution (Berlingieri et al., 2024). The objective of this research was therefore to gain a better understanding of the factors that promote successful digitalisation in manufacturing companies in South Africa in order provide the knowledge base for academics that guide policy and manufacturing firm practitioners.

7.2 Academic significance

The study has shown that the majority of recent digitalisation studies have focused on the discovering, evaluating and managing barriers, enablers and critical success factors to digitalisation and how these impact on operational performance , the

organisation's competitiveness and how to address or mitigate the barriers (Bhatia & Kumar, 2022; Hughes et al., 2022; Mishra et al., 2023; Pozzi et al., 2023; Raj et al., 2020; Sharma et al., 2023; L. Yang et al., 2023). More studies have been done to discover and define digitalisation strategic and implementation frameworks (Björkdahl, 2020; Gaglio et al., 2022; Stark et al., 2023) and some to determine the digitalisation capabilities and competencies of a firm (Buer et al., 2021; Chatterjee et al., 2021; Peerally et al., 2022; Roscoe et al., 2019).

The study also evidenced that a number of these digitalisation studies have been done in specific geographic and economic contexts, including developed economies like Italy and Greece (Giotopoulos et al., 2017; Zangiacomi et al., 2019), developing economies like India and Brazil (Mishra et al., 2023; G. L. Tortorella et al., 2023) and even a combination of economies (Björkdahl, 2020; Gillani et al., 2020; Raj & Jeyaraj, 2022).

Only a handful digitalisation qualitative studies have been done to discover more factors over and above those discovered through established theoretical frameworks (Ivanov et al., 2019; Mishra et al., 2023), and even less in a developing economy such as South Africa (Bag et al., 2021). The majority of the studies have focused on quantifying the factors and their impact on performance or success of digitalisation (Chatterjee et al., 2021; Guo et al., 2021; Mukherjee et al., 2023; Wen et al., 2022).

As a result, the study found that existing research is insufficient in identifying digitalisation factors in a South African context, and that more qualitative research was required to investigate the factors within this context, compare them to established factors identified in the existing literature, and determine whether there are any other context-specific factors. Furthermore, the study has revealed evidence that, over and above the factors, there is an opportunity to explore strategic approaches to digitalisation and the fundamental capabilities or practices to ensure successful digitalisation.

7.3 Research questions and methodology

In order to address the deficiencies identified in current literature, the study therefore attempted to answer the following research questions:

- Research question 1: What are the key drivers of digitalisation in the South African manufacturing sector?

- Research question 2: Do South African manufacturers use strategy frameworks to drive digitalisation in their organisations?

- Research question 3: What are the pre-requisite requirements for a strategic approach to digitalisation?

Given the objective of this study, which aimed to gain an in-depth understanding of the perspectives and lived experiences of individuals involved with the decision-making related to digitalisation from a social constructivist perspective, the most appropriate research strategy employed, according to these definitions, was determined to be a qualitative inquiry. A phenomenological research methodology was used as the research blueprint in line with the selected qualitative research design and guided by the researcher's philosophical paradigm.

The target population for this research consisted of 16 manufacturing firms operating inside South Africa. The research objectives and research questions presupposed a certain degree of digitisation as a prerequisite for this study in the firms that were chosen for this qualitative investigation. 16 open-ended, semi-structured in-depth one-on-one interviews were used as the instrument and the data gathered was analysed using a combination of inductive and deductive phenomenological analysis to come up with the textual descriptors and structural descriptors of digitalisation. These textual and structural descriptors resulted in the findings that answered the research questions of the study.

7.4 Research study outcome: The digitalisation house

In chapter 6 of this research study, a conceptual framework was introduced to capture the findings of the study. The framework was constructed from the basis of the findings, in combination with the phenomenological analysis approach of the study that structures the findings into textual and structural descriptors. The conceptual framework took the form of a digitalisation house with the textual descriptor (Finding 1) providing the foundation of the house and the structural descriptors (Finding 2 to 6) providing the main structure.

The consolidated digitalisation house is presented in figure below and relevance of the digitalisation house will now be detailed and provide the conclusion to the findings.

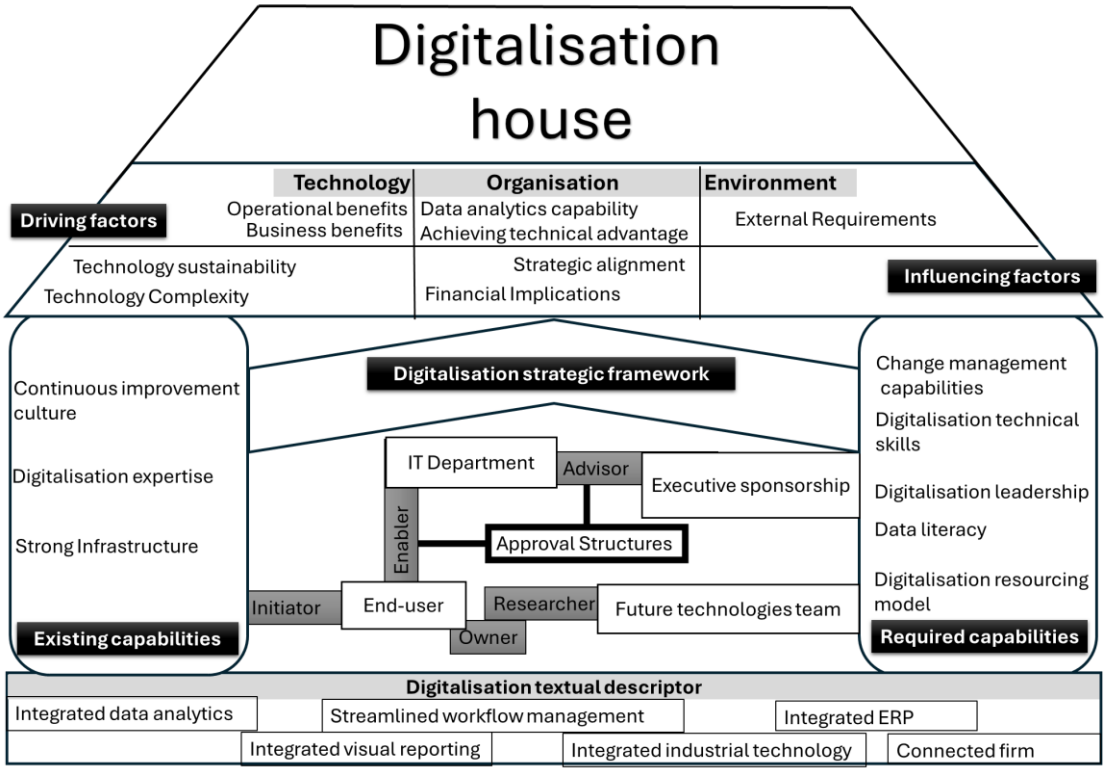

Figure 20: The digitalisation house

7.4.1 The foundation

The definitions presented by prior literature aligned with the descriptions offered by the participants, including the framework offered by Ivanov et al. (2019) and the expanded description by Mishra et al. (2023) that discusses the integration of the whole value chain through digitalisation. The consolidation of these descriptions resulted in a pattern that indicated that the overall description of digitalisation is a representation of the technologies that integrate products, processes and people within the manufacturing value chain and form the foundation of the digitalisation house.

7.4.2 The roof

The objective of research question 1 was to establish the digitalisation factors within a South African context and compare these to the TOE framework as defined by Raj and Jeyaraj (2022). As a result, the outcomes from findings 2 and 3 provided the

driving and influential factors that were organised into the TOE framework, and since they indicated the reasons why manufacturing firms would aspire to digitalise - they represent the goals or objectives of the organisation for digitalisation. Consequently, they are characterised the roof of the digitalisation house and serve as the canopy for all digitalisation initiatives. The driving factors are positioned at the top of the roof as they inform the digitalisation goals of the organisation which are then categorised into the TOE domains and below that are the influencing factors which will enable a foundation for the driving factors.

7.4.3 The structure

Building on Björkdahl's (2020) finding, the study answered research question 2, by illustrating that an effective digitalisation strategic framework is made up of the important strategic drivers within the company as building blocks that enable coordinated digitalisation efforts with a clear vision and accountabilities. These efforts are coordinated through an empowered approval governance structure with clear roles and responsibilities. This is the structure of the digitalisation house, representing the "who" drives digitalisation and "how" it is to be executed.

7.4.4 The pillars

Peerally et al. (2022) created a firm-level technological capabilities framework that considers the capabilities, practices and resources that firms will need to digitalise. This study aimed to expand and use their framework to elicit the prerequisite capabilities required for successful digitalisation from the sampled manufacturers in South Africa. Finding 5 and 6 provide the responses categorised into existing and required capabilities. These provide the pillars of the digitalisation house.

These existing capabilities should direct efforts to determine what capabilities or practices should be in place before embarking on a digitalisation journey and the required capabilities should direct organisations to determine what will enable the successful implementation of digitalisation in their organisations.

7.5 Academic contribution

This study's approach to the digitalisation phenomena through a phenomenological lens has resulted in a different perspective, providing a textual description based on how persons who encounter it define it. This definition was found to be consistent

with how other researchers, using other study approaches, defined it. The qualitative phenomenological methodology also provided a structural descriptor for digitalisation, enabling the discovery of structural determinants and enablers based on the essence extracted from various experiences (Bloomberg & Volpe, 2012; Gill, 2014). This addressed the methodical call for more qualitative studies, specifically in a different context (Bhatia & Kumar, 2022; Gillani et al., 2020; Mishra et al., 2023; G. L. Tortorella et al., 2023). This structural description was exposed to the TOE and PBV to test its validity and trustworthiness, and it was found to align and support current theories while revealing nuances that may not have been uncovered using standard research approaches (Bromiley & Rau, 2014, 2016b; Raj & Jeyaraj, 2022).

Contextually, the study has provided exploration of the factors that influence successful digitalisation in a sample of organisations within a South African developing economy perspective, highlighting the similarities to the factors in other economies but also the accentuated factors due to the different dynamics and socio-economic challenges within a South African context (Bhatia & Kumar, 2022). The study also determined the effective strategic model that can be used to accentuate the effectiveness of digitalisation, addressing a research need raised by Björkdahl (2020) and also explored the technological capabilities that are required for the next level of digitalisation capability (Peerally et al., 2022).

7.6 Practical contribution

Manufacturing organisations need to adequately describe what digitalisation means for them as there is a discrepancy between how digitalisation is defined in literature and the limited description deduced in this study from the participant responses. Firms must be able to assess where they are using frameworks like Peerally's framework, so that they can identify where they need to be and take the necessary steps to gain the capabilities required to get them there. Gillani started to address a call to provide digitalisation implementation guidelines and acknowledges providing the factors that enable and inhibit digitalisation as well as linking these factors to the TOE framework but admits to falling short in providing strategies and approaches to guide a step-by-step implementation of digitalisation (Gillani et al., 2020).

The digitalisation house with the foundation as digitalisation descriptors, pillars as capabilities and roof of the house as the overall digitalisation objective for the organisation can guide practitioners in a structured approach to digitalisation that

provides for a uniform descriptor, enabling an aligned vision, clear organisation objectives with an upfront view of the capabilities required as well as setting up the right structures to direct the digitalisation efforts.

7.7 Limitations and future research recommendations

The objective of the study was to explore the stated research questions in the South African manufacturing context, however, only a sample population was used, although attempts to make the sample heterogenous through purposive maximum variation sampling, the findings cannot be generalised to the whole south African manufacturing sectors as the sample was too small and limited in representation for such a purpose.

Future research is recommended to expand the sample size and perform a longitudinal study using the phenomenological approach, allowing for proper depth and phases of questioning to get a holistic perspective of the organisational participants experience of digitalisation over time (Gill, 2014). Additional quantitative studies can be undertaken to assess the impact of the identified capabilities and their impact on digitalisation efforts and progressing to next levels of technological capabilities as defined by Peerally et al. (2022).

7.8 Conclusion

The findings of this study have the potential to facilitate the identification of the most effective approach for the local manufacturing sector to choose, implement, and benefit from digitalisation initiatives. Furthermore, it provides new insights into the factors that influence digitalisation from a South African perspective and highlight the relevance of the Technology-Organization-Environment framework to organisations.

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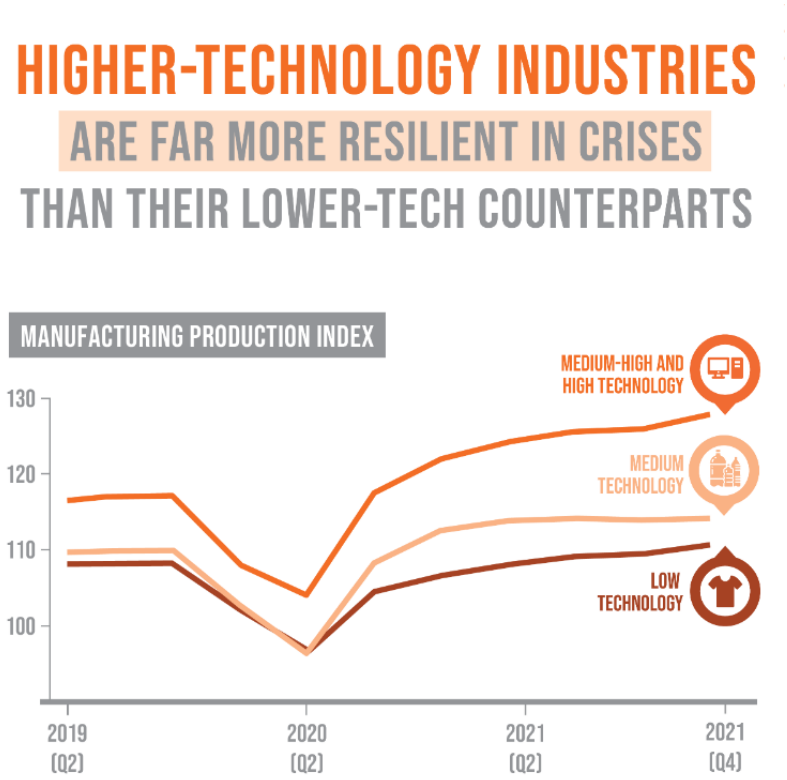
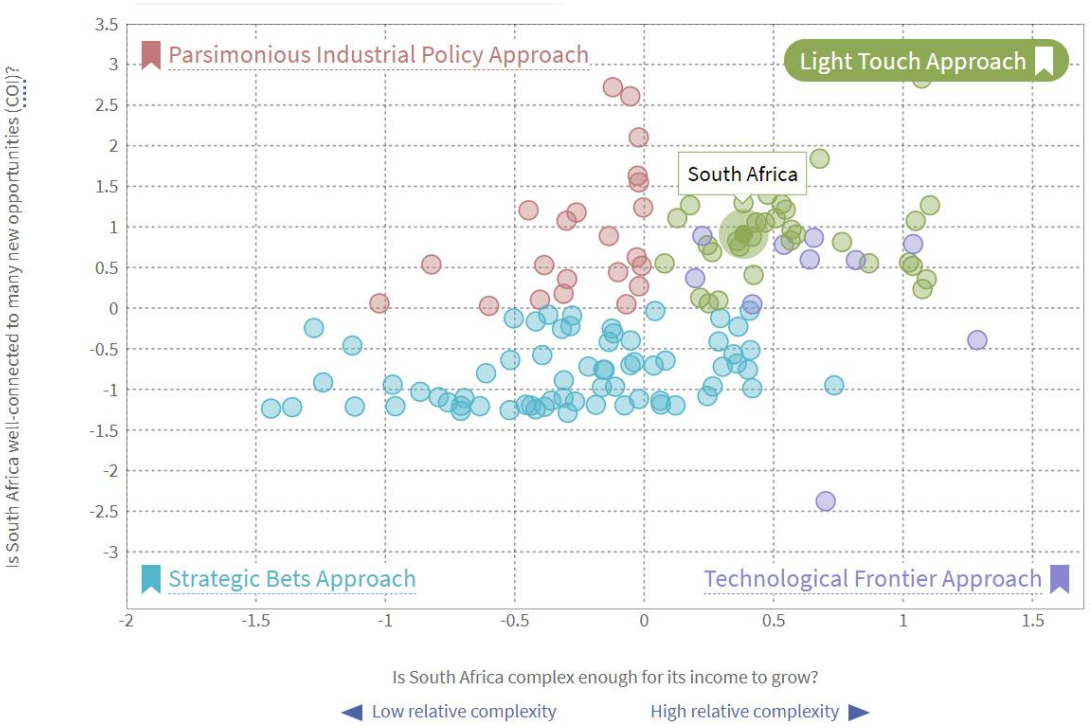
9 Appendices

9.1 Appendix 1: Manufacturing high technology vs. low technology production

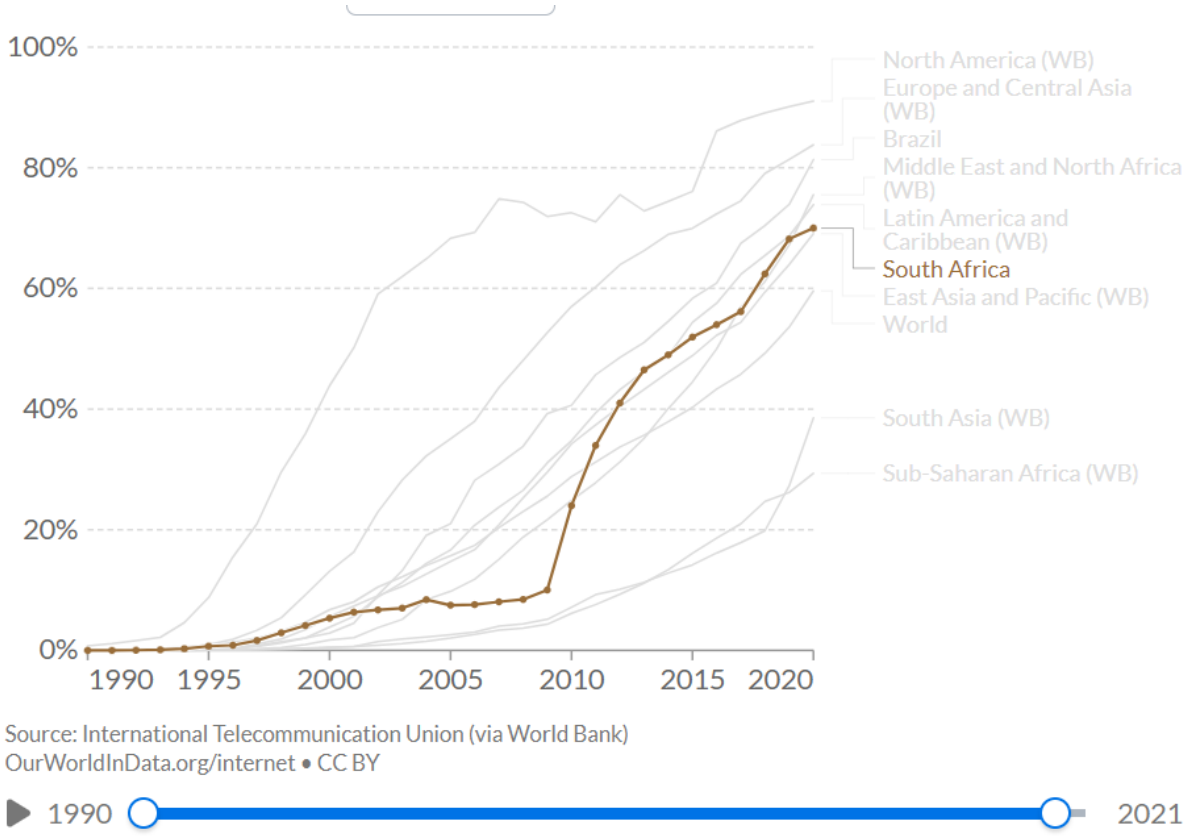


Source: U.N Statistics Division, 2022.

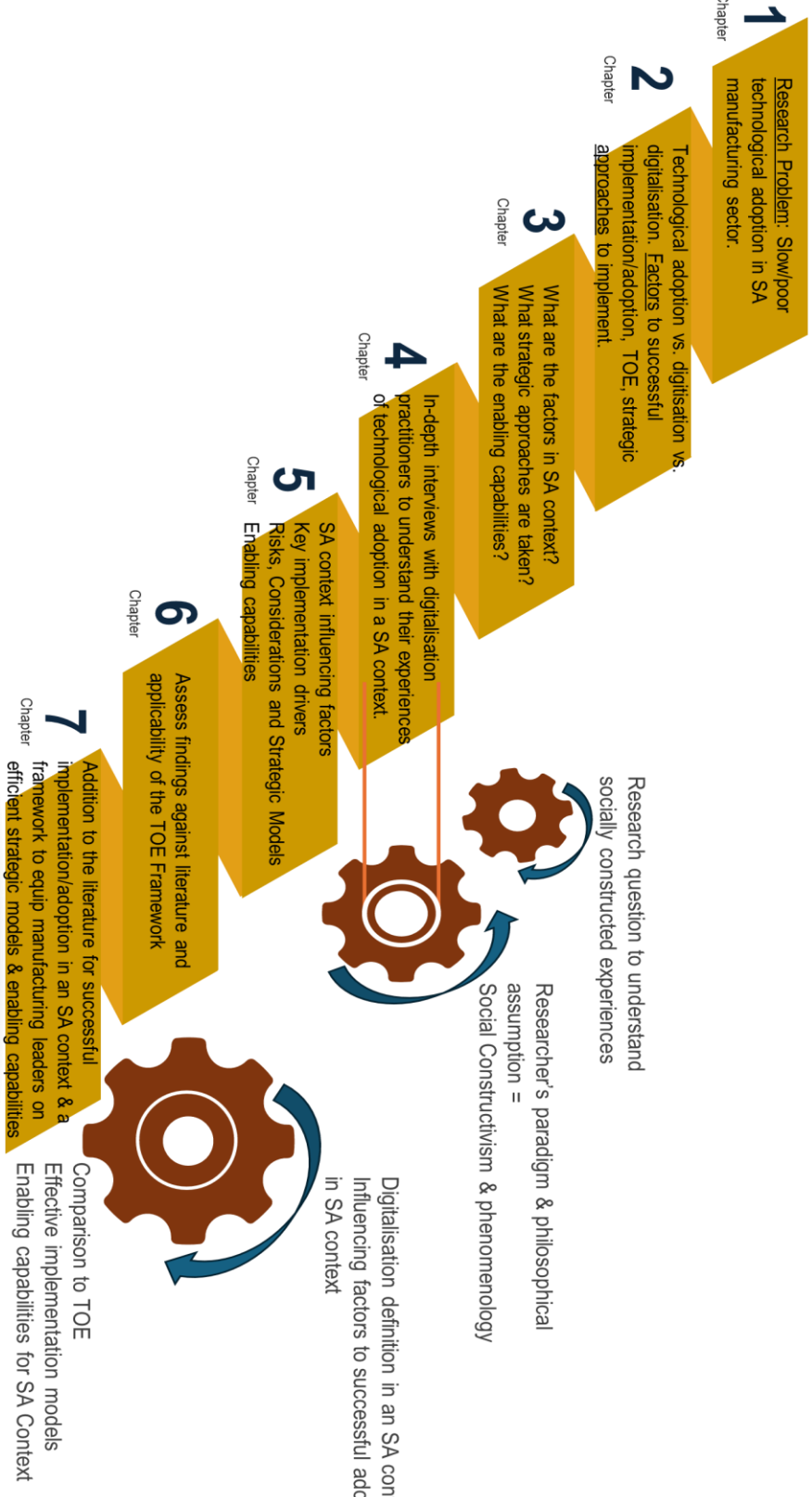
9.2 Appendix 2: South Africa's relative complexity



9.3 Appendix 3: Share of population using Internet



9.4 Appendix 4: Research golden thread



9.5 Appendix 5 – Interview Schedule

Interview Schedule

Thank you for consenting to take part in this study, which seeks to understand the factors that influence the successful implementation of digitalisation in manufacturing firms. The duration of this interview is expected to be no more than one hour. There are no wrong replies; all responses are contingent upon your individual experience and firsthand knowledge. The responses supplied will be treated with the highest level of confidentiality.

Please feel free to contact me or my supervisor if you have any questions about this interview.

Questions

1. Please state your full name, job title and the organisation that you are representing (These will not be included in the final report)
2. Please describe your organisation in terms of:
   a. Size of the organisation
   b. How long it has been operating?
3. What digital technologies has your organisation adopted over the last five years?
4. What have been the key drivers for digital technology implementation?
5. What internal and external factors have influenced your level of technology adoption as an organisation?
6. Who is the key driver of technology adoption within your organisation (function, role or department)?
7. How does your organisation decide on which technology to adopt?
8. What strategic concerns do you take into account when considering which technology to adopt?

9. What aspects of technology and technology adoption are included in your organisational strategy?

10. What are the pre-existing internal capabilities or abilities that have enabled your digitalisation success?

11. Have the technologies you have adopted so far further enhanced your overall technological capabilities? i.e., are you more capable of taking on more advanced technologies?

12. Based on your learnings to date, what interventions have you undertaken or plan to undertake to enhance your technological capabilities?

9.6 Appendix 6: Raw data reduction

The initial codes totalled 317 for all 16 interviews and had 1001 quotations linked to them.

After the initial coding process, the next phase followed was to group the data into meaningful baskets based on the research questions, and more specifically, the interview questions. During the code grouping and review, some codes were merged with others; others were changed to more applicable codes; this happened more for the documents that were coded initially, where it was found that a more appropriate code was discovered in later documents. After the grouping and combining of codes, 209 codes remained from the initial 317 codes and these were grouped into 10 groups, two of which were related to participant or organisation's information. The code grouping helped formulate the different categories of the codes that can later be consolidated into themes. Table 8 below shows the resultant groups, in line with the expected answers from the conceptual framework.

Table 8: Initial coding groups

Coding Group	**No. of Codes**
Reasons to adopt	64
Adoption Considerations	45
Internal Capabilities	33
Recent digitalisation	26
Required capabilities	18
Technology approval process	13
Hindering Factors	11
Strategic model	9
Driving Role	6
Participant Information	3

The coded groups also allowed for additional code reduction and merging with an emphasis on derived meaning and conceptual commonalities. As a result, the code list was reduced from 209 to 183 while keeping the same initial code groups. The reduction method was to first identify the codes with the fewest quotations and merge them with codes of a similar concept, while also identifying the codes that belonged to more than one group and classifying them into one group, allowing for more precise and clear allocation that could later be transferred to code categories.

Certain codes associated with the researcher bias were eliminated or merged through the reduction process. An example of the stated researcher bias was the process-related statements, which were found to be a means to an end rather than the end in and of themselves. A few quotations labelled "Process Optimisation" were subsequently merged with "Visibility," "Cost Reduction," or "Manual migration," considering that the activity of optimising the process itself necessitates the application of technology to achieve visibility or transition away from manual tasks; this was cited as the main reason for technology adoption. An additional illustration was "Machine Information," which was common in the data but served to offer the "Visibility" of the information in question. Consequently, the code was merged with "Visibility" to include it as a factor motivating South African manufacturers to adopt new technologies. The participant quotations below are examples of the quotes whose codes were merged.

3:29 ¶ 21 in I3 – Automotive:

"So what we always trying to do is trying to umm do two, two-prong approach, one is to drive costs down. where we're trying to reduce the cost of what certain processes are taking within the business like for instance in the sense of there's extra overheads in the sense of people, they are focusing on the wrong tasks and taking up too much time and rather than going and spending and, how can I say, employing more people to do a specific function, we are trying to streamline that work into electronic workflows and so forth to ensure that we don't have to incur additional costs to support an inefficient process."

1:11 ¶ 23 in I1 - Food & Beverages:

"… we will have a whole lot of production lines on our within our environment, in our production environment, industrial environments in each of those will have what we call a PLC as I mentioned just now and they are some sort of communication between the machine and in our case the cloud or a server that's been installed there by a supplier that can give you, umm information on the fly about how the machine is, is, is working, what's it's output, what's it's downtimes and people are actually managing these machines and giving input into these machines at all the time during production."

12:15 ¶ 15 in I12 - Wood & Printing:

"Of course, we are now in the process of integrating machine data in terms of, you know, sort of operational performance management so that we understand clearly what conditions are our machines at any given point in time during the printing process so that we can be able to isolate whenever there was some deviations from the standard conditions were able to tell."

The next step after reducing codes through merging was to construct code categories within each group. Because the grouping had previously been done in accordance with the research question, the creation of categories followed the same procedure, allowing for the continuation of code reduction as codes with fewer quotations were merged with codes addressing the same meaning and concept. The conceptual framework led the general categories through an iterative process of shifting back and forth between groups, transferring some codes that were originally assigned to more than one group to a category and thus one group. After several rounds of this iterative process, the code categories were organised into themes and folders in accordance with the constructed conceptual framework. Eight code groupings remained, with 136 codes from the original 317 linked to 913 quotations.

The final outcome is represented in Table 9 below which shows the final code groupings.

Table 9: Final code groups

Coding Group	**Codes**
Internal Capabilities	22
Reasons to adopt	20
Adoption Considerations	19
Recent digitalisation	18
Required capabilities	15
Driving Role	5
Strategic model	4
Participant Information	3

Apart from the participant information folder, six themes emerged from the data analysis and coding, including the digitalisation description theme. This is in line with Bazeley (2013) who states that no more than 10 groupings of codes are sufficient to cover a study of moderate complexity.

9.7 Appendix 7: Consistency diagram