

CRANFIELD UNIVERSITY

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**Digital Transformation Framework for the Egyptian Manufacturing
Industry**

School of Aerospace, Transport, and Manufacturing (SATM)

PhD

Academic Year: 2019 - 2023

Supervisors: Prof. Essam Shehab and Dr Ahmed Al-Ashaab
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Abstract

Digital transformation is of crucial importance in the manufacturing industry, especially after the COVID-19 pandemic because of the increasing need for remote working and socially distanced workplaces. However, there is a lack of a clear and well-defined process to implement digital transformation in manufacturing. This research aims to develop an innovative framework to support digital transformation in the manufacturing sector and define its key assessment criteria for its successful implementation.

This research contributes to the body of literature by creating a prioritised DT implementation method that is specifically customised for the manufacturing industry in Egypt. Additionally, this study considers the majority of DT process implementation factors, including leadership support, human factors, and digital technologies. A mixed research methodology approach has been employed in this research. Firstly, an extensive literature review related to digital transformation in the manufacturing industry was conducted. Secondly, a mixed method techniques were implemented to gather the required data from experts who are involved in digital transformation projects in their companies. Validation of the results was carried out using real life industrial case studies and experts judgment.

The digital transformation process comprises eight stages covering technology, management, communications, and customer elements. The main contribution of this research work is the balance between the different elements of digital transformation – digital technologies, leadership and strategy, people and business processes – to create an integrated 8-step process of digital transformation in the manufacturing sector of developing economies such as the Egyptian economy.

A new readiness assessment model was developed to measure the degree of readiness of manufacturing organisations to begin and develop their digital transformation processes. The model uses two dimensions as assessment criteria namely, Business Competencies Dimension and Technology Competencies Dimension.

In addition, a proposed model of four main attributes and 19 sub-attributes was developed to determine the most important attributes regarding digital leadership given

the special nature of developing economies and cultural and environmental changes in the Egyptian economy. The results indicated that an innovation mindset is the most important attribute to becoming a successful digital leader, followed by a digital business mindset, then the transformational mindset, and finally the inspirational mindset.

Digital Transformation processes are unique and different from one case to another. Helping manufacturing organisations assess their readiness for Digital Transformation processes from a strategic level helps them better understand their capabilities and draw their vision based on this assessment.

Keywords

Digital Transformation, Manufacturing Industry, Digitalisation, Readiness Assessment, Digital Leadership

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6. Assel Yezhebay, Venera Sengirova, Dastan Igali, Yasser Omar Abdallah, Essam Shehab (2021) Digital Maturity and Readiness Model for Kazakhstan SMEs. In: 2021 *IEEE Smart Information Systems and Technologies (SIST)*, Nur-Sultan, Kazakhstan, 18-30 April, 2021.

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1 INTRODUCTION

1.1 Research Background

In today's exponential change towards digital technologies and the utilisation of these new tools in different fields and sectors, organisations will continually change how they do business to achieve their organisational goals (Bharadwaj et al., 2013). This change will affect not only the internal operations of firms but also the way they reach out to their customers and provide goods and services. The manufacturing industry, as one of the most critical sectors of the economy, is greatly affected by the digitalisation process as new technologies that can be used to enhance the productivity of firms continue to emerge.

In the manufacturing industry, digital transformation (DT) is critical to keeping any organisation sustain with the competition. The only way companies can attain sustainability within any competitive market is by transforming their business processes to respond to the demands of the digital world. From this stems the significance of digital transformation in existing businesses, which allows them to compete with native digital organisations that have emerged in the last 10-15 years (Aly,2020).

Given the fast pace of technological development, business processes are also needed to cope with this rapid change, especially in developing countries that lack research in this field. New organisations can also grow their businesses more rapidly due to their high degree of flexibility, their ability to respond to consumer needs, and the adoption of fast-paced technologies.

However, the adoption of new DT tools is faced with many challenges and constraints in both small and medium-sized enterprises (SMEs) and large corporations. These challenges may differ from industry to industry, and the degree of the same problems may also change across different sectors. This research will focus on the manufacturing industry and the challenges facing the digital transformation processes there.

The purpose of this chapter is to outline the fundamentals of this research. This includes introducing the research background and positioning the research in its context (the digital transformation of Egypt as one of the developing countries). A brief comparison between digital transformation efforts in developed and developing countries is presented. Next, a background on the digital transformation initiatives in Egypt is provided. Later, the research motivations and significance are discussed, the research question, aim, and objectives are addressed, and an overview of the thesis chapters is presented. An outline of Chapter 1 is illustrated in Figure 1-1.

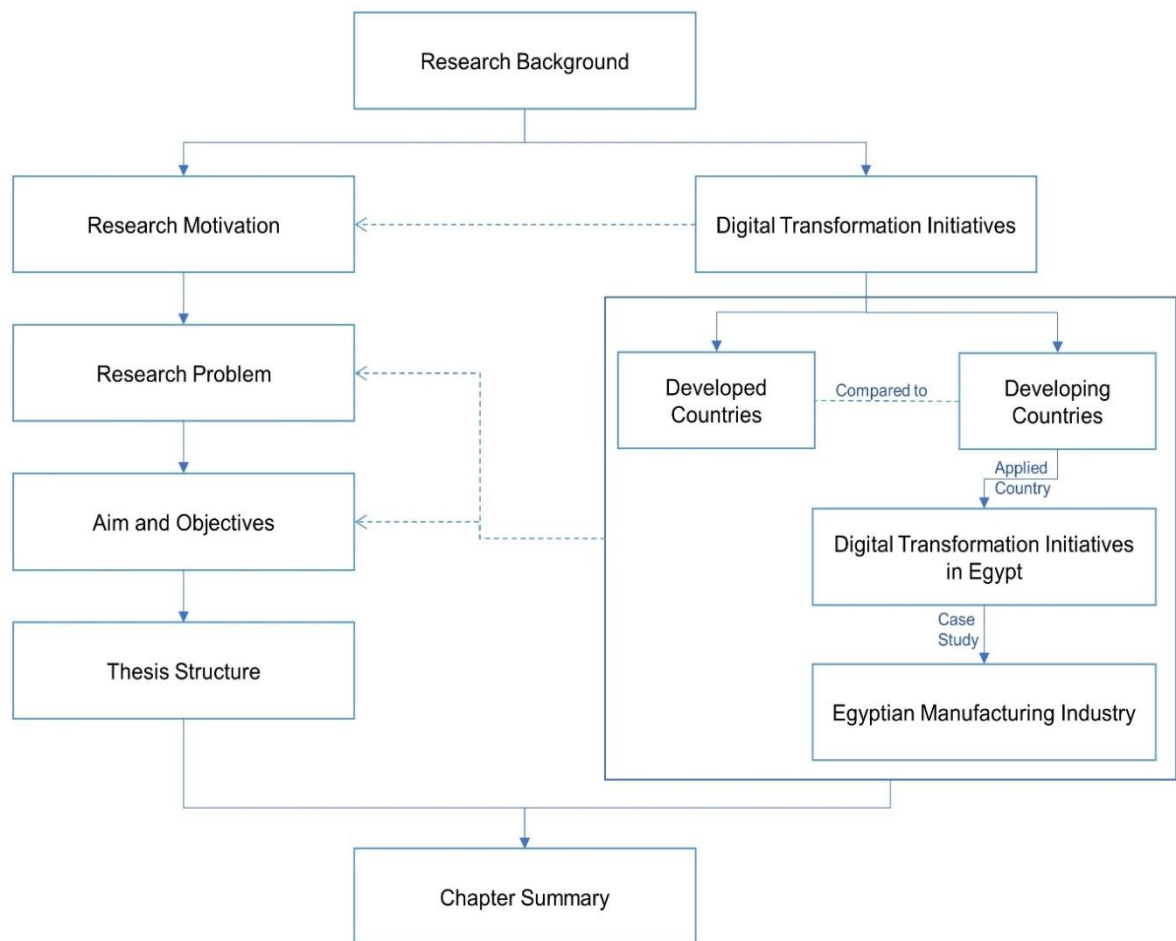


Figure 1-1: Outline of Chapter 1

1.2 Digital Transformation Experiences

As companies continue to gain an advanced understanding of the power of new technologies, they have come to learn that digitalisation is vital for business. The adoption of new technologies in various business areas has become a significant focus of most firms because of its immense potential to improve efficiency. However, many organisations are struggling to navigate the complex world of new technologies (Hitt, Keats, and DeMarie, 1998). There is always a heightened need for change, and the constant search for new models or organisational structures and cultures that can support the current digital technologies has made it more difficult for companies to gain a competitive edge with the new processes that the technologies are likely to bring about. Moreover, incorporating digital norms and habits into the manufacturing management system is crucial to successfully implement digital transformation (Criado, 2021). Digital culture, refers to the collective mindset, values, behaviours, and practices that shape how individuals and organisations interact with and utilise digital technologies in their daily lives, work, and decision-making processes. It encompasses attitudes, skills, and behaviours related to digital literacy, digital innovation, and the integration of digital technologies into various aspects of society, including business, education, government, and everyday life (Abdallah et.al. 2022). Even as they strive to realise more economic benefits with the current opportunities, the business world continues to become more competitive due to the current challenges being witnessed across the world (Greenhalgh et al., 2017).

Moreover, it is also not easy to introduce new changes in a business because the process requires resources, time, and employee readiness. Effective change models and leadership strategies are required to encourage employees to adapt to the new changes and use them to improve the productivity of their firms. Digital leadership, in refers to the skills, qualities, and behaviours that enable individuals and organisations to effectively navigate and harness the opportunities and challenges presented by the digital age. It encompasses the ability to lead and inspire others in leveraging digital technologies, data-driven decision-making, and digital transformation initiatives to drive innovation, competitiveness, and growth (Banks et.al. 2022).Studies have shown that

even with their vision, mission, goals, and strategies, some companies still find it challenging to develop effective plans to help them in the implementation of strategic initiatives (Kanter, 2003). Moreover, research shows that although businesses feel that new technologies necessitate the adoption of innovative ways of doing things, the reality is that many organisations still face a series of challenges trying to exploit the full benefits of the current digital tools to transform their business activities. Some of the challenges experienced by firms can be attributed to employees' resistance to change, lack of adequate skills and knowledge to implement and use new technologies, and insufficient leadership to lead change in some organisations (Andersson et al., 2018).

1.2.1 Digital Transformation: Developing Versus Developed Countries

Aly (2020) argues that digital technologies bring many opportunities that can help transform the world economy. However, there is a widespread feeling that not all regions or countries can fully benefit from the new technologies. While the new digital tools can lift some of the burden being experienced in the current competitive business world, the same capabilities can make work harder for other industry players. In some countries, digital transformation can function as an engine for spurring economic growth world economy. However, there is a widespread feeling that not all regions or countries can fully benefit from the new technologies.. Labour productivity is defined measure of the output or goods and services produced per unit of labour input during a given period of time. It is typically calculated as the ratio of total output to total labour input, and is used as a key indicator of economic performance and efficiency. Labour productivity is an important metric for businesses, industries, and economies, as it reflects how effectively labour is utilized to generate output (Guzmán et.al. 2020).

In some developing nations, the possible impact of new technologies may still be unknown. It may be subject to various factors, such as human and physical capital, the extent of development, and unemployment rates.

The developing world still has great potential for improving labour productivity by adopting new technologies. Many businesses in these nations can shift from old and

outdated technologies and activities to advanced techniques and methods such as artificial intelligence (AI), the internet of things (IoT), and agile methodologies to reduce the cost of operations and increase productivity. However, studies have shown that high technology adoption is always associated with a high Gross National Product (GNI), indicating that developing nations may remain behind the current developments. This is why developed nations are far ahead in digital transformation, as their effective utilisation of advanced technological tools continues to help them improve their economies because of increased labour productivity (Aly, 2020).

Depending on the level of development and resource availability, structural factors can influence digital transformation in a variety of ways. In nations with heterogeneous and undiversified production structures and socioeconomic constraints, as well as those with insecure and informal labour markets, a greater percentage of the population will be unable to exploit all the benefits of digital technologies. For example, nations in Latin America and the Caribbean still face several challenges in their efforts to increase their productivity and create more jobs through the adoption of new technologies and structural arrangements.

This is contrary to the developed world, which has heavily invested in digital technologies and used the same as tools for enhancing economic development through creating jobs and increasing labour productivity (Criado, 2021,). A good example of an economy that has significantly transformed its productivity is the Republic of Korea, which managed to realise a huge growth rate by incorporating technologies into its diverse sectors to enhance production activities. Taiwan also achieved tremendous results when it adopted a comprehensive plan to transform its economy beginning in the 1980s. These economies are some of the most vibrant ones in the world, especially in areas that involve the development of new gadgets that drive digital transformation (Wang and Tsai, 2010).

To conclude, digital transformation is a process that is occurring in countries around the world, both developed and developing. In developed countries, the adoption of new technologies such as the Internet of Things (IoT), artificial intelligence (AI), and robotics

is often more advanced, as these countries tend to have more established infrastructure and a higher level of technological development. As a result, the impact of digital transformation on industries in developed countries may be more pronounced.

In developing countries, the adoption of new technologies may be more limited due to a variety of factors, such as a lack of infrastructure, lower levels of education and training, and less access to capital. However, many developing countries are making significant efforts to accelerate the adoption of digital technologies in order to catch up with more developed countries and improve their competitiveness. In these countries, the impact of digital transformation may be less pronounced, but it is still likely to be significant over the long term.

1.2.2 Digital Transformation in Egypt

Egypt has reached a considerable level of digital transformation, though there are still areas that require significant improvements for the nation to realise its full potential in terms of economic growth. According to a report by the World Bank, digital transformation is one of the major drivers of Egypt's economy, as new digital tools have been adopted both in the public and private sectors. The report also indicates that the country can emerge as one of the leaders in digital transformation in the Middle East and North Africa (MENA) region if it continues on the same trajectory. Egypt has a high population and a large number of educated youths who can help it adopt digital technologies in various sectors of its economy. Today, various innovative technologies are being used in the manufacturing, commercial, agricultural, automotive, and textile sectors (World Bank, 2021).

The government is dedicated to reforming its ICT sector to spur economic growth across the country. Since 2016, the country has been focusing on expanding its internet connectivity, increasing electricity connections across the country, and ensuring sufficient gas supply to the people. These efforts have helped it increase new frontiers of development as it also seeks to build its human capital. Through its ICT Sustainable Development Strategy, the government seeks to ensure a robust digital economy to

enhance job creation and economic growth. Some of its goals are to become a regional digital hub, reduce the unemployment rate, and increase GDP growth. The effects of the COVID-19 pandemic also led to heightened activities in the area of ICT adoption in the country, as it made many industries and organisations realise the power of digitalisation in improving their communication and business processes. To help it fully utilise the new digital technologies, the country still needs to build a strong foundation for digital transformation and innovation (World Bank, 2021).

The government of Egypt has implemented a number of initiatives to support the digital transformation of the country's economy, including the manufacturing sector. Some of these initiatives include (Aboelmaged, 2018) :

1. **Egypt Vision 2030:** This is a long-term development plan that aims to transform Egypt into a leading regional and global player through the adoption of new technologies and the development of key sectors such as manufacturing.
2. **National Digital Transformation Plan:** This plan aims to accelerate the adoption of digital technologies across all sectors of the economy, including manufacturing. It includes a number of initiatives to improve digital infrastructure, promote innovation and entrepreneurship, and build digital skills.
3. **Egypt ICT Trust Fund:** This fund provides financing and support for projects that aim to promote the adoption of digital technologies in Egypt. It has supported a number of initiatives in the manufacturing sector, including the development of IoT-enabled solutions and the adoption of robotics and automation.
4. **Industrial Modernization Center:** This centre provides support to small and medium-sized enterprises (SMEs) in the manufacturing sector, including training and consulting services to help them adopt new technologies and improve their competitiveness.

Overall, these initiatives aim to support the digital transformation of the manufacturing sector in Egypt and help the country's manufacturers become more productive and competitive in the global marketplace.

1.3 Manufacturing Industry in Egypt

The manufacturing industry in Egypt plays a significant role in the country's economy. It is a major contributor to the country's GDP and employs a significant portion of the labour force. The industry is diverse and includes the production of a wide range of products such as textiles, clothing, food products, chemicals, pharmaceuticals, and engineering goods. The industry has experienced significant growth in recent years, driven by increasing domestic and foreign demand, improved infrastructure, and a favourable investment climate. The government has also implemented a number of initiatives to support the growth of the manufacturing sector, including investments in technology, education, and training.

According to the World Bank, the manufacturing sector accounted for around 16% of Egypt's GDP in 2019. This is down slightly from a peak of around 18% in 2014. However, the sector remains a significant contributor to the country's economy and a major source of employment. As shown in Figure 1-2, it is possible for the manufacturing sector to increase its percentage of GDP in Egypt through a combination of economic growth and an increase in the relative size of the manufacturing sector. Economic growth can be achieved through a variety of factors, such as an increase in domestic and foreign demand, improved infrastructure, and a favourable investment climate. This can lead to an overall increase in GDP, with the manufacturing sector potentially benefiting if it grows at a faster rate than other sectors of the economy. The government has made the development of the manufacturing sector a priority and has implemented.

a number of initiatives to support its growth. These efforts have helped to attract foreign investment and improve the competitiveness of the industry (world bank, 2021).

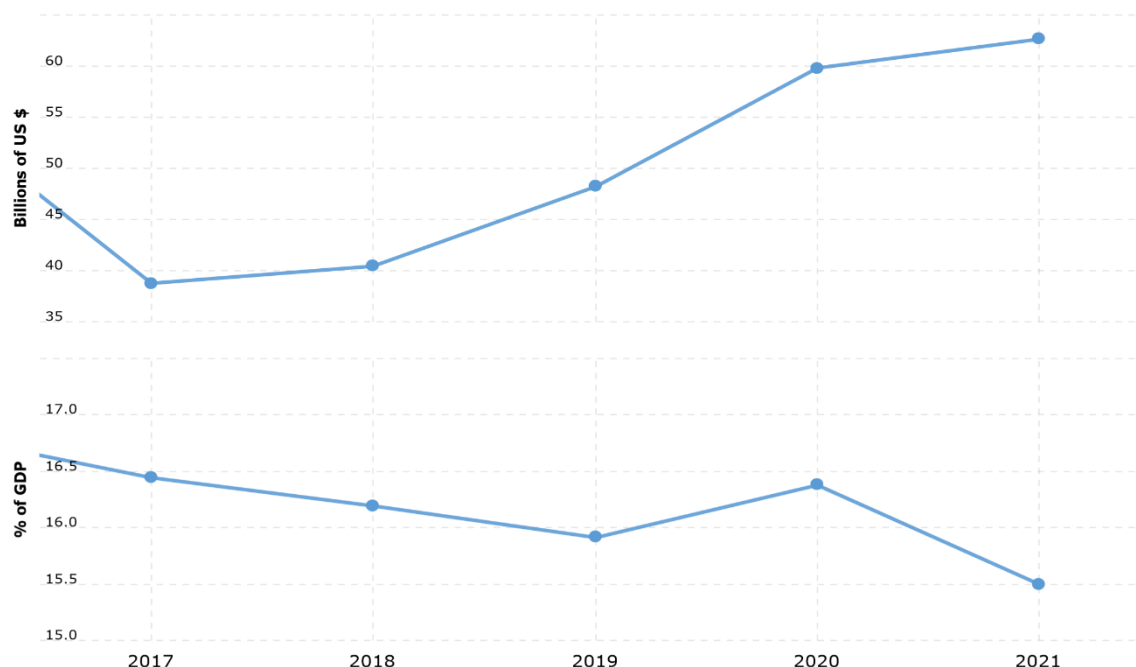


Figure 1-2: Manufacturing Industry as a percentage of the GDP of Egypt

Like many countries, the Egyptian manufacturing industry is undergoing a process of digital transformation with the adoption of new technologies such as the Internet of Things (IoT), artificial intelligence (AI), and robotics. These technologies are being used to improve efficiency, reduce costs, and enhance the quality of products. For example, IoT-enabled sensors can be used to monitor production processes in real-time and identify areas for improvement, while AI can be used to analyse data and identify trends. Additionally, robotics and automation are being used to improve the accuracy and speed of manufacturing processes.

The Egyptian Government has recognised the importance of digital transformation and has implemented a number of initiatives to support the adoption of new technologies in the manufacturing sector. These efforts include investments in infrastructure, training programs, and initiatives to promote innovation and entrepreneurship. The aim is to help

the country's manufacturing industry become more competitive and better positioned to meet the demands of the modern global economy.

1.4 Research Motivation

Digital Transformation is of crucial importance for the manufacturing industry in developing economies, specially after Covid-19 pandemic and its effect of the manufacturing operations. There is a need to develop a clear and well-defined process to successfully implement digital transformation in the whole ecosystem (Vial,2019). Although academic research has placed significant emphasis on DT in recent years, there is controversy surrounding the term's definition, context, and problems, particularly in the manufacturing industry. There is no widely agreed-upon definition of DT; in addition, writers who attempt to describe it often represent the authors' backgrounds and perspectives (e.g., financial sector and government domain). Furthermore, no adequate literature review has been conducted to address this idea in the manufacturing industry or elucidate how manufacturing organisations assess their needs and capabilities to begin this transformation journey (Mokhtar et al., 2020; Mahmoud et al., 2018).

This study will try to fill this gap by developing a systematic literature review for digital transformation across the manufacturing industry. The present research will also propose a DT Readiness Assessment model for manufacturing companies to help them identify their readiness levels and provide the steps to be followed to continue improving their DT processes. Finally, this study will provide a framework to implement digital transformation successfully inside manufacturing organisations with the right tools to measure the readiness of the organisation at each stage of the digital transformation process.

1.5 Research Problem

Transforming the manufacturing sector digitally comes with lots of benefits and opportunities. However, the concept of digital transformation means different things to different people, which has significantly affected its level of acceptance and

implementation (Santos et al. 2020). The concept of digital transformation is complex, with different requirements for different companies, a lack of defined ways of performing, and results that differ from each other (Kane, 2019).

Manavalan et al. (2019) state that very few companies have attempted the implementation process, while the rest of the companies still need to be ready for the transformation. Inadequate planning, inappropriate strategy, and many other factors are responsible for the unsuccessful implementation of digital transformation in certain companies (Schuh et al., 2017). Yildirim & Demirbag (2020), however, add that the absence of research indicating current happenings with regard to digital transformation could be seen as a significant factor that has contributed to companies' unreadiness to implement DT. Manavalan et al. (2019) claim that digital transformation is gradually becoming a reality despite these challenges.

Despite these setbacks, the need to have a digitally transformed company remains a significant prerequisite for companies that will be able to handle the rise in competition, changes in customer demand, and the need for better quality (Yildirim & Demirbag, 2020). Products must be manufactured within the shortest possible time (lead time reduction) and delivery time reduced while ensuring that costs are minimized and quality is not compromised. It has become paramount that all companies intending to remain relevant in the market in the near future go with the trend by ensuring that they are part of the transformation (Zheng, 2020). Failure to move with the digital transformation trend can cause a company to lose its relevance in the near future (Zapata et al., 2020; Bechtold et al., 2014).

A primary reason for moving with the current digital transformation trend is that most companies lack sufficient knowledge regarding these technologies, their modus operandi, the capital required for investment, and technical skills (Schuh et al. 2014). Sanders et al. (2016) added that the cost of investing in digital technologies is also a major factor influencing the extent to which firms implement digital technologies. Schuh et al. (2014), however, argue that more than just investment in technology is needed.

Still, there must be an effort to understand how it works, which has led to failure in implementation and frustration, with some companies wondering if it is worth it.

Efforts have been made to develop readiness frameworks and maturity models to ensure the successful implementation of digital transformation in manufacturing companies (De Carolis et al., 2017; Santos and Martinho, 2020). However, when it comes to the factors that affect digital transformation in manufacturing companies, there is a lot that still needs to be done. Digital transformation still lacks defined methods of implementation, and practitioners are yet to experience massive progress in their journey. It lacks rules and definite methods of handling the transition to producing results (Kane, 2019). In this research, the author will carefully distinguish and evaluate the numerous factors that affect digital transformation within the manufacturing industry for easy identification of all elements available in the literature and establish the connection between them, which will benefit researchers, practitioners, related stakeholders, and management within the manufacturing industry.

1.6 Research Questions, Aim, and Objectives

1.6.1 Research Questions

The main research question is:

"How can the manufacturing industry in a developing economy characteristics assess, develop, and implement a successful digital transformation process?"

This research question has three main sub-questions, as shown in Figures 1–3, as follows:

RQ1: What are the main challenges to the successful implementation of the digital transformation process in the manufacturing industry in Egypt?

RQ2: What is the connection between technology and business aspects to achieve successful digital transformation in the manufacturing industry in Egypt?

RQ3: What is the role of digital leadership in the manufacturing industry for productive digital transformation?

Figure 1-3 shows the main research questions and how the research objectives are linked to the sub-questions and the main aim of the research.

1.6.2 Research Aims and Objectives

This research aims to:

To develop an innovative framework and define its key assessment criteria and process to support the successful implementation of digital transformation in the Egyptian manufacturing sector,

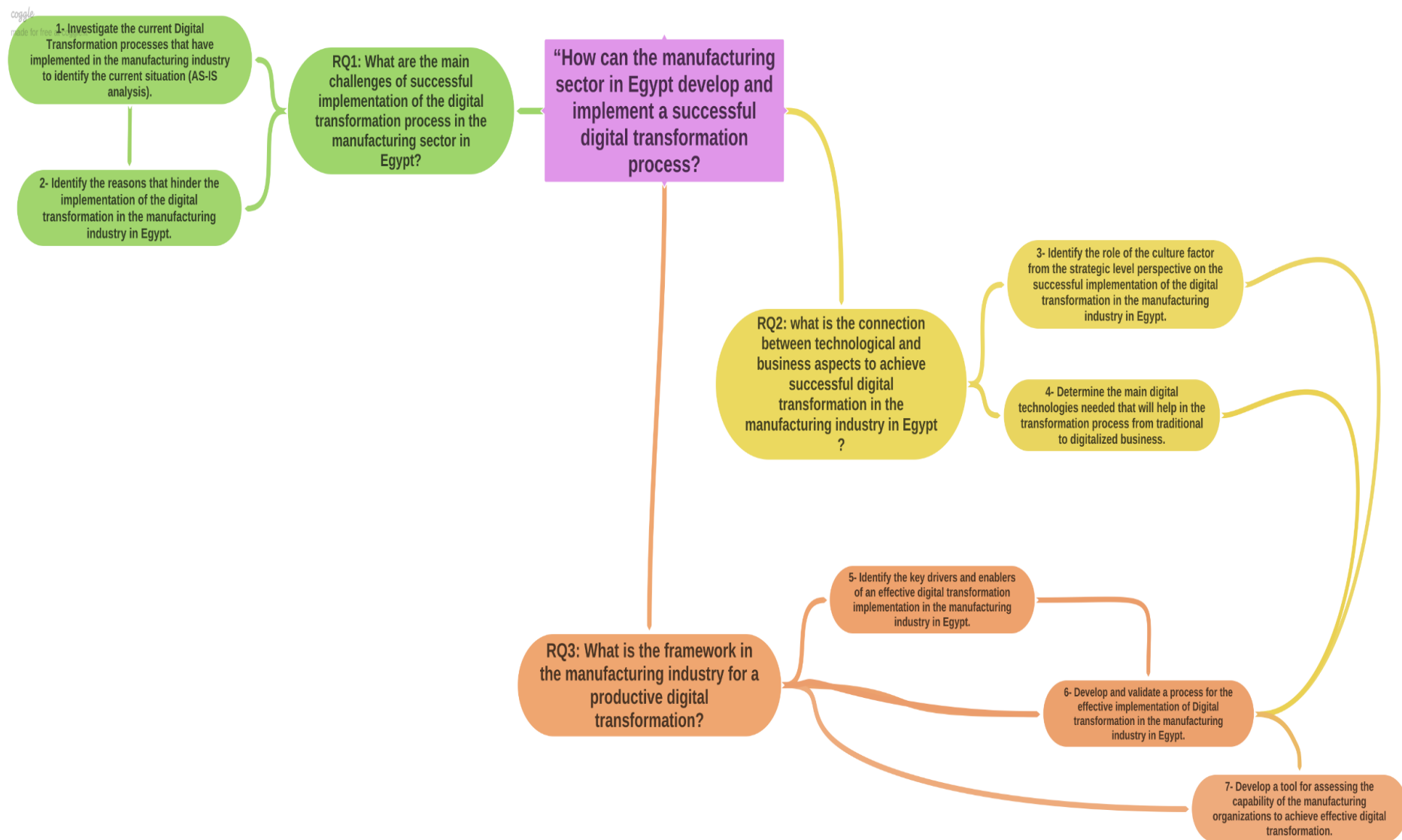


Figure 1-3 Research Mapping

The main research objectives are to:

1. Analyse and capture the good practices of the current digital transformation processes via an extensive literature review.
2. Capture the industrial perspectives of digital transformation processes and their implementation challenges via field study (online survey).
3. Study and analyse the current digital transformation needs, challenges, and enablers in the Egyptian manufacturing sector.
4. Develop an assessment tool to measure the readiness of the manufacturing organisation to implement digital transformation processes.
5. Develop an innovative process to support digital transformation in the manufacturing sector.
6. Identify the key digital leadership attributes that can foster successful implementation of digital transformation in the manufacturing industry.
7. Validate the framework via a case study in the Egyptian manufacturing company and to experts judgment.

1.7 Thesis Structure

The thesis is divided into eight chapters as presented in Figure 1-4. Chapter 1 outlines the fundamental research issue. Research background, motivation, scope and aim and objectives of this study are clearly mentioned in this chapter. In Chapter 2, a structured account of existing literature is critically analysed. Chapter 3 presents the research methodology developed to achieve the research aim and objectives. An analysis of the possible approaches and strategies to design this research was carried out, and the justification of the methodology selected is presented. Chapters 4,5, and 6 presents the findings of this research which are Digital Transformation Implementation Process, Digital Transformation Readiness Assessment Model, and Digital Leadership Attributes Model. Chapter 7 outlines data validation methods and techniques. Chapter 8 the work

of this thesis is synthesised and the implications of the research findings are discussed. The main research contributions are stated, along with the limitations and the future research directions.

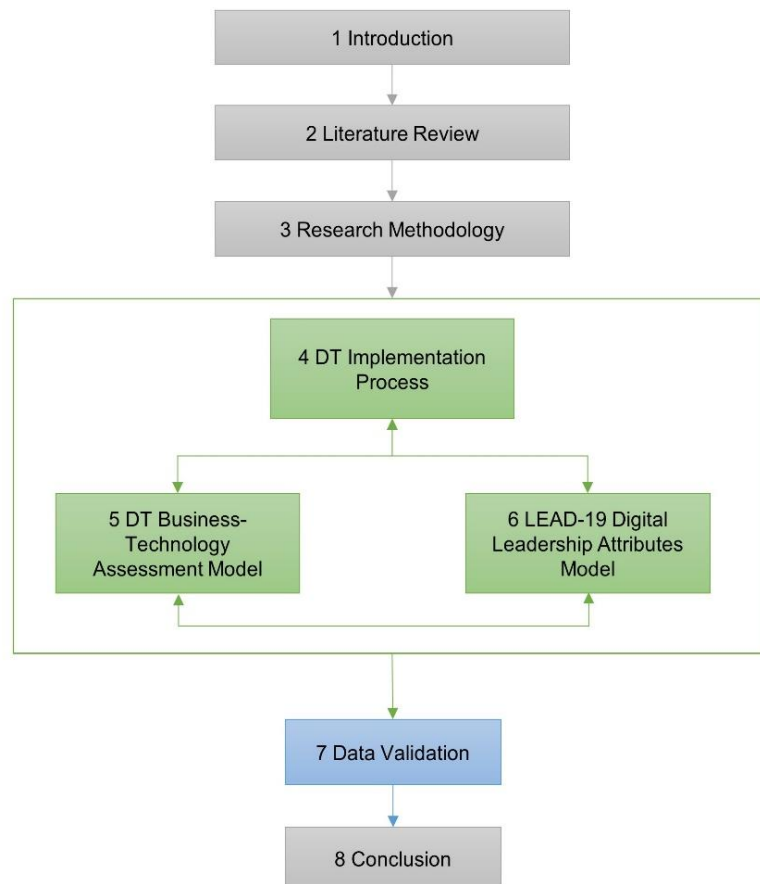


Figure 1-4 Thesis Structure

1.8 Chapter Summary

This chapter has provided an overview of the description of digital transformation in the manufacturing sector. It highlights the importance of digital transformation as well as the differences in how the concept is defined. It has also highlighted DT processes in developed versus developing countries. In addition, the research aim and objectives are stated, and the likely challenges in implementing digital transformation in developing countries are also highlighted. The immediate chapter of this study will highlight relevant literature reviews.

2 LITERATURE REVIEW

2.1 Introduction

In chapter 1, the fundamental research issues have been outlined: the research context has been introduced, and the research aim, questions, and objectives have been specified. This chapter examines the existing literature associated with the context and research areas related to digital transformation (DT).

A review of prior, relevant literature is an essential feature of academic research and serves a vital scientific function (Easterby-Smith et al., 2002; Baumeister & Leary, 1997). An adequate review creates a firm foundation for advancing knowledge. It facilitates theory development, closes areas where an excess of research exists, and uncovers areas where research is needed (Webster & Watson, 2002).

This chapter is organised as seen in Figure 2-1. The chapter aims to ensure a better understanding of the state of the art in the areas of digital transformation in the manufacturing industry and any existing research gaps. Section 2.2 focuses on the development of the concept through time. Section 2.3 will focus on the definition of digital transformation in the manufacturing industry. Section 2.4 will discuss the challenges faced by the manufacturing industry in the process of implementing digital transformation successfully.

Section 2.5 will highlight the key benefits of implementing digital transformation in the manufacturing industry and the whole ecosystem. Section 2.6 will discuss how DT can affect the entire ecosystem. Section 2.7 discusses the key enabling technologies of digital transformation in the manufacturing industry. Sections 2.8 will mention the role of digital culture as an enabler in DT processes. Section 2.9 focuses on the key digital leadership attributes that can foster DT process. Section 2.10 shows the current readiness models for implementing digital transformation in the manufacturing sector. Section 2.11 will discuss the DT conceptual framework developed from the literature

review study. Finally, Section 2.12 will present the research gap and section 2.13 provides a chapter summary.

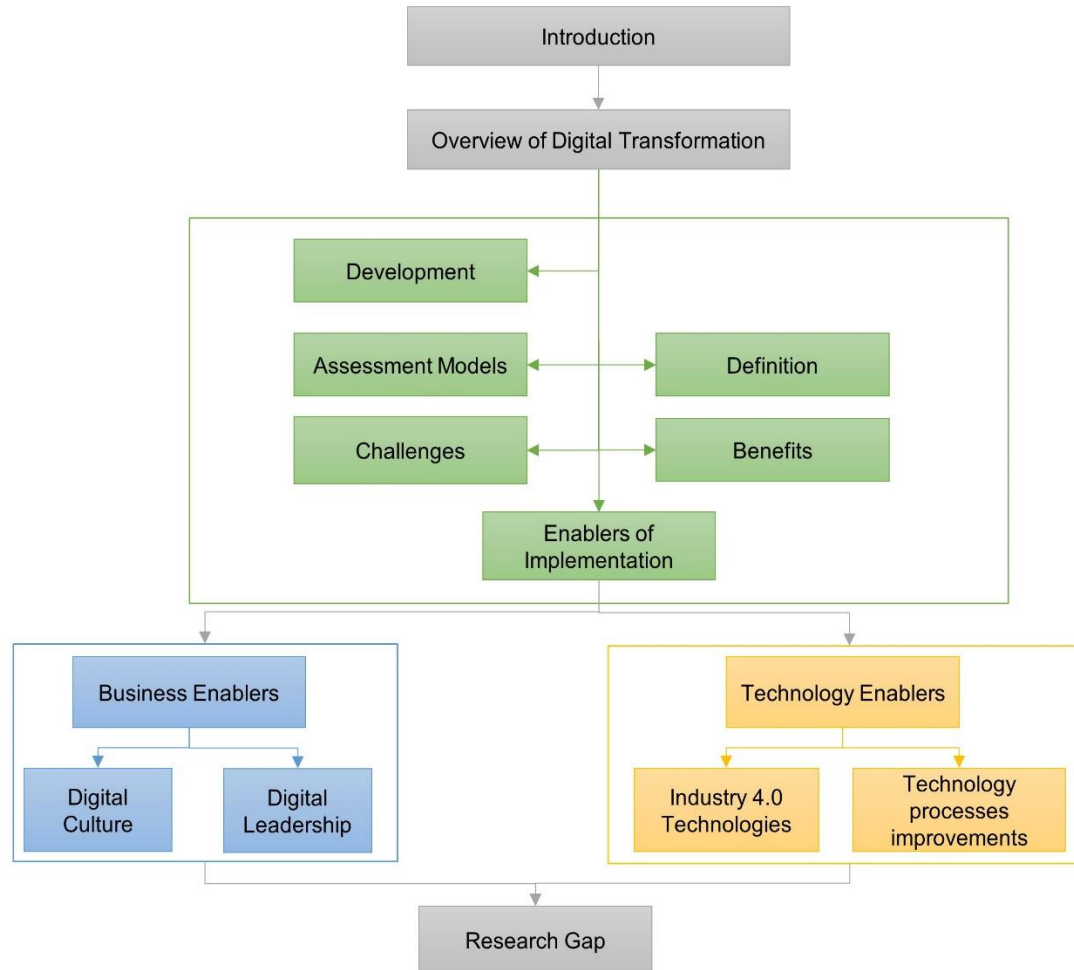


Figure 2-1 Chapter Outline

2.2 Development of the DT Concept

To begin, a search on online databases about “Digital Transformation” only has been initiated. This search gave a quite understanding about how this term is searched in different fields like Information Systems, Healthcare, Management, Manufacturing. The number of findings in these resources showed considerable interest in this concept, especially in the last few years in all varied disciplines.

This research is focused on sources from manufacturing literature to maintain a certain degree of consistency with regards to the specific topics of interest while ensuring that the research sample size would remain considerable. WoS (Web of Science), EBESCO (business source complete), ScienceDirect, and Scopus had been chosen to filter the research. WoS has the leading journals in the digital manufacturing theme. Business source complete had been investigated to add other journals that are not focused on manufacturing but have journals that talk about Digital Transformation from a business perspective. ScienceDirect and Scopus for validation and ensuring that every journal that is not in WoS or EBESCO will be considered into the research.

Criteria for exclusion included: works in progress; panel introductions; sources not available in English; unavailable full papers; papers before 2005. This study's time frame is to address Digital Transformation in the present and future direction. In the initial search, papers from the '80s and '90s that talk about Digital Transformation had been found but from old or obsolete technology. Therefore, to make the research more reliable, papers that age 15 years old or less were selected. Moreover, papers that are not related to the manufacturing industry had been excluded to keep this field's scope. The reason for this that Digital Transformation has different meanings according to the sector it is applied in.

For example, Digital Transformation in the banking sector has a different perspective and more service-focused than when applying the same concept in the manufacturing industry. From the initial search, there are interchangeable words with Digital Transformation like Digital Disruption or Digitalisation of Manufacturing had been noticed (Peillon & Dubruc, 2019; Tolkachev et al., 2020; Zangiacomi et al., 2020), so

these words had been identified that could be linked to Digital Transformation like Digital disruption, Digitalisation and Industry 4.0. The outlined research databases then searched using a combination of these keywords. The list then refined to remove duplicates, and the titles were checked to ensure the paper's consistency with this review. Then the abstracts also checked to before selecting the publication for a full review.

The term 'Digital Transformation' has evolved through time. In the '70s and '80s, it was used to refer to the use of computing technologies inside manufacturing firms. Now, it has a different and more generic definition. As shown in Figure 2-2, the development of this term has passed through three main steps in the research literature as follows:

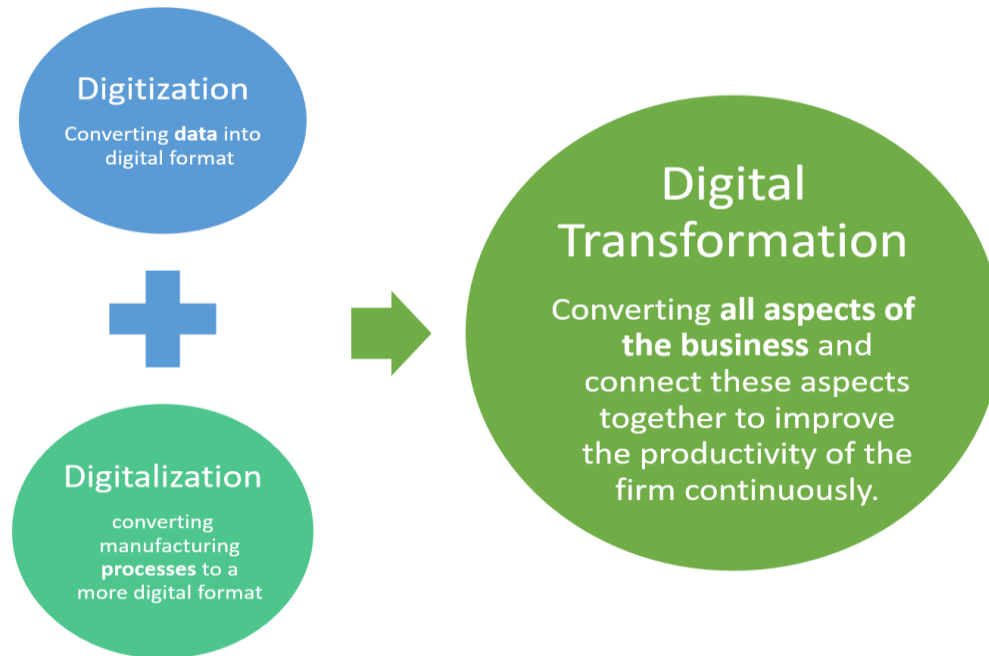


Figure 2-2 The Evolution of DT (Abdallah et al., 2021)

2.2.1 Digitisation

The oldest term in this area is digitisation. According to the Gartner IT glossary, it refers to "the conversion of analogue or physical information to a digital format" (Zangiacomi et al., 2020, p.143). This definition shows that digitisation is like converting a paper instruction manual into a digital format. This process is the simplest way of

transformation. It is just transforming the data from a paper-based into a more electronic-based format. When converting the process and the information, here comes the role of Digitalisation (Nwankpa & Roumani, 2016).

2.2.2 Digitalisation

Both digitalisation and digitisation are relative terms, and most of the existing literature has used them interchangeably. However, it is better to see them as a development of one from the other. Digitalisation could be defined as "the way in which many domains of social life are restructured around digital communication and media infrastructures" (Brennen & Kreiss, 2016). This change happens when transforming the business processes into a more digital format. For example, using smart glasses to provide mechanics with a line of sight, digital instructions can improve efficiency and reduce errors.

2.2.3 Digital Transformation

As stated earlier, the concept is not about technology, like the previous two concepts. It is about business processes, management styles, organisational culture, corporate strategy, and, most importantly, linking all of these together using digital technologies (Ismagilova et al., 2019). The goal of this is to bring meaningful outcomes to the organisation. Integrating different digitalisation initiatives, such as augmented reality guided instructions and 3D printed tools with Internet of Things-enabled sensors, can result in the fundamental transformation of the manufacturing process (Borangiu et al., 2019). Thus, it can be concluded that both digitisation and digitalisation lead to digital transformation (Kutzner et al., 2018, p. 56; Zangiacomi et al., 2020).

Digital transformation has a long history, as it began in the late 1970s. At this time, computer-aided design and manufacturing were introduced and used for the very first time in business-related operations and processes. The introduction of enterprise resource planning followed DT during the 1980s and CRM during the early 1990s. By digitising all manual processes, DT increased business efficiency and productivity. During the late 1990s, there was a rise in e-commerce and online banking (Phung, 2022

Abad-Segura et al., 2020). However, in the past, banking was only done offline but moved online later after the invention of DT. It has become possible due to the fastest internet delivery in some countries. Social media was introduced during the 2000s, and social media has revolutionized ways of communicating (connecting with customers) in business. Companies began using communication channels to interact with customers. This happened due to the emergence of digital processes that supported customer interactions. Companies all over the world, in both developed and developing countries, have moved to digital tools for their business growth (Phung, 2022). Organisations all over the globe realised that they needed digital teams to manage social media, mobile channels, and other digital technologies for business.

The research has developed a brief history related to the evolution of DT in business. DT made it possible for companies worldwide to remain competitive in the marketplace. Everything has moved to digital form in the modern world of globalisation. Manufacturing companies do their promotions and advertising through different social media channels. This shift has become possible because of changes in technology, demographics, and the workplace itself. DT is influencing every aspect of the business (Phung, 2022). It is affecting communication and influencing how we learn and innovate. Therefore, organisations are continuing to embrace DT and making various business changes.

The study by Reis et al. (2018) found that developing countries such as Egypt are continuously making efforts to enhance their DT processes. The Egyptian government has promoted and developed an effective infrastructure to allow for the adoption of communication and IT tools (Oxford Business Group, 2022). Because of the new DT processes, everything is now possible. Similarly, governments in developed countries such as the United Kingdom and the United States have made significant efforts to innovate business through DT activities. Research has determined that IT specialists who have received their diplomas from the UK are in high demand (Vioreanu, 2022).

The digital transformation process is continuously shaping the way we work. On the other hand, a rise in the use of cloud-based applications has made it possible and easier to share information while connecting with one another through various platforms. The world is, therefore, more connected due to DT.

2.3 Digital Transformation Definition

According to the existing literature, only a few articles have focused on defining digital transformation, especially studies concentrating on manufacturing. This literature review also found an overlap between defining digital transformation and other related terms, for example, industry 4.0 or digital disruption.

Digital transformation is a process that takes place through various activities and progresses with time in different stages. A fruitful digital transformation ought to have an expanded measure of significant worth for the firm and its clients. Also, it is argued that while exploring digital transformation, one will examine change processes, including digitisation and digitalisation. These can be perceived as issues and critical ideas of the digital transformation.

Parviainen et al. (2017) defined "digital transformation" as the changes in activities, roles, and business offerings caused by implementing digital technologies in organisations. Here, digital transformation is the consequence of implementing digital technologies and refers to changes taking place on multiple levels, including organisational processes, the business industry, and society. Digital transformation is referred to as the adoption of digital tools to streamline operations and reduce the workload. It should allow the creation of new service and product offerings, make certain practices obsolete, and improve how existing offerings are provided. It should lead to changes in roles, value chains, and ecosystems, affecting the firm and the levels of the industrial network. On a societal level, digital transformation could change social structures, affect professions, make specific work obsolete, and influence new policy decisions. Digital transformation may affect multiple areas of business, including the use

of information technology, strategy and business models, products and services, internal and external processes, organisation, and company culture.

Henriette et al. (2015) portrayed digital transformation as a cycle driven by changes connected with the execution of advanced technologies in all parts of society. These authors' perspective on progressive change is vast and takes into account many issues, including technological abilities, digitisation, web innovations, information systems, versatility, interpersonal organisations, advanced information, and human skills. Digital transformation significantly affects business operations (Henriette et al., 2015). Firms undertaking digital transformation execute digital transformation projects, which the authors characterize as the "carrying out of advanced capacities to help plan action changes that influence whole organisations, particularly functional cycles and assets, inside and outside clients" (Henriette et al., 2015). The digital transformation process does not simply occur; it is something firms do and concerns all parts of their organisations.

Westerman et al. (2014) defined digital transformation as "the use of innovation to significantly improve the execution or reach of ventures." This progressive change suggests effectively executing technological abilities, innovations, authority capacities, vision, systems, and objectives arranged towards digital transformation. They named "advanced ACE" firms that effectively and carefully changed. These organisations have seized "huge advantages," implying that a digital transformation quantifiably affects a company's economy.

According to the study by Fletcher and Griffiths (2020), organisations in developed countries are rapidly adopting DT for better employee engagement and business-related processes. DT is serving the workforce and customers and improving a business's ability to compete internationally. Digital transformation includes the examination and reinvention of ideas and facts within an organisation. Organisations that succeed in implementing and adopting DT reap huge business benefits. They include popular multinational organisations such as Tesco, Tesla, Sainsbury, Walmart,

Amazon, Apple, HSBC and Unilever. DT has allowed the fulfilment of customer demands because it builds the infrastructure and skills necessary for the successful implementation of digital tools.

These aspects are significant in understanding that a digital transformation is certainly not a straightforward process and that firms can accomplish this process in various ways. Besides, digital transformation is not appropriate for all firms, including advanced innovation firms that have become technologically experienced. It should instead be preserved for firms changing their DNA to cope with the new digital world. A summary of the definitions found in the literature is summarised in Table 2-1.

Table 2-1 Definitions of DT (Abdallah et al.,2021)

Definition	Author
The use of new digital technologies in order to enable significant business improvements in operations and markets, such as enhancing customer experience, streamlining operations or creating new business models	Paavola et al. (2017)
Fundamental alterations in existing and the creation of new business models [...] in response to the diffusion of digital technologies such as cloud computing, mobile Internet, social media, and big data.	Remane et al. (2017)
Digital transformation is an organisational shift to big data, analytics, cloud, mobile and social media platforms. Whereas organisations are continually transforming and evolving in response to changing business landscape, digital transformation is the changes built on the foundation of digital technologies, ushering unique changes in business operations, business processes and value creation.	Nwankpa and Roumani (2016)
Digital transformation is the profound and accelerating	Demirkan et al.

transformation of business activities, processes, competencies, and models to fully leverage the changes and opportunities brought by digital technologies and their impact across society in a strategic and prioritised way.	(2016)
Digital transformation strategy is a blueprint that supports companies in governing the transformations that arise owing to the integration of digital technologies, as well as in their operations after a transformation.	Matt et al. (2015)
DIGITAL TRANSFORMATION (DX) is about adopting disruptive technologies to increase productivity, value creation, and social welfare.	Ebert C et al. (2018)
Digital transformation is a technology-induced change on many levels in the organisation that includes both the exploitation of digital technologies to improve existing processes and the exploration of digital innovation, which can potentially transform the business model	Berghaus and Back (2016)
A process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies	Vial G. (2019)

There are different ways of looking at digital transformation. One author defines it as a strategy, another as a process, and the third defines it as a disruptive element. This variation comes from the ambiguity of the term so far. So, there is no clarity about what digital transformation is (Castelo-Branco et al., 2019; Hartley & Sawaya, 2019; Kolla et al., 2019; Tokody, 2018; Vial, 2019; Zangiacomi et al., 2020). Most of the authors use the term "digital technologies" in their definition, which means that technology is a crucial element of digital transformation in any industry, specifically the manufacturing industry (Cachada et al., 2019; Dombrowski & Fochler, 2018; Lee et al., 2011; Mittal et al., 2019). There are unclear terms, such as "social welfare," or specific examples that weaken the definition. Moreover, there is some circularity in the definition, for example,

using the word "transformation" (Ananyin et al., 2018; Cimini et al., 2017; Ismagilova et al., 2019).

From the analysis of the concept and after reviewing these definitions, a conceptual definition of digital transformation has been constructed with a focus on the manufacturing industry as follows:

Digital Transformation (DT) is a customer-centric mechanism that enables continuous improvement in the productivity of the manufacturing processes using advanced digital technologies such as cloud computing, the Internet of Things, big data analytics, the digital twin, and artificial intelligence in all aspects of the organisation.

From this proposed definition, the following critical elements of this definition are illustrated as follows:

Customer-centric element

Most of the previous definitions neglected the voice of the customer when talking about transformation processes. However, listening to the customer is very crucial in formulating an organisation's digital transformation process to ensure that it will increase customer satisfaction and, hence, profitability (Dombrowski & Fochler, 2018; Horvath et al., 2018; Laird, 2017).

Continuity element

Digital transformation is a process that never ends. As long as more technologies evolve and arise over time, manufacturing organisations must continually transform their business processes to cope with this technological advancement (Chryssolouris et al., 2009b; Heikkila et al., 2016; Tokody, 2018). It is not one-time planning and implementation, and manufacturing firms must understand that element to remain competitive.

Digital technologies element

The technology element in digital transformation is crucial and selecting the most appropriate digital technologies that will adapt to the manufacturing theme is very critical to the success of the digital transformation process, given the cost of these technologies and the uncertainties surrounding them (Ananyin et al., 2018).

The organisation element

The digital transformation process will only succeed when it is embedded into all aspects of the organisation. DT requires the integration of digital technologies into all aspects of the organisation to ensure that the human factor in the firm makes the best use of digital technologies to improve the productivity of manufacturing processes (Ananyin et al., 2018; Cimini et al., 2017; Demirkan et al., 2016; Rojo Abollado et al., 2017; Schallmo et al., 2017).

2.4 Digital Transformation Challenges

Undoubtedly, most manufacturing companies are trying to adopt and operate digital transformation processes in their various departments because digital transformation is significant in scale. Moreover, it is impossible to escape the digital world if a company wants to compete fairly with others in the market.

Many businesses are responding to this phenomenon by launching numerous innovation and change initiatives, such as design thinking workshops and hackathons. However, the impact of these initiatives is far beyond the expected results.

Digital transformation is about technology and creating a dynamic framework for all aspects of the organisation, including structure, workforce, and culture, to cope with these changes. Digital transformation is a very vibrant and vastly changing process. According to the KPMG CIO survey report from 2017, less than one in five attempts at digital transformation succeeded. Moreover, only 18% of the 70 companies surveyed in the report have a competent digital transformation process (Fernández-Rovira et.al. 2021).

Significant challenges for digital transformation processes have been classified into four main categories: *skills gaps, adoption of new technologies, change management processes, and innovation policies and procedures* ((Fernández-Rovira et.al. 2021, Yu et.al.2020, Bai et.al. 2020) .

As Figure 2-3 shows, these four challenges have many subsequent problems. In addition to that, they are interconnected and affect each other. For example, if the organisation enhances human resource skills within it, this will help it adopt new technologies and make change more efficient and effective.

2.4.1 Skills Gap

There is an apparent skills gap between the manufacturing organisations' digital skills and how they want to keep up with the digital pace. According to the SAP report for 2018, there is, on average, a 20%–40% skills gap between what is needed and what is available (Osterrieder et.al. 2020). Moreover, in a recent study by the Technical University Munich (TUM), 64% of companies surveyed said they did not have the people with the skills necessary for digital transformation (Yu et.al. 2020). This portion was allocated to technologies such as artificial intelligence, cloud computing, big data analytics, the internet of things, and business networks.

Digital skills have become necessary to implement digital transformation successfully, and the need for these skills will increase in the upcoming years. Unfortunately, employers do not provide sufficient resources to train their employees. As more technologies develop and evolve in the manufacturing sector, employees need more training and capacity-building programs to acquire the necessary skills to cope with these technologies (Llopis-Albert, 2021).

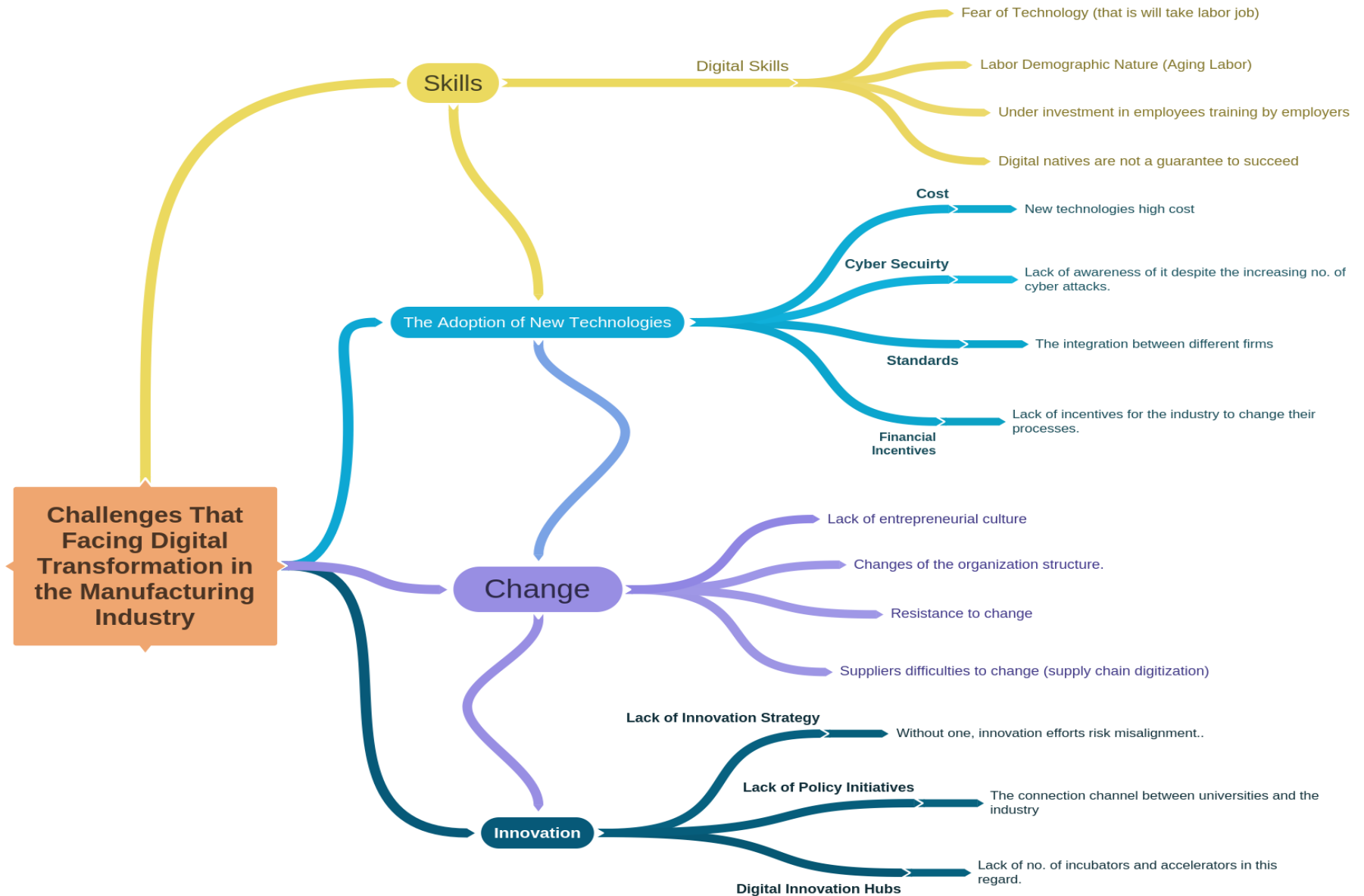


Figure 2-3 Challenges of DT in the Manufacturing Industry (Abdallah et al.,2021)

Another challenge in this regard is the fear of technology. Employees fear technology because they feel that it will replace their jobs. Nobody wants to lose their position in favour of technology or have a robot replace them. This mindset needs to be changed. Technology will not do away with jobs, but it will reshape them, create more opportunities to innovate, and make efficient use of these technologies to become more productive and creative (Benitez, 2020).

Moreover, the labour force became older over time. The total labour supply in the EU among those aged 20 to 64 is expected to fall by 9.6% over the next twenty years, according to the 2018 ageing population report. On the other hand, digital natives' young labour is not always a guarantee of success (Bai, 2020). They may be right in their knowledge of technology but not in its application in various manufacturing processes and functions. Learning should be passed down from generation to generation and vice versa. The older generation learns the technical skills of the digital world, while the younger generation understands the business applications of these digitalised technologies.

The digital transformation needs a team that can perform multiple tasks quickly and flexibly. Manufacturing organisations still need to gain enough knowledge about the concept of agile teamwork, as it requires much training on different skills and organisational structures.

2.4.2 Adoption of New Technologies

The adoption of new technologies requires a risk-taking culture inside the organisation. This high risk process comes from the increased initial investment and long-term returns involved. This type of culture is called entrepreneurial culture. Manufacturing firms lack awareness of this culture because businesses, in general, are risk averse. They tend to invest in low-risk projects with short-term returns (Gölzer, 2017). This risk aversion is shown in the Made Smarter report in 2017, where it is stated that there is little investment in new technologies in the manufacturing industry, especially in SMEs (Yu et.al. 2020).

Cyberattacks are also prevalent in the world of digital technologies. With the increasing number of attacks per day, businesses lose a lot of money and time trying to prevent them. The main problem with these types of attacks is that they are evolving, and every day, new measures are required to protect one's business (Gölzer, 2017). The manufacturing industry is one of the most attractive and vulnerable sectors to cyberattacks because of the lack of intellectual property rights and the complexity of supply chains. Manufacturers need to increase the awareness of their employees about cybersecurity and how to protect their machines (Zojer, 2019).

Moreover, one of the most significant obstacles that complicates digital technologies' adoption is the absence of usage standards for these technologies. There is no uniform way to identify or use it. This makes companies resort to different methods and integrate systems that later lead to various complications.

Huge ventures are necessary for technological change, and restricted spending plans might hinder the change. There needs to be more than innovation to lead a technological change, and the absence of useful information and skills for incorporating the innovation can challenge the outcome of the change (Albukhitan, 2020). Firms should employ new capabilities to oversee technological advances and change (Matthyssens, 2019; Roblek et al., 2016).

Roblek et al. (2016) state that there could be opposition to tangible impacts on people's outlooks and approaches to working. They propose that organisations should build strong expertise and knowledge around their activities to help them utilise technological innovations and embrace "technological thinking." Advanced business changes are supposed to come down to the general work scene and become the normal ways of doing things (Roblek et al., 2016). They emphasised the importance of occupations within businesses, creating more qualified positions while eliminating less skilled jobs.

2.4.3 Change Management Process

Digital transformation is a combination of disruptive technologies (Bongomin et.al. 2020). This makes it very hard to apply and use. Therefore, one of the most

complicated challenges for manufacturing firms is changing their structure. Changing an organisation's structure is challenging and requires much time and effort to overcome resistance (Bradley, 2020). Another challenge is the resistance to change among the existing employees. They do not want anything to move them from their comfort zones. This requires managing the change process and unfreezing the status quo to make the necessary modifications. This will also require recruiting change agents who believe in change and help the management convince their employees of the change and improve their work conditions.

Managing change is challenging in a dynamic business environment like that of the manufacturing industry. This requires collaborative efforts on all organisational levels. It also involves digitising the whole supply chain to enhance the system's productivity. This integration, as mentioned earlier, is a challenging task. The transformation will not occur only once. It is a continuous process that needs to be managed incrementally to achieve the digital transformation process's organisational goals (Halpern et.al. 2021).

The digital transformation may likewise be tested by rigid organisational structures as the interaction requires changes from innovations to action plans. Solid mechanistic organisational designs will discourage the progressions connected with digital transformation, as these may challenge those designs and the internal power elements that are given to line managers by this organisational structure (Albukhitan, 2020).

These obstructions were described by Tracker et al. (2020) while examining progressive change inside a business. The authors noticed a firm at the beginning phases of a massive digital transformation project. The company was pursuing a few technological ventures, rebuilding its organisation, and developing a statement of purpose cantered on its advanced change. The authors noticed boundaries and obstacles to technological change, including doubt and an apparent absence of control, and saw expanded risk around utilizing advanced specialised devices. They likewise noticed a lack of preparation of digital skills for the execution of advanced change projects, misalignment of jobs and capabilities, and a misunderstanding of the traditional regulatory designs of the firm, which caused failures.

2.4.4 Innovation Initiatives

Innovation is a critical element in the success of digital transformation processes inside the manufacturing industry. On the strategic level of the organisation, most firms lack an innovation strategy. On the national level, no sufficient number of innovation initiatives occur in the manufacturing industry. Short programs, such as incubators or accelerators, are effective in digitising the manufacturing industry.

These kinds of programs give SMEs the funding needed to work on these projects and provide them with the support and mentoring they need to succeed. In addition to that, the initiatives that already exist need to be clarified. Moreover, the manufacturing sector needs more collaboration between firms, universities, and research centres. Only some universities work with the industry or have technology transfer units that successfully help achieve this collaboration.

The technological innovation mentality is unique and requires a better approach to developing and obtaining new capacities. According to Matthyssens (2019), there are a few challenges involved in making such technological advancements. In order to solve these issues, he suggested that organisations should adopt what he refers to as the "IoT Outlook." This is done by providing for current and future needs in a perspective-taking manner, continuously reviving products using data generated by the Internet of Things, enabling recurring income (membership model), providing customised and environment-driven customisation of contributions, and coupling and utilizing other technological system partners for competitive advantage.

2.5 Benefits of Digital Transformation Implementation

Digital Transformation have tremendous benefits, especially in Business-to-business (B2B) networks. A B2B distribution network, distribution network, refers to the interconnected system of suppliers, manufacturers, wholesalers, distributors, and retailers that work together to move products or services from the point of origin to the end consumer, but within the context of business-to-business transactions (Berghaus et.al. 2016). In the course of investigating the digital transformation of B2B distribution

networks, specifically how digital technologies streamlined the buying-selling process, Ojala et al. (2016) observed multiple benefits, such as increasing profits by improving marketing and sales activities, which require increased collaboration between sellers and buyers.

From a business standpoint, the digital transformation will have a significant impact on internal and external business processes. As mentioned earlier, this is a very long and hard-to-achieve journey. However, once achieved, the pattern of digital transformation will be embedded inside an organisation's manufacturing processes, and the business will begin to reap its benefits (National Archives of Australia, 2011; Rojo Abollado et al., 2017). Extant literature in this area has mentioned many benefits of implementing Digital Transformation, as summarised in Figure 2-4 below (Agrawal & Narain, 2018; Demirkan et al., 2016; Ulas, 2019).

Additional discussion for each one of them in detail is held in this section.



Figure 2-4 Benefits of DT implementation (Abdallah et al., 2021)

These benefits depend on each other, so they are cumulative, step-by-step advantages that depend on digital transformation implementation. As stated in the proposed definition of "digital transformation," the process is a customer-centric mechanism.

Therefore, the organisation implementing digital transformation tools will listen more to the voice of the customer in every aspect (Cozmiuc & Petrisor, 2018; Drake, 2019; Ismagilova et al., 2019). This communication occurs from the beginning of the product's design to the manufacturing processes, with the proper cost-to-delivery channels convenient to the customer, as well as after-sale services. This communication will increase the organisation's profitability and make customers more loyal to the organisation's products and services (Laird, 2017).

Digital transformation is all about continuous development. Therefore, applying digital transformation to the manufacturing process will enhance an organisation's existing operations and make them less costly. Digital tools can also reduce manufacturing time, especially when organisations adopt digital technologies that make complex manufacturing processes more Comfortable to implement (Gökalp et al., 2017). Implementing digital transformation will help organisations embrace an open innovation culture, especially in the manufacturing processes that focus on these enabling digital technologies (Ismagilova et al., 2019).

All the above benefits will give you a competitive advantage over your rivals. If an organisation does not apply digital technologies, its opponents will do so and gain an edge over it (Demirkan et al., 2016). Companies with high-tech products often outperform their competitors, especially in the business-to-business market. Implementing digital transformation will strengthen an organisation's strategy, whether it is adopting differentiation, cost reduction, or a robust market approach (Bharadwaj et al., 2013; Horvath et al., 2018; Ismagilova et al., 2019).

The fundamental reason businesses exist is to make profits for their owners or shareholders, so any process or strategy applied inside the organisation aims to attain this significant goal. Digital tools can lead to more profits by increasing sales channels

and making manufacturing processes more productive because they can reduce operating costs and operation time (Fernández-Rovira et al., 2021).

Albukhitan (2020) proposed five categories of benefits derived from digital transformation for the manufacturing industry specifically. First, it should improve productivity through faster and higher-quality processes. Productivity improvements can be achieved by creating machine connectivity (IoT) and communicating essential maintenance data to help prevent faults and improve outputs.

Second, other benefits should be derived from overall quality improvements through better production monitoring, output measuring, and fine-tuning. For example, machine learning can automatically assess the quality of products and apply the learned parameters back into production and fine-tuning. A third category of benefits relates to the cost reductions made from analysing all the processes, machines, production lines, transportation, and logistics data captured. Data analysis helps to find new cost reduction opportunities as well as ways to improve inventory management.

Fourth, there are benefits related to the customisation of product offerings. Digital technologies allow firms to develop new functionalities and more customised and specialised offerings that better address customer-specific needs while still producing efficiently and at a competitive price. Finally, digital transformation should provide safety benefits for the production line employees in the workshop environment. The addition of sensors, robots, and IoT creates an additional safety layer for employees, reducing human errors, accidents, and injuries.

Through digital transformation, businesses are able to incorporate cutting-edge technologies like the Industrial Internet of Things (IIoT), social media, 3D printing, robotics, cloud robotics, etc. into their stock management systems. Digitalisation saves time and resources by eliminating the need for manual inspections and data hunting on the part of businesses (Aboelmaged, 2018). It allows them to monitor stock and know exactly where things are, how many there are, what condition they are in, etc. Through digitalisation, businesses may boost production and efficiency, lowering product costs.

They may streamline operations and save costs using cutting-edge resources like analytics, machine learning, etc. Another way they may cut down on waste is by identifying the many tasks they do that bring little value but take up valuable time.

Through digital transformation, businesses may better manage their equipment by integrating various technologies, such as the Internet of Things (IoT), social media, etc. It also offers precise information about equipment's location, use, market value, etc., allowing for easier tracking of individual pieces. In turn, this aids inventory management and cuts down on the theft of pricey equipment. Using cutting-edge technology like machine learning, businesses may more quickly create analytical reports and meet client expectations, allowing them to implement more effective plans. Improves a company's standing by keeping them one step ahead of the competition and in tune with its clientele.

The digital transformation that started in the late 1970s is still transforming the world with the rapid acceleration of different digital technologies in the business world. People have also become very digitalised and worked in the twenty-first century. There is a growing need for DT across industries, mainly in manufacturing. Manufacturing sectors contribute more to GDP. Therefore, DT is helping this sector to strengthen economies all over the globe. In addition, organisations also believe in changing management processes to become digitalised (Pratt, 2022). DT improves employees' performance because it helps them communicate quickly through social media channels. It allows employees to connect with their respective leaders through the internet, social media, and mobile channels. DT is enhancing productivity and service in the manufacturing industry by innovating new technologies. It is helping with security concerns (the concept of cyber security through DT). DT has decreased the skills gap, and people are learning new skills to follow DT in business (Verhoef et al., 2021).

The importance of DT can be seen in the invention of various new technologies, digital processes, and digital applications. For example, Amazon is the digital business platform where people buy products online. It is an electronic seller all over the world. It is the most significant retail player and has become possible through DT (Verhoef et al.,

2021). Emerging technologies enable new business models by engaging and retaining customers and their experiences.

2.6 Digital Transformation and the Manufacturing Ecosystem

Undoubtedly, the manufacturing industry, with its different sub-sectors, is one of the industries with the most complex ecosystems. This is because of the complexity of its supply chain, which comprises multiple suppliers who operate in different layers (De Carolis et al., 2018). Its complexity is further determined by the supply of physical goods from direct to indirect distribution channels until the product reaches its end user (Ashrafian et al., 2019; Hartley & Sawaya, 2019; Nwankpa & Roumani, 2016; Zangiacomi et al., 2020).

Besides, the complexity comes from the products' internal value chain, which ranges from the design to the manufacturing processes. Digital tools help to connect the different entities operating in this network efficiently. When using advanced digital technologies to create links between those parties, the communication between the entire ecosystem will be conducted in real-time (Ananyin et al., 2018; Holmström & Partanen, 2014; Zangiacomi et al., 2020).

The manufacturing company, which is in the heart of the ecosystem, is not only connected to its direct suppliers but also to tier 2 or even tier 3 suppliers to enhance raw material quality and make their products more suitable for their customers (Bordeleau et al., 2020). Moreover, most manufacturing companies have multiple suppliers that need to coordinate and manage their activities effectively (Benitez et al., 2020; Schniederjans et al., 2020).

Using advanced digital technologies in an organisation's manufacturing process, like smart machines and robots/cobots through advanced robotics management, will enhance an organisation's productivity and continuously develop its products and services (Demirkan et al., 2016). Another critical aspect of manufacturing is the maintenance department. Digital twin technologies are increasingly being used for

training purposes. So, in urgent situations, the maintenance team will be ready to do the task quickly and in the most effective way possible.

Another internal process is product design. By getting feedback from marketing research activities and listening to the customers' needs, companies can develop products that suit their customers' needs. As discussed earlier, digital transformation is a customer-centric approach to doing business. Hearing the customer's voice is essential in developing an organisation's products and services.

Again, companies can adopt new techniques like customer relationship management (CRM) and digital channels to communicate with direct or indirect customers. From a product point of view, consider the example of an aircraft manufacturer. The manufacturer has multiple suppliers for different components, and these suppliers have another tier of suppliers that the manufacturer needs to manage. Besides, the manufacturer has many stakeholders affected directly by them, like the airport's administration, travel agencies, and passengers. Other indirectly affected stakeholders include, for instance, the duty-free market, the customs duty department, and airport workers. Therefore, if something happens to an aircraft that needs maintenance and the flight is delayed without digital communication between different parties, this may lead to chaos in the airport, resulting in customer anger (Ananyin et al., 2018).

With the current digital tools, any urgent information delays may be passed on in real-time to avert any negative experiences. This flexibility will also help airport administrators send maintenance teams, which will communicate with the supplier to provide the necessary tools. The maintenance team will also provide high-quality work because they are well-trained in such scenarios using digital twin technologies. Another connected beneficiary is the duty-free markets, which can engage with customers to encourage them to buy more products. This example shows how communication tools can connect various stakeholders of manufacturing firms in real-time for maximum benefits (Ananyin et al., 2018).

2.7 Enabling Technologies for Digital Transformation

There are DT-enabling technologies that worked like magic for the industrial sector, especially during COVID-19. Autonomous systems, the Industrial Internet of Things (IIoT), robotics, cloud robotics, 3D printing, digital twins, and other technologies like them are among the enablers. During COVID, all of these technologies were crucial to the survival of the world's industrial sectors.

2.7.1 Digital Transformation and Factors Related to Infrastructural Investment

This alludes to the fact that manufacturing organisations should put resources into it while implementing digital transformation. Organisations that are dynamic in their product areas are well prepared to implement industry 4.0 technologies. The size of the organisation assumes a significant role when considering the difficulties and advantages connected with the transition to Industry 4.0. Where the vital obstruction for SMEs is the absence of monetary assets, the most essential element for massive undertakings is the change to Industry 4.0. (Yildirim and Demirba, 2020). Buer et al. (2020) concur that more modest organisations are less ready for Industry 4.0 according to a monetary viewpoint and are likewise less prepared from a technological perspective. Different difficulties while carrying out digitisation are low creation volumes, the requirement for normalization, stresses in regards to information security, and less admittance to prepared workers.

Subsequently, numerous SMEs can expect that the progress toward digitisation could be more productive. The most effective method to execute digitisation in organisations can vary among large and small organisations. Buer et al. (2020) contend that the change to industry 4.0 is not restricted to enormous undertakings since industry 4.0 can make extraordinary advantages for SMEs, for example, by creating new items, making new administrations, and creating creative plans of action. Other unique benefits that digitalisation can add to our expanded productivity and decreased costs are independent of the organisation's size.

Top management activities play a significant part in growing IT skills. Directors should encourage activities that will help their employees improve their IT skills, which could include conducting research and participating in information-sharing organisations (Buer et al., 2020). Nations that are in a transformative phase are deficient with regards to capital collection (Yildirim & Demirba, 2020; Ruiz Zuniga et al., 2017) and need tweaked approaches and valuable models on the most proficient method to make the innovation move as successfully as could really be expected and how to fabricate a limit that should be created from profound contextual analyses (Yildirim & Demirba, 2020). In any case, many organisations agree that the excessive costs, lack of capability, and lack of operational resources make it unwise to invest in digitisation (Schiffer et al., 2019).

2.7.2 The Leading Enabling Technologies in DT Implementation

One of the critical determinants of the digital transformation process's success is the digital technologies applied in the manufacturing firm. Many researchers state that different technologies are used in the digital transformation process according to the organisation's field (De Carolis et al., 2018). Within the focus of this research, the digital technologies applied in manufacturing firms have been illustrated in Figure 2–5. All these technologies are linked together to achieve a more valid digital transformation process (Bai et al., 2020; Osterrieder et al., 2020).

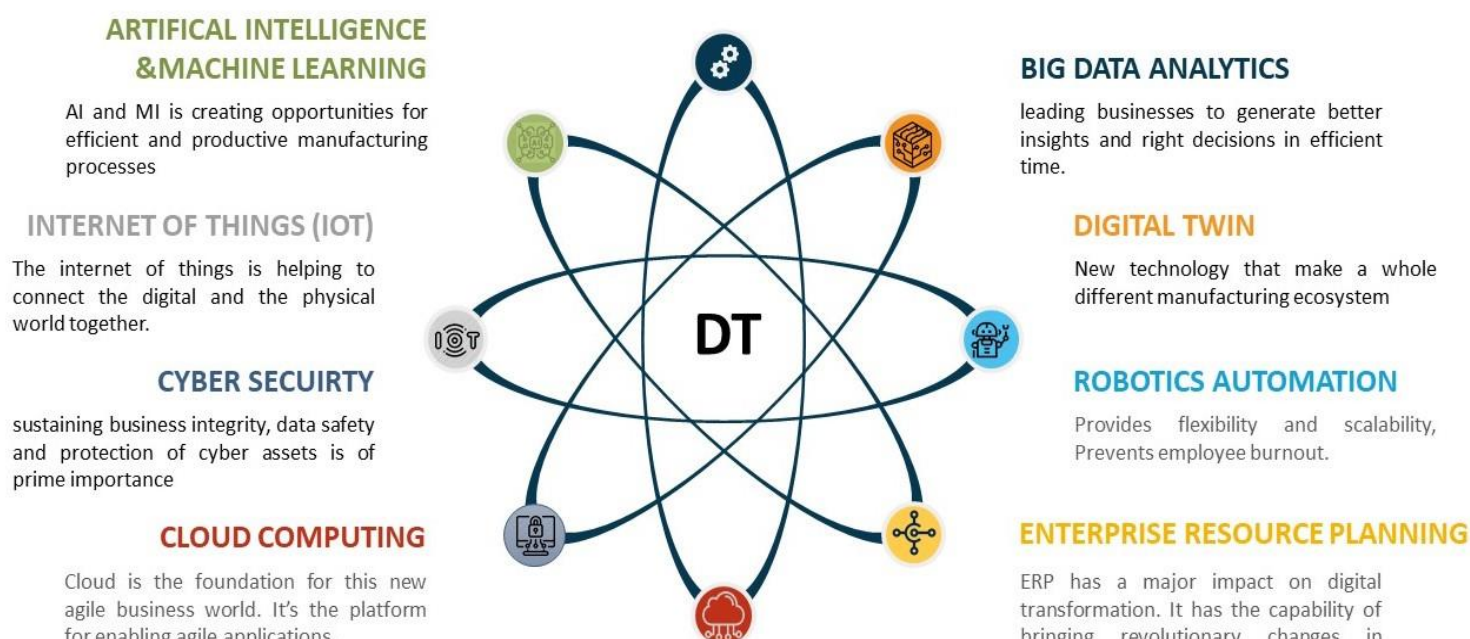


Figure 2-5 Enabling Technologies of DT (Abdallah et al., 2021)

2.7.2.1 Artificial Intelligence & Machine Learning

One of the commonly adopted technologies to drive Digital Transformation inside any organisation is artificial intelligence and its associated applications (Demirkan et al., 2016; Hartley & Sawaya, 2019; Qi & Tao, 2018; Ulas, 2019). This new technology and machine learning have helped organisations increase the efficiency and effectiveness of various operations. This happens as businesses continually become more aware of the new processes and know how to self-learn and solve any problems that come their way (Hartley & Sawaya, 2019).

Artificial intelligence (AI) has the potential to revolutionize the manufacturing industry by improving efficiency, quality, and speed of production. There are a number of ways in which AI can be utilised in the manufacturing industry, including (Brock & von Wangenheim, 2019):

1. Predictive maintenance: AI can be used to predict when equipment is likely to fail, allowing for preventative maintenance to be scheduled before a breakdown occurs. This can help reduce downtime and increase the overall efficiency of the production process.
2. Quality control: AI can be used to inspect products for defects and ensure that they meet specific quality standards. This can help improve the overall quality of the finished product and reduce the need for manual inspection.
3. Supply chain optimization: AI can be used to analyse and optimize the supply chain, including forecasting demand and identifying bottlenecks in the production process. This can help increase efficiency and reduce waste.
4. Process optimization: AI can be used to analyse and optimize production processes, identifying inefficiencies and suggesting ways to improve them. This can help increase the speed and efficiency of the production process.

Some examples of how AI can support digital transformation include the following:

1. Automating routine tasks: AI can be used to automate routine tasks, freeing up human workers to focus on more complex and value-added tasks.

2. Enhancing decision-making: AI can be used to analyse data and provide insights that can inform decision-making and improve the accuracy of predictions.
3. Personalizing customer experiences: AI can be used to analyse customer data and provide personalized recommendations or experiences.
4. Optimizing operations: AI can be used to optimize business processes and increase efficiency.

Overall, AI can support digital transformation by enabling organisations to automate certain tasks and processes and by providing them with the tools to analyse and make sense of large amounts of data. This can help organisations become more efficient, agile, and responsive to the needs of their customers.

In the manufacturing sector, machine learning refers to the use of algorithms that are able to learn from data in order to improve the efficiency and effectiveness of production processes. Machine learning algorithms are designed to identify patterns in data and use these patterns to make predictions or decisions. In the manufacturing industry, machine learning can be used to optimize a wide range of processes, including predictive maintenance, quality control, supply chain optimization, and process optimization (Gavilanes-Trapote et al., 2018; Min et al., 2019).

For example, machine learning algorithms can be used to analyse data from equipment sensors to predict when maintenance is required, helping to reduce downtime and improve the overall efficiency of the production process. Machine learning can also be used to inspect products for defects and ensure that they meet specific quality standards or to analyse and optimize the supply chain in order to increase efficiency and reduce waste.

2.7.2.2 Internet of Things (IoT)

IoT technology enables businesses to link the physical world with the digital world. It helps manufacturing firms gather more data from machines and equipment, and this helps a lot in understanding manufacturing problems and how to handle them more

efficiently to make operations more productive (Borangiu et al., 2019; Cachada et al., 2019; Castelo-Branco et al., 2019; Gökalp et al., 2017).

The "Internet of Things" (IoT) refers to the integration of internet-connected sensors and other devices with everyday objects, allowing them to collect and exchange data. In the context of digital transformation, the IoT can fundamentally change how organisations operate and deliver value to their customers. Some examples of how the IoT can support digital transformation include:

1. Automating routine tasks: IoT-connected devices can be used to automate routine tasks, freeing up human workers to focus on more complex and value-added tasks.
2. Enhancing decision-making: The data collected by IoT-connected devices can be analysed to inform decision-making and improve the accuracy of predictions.
3. Personalizing customer experiences: The IoT can be used to collect data on customer behaviour and preferences, allowing for the creation of personalized recommendations or experiences.

Optimizing operations: The IoT can be used to monitor and optimize business processes in real-time, increasing efficiency and reducing waste.

Overall, the IoT has the potential to support digital transformation by enabling organisations to automate certain tasks and processes and by providing them with the tools to analyse and make sense of large amounts of data. This can help organisations become more efficient, agile, and responsive to the needs of their customers.

The Industrial Internet of Things (IIoT) refers to the integration of internet-connected sensors and other devices with industrial equipment and systems. This integration allows for the collection and analysis of real-time data from these systems, which can be used to improve the efficiency, reliability, and safety of industrial processes (Mourtzis et al., 2018).

The IIoT is a subset of the IoT that focuses on industrial-specific applications. Using the IIoT, companies can instantaneously adjust the production process, which is a game changer for the industrial industry. Manufacturing analytics even allows them to draw more evidence-based judgments. McKinsey estimates that by 2025, the market value of the IIoT will have increased to \$500 billion. Predictive maintenance, improved energy efficiency, improved forecasting ability, and more transparency across the supply chain are just some of the benefits of IIoT technology.

2.7.2.3 Cyber Security

Furthermore, the organisation's digital world security is a critical component in the successful implementation of digital transformation. As previously stated, with the increasing number of cyber-attacks occurring every day, cybersecurity technology is becoming increasingly important in any organisation today (Heikkila et al., 2016; Mittal et al., 2019; Tokody, 2018; Tolkachev et al., 2020). Manufacturing organisations need to build a robust cyber system to ease the accessibility of data and, at the same time, make it secure enough from digital attacks. Another matter in this regard is data privacy, especially customer data. If customers feel that third parties are using their data, they will no longer use the organisation's products or services (Tokody, 2018).

Cybersecurity is a critical concern in the context of digital transformation, as the increased reliance on digital technologies and connected systems can also increase an organisation's vulnerability to cyber threats. To ensure the security of their digital systems and data, organisations undergoing digital transformation should implement robust cybersecurity measures (Makki & Xie, 2020; Mitra & Munir, 2019), such as:

1. Strong passwords and multifactor authentication: Organisations should use strong passwords and multifactor authentication whenever possible to prevent unauthorized access to systems and data.
2. Encryption: Sensitive data should be encrypted to prevent unauthorized parties from accessing it.
3. Network security: Network security measures such as firewalls and intrusion detection systems can help protect against cyber threats.

4. Cybersecurity training: It is important to educate employees on cybersecurity best practices, including how to identify and report potential threats.
5. Regular security updates and patches: Organisations should regularly update and patch their systems to ensure that they are protected against the latest cyber threats.

Cybersecurity is a critical consideration in the context of digital transformation, and organisations should take steps to ensure the security of their systems and data in order to protect against cyber threats.

Cyberattacks can pose a serious risk to the manufacturing sector, as they can disrupt production, compromise sensitive data, and damage an organisation's reputation. Some common types of cyberattacks that can affect the manufacturing sector include:

1. Ransomware: This is a type of malware that encrypts an organisation's data and demands a ransom for the decryption key. Ransomware attacks can disrupt production and cause significant financial losses.
2. Industrial control system (ICS) attacks: These attacks target the control systems that are used to manage industrial processes, such as those in manufacturing plants. ICS attacks can disrupt production and pose a risk to safety.
3. Phishing attacks: These attacks involve the use of fraudulent emails or websites to trick employees into revealing sensitive information or installing malware on their systems.
4. Supply chain attacks: These attacks involve the compromise of a supplier's systems, which can then be used to gain access to an organisation's systems.

Overall, it is important for organisations in the manufacturing sector to implement robust cybersecurity measures in order to protect against these and other types of cyberattacks. This can include measures such as strong passwords, multifactor authentication, encryption, and cybersecurity training for employees.

2.7.2.4 Cloud Computing

Cloud computing is also one of the foundations of digital transformation. With the adoption of agile applications and the need to access data anytime from anywhere, an organisation needs to have a robust cloud system that enables employees to work with it and has the accessibility of data necessary to perform their operations (Borangiu et al., 2019; Castelo-Branco et al., 2019; Piccinini et al., 2015). Machine learning and the Internet of Things (IoT) provide vast amounts of data on everything that happens within a factory. Big data analytics help provide great insights from these data and how to collect, analyse, and organise them to help the management take the right decisions promptly and provide new ways of innovation (Castelo-Branco et al., 2019; Paritala et al., 2017; Qi & Tao, 2018).

Cloud computing has been adopted in various organisations and industries, allowing for increased cloud-based collaboration, communication, and productivity. Since cloud computing will enable companies to adopt a digital method of sharing and storing files, applications, and software, it ushers in a new opportunity for businesses to shift from traditional data storage and management methods. Organisations require the right systems, skills, and management strategies to adopt these new technologies properly (Pillen and Eckard, 2022; Marston et al., 2011; Iwai and Aoyama, 2011). Organisations should adopt the proper practices to maximize the advantages of these new opportunities. For instance, companies must ensure the integrity of the information and the functionality of the systems to ensure efficient access and retrieval of data. The systems must be secure, and various data access rules should be implemented to ensure that no unauthorized access to data is allowed. Organisations must be ready to meet all the requirements for secure, safe, and efficient cloud-based systems before they decide to migrate their data to cloud-based systems (Alzahrani, 2021; Reddy, 2014; Sharaf and Shilbayeh, 2019).

Cloud computing can be used to support a wide range of activities in the manufacturing industry, including (Nelson, 2017; Soni Fajar Surya & Nugroho, 2018):

1. Data storage and analysis: The cloud can be used to store and analyse large amounts of data, including data from equipment sensors and production processes. This can help improve decision-making and optimize operations.
2. Collaboration and communication: Cloud-based tools can be used to facilitate collaboration and communication among team members, regardless of their location.
3. Product development: Cloud-based tools can be used to support the product development process, including the design and testing of new products.
4. Supply chain management: The cloud can be used to manage and optimize the supply chain, including forecasting demand and identifying bottlenecks in the production process.

2.7.2.5 Digital Twin

The term "digital twin" is a new one, first coined in 2003 and redefined in 2015 as part of product lifecycle management. It describes one of the most advanced technologies today. With this digital technology, an organisation makes a replica of its machines, systems, processes, or even products (Kritzinger et al., 2018; SME Media Staff, 2017). This replica enables organisations to train employees and determine how to handle manufacturing problems more efficiently. Moreover, the digital twin allows organisations to share data and critical insights through platforms that can also allow them to process the same.

A digital twin is created using systems that can merge data, allow for the use of advanced analytics in processing the data, enhance the visualization process, and enable the incorporation of machine learning into data management. These functionalities have enabled the business to create value and increase the agility of its data processing activities. Therefore, organisations must have the right technical expertise and knowledge to implement such systems (Laborie et al., 2019; Slot et al., 2022).

A "digital twin" is a virtual representation of a physical asset, process, or system that can be used to simulate and analyse its performance. Digital twins are created by

integrating data from sensors, simulations, and other sources, and they can be used to optimize the design, operation, and maintenance of the physical asset, process, or system they represent. Some characteristics of digital twins include:

1. Real-time data integration: Digital twins are constantly updated with real-time data from sensors and other sources, allowing for the simulation and analysis of the physical asset, process, or system in real-time.
2. Virtual testing: Digital twins can be used to test and optimize the performance of physical assets, processes, or systems under a wide range of conditions without the need for physical prototypes.
3. Predictive analytics: Digital twins can be used to predict the performance of physical assets, processes, or systems based on data analysis and simulations, allowing for proactive maintenance and optimization.
4. Collaboration: Digital twins can be accessed and shared by multiple stakeholders, enabling collaboration and decision-making across an organisation.

Digital twins are powerful tools for optimizing the design, operation, and maintenance of physical assets, processes, and systems by enabling the simulation and analysis of their performance in real-time.

2.7.2.6 Big Data Analytics

"Big data analytics" refers to the process of analysing large and complex datasets in order to extract insights and inform decision-making. In the context of digital transformation, big data analytics can be used to support a wide range of activities, including:

1. Enhancing decision-making: big data analytics can be used to analyse large amounts of data from various sources, providing insights that can inform decision-making and improve the accuracy of predictions.
2. Personalizing customer experiences: big data analytics can be used to analyse customer data and provide personalized recommendations or experiences.

3. Optimizing operations: big data analytics can be used to identify inefficiencies and suggest ways to improve business processes, increasing efficiency and reducing waste.
4. Developing new products and services: big data analytics can be used to identify market trends and customer needs, informing the development of new products and services.

Big data analytics has the potential to support digital transformation by providing organisations with the tools to analyse and make sense of large amounts of data, thereby informing decision-making and enabling the optimization of operations.

2.7.2.7 Robotics & Automation

Robots are one of the advanced technologies used inside manufacturing firms to handle complex tasks, reduce workplace burnout, and increase the factory's health and safety procedures. However, in order to ensure effective processes and make the most of firm machines, manufacturing organisations must balance robots and human labour (Agrawal & Narain, 2018; Demirkan et al., 2016; Ulas, 2019). Robotics is a production method that uses automated machinery, equipment, and electronic control systems. Robotics may be used in many different types of manufacturing, such as the flexible automation of consumer items, semiconductors, telecommunications equipment, medicines, etc. Machine-made furniture, ironing robots, autonomous maintenance robots, and industrial robots are all products of robotics in the industry.

Data from smart machines like sensors, microcontrollers, networked systems, etc. may be stored, processed, shared, and analysed with the help of cloud computing. In addition, cloud robotics enables businesses to remotely monitor their manufacturing process using real-time data, perform predictive maintenance, and make educated choices to increase productivity (Abdel-Basset et al., 2021). To successfully integrate cloud robotics, it is essential to take advantage of the natural compatibility between cloud computing and robots. Cloud robotics have several uses in production, such as remote monitoring of machines and processes, machine-to-machine (M2M)

communication between robots, smart devices, and other connected equipment, and predictive maintenance.

Robotics can play a significant role in digital transformation, as they can be used to automate a wide range of tasks, including those that are complex or require a high level of human expertise. Robotics can support digital transformation by enabling organisations to automate specific tasks and processes and by providing them with the tools to analyse and make sense of large amounts of data. This can help organisations become more efficient, agile, and responsive to the needs of their customers.

For autonomous systems, the data gleaned from environmental sensors is invaluable. Sensors such as cameras, microphones, speakers, IR detectors, radar, ultrasound, and more let the system observe its surroundings in real-time and respond accordingly without human interaction. Robots, drones, and automated storage and production facilities are just a few examples of autonomous systems used in manufacturing in real time.

2.7.2.8 Enterprise Resource Planning (ERP)

Enterprise resource planning (ERP) systems are software platforms that are used to manage and integrate the various functions and processes of an organisation, including finance, accounting, supply chain management, and production (Lee et al., 2011). In the manufacturing industry, ERP systems can be used to support a wide range of activities, including:

1. Production planning: ERP systems can be used to plan and schedule production, taking into account factors such as capacity, demand, and available resources.
2. Supply chain management: ERP systems can be used to manage and optimize the supply chain, including forecasting demand and identifying bottlenecks in the production process.
3. Quality control: ERP systems can be used to monitor the quality of products during the production process and ensure that they meet specific quality standards.

4. Financial management: ERP systems can be used to manage financial transactions and generate financial reports, helping to improve the overall financial management of the organisation.

The use of ERP systems can help improve the efficiency and effectiveness of the manufacturing industry by enabling the integration and optimization of various functions and processes.

ERP is a software toolkit that helps organisations link all their departments to help transfer information widely and in real-time. With the current robust cloud systems, cloud ERP will be more efficient in ensuring data privacy and transfer velocity as organisations stop relying on traditional ERP software (Lee et al., 2011). ERP can contribute to digital transformation in firms in various ways, especially in areas such as decision-making, gaining a competitive edge over others, adopting customer-friendly practices, and reducing operational costs. Modern ERP systems have proven to be effective in digitising businesses because they enable the implementation of integrated information management systems that transform how organisations manage their data. The ERP system has various functionalities that protect the integrity of information, ensure quality and faster access to data, and increase the efficiency of data management activities (Ivanović and Marić, 2021).

2.8 The Role of Digital Culture in Successfully Implementing Digital Transformation

To this end, many businesses are turning to digital technology, causing seismic shifts in every sector (Hamad et al., 2018). The International Data Corporation predicts that by 2024, businesses will have spent roughly \$2 trillion on digital transformation, driven by the emergence of novel digital technologies and the dread of being disrupted by tech-enabled rivals. Nevertheless, there is more to digital transformation than merely making technical improvements or aesthetic adjustments to existing goods. There are hazards to a company's culture if the effort is not aligned with employee beliefs and habits. However, a concerted group effort may assist everyone in the business in learning

about and accepting digital transformation (Abonazel & Abd-Elftah, 2019). Organisational growth may be stymied in many directions if, during digital transformation, priority is given solely to technology rather than also to the company's culture.

For example, Oven cites a financial services firm that is trying to implement RPA despite having a culture that is traditionally sceptical of new technologies in Deloitte's report on the future of risk in the digital age (Aboelimged, 2018). A year after its first installation, the company still needed to be able to deploy a bot to carry out procedures due to employee reluctance. The digital transformation includes technology, but it might stagnate or be less effective if leaders cannot win hearts and minds.

In addition, there are other dangers to a company's culture, such as poor morale and an inability to recruit talent, if the aims of a digital transformation are not aligned with employee values and behaviour (Centobelli et al., 2020). Making sure the change fits in with the culture helps remove obstacles and speed up the process. Having the right tone from the top to support the change is essential to its success. It is also important to get the buy-in of upper management and employees at lower levels. Leaders need to monitor the mood in the middle and the buzz at the bottom to assist in bridging the gap between the ideal and authentic culture and actions of their organisations.

According to Vial (2021), managing director of Deloitte Risk and Financial Advisory at Deloitte & Touche LLP, clear and consistent communication is essential throughout the digital transformation process. C-suites and boards may prioritise communications articulating the cultural traits that may assist the initiative's success, such as openness, responsibility, and a willingness to experiment, according to Abdel-Basset et al. (2021). The messages may also highlight the organisation's principles, goals, and the connection between the two.

Ineffective adoption of digital technology decreased market competitiveness, and the collapse of the effort, along with the associated losses in productivity and income, are all possible outcomes for businesses that fail to match digital transformation objectives

with employee values (Abdel-Basset et al., 2020). These initiatives can span HR, risk, finance, accounting, and other disciplines as well, paving the way for more comprehensive digital transformation and a unified company culture. Also, activities that are not directly supervised, such as the extended enterprise or temporary employees, might benefit from cultural alignment, even if they have a more limited awareness of the organisation's strategy and culture (ElMassah & Mohieldin, 2020).

In order to successfully implement a digital transformation, an environment where risk is everyone's concern, and technological literacy are prerequisites must be fostered. Leaders at the top levels of an organisation may convey this message consistently. Success in today's fast-paced digital market requires a culture that supports the company's goals and objectives.

The discussed elements as pillars of sustainable digital transformation can only work with the proper business environments supporting these strongly changing projects. This requires changing organisational culture's norms and making change more adaptive and agile. In this section, the most essential digital culture attributes are discussed according to the literature, as seen in Figures 2-6.

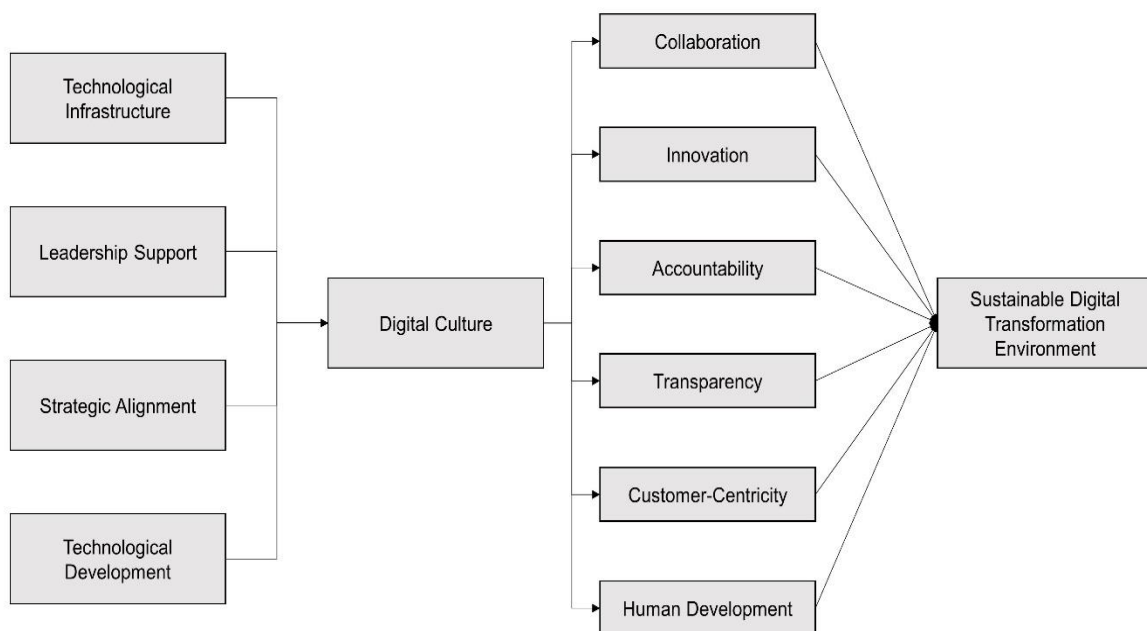


Figure 2-6 The role of Digital Culture in DT (Abdallah et al., 2022)

2.8.1 Collaboration

Initially, the assembly line method planted the seeds of teamwork. However, with time, teams for highly specialised jobs replaced individuals performing highly specialised responsibilities. This led to the silo effect when teams worked within the parameters of their respective job descriptions.

We now see that this is a flawed system that inhibits learning, restricts the development of skill sets, and leads to much duplication of effort. Over the years, corporations have discovered that this mode of operation also discourages workers from raising questions and admitting ignorance. Consequently, workers are set up for failure when given more significant duties.

Organisations with mature digital cultures have undertaken innovative steps to address these anxieties and release their employees to cooperate. This made it possible for individuals to work together without fear. To empower individuals and foster an environment conducive to collaboration, organisations should adopt a flexible title system, if not eliminate employee titles.

2.8.2 Innovation

Without a doubt, open innovation practices are critical in any change management practices. Today's businesses are under increased pressure to reinvent themselves, expand their influence, and pave the way for future success. This can be achieved by recognising disruptors who drive good transformation, namely those that encourage an innovative culture to pave the road for a sustainable future. Moreover, adopting a future-centric perspective helps foster digital change.

Implementing a collection of accelerators could contribute more to being an augmented organisation than adopting a particular technology. It represents a significant change in how a business run. In many instances, making sophisticated technical and organisational adjustments is also necessary. It involves creating an organisation that understands how to use technology, culture, and trends to maximize its potential.

2.8.3 Accountability

According to Forbes, digital change increases employees' sense of accountability. Employees are aware of the choices they may make and the needed justifications. This is closely related to an organisation's capacity to mix predicted and historical data analysis with design. This refers to an organisation's "instinct"—how it makes choices and adjusts to change.

Moreover, our increased dependence on digital technologies to perform work tasks and daily communications inside the workday. There is an increasing demand for "digital regulations" as part of the rules and procedures in the organisation.

2.8.4 Transparency

To flourish in the digital era, the default setting for a company must be transparency. People are an organisation's most valuable resource. If every employee is not considered essential to the company's success, then the organisation has no business maintaining them. If, on the other hand, a firm finds every employee to be significant and valued, it must be upfront with its workers. Unfortunately, this is the perfect condition. 42 percent of workers, according to research, are unaware of the organisation's vision, purpose, and values, let alone more helpful information.

Transparency creates trust, improves employee engagement, fosters connections, raises productivity, and fosters creativity, to mention a few advantages. The degree of openness with which an organisation chooses to function is a matter of discretion. Organisations need to put some effort into fostering this sense of transparency, from social media management platforms to live Q&A seminars for their employees.

2.8.5 Customer-Centricity

In the digital age, customer-centricity is the most crucial instrument for success. Unfortunately, the organisation's absence of a customer-centric culture is one of the most significant obstacles to implementing digital transformation processes.

successfully. In the past, the industrial era taught us that consumers would flock to us if we provided a superior product or service. In the post-COVID era, this is no longer the case.

Customers are knowledgeable. They at the very least know what they DO NOT want. When developing a portfolio of goods and/or services, organisations must place an almost obsessive emphasis on the consumer. Amazon's customer-centricity rules serve as ideal guidance in this regard.

2.8.6 Human Development

For decades, research has discussed the need for learning and development to attract and retain high-potential, high-performing individuals. Organisations have created calendared schedules to enable their workers to learn as well. However, digital disruption impacts all aspects of business, including learning and development.

Human capital is the foundation of all organisational change initiatives. Digital transformation necessitates the application of specialised capabilities in the organisation's personnel. Assessing the digital skills gap in the organisation is the first step in improving the organisation's human capital.

Today, learning is more comprehensive than taking a few courses each year that are relevant to your current position. The amount of knowledge that workers must possess has multiplied significantly. To be effective and make an impact in a world where the distinctions between jobs, teams, companies, and sectors are blurred, individuals must possess knowledge and skill sets that are exceptionally Adaptable.

2.9 Digital Leadership

The term "digital leadership" refers to a certain kind of management that prioritises the adoption of new technologies inside a business. It paves the way for businesses to computerize their offices and pedagogical practices (Purwanto et al., 2021). This makes it an essential piece of literature for 21st-century companies that want to stay

competitive and relevant. The importance of digital leadership was highlighted, and research into the traits of digital leaders was outlined, all from an examination of secondary sources that laid the groundwork for a conceptual framework for digital leadership.

Scholars have tried to differentiate between "digital leadership" and "leadership in the digital era," arguing that although the terms mean two different things, they can lead to similar results. Leadership in the digital era refers to the type of leadership exercised when people are adopting information technologies. Digital leadership entails the type of leadership required in information sectors such as media, communication, and the press. These two types of leadership can help firms operating in different sectors adopt digital tools and link up with their customers and other stakeholders. In today's rapidly advancing digital world, all business leaders must have the kind of leadership required to ensure the efficient adoption of digital technologies in their firms (de Araujo et al., 2021; Bresciani et al., 2021; Banks et al., 2022).

With increased digitalisation, there will be additional leadership challenges for business leaders. Since companies are digitising their communication and supply chain activities, almost every activity that involves engaging with people will be done virtually, and they will require unique leadership and management skills to work (Temelkova, 2018; Steude, 2021; Klus & Müller, 2021). Moreover, the workplace environment is also changing as the workforce becomes more diverse. People are likely to work with others on virtual platforms, requiring everyone to embrace other cultures. Workplaces will be flexible and more Adaptable to people from diverse cultural backgrounds. Therefore, there will be a need for leaders with the requisite skills to lead others in such work environments (Rüth & Netzer, 2020; Petry, 2018).

Moreover, leaders will also realise that not every activity, work, or production process can be digitised, which will require them to adopt effective measures or strategies to address them even as other areas of the business will be digitised (Cortellazzo, Bruni, and Zampieri, 2019; Meier et al., 2017). Thus, leaders require the right skills and qualifications to deal with the challenges they will face in an increasingly digital world.

For digital transformation to take place, digital leadership is necessary to offer direction, effective leadership, and guidance to ensure efficient adoption of the current digital technologies (Kreutzer, Neugebauer, and Pattloch, 2017; Larjovuori et al., 2016).

Businesses are shifting their business methods in response to the increasing sophistication of digital platforms. They are still using their websites to interact with customers and smart technologies and processes to increase production (e.g., AI). Because the companies that enable these deals stand to gain in the long run, they have become digitalisation targets for other organisations in the same field (Elmagrhi et al., 2019). Businesses' rivalry with one another has gradually seeped into the marketplace, causing shifts in supply and demand. Achieving continuous optimization as a business that can detect and react quickly to changes in the market is key to digital transformation. This is not a natural occurrence and does not happen by coincidence. As companies have gone digital, so too have their executives, giving rise to the concept of "digital leadership. Since digital transformation rarely occurs by chance, we need leaders who can systematically work toward the goal of digitalisation, enable their staff to act in accordance with this goal, adjust to new circumstances, and craft strategies that strike a balance between technological and human considerations.

The traits of digital leaders may aid digital transformation because of the need to employ disruptive technologies to increase productivity, value creation, and social welfare. Establishing a long-term digital learning culture may be essential for a company to embrace disruptive technologies. Leaders in the digital age are those that make spreading a culture of digital learning among employees a top priority (Abou-El-Fadl, 2018). One of the many reasons digital transformation initiatives fail is a lack of attention to the people who will be most affected by the transformation: the workers and consumers.

Due to its extensive digital expertise, digital leadership may lessen the risk of failed digital transformation initiatives. Managing and adapting to the rise of digital workplaces poses new challenges as innovative technology continues to proliferate in the corporate world. These problems are what the notion of the digital leader was created to solve.

Enterprises will need human resources trained in the skills essential to helping them navigate the challenges of digital transformation to succeed.

The rapid rate of globalisation and technological change is increasing this complexity and unpredictability. The adaptability of talented employees in the digital era depends on leaders who themselves are digitally savvy. As digital transformation approaches touch not only processes but also products, services, and business models, this creates a distinct divide between automation and optimization (El Khatib et al., 2022). In recent years, especially after the spread of the Covington virus, these transformational processes have accelerated. Redesigning organisations digitally is propelled by a clear digital strategy backed by CEOs who foster a culture of flexibility and innovation.

Hierarchical systems allude to how techniques are utilised inside the organisation before implementing digital transformation. The organisation's procedures are fundamental in moving from the conventional technique for getting things done to a digital strategy. The digital transformation should be set out with methodologies that can deliver results throughout. The organisation genuinely should have a technological vision that will impact its methodology (Sjobakk, 2018).

This highlights that an organisation's system can influence the change to digital transformation. The organisation should fundamentally look at its business methodology to decide whether it will suit the progress or whether there will be a need to develop a completely unique procedure for the change. It is often the ideal choice to change the digital transformation procedure with the business technique to achieve more successful progress (Sjobakk, 2018).

Slovak (2018) claims that since the systems utilised during the change influence the whole interaction, then, at that point, it will not be awkward to say that the methodology made during this progress is affected by "advanced innovations" (Sjobakk, 2018). A suitable method helps in assessing and evaluating the advancement of the change. This is necessary for progress to prompt more intricacies, ultimately prompting disappointment. Vision is significant in the transformation cycle (Sjobakk, 2018). It aids

job relegating and assist the executives in accomplishing the ideal objective. Benchmarking, guiding, and lean are some of the methodologies that can be utilised in the change (Yildirim & Demirba, 2020).

Digital leadership is one of the core competencies that are necessary to implement digital transformation in the organisation (Abdallah YO et al., 2022). A leader with digital leadership is fully committed to implementing DT. Below is a description of the key digital leadership attributes found in the literature that must possess by a digital leader to implement DT.

2.9.1 Inspirational Mindset

An inspirational mindset contains certain aspects in a person, so as a digital leader in any organisation, it is critical that a leader possess a certain mind-set (an inspirational mindset), as it contains various behaviours, which are defined below. These aspects help a leader implement DT in business (Mhlanga and Moloi, 2020).

The digital transformation process requires leaders with an inspiring vision. Essential qualities of an inspiring digital leader include openness, high motivation levels, courage and decisiveness, enthusiasm, openness, and trustworthiness. In this digital transformation age, where businesses require the cooperation of every employee to succeed, a leader must be able to inspire and incorporate others in implementing digital tools. A digital leader should motivate others and seek new growth opportunities, guiding everybody per the organisation's values to attain a common goal. Leaders should be inspirational and motivating to lift one another's spirits, challenge everyone, and help them derive meaning from their everyday work. By taking measures to communicate an organisation's vision and incorporating everyone in the digital transformation process, a digital leader will be able to create commitment by encouraging everyone to commit themselves to the shared vision (Khan, 2016).

Inspirational leadership is often linked to transformational leadership. Transformational leaders can inspire others and lead them toward the desired changes. Through transformational leadership, leaders can engage with their followers in a conscious and

spiritual process that allows for the establishment of a power relationship that leads to the attainment of common goals. This kind of leadership is characterized by inspirational motivation, idealized influence, personal judgement, and intellectual stimulation. These elements define some of the characteristics that make transformational leadership an essential factor in the change process. Implementing new technologies involves making transformative changes that will require intellectual power, creativity, motivation, and influence over others to make them dedicate themselves to a single goal (Utomo et al., 2020).

Leaders with an inspirational mindset will continue to play a pivotal role in making critical decisions, as humans will still be more valuable than machines. Even though organisations are taking measures to digitise most of their activities, humans are still needed to create, implement, and oversee the work of digital tools. Inspirational leaders are needed to make the right decisions, inspire others, and lead them in the desired direction. In a world where most activities are driven by technology, how one exercises his or her leadership will make a big difference. The digital age requires leaders who can lead others with optimism, leading, engaging, and inspiring their subordinates to make good use of digital technologies (Kapure, 2021).

2.9.1.1 Motivational

The motivational aspect of inspirational leadership is crucial for organisations because, through it, they can translate their employees' skills and knowledge into practical use. Inspirational leaders motivate employees to contribute effectively to their organisation's success. Motivating employees is a critical task performed by leaders to encourage employees to use their abilities to engage in meaningful activities that lead to the attainment of organisational goals. Employee motivation is needed during the change management process, such as those involving digital technologies, to ensure that everybody's actions are aligned with the new culture and goals. Motivated employees put more effort into their work and are always ready to push an organisation's agenda as expected. Moreover, employees with the right level of motivation are likely to embrace change, an indication that one way of addressing resistance to change is to empower and encourage them to support such new initiatives (Roßnagel, 2017).

A leader with motivational thinking can inspire employees. It includes a positive and goal-oriented person who inspires others in the organisation. It means a motivated person can bring change to the organisation, which is vital to implementing digital transformation (Jones et al., 2021).

2.9.1.2 Openness

In the context of digital transformation, openness refers to one's readiness to accept or consider new ideas or those that differ from his or her own. An open leader is one who can be approached by every employee, especially if there is anything to discuss concerning existing technologies or new ones to adopt (Jia, Chen, Mei, and Wu, 2018). Digital leaders should be willing to engage with other employees to share fresh ideas that can lead to the improvement of services and production processes.

It includes creative and insightful people who seek new experiences and focus on new tasks (Junge, 2019). This aspect can also help bring about the change in the organisation that is vital for any leader's successful implementation of digital transformation.

2.9.1.3 Decisive Courage

Despite the uncertainties and challenges that face the current business world, leaders must have the courage to move forward regardless of the outcomes of their actions, so long as they are making the right moves. Concerning the DT process, implementing digital technologies may face unprecedented drawbacks or bottlenecks that may discourage any further action. However, when leaders are decisive and courageous enough to make bold decisions and act on them promptly, digital leaders should be critical decision-makers and creative problem solvers who are always ready to face every challenge and address all the challenges associated with digital technologies (Oginde, 2011).

This aspect indicates the true nature of a digital leader that can help in the implementation of complete digital transformation in business (Jimeno-Morenilla et al., 2021). Decisive courage means that a person can make decisions and is courageous

as a leader; this aspect can bring a good change in business to become more competitive by implementing DT.

2.9.1.4 Trustworthy

Trust is a fundamental aspect of leadership and an organisation's well-being. When leaders create trust between themselves and other employees, they are likely to nurture positive relationships in the workplace and a long-term commitment to organisational goals. Digital leaders must aim to build and earn the trust of their subjects, as doing so will help build a strong team that is dedicated to attaining all their organisation's goals. There will be no insecurity, conflicts, or other problems that may prevent the successful adoption of new digital tools (Savolainen and Häkkinen, 2011).

A leader must be truthful and honest in order for anyone to create a truly trustworthy environment (Mhlanga and Moloi, 2020). It is necessary to stay committed to employees' care and true teaching to prepare them for digital transformation.

2.9.1.5 Enthusiastic

Leaders who show sincere enthusiasm are likely to influence others to follow their example. Enthusiastic leaders are needed in the workplace to help communicate an organisation's vision, encouraging and leading others to dedicate themselves to attaining it. As many digital technologies continue to emerge, organisational leaders must be enthusiastic about them to encourage other employees to do the same. When digital leaders act as innovators and drivers of change, they show their enthusiasm and readiness to improve an organisation's effectiveness in delivering to its customers according to its mission and vision. This kind of spirit can encourage other employees to collaborate and brainstorm new ideas. This is necessary to create an innovative culture within an organisation, an environment that encourages innovativeness by supporting every person's ideas (Weber, Krehl, and Büttgen, 2022).

It means possessing high energy to show enjoyment, eagerness, interest, and approval. A digital leader who possesses this aspect can best treat his employees because he

can give fair feedback to employees that can help them implement the correct digital transformation enablers in business (Lee et al., 2021).

2.9.2 Innovation Mindset

Digital leaders play an active role in encouraging others to embrace innovation and constant improvement. Organisations that constantly innovate or embrace innovative technologies have supportive leadership that encourages participation in the entire process. For digital leaders to create such environments, they must have specific attributes such as risk-taking behaviours, agility, collaboration, and anticipation. Specific leadership roles will be more important than others for digital transformation to occur in organisations. The DT process will require important skills like networking, innovation, and the ability to create conditions that lead to an organisation's digital maturity. Certain leadership skills will be more crucial, especially a leader's innovativeness and the ability to lead teams (Weber, Krehl, and Büttgen, 2022).

As an innovator, a digital leader should apply innovative ideas to lead and drive change in their organisations. The leader should lead enthusiastically and inspire others by inventing new tools and processes. Digital leaders should take innovative measures, engage in creative problem-solving, and create workplace environments that support other employees' innovativeness to encourage an innovative culture within their organisations. Through this process, a leader will act as an enabler of digital transformation by creating flexible and agile workplaces that support innovation. They constantly create supportive structures that allow employees to embrace continual learning and try out new ideas. The innovative leader will also encourage others to work in groups and collaborate with others in attaining common goals, as this is also likely to help them see themselves as active and important members of the organisation (Weber, Krehl, and Büttgen, 2022).

An innovative person can bring change, such as in the form of any new technology in business. He possesses some attributes like being a risk taker, agile, anticipatory, and collaborative. All these attributes are described below:

2.9.2.1 Risk Taker

Digital leaders must be ready to take calculated risks to implement new digital tools in their organisations. The ability to take risks is a positive trait that leaders must possess because it keeps organisations going even in times of uncertainty. Studies have shown that risk taking behaviour leads to leadership effectiveness, as leaders who like taking risks are viewed by their subjects as influential in what they do (Frost, Fiedler, and Anderson, 1983).

The "innovative" role means a leader who has the mindset to bring innovative ideas and activities into business. Such a leader can bring a good form of digital transformation to different business operations. He is also a risk taker, so he does not fear implementing any new change, such as a change in DT in business (Jimeno-Morenilla et al., 2021).

2.9.2.2 Agile

Agile means a person or a leader can move quickly and easily. For example, suppose a leader fails to implement any form of digital transformation. In that case, he or she, with an agile mindset, can move quickly by removing a failed implementation and replacing it with a new one (Mhlanga and Moloi, 2020).

Leaders require various competencies to perform effectively in their respective areas of responsibility. Agility is the ability to respond to emerging needs promptly and with tact, ensuring that all the arising concerns are addressed quickly and skillfully. This quality is required in various contexts, such as responding to stakeholders' needs, problem-solving, and self-leadership. One requires context agility to examine their environment, identify every need, and take appropriate measures to respond to them. Stakeholder agility is needed to respond to stakeholders' concerns, while creative agility is the ability to apply one's creative powers to respond to everyday challenges and turn them into tangible results. In the context of digital transformation, leadership agility is required to help identify new opportunities and the right initiatives one can take to exploit them. A leader must keep himself or herself abreast of the latest developments in the technology

field, always testing new tools to ensure constant improvement (Joiner and Josephs, 2007).

2.9.2.3 Anticipatory

Anticipatory leaders are those who have the ability to position their organisations to attain their goals and realise future success. These futurists keep themselves abreast of current business developments and trends, learning about the available opportunities and threats, and taking appropriate measures to move their organisations towards the desired goals. Furthermore, these are leaders who are always looking forward to incorporating new ideas into their organisations, influencing everyone and encouraging them to work toward a common goal. Anticipatory leaders can also align resources with the most pressing needs, ensuring that their organisations are operating within budget and accomplishing their goals on time. This kind of leadership is required of digital leaders because it can help organisations make use of the available opportunities, resources, and innovations to improve their businesses and position themselves for future success (Savage and Sales, 2008).

This aspect means hope or a reason to feel something. For example, if any change, such as any digital transformation technology, is implemented in the manufacturing operations of a business, a person may feel excited or expect something good from this change (Li et al., 2022).

2.9.2.4 Collaborative

Collaborative leadership involves working beyond the boundaries and engaging with others harmoniously, establishing deep connections, and eliminating contradictions. Collaborative leadership is a significant source of competitive advantage because it ensures that everyone is brought on board to ensure a collective approach to addressing organisational needs. Working collaboratively with others allows for sharing ideas while making it easy for leaders to motivate and engage their subjects throughout the digital transformation process (Maalouf, 2019).

A person must be collaborative because collaboration is necessary for teamwork. If a leader is collaborative, he can best guide his respected employees about new implementations of DT, such as enablers of digital transformation like Facebook and many others; this can help them communicate with customers from anywhere at any time (Limani et al., 2019).

2.9.3 Digital Business Mindset

A leader with a digital business mindset has qualities such as digital intelligence and ambidexterity. He is also a complexity master and a digital talent scout. Mindset refers to how individuals or professionals view, perceive, and interact with the world. A "digital mindset" refers to how organisations or individuals view or interact with the current digital technologies, exploiting their capabilities and powers for their individual or business benefit. Employees or leaders with a digital business mindset constantly seek new opportunities and possibilities through which they can attain success in the various sectors in which they operate as they apply new digital tools and capabilities such as AI, big data analytics, and cloud computing. Such leaders are likely to set their organisations on the path to success. They can build a more resilient workforce that is responsive to digital changes and any cultural transformations that come with them. It has also been determined that companies that have leaders with a business digital mindset can respond faster to market shifts and position themselves to exploit new opportunities (Neeley and Leonardi, 2022).

Since employees may be resistant to specific organisational changes, leaders can help change their attitudes and encourage them to embrace any transformation that comes their way. Leaders with a digital mindset can play an active role in this process by preparing their subordinates to embrace the new digital culture implemented in their organisations. They can also contribute significantly to their organisation's progress by designing systems and ensuring they are aligned with their activities and processes (Neeley and Leonardi, 2022).

A leader with this type of mindset possesses the following attributes in his or her character:

2.9.3.1 Digital Intelligence

It is the ability to learn and apply new information in the form of digital aspects in business (Nissen et al., 2018). A leader must be digitally intelligent in order to understand new technological aspects such as cloud computing, cyber security, AI, AR, and VR.

Leaders require digital intelligence to operate effectively in the current digital age. Digital intelligence entails having the right knowledge of the current digital tools and how they can be used to improve organisational activities and processes. Leaders with digital intelligence can identify the right digital tools for every business need and adopt the right measures and techniques to implement and incorporate them into their daily activities (Rahman, Amalia, and Aziz, 2021).

2.9.3.2 Digital Talent Scout

It is a person who seeks digital talent to hire for the business. Therefore, a digital talent scout can fully bring about digital change to make the business competitive in the market (Pihir et al., 2018).

Talent scouting is a critical aspect of recruiting that leaders use to identify fresh talent and incorporate them into their organisations. The current digital age requires leaders who can identify people with the right knowledge and skills to help their organisations implement new digital technologies. They must be able to identify the right candidates for the job and introduce them to their organisations, allowing them to learn about and adapt to the culture of those organisations. It is important to employ the right employees who can steer an organisation's agenda in accordance with its mission and vision for the future (Budianto et al., 2022).

2.9.3.3 Complexity Master

A leader with this attribute develops personal capabilities; he examines his own ideas and determines different ways to see the world (Petry, 2018). As a result, a complexity master can analyse the best digital technology and tools to implement for the organisation's benefit.

Complexity leadership can help organisations enhance the performance of their teams, increase their innovativeness, and ensure quality services and outcomes. Complexity in leadership is characterized by the ability to innovate and identify complex relationships. As opposed to controlling behaviours, complexity masters can recognise the complex interactions among teams and individuals, always aiming to enhance teams' creativity and allow employees to network and connect with one another. This kind of leadership is necessary to create internal connections and networks, which can help organisations work as a unit to incorporate new ideas and innovate (Weberg, 2013).

2.9.3.4 Ambidexterity

Ambidexterity has been identified as an essential aspect of innovation. It refers to the ability to explore and exploit new opportunities, taking various measures to exploit them to benefit one's business. Leaders should be ambidextrous enough to identify innovative ideas, taking measures to explore and exploit them for the benefit of their businesses (Rosing, Frese, and Bausch, 2011).

It means using both hands equally, so a leader who follows this approach treats his employees equally. It influences employees, and they stay committed to an organisation that has a leader who possesses this attribute by nature.

2.9.3.5 Digital Savvy

Tech-savviness is required in today's digital world because organisations require leaders who can implement new technologies to improve business operations. A digital leader must be tech-savvy, which means they must be knowable and have the skills to use the existing digital technologies to transform how they deliver services and engage with their stakeholders. This attribute is necessary for the DT process because leaders who possess it are likely to help their organisations implement the right tools that will lead to their future success (Raveendhran, Ryu, and Guarana, 2020).

A leader with digital savvy means that he has the right skills for operating modern devices effectively. Digital transformation in business is critical for any organisation.

2.9.4 Transformational Mindset

The theory of transformational leadership has undergone significant changes and developments since it was coined in the 1970s. Through the transformational leadership model, leaders are encouraged to show authentic and inspiring leadership behaviours that can influence employees to follow in the footsteps of their leaders. Transformational leadership is demonstrated when leaders can motivate and encourage others to reach a higher level of performance, motivation, and moral standing concerning their organisation's values and culture (Bradley, 2020).

Transformational leaders use their strong vision and strength to inspire hope and encourage their followers to adopt new perceptions and work towards a common aim. A transformational mindset is needed in the current crop of digital leaders because it can motivate and inspire employees to embrace the use of new digital tools and innovate new activities and processes that use digital technologies. A transformational mindset is needed to create a corporate culture that supports digital transformation and innovativeness and sets an organisation on a path of growth and future development. This should be done by setting a great example at the top of the organisation and then influencing others to heed and reflect on what their seniors want (Bradley, 2020).

A transformational mindset is a mindset in which a person or a leader possesses attributes that can help bring about a good change in the organisation (Priyono et al., 2020). Below are some attributes of a transformational mindset. All of these characteristics can significantly aid in bringing digital transformation to business.

2.9.4.1 Diversity Champion

A leader with a transformational set possesses diversity and promotes diversity. Such a leader demonstrates diversity by promoting a diverse workforce with a variety of skills (Sanchis et al., 2019). It is necessary in this globalised world of business because diverse skills in this era include skills with technology like cloud computing, AI, enablers of digital transformation, and other technological processes.

A transformational leader encourages diversity in the workplace and works towards creating structures that support peaceful coexistence among employees from different social and cultural backgrounds. A transformational leader understands the impact of globalisation in the workplace, especially in making it easy for people to work in different places away from their home countries. Such leaders embrace diversity as a tool for transforming and making businesses grow. They use diversity to promote innovation and plurality of ideas (Bass and Riggio, 2006).

2.9.4.2 Encouraging

A leader with an encouraging nature encourages respected employees in the organisation. Encouragement gives employees the power to do more hard work. It promotes a sense of comfort and a stress-free environment towards employees in the business (Sanchis et al., 2019). Thereby, employees can easily bring about any new change in the organisation, such as DT.

A leader must be able to encourage others and influence them to follow their steps. They must be able to earn employees' trust by offering guidance and encouragement wherever needed to raise their confidence levels and make them believe in the new activities and processes being introduced into their organisations (Daz-Sáenz, 2011).

2.9.4.3 Visionary

A visionary leader establishes goals and objectives from the start. It has also been defined that setting goals first is vital for DT, so, with a visionary attribute, a leader can successfully achieve DT goals while possessing digital leadership (Priyono et al., 2020).

Transformational leaders are visionary and future-oriented. Using innovative tools, techniques, and new processes, they take appropriate measures to position their organisations for future development and success. Visionary leaders are needed in the DT process because they ensure continuity of ideas, continuous improvement, and a long-term commitment to organisational goals (Bass and Riggio, 2006).

2.9.4.4 Accountable

An Accountable leader is answerable and responsible for his good and bad deeds in business. He gives a reason for doing something he does for business. Such an attribute of digital leadership helps to bring about an Acceptable change in the business (Abdallah, 2021).

Transformational leaders take responsibility for their actions and are Accountable for every success or failure. This attribute helps them to earn the trust of others and commit themselves to what they do despite the challenges or failures they are likely to meet. Such leaders are required during the digital transformation process because they can take the initiative even when situations do not seem promising (Daz-Sáenz, 2011). The next section discusses the data analysis methods and the key prioritisation of the leading attributes.

2.10 Digital Transformation Readiness Assessment Models

Although this area of research has recently attracted great interest in academia, there is a lack of assessment tools that can measure the readiness of manufacturing organisations to ensure digital transformation. Moreover, the current models discussed in the literature focus mainly on industry 4.0 practices, as some of them discuss DT as a whole and include the four main factors in the DT process, as shown in Table 2-2 (Bibby & Dehe, 2018; Santos et al., 2020; Sony & Naik, 2019).

The scientific community and consulting firms are actively engaged in research in the field of DT. The theoretical foundations for selecting a DT approach are typically examined for specific domains. Moreover, larger businesses have made more significant strides in DT than their smaller counterparts have (Benitez et al., 2020; Yu & Schweisfurth, 2020). The models used most frequently in the literature are summarised in Table 2-2 and discussed briefly.

Table 2-2 DT Readiness Assessment Models

No.	Model	Reference	Dimensions	Discussion
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1	The five digital business aptitude domains	(KMPG, 2015)	Vision & strategy, digital talent, digital first processes, sourcing and infrastructure, governance	The model is used solely to help KPMG understand the needs of their clients.
2	McKinsey's 7S framework	(Airiodion Global Services, 2021)	Complicated group factors are strategy, structure and systems; soft group factors are skills, staff, style and shared values.	The model is a legacy model introduced in the late 1980s, and it neglects the technological part of Industry 4.0
3	Deloitte digital maturity model	(Anderson & Ellerby, 2018)	Customer, strategy, technology, operations, organisation and culture	One of the most adopted models in the industry; one limitation is that the model is made for large organisations and may not be suitable for small and medium-sized enterprises (SMEs)
4	Pacchini's Industry 4.0 model focussing on technological development	(Pacchini et al., 2019)	Internet of Things (IoT), Big Data, Cloud technology, cyber-systems, autonomous robots, additive manufacturing, augmented reality (AR) extended with artificial intelligence (AI)	Focusses mainly on technological aspects
5	Digital Readiness Assessment Maturity model	(De Carolis et al., 2017)	Design and engineering, production management, quality management, maintenance management, logistics management	Technical aspects of the manufacturing facility

6	IMPULS maturity model	(Schumacher et al., 2016)	Six dimensions: employees, strategy and organisation, smart factory, smart operations, data-driven services and smart products	One of the most famous assessments in Industry 4.0
7	System Integration Maturity Model Industry 4.0 (SIMMI 4.0)	(Leyh et al., 2016)	Vertical integration, horizontal integration, digital product development and cross-sectional technology criteria	Focus on the integration between different entities in the supply chain
8	Smart Manufacturing Maturity Model for SMEs (SM ³ E)	(Mittal et al., 2018)	Three-axis model consisting of five critical organisational dimensions (x-axis) related to the manufacturing operations, modular toolkit (y-axis), including seven toolboxes and five maturity levels (z-axis)	Highly complicated model

2.10.1 McKinsey's 7S Framework

Assessment methods and tools differ from organisation to organisation. One way of assessing maturity in the technology business is McKinsey's 7S framework. The model was introduced in the 1980s by the consultants of the McKinsey company, and this model is still used and considered the most popular strategic planning tool. The 7S framework consists of seven different factors and is divided into two groups hard and soft. Hard group factors are strategy, structure, and systems, while soft group factors are skills, staff, style, and shared values. This model is used to check the organisational design and its effectiveness and assesses its digital maturity. According to Ravanfar, five steps need to be followed to apply this tool:

1. Identify the wrong targets.

2. Establish the most Suitable organisation design.
3. Determine the types of modifications and where they should be applied.
4. Apply these modifications.
5. Continuously repeat these steps of the 7s framework.

In the article by Demir, the case of a consulting company in the IT-sphere that was in the digital transformation process for three years and continuing to transform regarding Industry 4.0. Together with three company experts, McKinsey's 7s framework was applied for each 7S digital transformation, sub-criteria were developed and, using an analytic hierarchy process, defined its weights; as a result of the six-week job done, the company's current performance was equal to 78%. It was listed from the weight with highest to lowest, "Strategy", "Shared Values", "Structure", "Skills", "Style", "Systems", and "Staff". This analysis showed which criteria performance is weak and where additional improvements are needed.

2.10.2 Deloitte Digital Maturity Model

One thing that discourages the development of digital transformation is a need for better strategy and specified knowledge and roadmap for applying this strategy. The Deloitte digital maturity model covers the business's five principal dimensions: customer, strategy, technology, operations, organisation, and culture. The resulting digital maturity model avoids the usage of multiple tools to assess the organisation's readiness level and cuts costs.

They were divided into 179 individual sub dimensions, such as customer engagement, delivery governance, network, security, technology architecture, change management, workforce enablement, organisational design, and others, to broaden them and facilitate the process of grading each dimension. Thus, dimensions build the model of digital maturity for any applied organisation.

2.10.3 Pacchini's Industry 4.0 Model

Regarding Industry 4.0 as digital technology, Pacchini proposed a model based on the Society of Automotive Engineers standard J400 to measure the readiness and maturity

level of the manufacturing company. This standard was developed to measure lean manufacturing implementation, and the authors adopted its principle for measuring readiness level regarding Industry 4.0 implementation.

During the approach established, the first step was to identify the technologies that enable proper Industry 4.0 implementation. The identified "enablers" were IoT, Big Data, Cloud technology, Cyber systems, Autonomous robots, Additive manufacturing, AR and then extended with AI. Then, for each enabler, six prerequisites were identified. For example, for the enabler of Big Data, six prerequisites for a company were: a) availability of infrastructure for digital systems, b) information has to be organised and maintained in protected digital systems, c) availability of data communication network, d) availability of staff to collect data, e) treatment of big data at a strategic way, f) knowing the problems that to be solved with acquired data. Four possible levels of answers were used for each prerequisite: L0, L1, L2, and L3. Which correspond to "No", "Small", "Medium", and "Complete infrastructure", with respective points assigned to each level.

Similarly, applying such an approach to other prerequisites, the following formula (1) is used to measure the degree of readiness with regard to technology enabler:

$$g_n = \frac{\sum \text{points obtained as a result of evaluation of components of elements } e}{\text{Maximum points possible}} \quad (1)$$

However, to assess the company's readiness degree, it needs to be determined readiness degree regarding all the technology enablers using the formula:

$$D_R = \frac{g_1 + g_2 + g_3 + \dots + g_n}{n} = \frac{\sum_{m=1}^n g_m}{n} \quad (2)$$

Where $g_1, g_2 \dots g_n$ - degree of readiness of enabling technologies 1, 2...n, respectively. Where $g_1, g_2 \dots g_n$ - degree of readiness of enabling technologies 1, 2...n, respectively; n - number of enabling technologies and, D_R - readiness degree of a company towards Industry 4.0. Table 2-3 below presents the readiness degree status.

Table 2-3 Pacchini's Industry 4.0 model readiness degree

Degree of Readiness (D_R) - %	Status	Characteristics of the company
$0 \leq D_R \leq 10$	Embryonic	Some superficial knowledge
$10 \leq D_R \leq 25$	Initial	Some knowledge of some technologies but may not know all of them
$25 \leq D_R \leq 50$	Primary	A good knowledge of all technologies, only some were adopted.
$50 \leq D_R \leq 75$	Intermediate	Complete knowledge of all technologies and begun to be adopted
$75 \leq D_R \leq 90$	Advanced	Complete knowledge of all technologies and have a high degree of adoption.
$90 \leq D_R \leq 100$	Ready	Practically all the enabling technologies in the full degree of maximum adoption

2.10.4 The Acatech Industries 4.0 Maturity Index framework focused on data analytics

Gürdür, 2014 employed the Acatech Industrie 4.0 Maturity Index framework to assess Sweden's industry. The model focuses on four capabilities: resources, information systems, culture, and organisational structure. The authors designed the questionnaire containing 22 questions from Q1 to Q22.

The answers to the questions were constructed based on fully agree, agree, neutral, disagree and entirely disagree, and some answers were based on a "yes/no" format. Afterwards, the average of the responses was calculated to assess the readiness level, according to Table 2-4. This framework is helpful in assessing a company's current Industry 4.0 maturity level and identifying measures to achieve a higher maturity level. However, it was used for data analytics of the company.

Table 2-4 The Acatech Industrie 4.0 Maturity Index Model Scoring Guide

Average Score	Alignment Assessment	Readiness level
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0%-20%	Very Low	1
21%-40%	Low	2
41%-60%	Medium	3
61%-80%	High	4
81%-100%	Very High	5

2.10.5 The System Integration Maturity Model Industry 4.0 (SIMMI 4.0)

The SIMMI 4.0 aims to determine the SMEs' readiness for Industry 4.0 regarding the IT system landscape. This maturity model assesses the IT performance of the enterprise in terms of four dimensions, including vertical integration, horizontal integration, digital product development, and cross-sectional technology criteria.

Overall, the five maturity stages were considered in this model, including basic digitisation level (stage 1), cross-departmental digitisation (stage 2), horizontal and vertical digitisation (stage 3), complete digitisation (stage 4), optimised full digitisation (stage 5). Based on the questionnaire, there are formulae to compute each dimension's maturity stage. The overall maturity level is found by calculating the arithmetic mean of the maturity levels of all dimensions. This maturity model has been applied to six companies coming from the manufacturing, system engineering/consulting, service provider/tax consultant, and commerce sectors.

2.10.6 Smart Manufacturing Maturity Model for SMEs (SM³E)

The SM³E maturity model is a three-axis model that consists of five critical organisational dimensions (x-axis) related to the manufacturing operations, a modular toolkit (y-axis) including seven toolboxes, and five maturity levels (z-axis). In this SM³E maturity model, the five organisational dimensions, including finance, people, strategy, process, and product, were selected from the SME perspective.

The toolkit is a collection of techniques and practices that lead to the desired goal. The modular toolkit of the model considers the following seven toolboxes: (1) manufacturing toolbox; (2) design and simulation toolbox; (3) robotics and automation toolbox; (4) sensors and connectivity toolbox; (5) cloud/storage toolbox; (6) data analytics toolbox;

(7) business management toolbox. The five basic maturity levels for SMEs were considered in this model, which includes: *Novice, Beginner, Learner, Intermediate, and Expert*.

2.10.7 IMPULS Maturity Model

The IMPULS Foundation of the German Engineering Federation developed the IMPULS "Industry 4.0 Readiness" model. It was primarily dedicated to the Assessment of manufacturing and mechanical engineering companies. The model comprises six dimensions: employees, strategy and organisation, smart factory, smart operations, data-driven services and smart products.

The six dimensions are applied for developing a six-level model (from 0 to 5), each of which contains the minimum requirements for movement to the next level. In this system, Level 0 is the companies unprepared for implementing digitalisation activities, and Level 5 are top performers showing all digital maturity features. Hamidi et al. (2018) applied the IMPULS model for the assessment of Malaysian SMEs via questionnaires that were distributed via email to more than 250 companies from various industries. The representatives of companies weighted the score of dimensions by themselves, and the average result was taken for further Assessment. The study showed that overall, the SMEs in Malaysia lack the knowledge required for digitalisation, primarily in the field of data-driven services, strategy and smart factories.

2.11 DT Conceptual Framework

Digital transformation is not about technology only, as it requires the integration of all parts of the organisation to successfully develop and implement this transformation process. Moreover, to make it a continuous process, we need to change the organisation's strategy and embed this transformation into its core values, vision, and even culture. As in Figure 2-7, we categorised the building blocks of Digital transformation as follows: People, Tools and Enabling Technology, Strategy and Leadership, and Business Processes.

2.11.1 People

Human capital is the backbone of any change projects inside the organisation. Digital Transformation requires special skills that need to be embedded in the employees and workers of the organisation. The first step to begin developing the organisation's human capital is to assess the gap that exists in the digital skills of the organisation. This could be done by need assessment surveys or training focus groups to assess the employees' needs to cope with Digital Transformation.

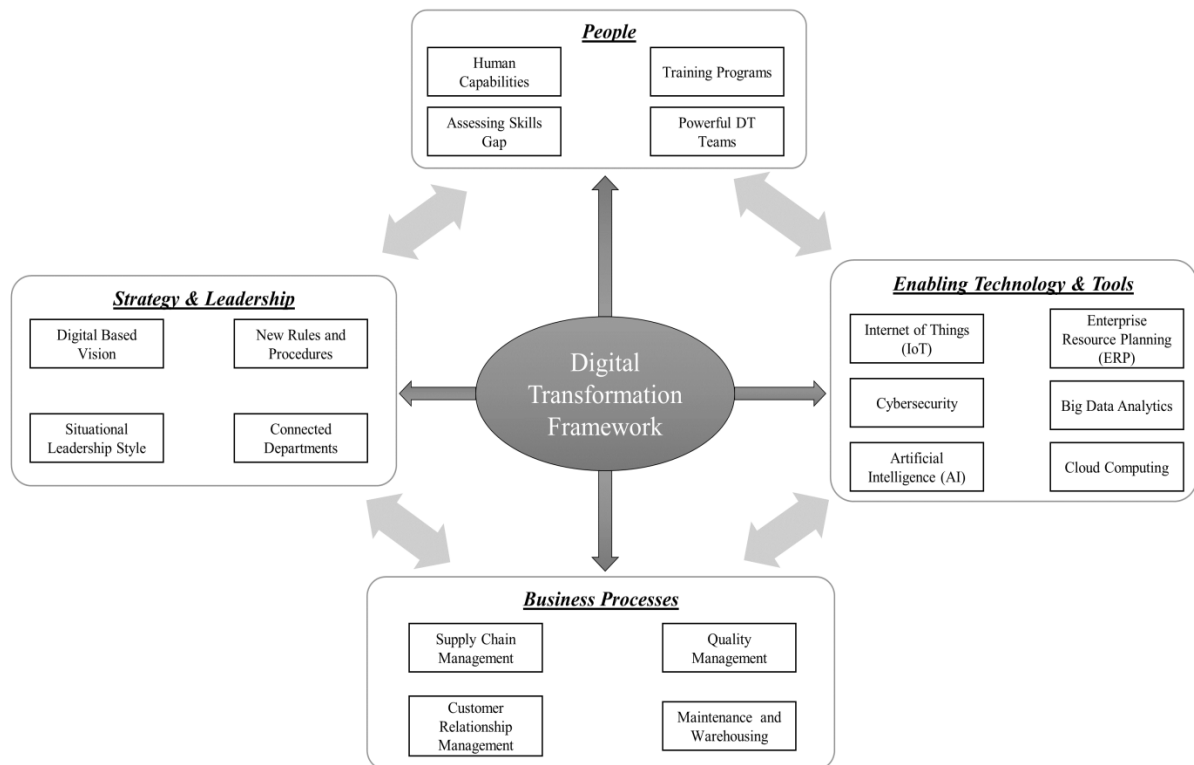


Figure 2-7 Digital Transformation Conceptual Framework (Abdallah et al., 2021)

Training programs should focus on technical skills, new technologies, and agile management practices to encourage workers to change and reduce their resistance to digital transformation practices. Another crucial element in human capital is team building and management.

Digital transformation is group work requiring different departments and parts to be integrated to achieve good digital transformation results. The team should consist of 1.

The digital transformation leader manages the whole process and resolves any conflict during the project's implementation. 2. *The change agent* encourages other members to cope with the change and be flexible in their job roles and work. 3. *The business expert* who has experience in marketing and distribution channel operations to reflect their perspective on the project. 4. *The data architect* who analyses and generates reports that help the top management make decisions at the right time. This is a swift process that needs much flexibility and taking the right decisions at the right time. 5. *The financial analyst* who makes the cost-benefit analysis for the project and handles the project's financial budget. 6. *The UX professional* who can reflect the customer's voice and make the organisation's solutions suitable for the end-user.

2.11.2 Strategy & Leadership Style

As highlighted before, in the proposed definition of DT, it is a continuous process that needs to be embedded in an organisation's strategy. Top management should create an organisational culture that encourages digital transformation practices and make internal incentives for these practices.

Another vital part of any digital transformation's strategic role is ensuring that the digital transformation process is in all aspects of the organisation, not only the manufacturing and operations process. This will require developing new rules and procedures for every department to implement, enhancing the human capital digital skills capabilities.

The leader plays a significant role in digital transformation. Changing their leadership style to suit the situation (Situational Leadership Style) is the most appropriate digital transformation project. A leader should have the following traits to be successful in the process: *Flexibility*: Being open to change requires an entrepreneurial attitude. *Diversified Knowledge*: By looking at what is happening in other sectors and seeing what works and applies to their industries. *Priority and Results Focus*: These are a must-win process that determines success or failure and are focused on improving the company's performance in the marketplace. *Ownership and Responsibility*: People respect courage and accountability. To lead effectively, executives and managers need to ultimately hold themselves responsible for their team's performance.

2.11.3 Enabling Technologies & Tools

One of the critical determinants of the Digital Transformation process's success is its digital technologies. Many researchers state different technologies used in the Digital Transformation process according to the organisation's field. All these technologies are linked together to achieve a more valid Digital Transformation process, as stated earlier in section 2.6.

2.11.4 Business Processes

Linking departments together is very important to digital transformation. Connected business processes are vital, from supply chain integration with suppliers and their different tiers to warehousing and quality management and ending with customer relationship management and hearing customer feedback. Linking all the processes across the value chain is very important, as single efforts will only succeed with integrating other processes across different departments.

This complexity of suppliers should be managed jointly for the transportation and storage of raw materials through Supplier Relationship Management software using the Internet of Things and Big Data analytics to ensure that there will be no shortage of raw materials for the manufacturing processes. So, this needs to be carefully managed and coordinated with the procurement department.

Using advanced Digital Transformation technologies in the organisation's manufacturing process, like robots/cobots through advanced robotics management, will enhance the organisation's productivity and continuously develop its products and services.

2.12 Research Gap

This chapter has discussed the meaning of Digital Transformation and its adoption in various business areas, reviewing the existing literature on specific factors. Based on the information from the reviewed literature, there is little guidance available for manufacturers adopting various digital technologies to improve their business activities.

Indeed, the following research questions have still not been effectively answered by the existing studies:

1. There is a lack of assessing the business readiness for Digital Transformation inside the manufacturing firm.
2. Further research is required to discuss the connection between technology and business aspects that can help businesses to achieve successful Digital Transformation in the manufacturing industry.
3. There is not enough research in the literature that discusses key digital leadership attributes that can help in successfully implementing digital transformation in the manufacturing industry.
4. Validated research studies are needed to identify and prioritise the most important steps in developing a digital transformation process in the manufacturing industry in a developing economy characteristics.

Based on these questions, it can be argued that there currently needs to be proper guidance and assessment frameworks to ensure adequate adoption of digital transformation tools in the manufacturing sector. This study aims to help bridge this gap by exploring this area to develop effective roadmaps, plans, and strategies to ensure digital transformation in this sector.

2.13 Chapter Summary

This literature review has analysed the existing literature on digital transformation and its impact on transforming business activities in various industries, especially the manufacturing sector. In summary, Digital Transformation (DT) is a customer-centric mechanism that enables continuous improvement in the productivity of the manufacturing processes using advanced digital technologies such as cloud computing, the Internet of Things, big data analytics, and digital twin in all aspects of the organisation. To date, most contributors have been academics from information systems. There is a diverse range of Digital Transformation examples in the literature, with some demonstrating benefits of embracing the Digital Transformation process in the manufacturing industry. There are, however, some key barriers to adopting digital

tools; for instance, lack of training and the skills gap in the manufacturing industry. This paper summarised the most adopted digital technologies in the Digital Transformation process, which include the Internet of Things (IoT) and Digital Twin.

The findings confirm that Digital Transformation solutions can bring revolutionary benefits to manufacturing organisations by increasing their productivity and enhancing customer engagement initiatives. The issues raised in this paper provide a valuable basis for further work. Digital Transformation is a concept of enormous potential and great significance for manufacturers. It offers routes for companies to step up the value chain and leverage value-added business activities.

3 METHODOLOGY

3.1 Introduction

This chapter provides brief information and an explanation of different philosophies, procedures, data collection methods, and tools used to complete this research. Chapter 3 is a significant chapter to include in the study because it talks about the framework used in research to complete it from start to finish. The methodology chapter provides readers with an overview of the study type. It contains a detailed plan so that research stays on track. It makes research smooth and manageable. Section 3.2 discusses the research methods, followed by Section 3.3, which discusses the chosen method and its justification. Section 3.4 describes the research methodology framework used in detail. Finally, Section 3.5 provides a chapter summary.

3.2 Overview of Research Methods

The study contains mixed methods, which have both types of research methods, including qualitative and quantitative. Due to its more likely qualitative nature, the study includes a descriptive research method. Descriptive means subjective in nature; therefore, the research contains essential information from the literature of different studies. It also consists of a mixed research method, due to which the research studies a new phenomenon that is new to both academia and the practical world. Furthermore, a combination of qualitative and quantitative methods has made this research analytical in nature. Analytical, in essence, means that the researcher has fully used various research methods, namely qualitative and quantitative. Due to analytical research, the study contains critical thinking. The mixed methodology has made it possible to include survey and interview methods to analyse facts and experiences related to different aspects and factors of digital transformation.

The research, therefore, also contains this aspect, in which qualitative research is mainly based on the views of participants who will give answers as a result of interview questions. It establishes common themes in the literature review section of the study,

such as focusing on a lengthy discussion related to different information on DT. It includes an open-ended questionnaire about the research and observations; however, the quantitative study contains close-ended questions for personally testing the assumptions of this study. According to research, a mixed methods study combines both types of research, including qualitative and quantitative. Therefore, it is easy to include information in a much broader way. It helps to have an in-depth understanding of the study topic by allowing the addition of qualitative and quantitative types of research instruments, such as interview questions or survey questionnaires. It includes different types of data collection approaches: primary and secondary.

The questionnaire is based on a 5-point Likert scale. On the other hand, secondary data is readily available in academic databases. Using the internet, a researcher has easily included secondary forms in a research study by utilizing information from various data sources. The information used from secondary sources is very efficient because it consists of the literature review section and generates accurate results. It also justifies the quantitative results of this study. All data sources are described in the data sources heading. Secondary research is beneficial because it allows for the most significant part of the study, which is the literature review. According to research, mixed methods can generate new ideas and understanding by reducing the complexity of research. It provides a sense of societal experiences and thoughts about the topic in a much more accurate way by using the quantitative nature of research. The study also contains more than one philosophical aspect due to the mixed methods. such that it includes both interpretivism and positivism as philosophical paradigms. The positivism paradigm is due to a quantitative form of study, and interpretivism is a qualitative form of analysis. Positivism does not include a personal form of research, unlike the humanistic qualitative method philosophy. It explores social reality to understand human behaviour in terms of its objective nature.

3.3 Philosophical Paradigms of Research

The philosophical research paradigms for the research are interpretivism and positivism. These two types of methodology—interpretivism and positivism—are used

due to the presence of mixed methodology. The positivism paradigm is due to a quantitative form of study, and interpretivism is a qualitative form of study. Because of the benefits of both types of philosophies, a researcher has used these two types of philosophical paradigms. Interpretivism benefits in the form of flexibility because it provides flexibility to the study and helps generate societal thoughts in research based on meanings and understandings on social and experimental levels. Deep analyses are also aided by interpretivism. Likewise, there are various advantages to the positivist philosophy. It helps formulate a hypothesis; a researcher can easily decide the null hypothesis of the study; and it helps maintain the true results and outcomes of the study.

The above two paradigms help in the generation and quick analysis of data. The positivist philosophy contains data reliability and allows the addition of objective data to the study.

3.4 Research Approaches

Research approaches that are used in this study include inductive and deductive approaches. Due to mixed methodology, the researcher has used both forms of research. The inductive approach is used as a qualitative research method, providing various advantages to the study. It does not require any form of test related to theory. An inductive research approach allows researchers to obtain research findings from raw data without any rigorous processes brought about by structured data analysis techniques. The main aims of inductive approaches are to gather extensive data, summarise them into a brief format, link the research objectives with the findings, and develop a framework, model, or theory on issues evident in the research findings. This approach allows researchers to develop categories from the collected data and use them to create frameworks or models containing key themes and activities of great interest (Thomas, 2003).

However, conclusions drawn from inductive research may still need to be fully proven, which is why a researcher sought help from the quantitative study method by utilizing

the deductive approach. The deductive approach is used to test theories and provides various advantages for research studies. The deductive approach helps to maintain the problem statement, prove the true hypothesis by analysing survey results, and decide whether to reject the null hypothesis.

3.5 Mixed methods Research Strategies, Justifications, and Selection

The research contains various research strategies, including survey and interview research strategies. The study uses these strategies to cover research's quantitative, qualitative, secondary, and primary aspects. It includes sampling information and observations. At the same time, the study contains observations to analyse the nature, behaviour, and thinking of society related to the topic of study (the DT process).

3.5.1 The Ontology and Epistemology of Research

The ontology of a mixed research method refers to the underlying philosophical assumptions about the nature of reality that inform the design and execution of a research study that uses both qualitative and quantitative methods. In mixed methods research, ontology is typically mixed as well, reflecting the belief that reality is multi-faceted and can be studied using a variety of approaches.

Mixed methods research typically involves collecting and analysing both qualitative and quantitative data in order to triangulate findings and increase the validity and reliability of the study. This approach recognises that different methods can provide complementary insights into a research question and that combining these insights can provide a more complete understanding of the phenomenon being studied.

The ontology of mixed methods research is often guided by a constructivist perspective, which recognises that individuals' understanding of the world is shaped by their experiences and social interactions. This perspective encourages researchers to be open to multiple perspectives and to consider the context in which the research is being conducted.

Ontology is related to beliefs that reflect the interpretation to constitute any fact related to any individual or an individual. The ontology of this research includes the reality of assumptions associated with the topic of study or the DT process. It consists of the nature of knowledge about this research's DT concept of this globalised world. It describes how the world looks at this aspect.

The epistemology of a mixed research method refers to the underlying philosophical assumptions about what can be known and how knowledge is acquired in the context of a research study that uses both qualitative and quantitative methods. In mixed methods research, the epistemology is typically pluralistic, recognising that there are multiple ways of acquiring knowledge and that each approach has its own strengths and limitations.

Mixed methods research typically involves collecting and analysing both qualitative and quantitative data in order to triangulate findings and increase the validity and reliability of the study. This approach recognises that different methods can provide complementary insights into a research question and that combining these insights can provide a more complete understanding of the phenomenon being studied.

Moreover, epistemology contains assumptions for this research: positivism and interpretivism, which are the two main assumptions of epistemology. Ontology is related to the reality of this research's issue or topic of study. At the same time, epistemology includes participants' experiences and fundamental beliefs. The study also includes the Pragmatist Paradigm for the fundamental set of different worldview perspectives related to DT.

3.5.2 The Rationale of the Pragmatist Paradigm

The pragmatic paradigm is anchored on the argument that the basis of research should be to examine the practical truth about the real world. It is based on using different methods and strategies to interrogate data by discussing its practical aspects. This paradigm was deemed appropriate for this study because it is relevant to studies focusing on how organisations learn and make meaning out of their everyday

experiences. The pragmatic paradigm can help researchers explore and understand how knowledge and actions are related and linked together, which, together with objective views about the real world, can help transform practice (Kelly and Cordeiro, 2020).

As Kaushik and Walsh (2019) argue, pragmatism supports adopting multiple research methods to conduct studies. It affirms that researchers should choose the best methods that fit the issues being investigated. In most cases, the pragmatic approach is mainly adopted in studies that use multiple or mixed methods. Moreover, pragmatist philosophy is based on the belief that human actions originate from our thoughts and past experiences. Pragmatists also contend that reality is diverse and continually evolves. The world is subject to changes, and every change only comes as a result of actions. Therefore, the pragmatist approach was deemed appropriate for this study because it suits studies aimed at examining the social realities surrounding employees and their environment, especially concerning the adoption of digital technologies within their firms.

3.5.3 The Rationale of the Mixed Methods Approach

A mixed methodology approach should be used in research for several reasons. One rationale is that it allows for the collection and analysis of both qualitative and quantitative data, which can provide a more comprehensive and nuanced understanding of the research question. Using multiple methods allows researchers to triangulate their findings and improve the study's validity and reliability.

A mixed methodology approach also allows for the incorporation of various perspectives and approaches to the research question. This can provide a more balanced and comprehensive understanding of the phenomenon being studied and can help address potential biases that may be present in a single-method approach.

A mixed-methods approach can also be useful in situations where the research question is complex and cannot be adequately addressed using a single method. This

approach allows for the use of multiple methods to explore different aspects of the research question and can help provide a more complete understanding of the issue.

Finally, a mixed methodology approach can be useful in situations where the research question is dynamic and requires the use of multiple methods to capture the complexity and changeability of the phenomenon being studied, like the DT in a complex sector like the manufacturing sector.

A mixed-methods research strategy was adopted for this study because it allowed for the collection of data from multiple sources. It helps researchers approach complex issues by allowing for the use of different philosophical frameworks and bringing together qualitative and quantitative data to explain a single research issue. This way, research issues are deeply explored and thoroughly explained, resulting in a clear understanding of the variables under investigation. Moreover, the mixed methods approach is also a flexible research technique that allows for flexibility in choosing research methods and helps researchers explore and understand small cases. As such, the mixed methods approach enables researchers to explore and understand issues of interest in depth, leading to research findings that can be generalised to the whole population (Dawadi, Shrestha, and Giri, 2021). For this particular study, the mixed methods research technique was helpful in collecting qualitative and quantitative data from the field, providing a rich information source on the issue under investigation.

3.5.4 Advantages of Mixed Methodology

There are various advantages to mixed methods, which are defined as follows:

Synergy: It includes quantitative methodology, which can be obtained objectively, and helps a researcher include the objective form in the research study. The basic concept of the mixed method is the integration of qualitative and quantitative data, which allows for synergistic utilisation to provide understanding of the research problem of study. A better understanding of research has been obtained through a set of results from the qualitative and quantitative analyses, thereby enhancing the validity and reliability of the study.

Expansion: Expansion is used for an in-depth and brief understanding of any aspect or topic. Therefore, the most significant advantage of the mixed methodology is that it allows for expansion of the research study. Using quantitative statistical data and subjective or argumentative qualitative data has generated meaningful and actual outcomes in the study. The researcher has easily expanded both qualitative and quantitative data.

Development: for example, the results of one methodology aided a researcher in developing the findings of a quantitative study. For example, discussion from different research studies and statements by different authors has helped a researcher develop a quantitative survey questionnaire. Thereby, participants answered those closed-ended questions, and the researcher then analysed the participants' answers to generate results. Quantitative and qualitative results are explained in more detail in the results chapter.

Participatory: This means the involvement of both types of participants, such as interviewers and participants, in the survey questionnaire. A participatory approach in the research process is necessary to fulfil the needs of the research study; participants' answers are essential to analysing the results. It is also crucial for the generation of fair outcomes from the study. The involvement of participants in mixed methods ensures that the study's findings are worthy and do not contain any false information about the research topic and its related aspects.

Evaluators can quickly analyse the clarity of research and validate the results with the help of research findings because of mixed methodology. Findings from both types of data sources, namely qualitative and quantitative, can be compared simultaneously. Data and results are analysed with the help of side-by-side discussions and the transformation of qualitative data sets into quantitative scores. In addition to all this, qualitative as well as quantitative data can validate each other by creating a solid foundation from which to draw conclusions and make evaluations.

3.5.5 The Rationale of the Survey Technique or Strategy

A rationale for the survey strategy is to use a process or tool to gather information related to the topic of study and issues related to the topic. It entails posing questions to a pre-determined group of people. It helps to exchange information between research participants and the thoughts of the researcher or society related to the topic or issue. The survey method is ideal for quantitative research because it allows the researcher to send any type of data via email. A survey means sending a survey questionnaire to different people. Those people have different experiences related to the questions present in the survey. For example, this study contains questions related to the DT process, the DT process in Egypt, the factors, challenges, and advantages of DT, its readiness, enablers, and various other information about DT. The answer to the survey questionnaire is significant to a researcher for this study's findings, analysis, and results. Including this, the respondents' answers are also worthy of readers' attention because they provide an overview of societal thoughts, experiences, readiness, challenges, limitations, and many more about the digital transformation process.

3.5.6 The Rationale of the Interview Technique or Strategy

The interview strategy is used due to the qualitative nature of this study, and it depends on asking participants interview questions. An interview involves more than two people or a group of people who are asked questions by the interviewer. There are various types of interviews, but this research includes open-ended interviews (open-ended interview questions). The interview gathered people who work in different organisations in Egypt and have information about DT processes. Therefore, the interview process for this study was very good. Face-to-face interview sessions are very efficient and provide a researcher with sufficient information about the topic.

3.5.7 Research Instruments for Mixed Methodology

To analyse the study's results, research instruments are essential. So, this study also contains research instruments, which include survey questionnaires and interview questions. Both types of research instruments cover the requirements of mixed

methodology. The survey questionnaire instrument is for the generation and determination of the results, which are of a quantitative nature in this study. It contains closed-ended questions on a five-point Likert scale. In addition to this, due to the complex nature of the study, interview questions are included as a research instrument. It has open-ended questions. However, the study's qualitative and quantitative nature questions aid in the generation of accurate results and test results.

3.6 Sampling procedure

3.6.1 Interviewing Sample

The study contains data from employees' perspectives, so the sample has been chosen from employees of Egyptian organisations that work in different manufacturing sectors. The population of this research represents the manufacturing firms in Egypt which have digital technologies enabled in their manufacturing processes. For this purpose, the research focussed on bog industrial firms that have been in operation for more than 10 years and have technological elements in their operations. Purposive sampling was applied to this research. Purposive sampling, also known as judgmental sampling or selective sampling, is a non-probability sampling method used in research where the researcher intentionally selects specific individuals or cases for inclusion in the sample based on their unique characteristics, expertise, or relevance to the research objectives. In purposive sampling, the selection of participants is not based on random chance, but rather on the purpose or intent of the research (Ortt et al. 2020). Due to COVID-19 restrictions during the time of the study and the difficulty of traveling across countries, it was not possible to select a large sample size for interview questions. So, 28 were contacted to conduct the interview, but only 21 responded positively. Therefore, the size of the interview for sampling contains 21 participants. Table 3-1 summarises the interviewee's title and experience in related industries.

Table 3-1 Experience of Experts Participating in the Interviews

No.	Industry	Title	Years of Experience
E1	Home Appliances	Production Planning Manager	15 Years
E2	Home Appliances	Quality Control Director	10 Years
E3	Home Appliances	Plant Manager	20 Years
E4	Home Appliances	Product Line Manager	8 Years
E5	Home Appliances	Production and Operations Supervisor	9 Years
E6	Food Processing	Plant Manager	10 Years
E7	Food Processing	Production Line Supervisor	9 Years
E8	Food Processing	Research & Development Director	10 Years
E9	Food Processing	Production Line Manager	7 Years
E10	Food Processing	Quality Inspection Manager	9 Years
E11	Food Processing	Plant Manager	15 Years
E12	Textiles and Clothing	Quality Inspection Director	10 Years
E13	Textiles and Clothing	Production Line Manager	15 Years
E14	Textile and Clothing	Research & Development Manager	12 Years
E15	Furniture	Plant Manager	7 Years
E16	Furniture	Product Design and Innovation Manager	11 Years
E17	Furniture	Production Line Manager	17 Years
E18	Plastics	Plant Manager	6 Years
E19	Plastics	Product Line Manager	8 Years
E20	Other (Oil & Gas)	Plant Manager	9 Years
E21	Other (Pharmaceuticals)	Production Manager	5 years

Interviewees were selected according to two main criteria: job experience relevance as working with digital technologies before and surveying the organisation's top

management on who should be interviewed according to our research aim. For the full list of questions during the interview, please see Appendix A.

3.6.2 Survey Collection Sampling

On the other side, for a survey, a sample size of 80 includes different departments of organisations in Egypt. So, the researcher has decided to collect data from interview answers and survey results. For this task, a researcher has taken the help of a non-probability sampling procedure with a self-selecting approach. The employees are from various organisations' technology-related work or technology departments to measure the usage and availability of DT in those organisations. The full list of questionnaire items can be found in Appendix B.

As Figure 3-1 shows, the number of employees who responded to the survey and belonging to the public sector is 23 (28.75%) and who work in the private sector is 57 (71.25%).

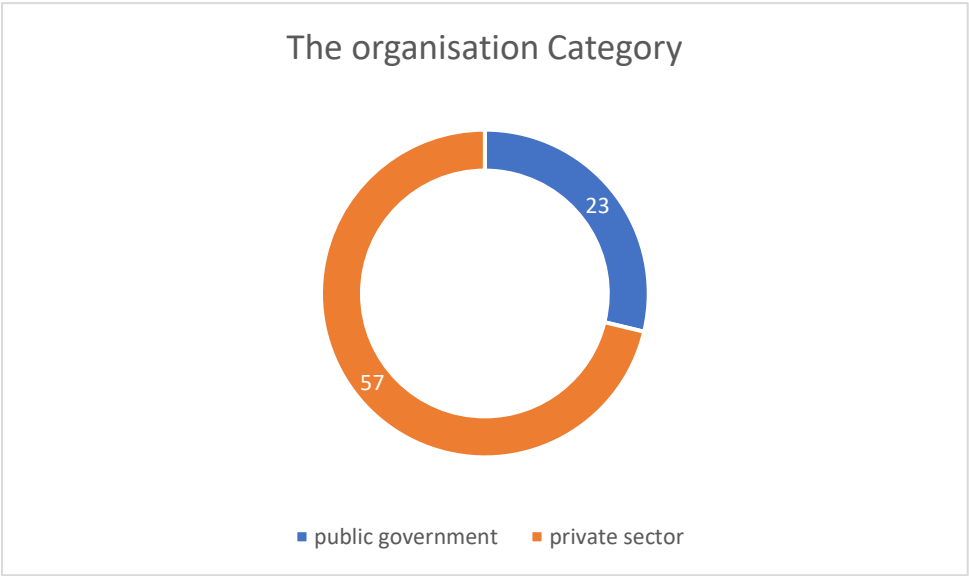


Figure 3-1 The Organisation Category

The survey focused on manufacturing firms that have strong experience, with 42 (52.5%) respondents coming from organisations that have more than 10 years of experience in the manufacturing sector, followed by 29 (36.25%) respondents coming from organisations that have 5-10 years of operations as in Figure 3-2.

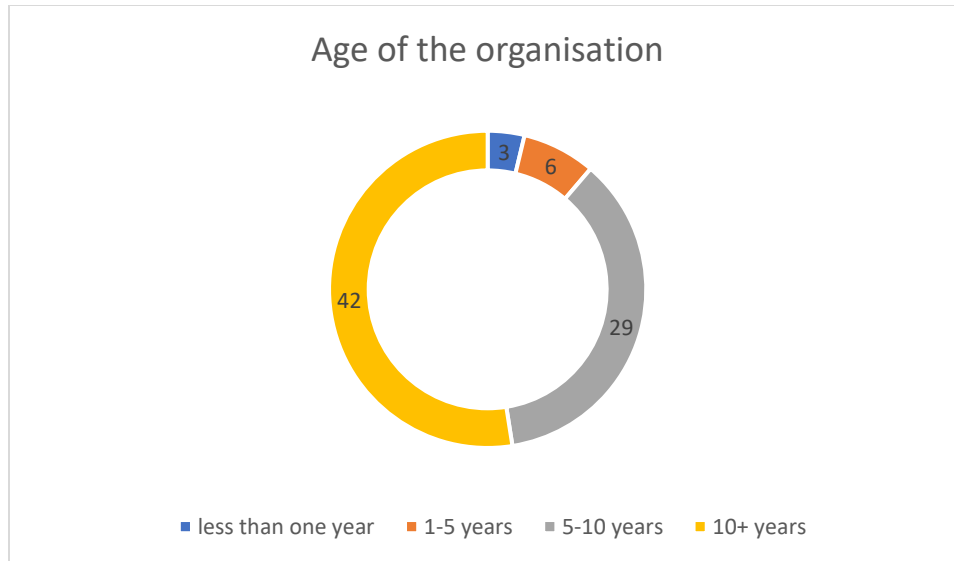


Figure 3-2 Age of the Organisation

The data was collected from different manufacturing sectors working in Egypt in different geographic areas. Table 3-2 shows that the most manufacturing sector represented in the data results was the food processing industry, with 26 (32.5%) respondents, followed by the textiles industry, with 16 (20%) respondents, and third, comes the home appliances industry with 12 (15%) respondents. This gives the indication that the results of this study are generally talking about the manufacturing industry, not about a specific sector.

Table 3-2 Manufacturing sector categories

Which manufacturing sector does your organisation belong to?

	Frequency	Percent	Valid Percent	Cumulative Percent
Textiles	16	20	20	20
food processing	26	32.5	32.5	52.5
chemicals	5	6.25	6.25	58.75
Electrical machines	4	5	5	63.75
Pharmaceuticals	7	8.75	8.75	72.5
Hydrocarbons	2	2.5	2.5	75

Cement	3	3.75	3.75	78.75
Oil and gas	3	3.75	3.75	82.5
home appliances	12	15	15	97.5
Others	2	2.5	2.5	100
Total	80	100	100	

The organisation's size also varies in the data collection process, as in Figure 3-3. Most of the respondents came from organisations with an average number of employees from 250-500, with 39 (48.75%) responses. 17 respondents came from organisations with 50-100 average number of employees, followed by 16 respondents from organisations with 100-250 average number of employees.

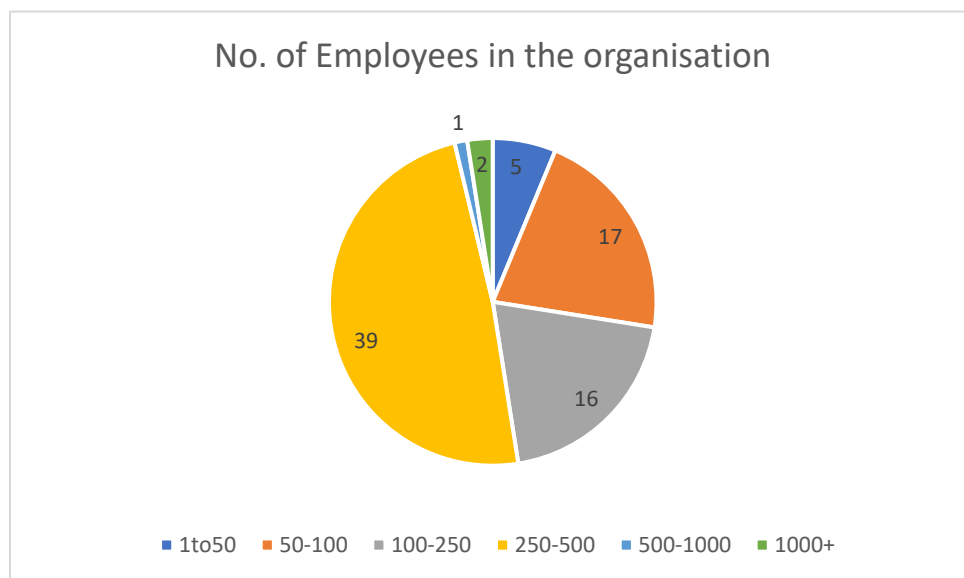


Figure 3-3 Size of the Organisations

Regarding the respondents themselves, most of the respondents having experience from 10-15 years (37.5%), followed by 5-10 years of experience (33.75%) as in Figure 3-4

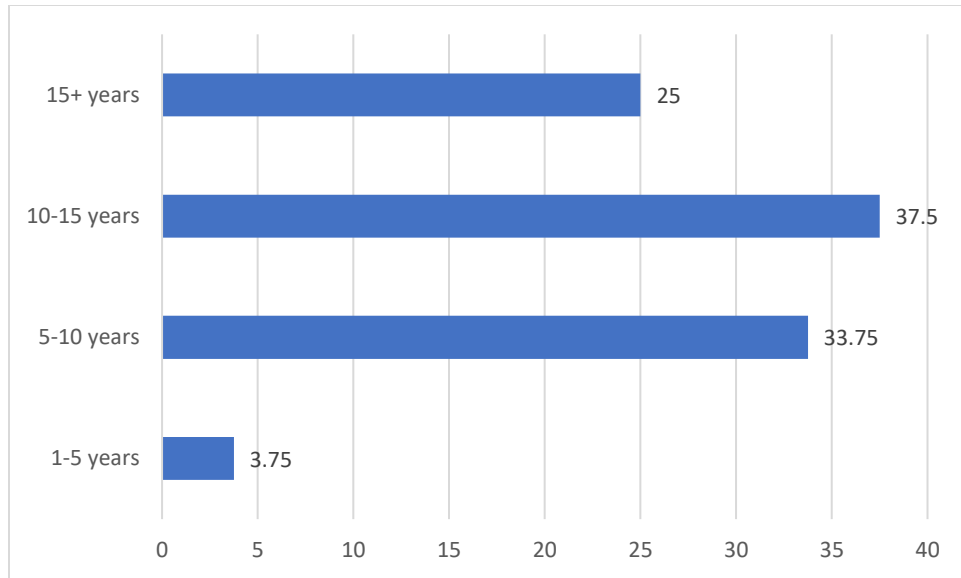


Figure 3-4 Level of experience of the survey respondents

Most of the respondents had professional experience in the field of Information technology (31), Operations and Manufacturing (27), marketing and public relations (22), sales and customer service (19), strategic management (16), human resources (15), financial management (5), top executive management (2) and Others (2) as in Figure 3-5

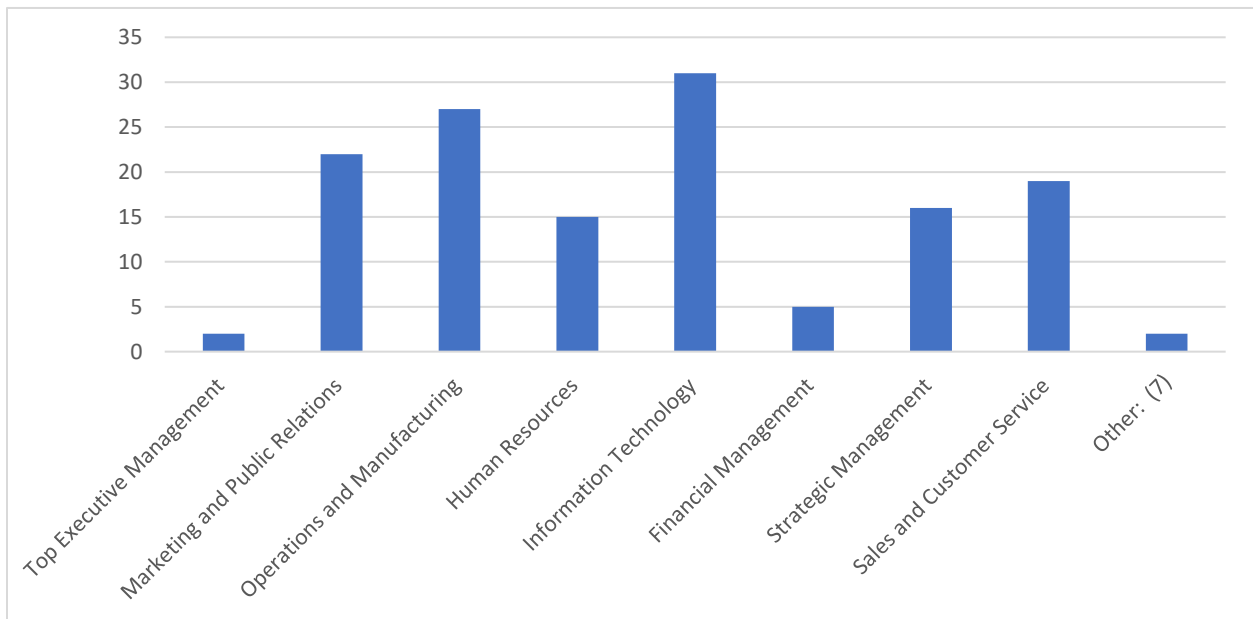


Figure 3-5 Areas of experience for the respondents

The variety of the organisation size and type, in addition to the different sectors represented in the survey collection, gives this study the strength that it can be generalised to a wide range of sectors among the manufacturing industry in any developing economy like the Egyptian economy.

3.6.3 Data Sources

Primary data was obtained from different sources using both qualitative and quantitative methods of data collection. These included interviews, panel discussions, and the use of questionnaires. A total of 21 interviews were conducted. The questionnaire responses were obtained from different companies or individuals operating in various sectors in Egypt. The selection of participants in the interview or the panel discussions from different organisations is meant to cover the whole DT ecosystem and gather different viewpoints and angles on this transformational process in the economy.

Secondary data sources are solely used for the generation of different chapters, mainly the literature review chapter of this research. All information and data are up-to-date and from the past five years. These sources include academic databases such as Scopus, EBESCO, and Web of Science; different websites related to the information in DT; articles; and various other published documents in electronic form.

3.7 Research Methodology Adopted

The research methodology is presented in four phases, as in Figure 3-6, which the research will follow to fulfil the research aim and objectives. The section below gives a picture of the steps followed for this study.

3.7.1 Background and Contextual Development

The initial phase of this research aimed to gain a contextual understanding of digital transformation and digitalisation concepts, along with the evolution, issues, and current trends in research and practices. It involves a thorough review of the literature and conference attendance to gather extensive information about the topic. As in chapter 2,

the literature review process focused on exploring the digital transformation process to get a deep understanding of the topic. To attain this goal, key drivers of the DT process as well as the challenges faced by organisations in their attempts to attain their DT goals were assessed. Another area of focus was the evolution of the concept of digitisation. This involved tracing the history of the concept of "digital transformation" or "digitisation" and how different technologies have transformed businesses from the beginning to this time. This process led to identifying and analysing research gaps, problems, aims, and objectives.

3.7.2 Field Study and Development of a Conceptual Framework

After an extensive literature review, a detailed list of critical challenges faced by organisations in their implementation of digital transformation was developed. Chapter 2 introduces a proposed model to categorise and represent these challenges, giving a vivid view or representation of each factor and their related elements. The study then developed a definition of "digital transformation" in the context of manufacturing firms. This process involved comparing different definitions by various authors to come up with a comprehensive and final definition of the term. Thus, with this definition and the analysis of research gaps, steps for the framework's development were identified, establishing the framework's base. A pilot survey was then developed to validate the information gathered from the literature review. The survey targeted the top manufacturing companies in Egypt to assess the readiness of their businesses to adopt digital tools. This process led to the identification of the DT challenges and the creation of a conceptual framework for DT development and implementation.

3.7.3 Data Development and Analysis

Different research techniques and methods were adopted to explore DT concepts and processes. Since this study aimed to collect information from different sources, a mixed methods approach was chosen to allow for the collection of both qualitative and quantitative data as described in chapter 3. The mixed methods approach was deemed appropriate for this study because it allows the adoption of different tools and

techniques of data collection to capture relevant data. Thus, the data collection process was carried out through focus group discussions, interviews, and questionnaires. Samples of industry experts with different levels of experience and companies operating in the manufacturing sector were interviewed to collect their views and personal experiences with different digital tools. Data analysis was then conducted using appropriate techniques and methods, leading to additional findings about the topic. This process led to further refinement of the framework.

A research study has mixed methodology due to its combination of constant comparative analysis and a statistical package approach for data analysis. To analyse the results of the quantitative study, a researcher used the constant comparative analysis technique. There are several advantages to both types of approaches in the study. The statistical package approach helps analyse the participants' results from the survey questionnaire, and the constant comparative analysis approach is flexible in analysing statements to make different observations. It is also used to analyse the results of the interview answers of participants related to the topic of study. A constant comparative analysis is primarily helping to compare studies and generate new studies. It has a defined sampling procedure used to cover study goals (to analyse the results of the qualitative and quantitative nature of research).

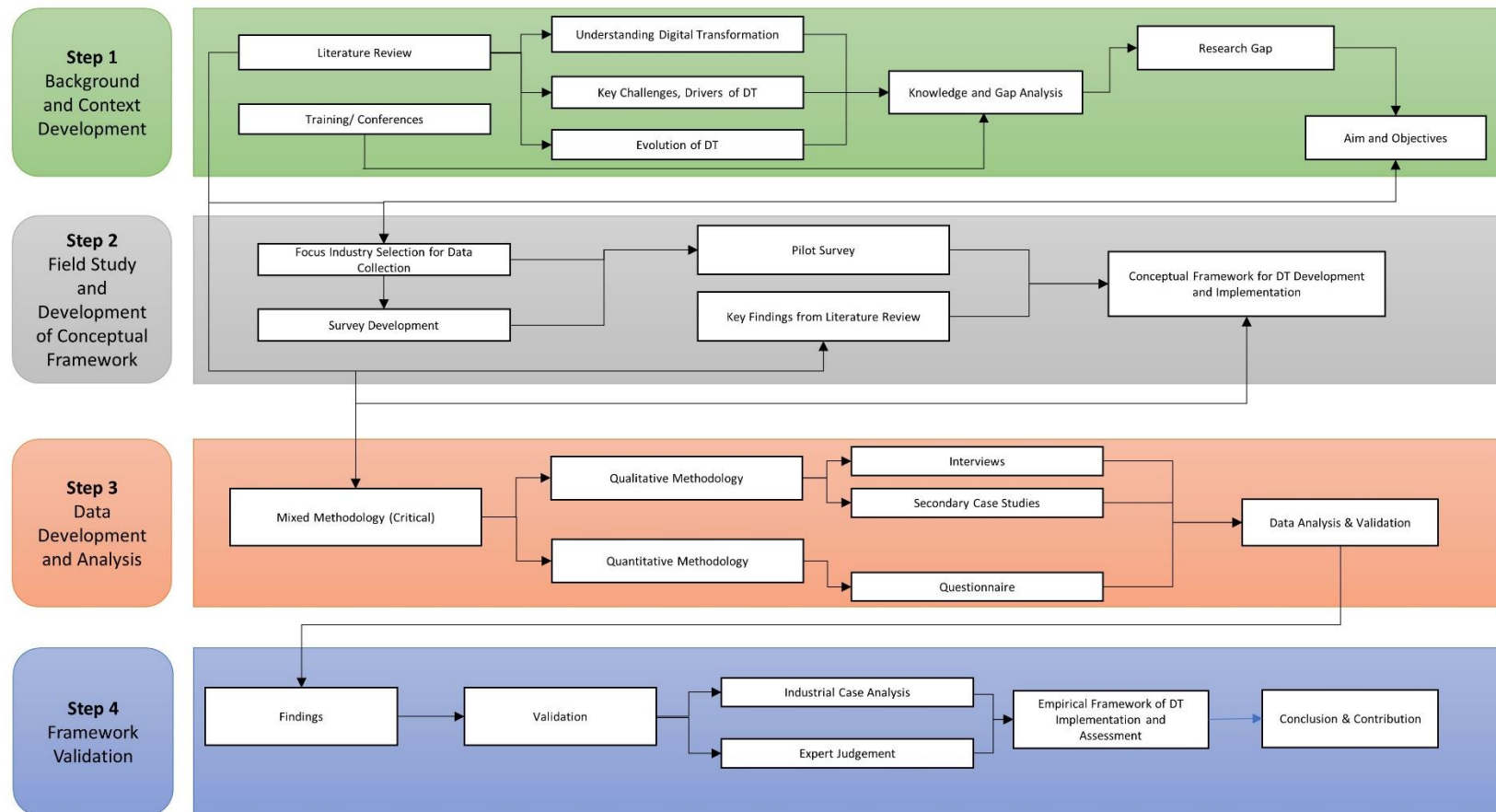


Figure 3-6 Research Methodology Framework

3.7.4 Framework Validation

An assessment was conducted in the final phase of the research to validate the framework. As seen in chapter 7, the validation was carried out in two steps, where the first stage involved conducting case studies to determine the framework's quality. Three case studies were used to fulfil this aim. The process involved selecting three companies operating in different manufacturing sub-sectors to assess their views and experiences based on the developed model. This was necessary to gather data using real-life experiences of businesses and use it to validate the model. In the second stage, experts' opinions were used to verify the model. This involved collecting the views of various professionals in this field to gain first-hand information about their experiences. The collected information was then used to develop assumptions and observations, leading to the final phase of the framework validation.

There are different forms of validation techniques; however, to ensure the validity and reliability of this research, a researcher has used a two-way-research process which has eliminated errors from this study. Due to the availability of secondary forms of data, information has gathered from valid sources, such as information from the latest electronically published papers with proper referencing sections and citations.

On the other hand, the internal validity technique includes ensuring the reliability of the information in a quantitative study by utilising sampling frames from different organisations. It has eliminated the risk of sampling bias. Moreover, the researcher used specific case study techniques to validate the readiness assessment model and used expert interviews to validate other results in this research. Validation techniques will be covered in a separate chapter after the results and findings chapter. In addition, the following tactics applied:

1. Prolonged involvement - The researcher engaged in a long period of interaction with the case companies spanning close on to three years, from initial access meetings to final meetings.

2. Data triangulation - by employing different research methods to capture data from different sources. These are documentation, archival records, interviews, and surveys. Panel discussions and direct observations.
3. Member checking - involved presenting results and analysis to participants in order to get feedback. Within this research, the findings were continuously reflected back to the interviewees in order to obtain clarification and assure relevance.
4. Peer debriefing and support - debriefing sessions with other researchers after data collection helped to reduce bias.
5. Audit trail - a record of activities was kept for the duration of the study. The majority of the data collection lasted for two years starting in 2020 and ending in late 2021. During this period, 21 interviews were conducted. Most of these interviews were tape-recorded. During all the interviews, notes were taken in order to capture the interpretations during the interview process.
6. Research dissemination - activities through which research was publicised resulted in the refinement of research due to criticism and feedback. The work carried out in this thesis resulted in a number of outputs. Amongst these, the most notable one is the two articles which were peer-reviewed and published in Product Management and Development Journal and Information Systems and E-Business Journal. In addition, one journal paper is currently under review in its second round in the Humanities and Social Science Communications Journal. Moreover, three conference papers were reviewed and accepted into the peer-reviewed International Conference of Manufacturing Research (ICMR) in 2021 and 2022.

3.8 Chapter Summary

This chapter has provided brief information related to different aspects of research. It has detailed information about different research strategies, philosophies, data collection, and analysis methods, which have been used due to the involvement of mixed method research study. It has clearly defined and indicated a research onion and framework from which we can analyse the importance of the methodology chapter of the study. Chapter 3 is an essential part of research likewise other parts, because it indicates which type of research is. It has shown the overall framework of research.

Chapter 3 of methodology in this research has also suggested that this research is of mixed type or it contains mixed methods. Due to this, it includes two research instruments: survey questionnaires and interview questions. It has defined the reliability and validity of the research and the data sources used to do this research. The rationale of mixed methodology has also explained why it is needed in the study.

4 DIGITAL TRANSFORMATION PROCESS IN THE MANUFACTURING INDUSTRY

4.1 Introduction

According to the study by Mouneer (2021), in Egypt, COVID-19 severely impacts the manufacturing sector, and the crisis is very dominant in almost all manufacturing sectors. It has reduced the output of manufacturing sectors. The COVID situation has also increased fear and anxiety among employees. Various employees were facing health-related issues. In this situation, a digital transformation was helping organisations stay competitive and in working mode. The study by Abdallah et al. (2021a) has defined the impact of the DT process, which requires change management. According to the study by Abdallah et al. (2021b), DT provides various benefits but requires some changes. DT is a combination of disruptive technologies that are very hard to apply and use.

A comprehensive literature review indicated that more effort was needed to develop a balanced process for implementing DT in the manufacturing sector that focuses on DT's four dimensions. The existing DT processes' significant limitation is that they primarily focus on adopting digital technologies. They also lacked the skills to overcome the challenges of implementing the DT process resulting from human resistance to change and the development of communication plans for integrating all stakeholders.

To overcome the above drawbacks, this research project has developed an integrated digital transformation process for the manufacturing industry. The process that has been developed has taken into consideration all the aspects of the entire digital transformation process.

This chapter describes the research findings and the digital transformation process in the manufacturing sector. It provides a detailed overview of the findings from the literature review and interview process, which resulted in the development of a prioritised-step process for successfully implementing DT in the manufacturing industry. It concludes with a discussion of the practical implications of the study's findings.

4.2 Research Methodology

This study followed an integrated approach to determining the stages necessary for DT in Egypt's manufacturing industry, which included stakeholder interviews and literature reviews. The research methodology, as shown in Figure 4-1, consists of four steps. First, analyse the literature review to find the most important and valid steps for developing a successful DT process in the manufacturing industry in Egypt. Second, conducting a qualitative analysis of the interviews held with 21 experts in the field to determine the most important steps using the Best-Worst Method (BWM) as a key multi-criteria decision-making (MCDM) approach. Third, a quantitative analysis was conducted for the survey results using descriptive statistics to support the data collected from the interview and increase the reliability of the model. Finally, a brief description of the process according to the ranking has been conducted, and the new proposed process to implement DT successfully in the manufacturing industry has been introduced. Each step will be discussed in the following sections. Figure 4-1 illustrates the adopted research methodology.

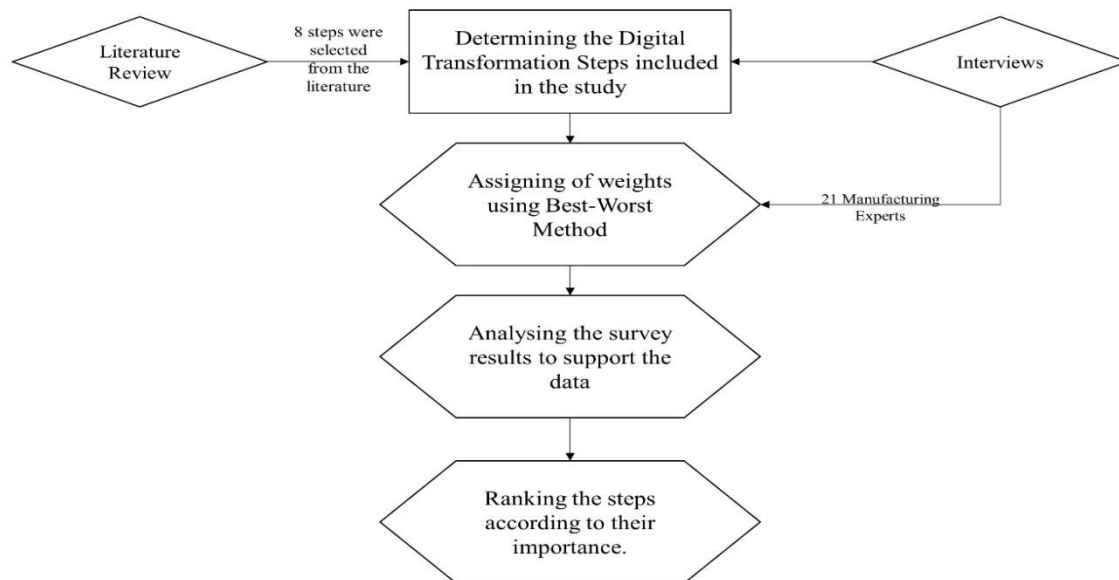


Figure 4-1 Methodology adopted for the study

4.2.1 The Rationale for Using the BWM Technique

Multi-criteria decision-making (MCDM) is a well-established technique for resolving complex situations, especially when several factors affect an objective (Wankhede and Vinodh, 2021). It is a subset of decision theory. MCDM issues can be classified into two types according to their solution space, namely discrete and continuous. Multi-attribute decision-making (MADM) approaches can be used to handle discrete problems, whereas multi-objective decision-making (MODM) methods can be used to tackle continuous problems. MCDM has been used in a variety of ways over the years, including the Analytic Hierarchy Process (AHP), Technique for Order of Preference by Similarity to the Ideal Solution, Analytic Network Process, and Preference Ranking Organisation Method for Enrichment Evaluations, among others (Rezaei 2015).

The best-worst method (BWM) was adopted in this research. According to Rezaei (2015), the BWM is yet another effective MCDM tool that, due to its unique properties, can be used to investigate complex problems like the one discussed in this study: (a) The BWM can be used alone or in conjunction with other qualitative or quantitative approaches; (b) The BWM's consistency in comparisons makes it extremely trustworthy; (c) The BWM makes use of integers for convenience; and (d) In comparison to the AHP approach, the BWM approach requires fewer pairwise comparisons. This is why the BWM technique was used in this study to weigh the variety of aspects evaluated.

The BWM can be calculated using the following stages (Rezaei 2015):

1. The first step involves the creation of the decision criteria set: $\{C_1, C_2, C_3 \dots C_n\}$.
2. The second step involves the determination of the best (i.e., most important) and worst criteria (least important).
3. Step three is the determination of the favourite of the best criterion over every other criterion by assigning a number from 1 to 9. In this case, the vector for the resulting Best-to-Others would be as indicated in Eq. (1):

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn}) \quad (4-1)$$

where a_{Bj} denotes the preference of the best criterion B over the j criterion, and $a_{BB} = 1$.

4. The next step is to determine the preference of the various criteria over the worst criterion by assigning any number between 1 and 9. In this instance, the vector for the Others-to-Worst would be as indicated in Eq. (2):

$$A_W = (a_{1W}, a_{2W}, \dots, a_{nW})^T \quad (4-2)$$

where the preference of criterion j over the worst criterion w is denoted by a_{jW} , where $a_{WW} = 1$.

5. The calculation of optimal weights are done at this step $(w_1^*, w_2^*, \dots, w_n^*)$. In assessing the optimal weight for the criteria (each pair of w_B/w_j and w_j/w_w), we have $w_B/w_j = a_{Bj}$ and $w_j/w_w = a_{jw}$. To meet these conditions for the entire j , one must identify a solution in which the maximum absolute differences $\left| \frac{w_B}{w_j} - a_{Bj} \right|$ and $\left| \frac{w_j}{w_w} - a_{jw} \right|$ for entire j is minimised. This results in Eq. (3) when factoring the non-negativity and sum conditions for the weights.

$$\begin{aligned} & \min \max_j \left\{ \left| \frac{w_B}{w_j} - a_{Bj} \right|, \left| \frac{w_j}{w_w} - a_{jw} \right| \right\} \\ & \text{s.t.} \\ & \sum_j w_j = 1 \\ & w_j \geq 0, \text{ for all } j \end{aligned} \quad (4-3)$$

6. The optimal weights $(w_1^*, w_2^*, \dots, w_n^*)$ and ξ^* would be obtained by solving Eq. (3). For the purposes of ensuring consistency, a consistency ratio (CR) also known as the Ksi value is assessed using ξ^* . The bigger the ξ^* value, the less reliable the CR and comparisons become. The comparison becomes more reliable when the ξ^* value is closer to zero.

The judgments for the analysis of the most critical stages in the manufacturing sector's DT process were acquired from industry experts with a minimum of ten years of experience in operations and production management roles and from different manufacturing sectors such as home appliances, food processing, clothing, pharmaceuticals, and furniture. They were contacted via structured face-to-face interviews. In total, 28 experts were targeted, but only 21 responses were deemed worthy of consideration for the analysis following data cleaning. The rejected responses had not completely answered all of the questions to provide an accurate assessment of the interview.

4.3 Results and Data Analysis

This section presents an overview of the most important stages in the DT process in the manufacturing industry, which cuts across all the sectors (i.e., managerial, economic, human, and technical aspects). The quantitative results are also presented in this section.

4.3.1 Qualitative Analysis

The interview that was held was a semi-structured interview. The questions were designed to allow the respondents to express their ideas openly and to suggest or add other comments they felt appropriate to add to the study. Appendix 1 includes the full list of questions from the interview. This section will provide the key insights that were discussed with the respondents during the open-ended questions.

Regarding the DT process discussions with the respondents, 10 of them reported that "*it is necessary to train employees about the latest technologies related to DT and give awareness of the latest applications to compete with the globalised nature of business and the organisations of the manufacturing sector in this world.*"

As stated by the respondents, it is also important to look into the training of employees, communication with employees, and relationships with customers. Another key insight that is shared among 15 of the respondents is:

".....Adoption of new technologies is giving full access to implement DT processes in all working operations of the manufacturing industry; investing in terms of robotics thus replaces human interactions and reduces working time, resulting in achieving milestones....."

New technologies such as machine learning with AI combinations, VR, and AR are very popular in the manufacturing sector of organisations. Customers are taking advantage of testing products online through VR. Customers' trust in such product brands grows as a result. It provides a flexible online shopping experience for customers. IoT is helping to connect the digital and physical worlds on one platform. According to the study of Mohapatra et al. (2022), there are some enablers of DT technology such as IoT, AI, machine learning, etc., and the usage of all these enablers has increased after COVID. IoT is giving an advantage to the manufacturing sector, due to which organisations are implementing it on a regular basis after COVID. For example, it is tackling manpower, machine condition monitoring, and the use of tracking for products.

Furthermore, economically, it is reducing costs, enhancing diagnostics, and helping to make effective control to reduce mistakes. On the other side, big data facilitates the process of automation through fast processing and establishing the digital ecosystem. Cybersecurity has given employees and organisations access to maintaining the security of their data. According to respondents' responses regarding DT enablers, one of the experts said:

".....Enablers of DT like; Big Data, Cloud Technology, Cyber Systems, AR, Robotics and AI lowered errors, product failure rate and reduced huge cost of different operations....."

With the advent of globalisation, things have become very change. Furthermore, the actions related to manufacturing operations have also changed. Technology has changed applications and their usage. For example, their usage for communication has become very fast and popular. The reason is that, during the time of COVID, everyone

was working remotely, and every business was managing its work online. It has improved online methods of different kinds.

Moreover, it is also used for marketing, promotions, sales, and accounting purposes. It means multiple aspects of business are taking place with the help of technology. Due to advanced communication and communication technologies, business organisations are communicating with customers in a much better way. Customers are major stakeholders in business activities because they give huge money and profit to organisations' businesses. Communication technologies are powerful means to achieve business goals. People can work from any area of the world as well as conduct business activities remotely. The working environment has transformed. The productivity of employees has also been boosted, which has made it possible to complete business activities much more smoothly. Technical applications optimize business operations.

14 respondents answered that the management of organisations in Egypt faced various challenges while implementing the DT process. A key insight that is shared among most of the responses was the following:

".....That's the change management that is necessary to adopt DT successfully. "It requires changes in the organisation's structure and efforts from the employees' side....."

In those challenges, change management has been discussed by three respondents. It means change management is a critical challenge in the Egyptian manufacturing industry. Change means a change in the organisation's structure, which is challenging. It takes a lot of time and effort. Moreover, it is also very difficult to change employees because they do not want to go out of their comfort zones. As the study of Abdallah et al. (2021) defined, change management requires recruitment changes. Management needs to believe in the idea of change so they can convince their employees to change to improve work.

Furthermore, respondents stated that the lack of skills is the most significant barrier to the application of DT processes and their use in the manufacturing sector in the Organisation of Egyptian States country. They said that the skills gap also lies in the category of challenges for DT, and there is a particular skills gap that restricts the DT process in the manufacturing sector of Egypt. The skills gap includes a lack of knowledge related to different aspects such as big data analytics, cloud computing, the internet of things, and artificial intelligence. According to the head of a production line in one of the food processing factories said:

“.....Digital skills are necessary to increase DT in Egypt manufacturing sector organisations, it simply will result in the successful implementation of DT and competitive business.....”

4.3.2 Using BWM to Analyse the Data

The results of the BWM used to assign the various weights to the identified stages of the DT process in the manufacturing sector, as presented in Table 4-1, are discussed in this section. A total of eight stages were identified and ranked by experts. These stages shall be discussed in detail in subsequent sections of this study.

Table 4-1 Identified Stages in the DT process

Identified Stages in the DT process
Invest in the right technologies and tools (S1)
Involve all departments in developing a strategy (S2)
Invest in staff training (S3)
Draw up a comprehensive yet flexible/Adaptable budget (S4)
Assign a board-level or C-level (Chief Executive Level) sponsor to the project (S5)
Pilot the project in one part of the business first (S6)

Communicate strategy and goals with employees (S7)
Communicate plans with customers (S8)

After assessing the various inputs from the consulted experts, investing in the right technologies and tools (S1) was selected as the most important step in the DT process, whereas communicating plans with customers (S8) was selected as the least important step in the DT process. As mentioned earlier in the introduction, all eight stages are crucial in the DT process, and in this paper, they are ranked according to their relative importance. In this example, S8 is the least important compared to S1, but this does not mean it is not important.

Based on the preferences provided by the consulted stakeholders for each step as provided in Table 4-1, further calculations were done to ascertain the weights for the various factors. A Ksi* value (CR) of 0.079 was determined, close to zero. Remember that in the BWM, the closer the CR is to zero, the more consistent the experts' comparisons. The weights for the various stages are presented in Figure 4-2. It reflects the respondents' views on the various identified factors that are considered important stages in the DT process in the manufacturing industry and that have the potential to positively affect the development of DT efforts in the manufacturing industry in a developing economy such as the Egyptian economy.

According to the results, investing in the right technologies (S1) was assigned the highest weight of 25.8%, followed by investing in staff training (S3), which was assigned 18.8%. Draw up a comprehensive yet flexible and Adaptable budget (S4) that comes close to S3 with a weight of 17.4%. This reflects the importance of financial resources in the DT process in the manufacturing industry. Involve all departments in developing a strategy (S2) comes next with a weight of 11.3%, which reflects the connected-departments factor in the DT definition. This is followed by piloting the project in one part of the business first (S6) with a weight of 9.7%. Next comes communicating strategy and goals with employees (S7), with a weight of 7.6%. Communicating the

strategy among employees reduces the resistance to change significantly, especially when employees feel that they are part of the decision-making process. The two least important stages are assigning a board-level or C-level sponsor to the project (S5) with a weight of 5% and communicating plans with customers (S8) with approximately the same weight of 4.5% as shown in table 4-2

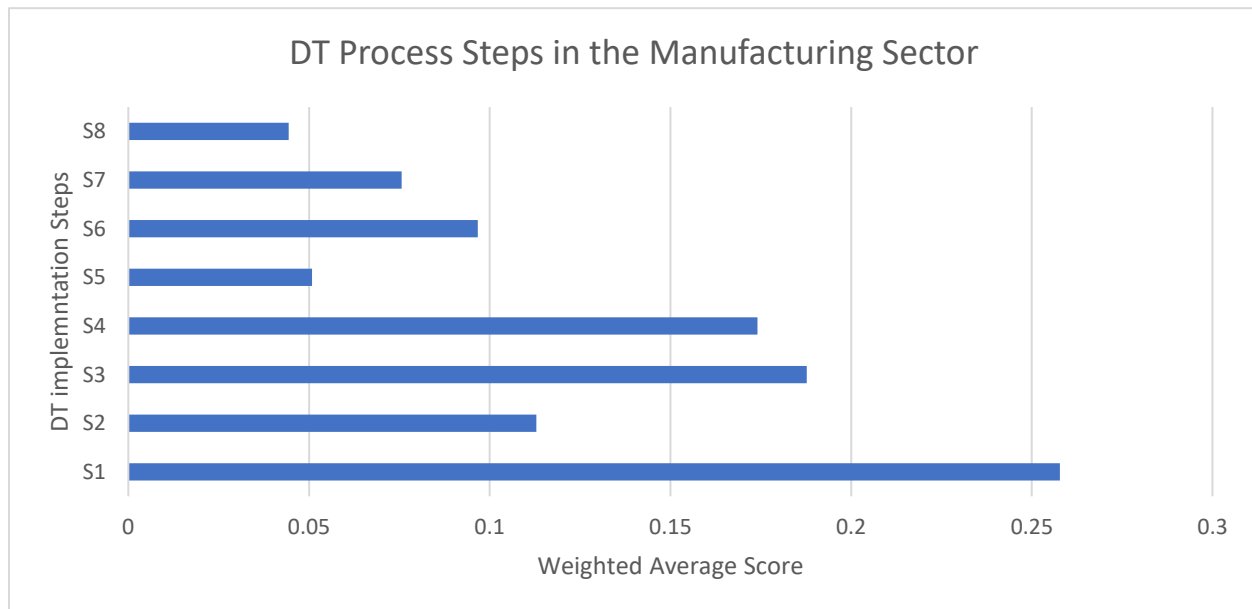


Figure 4-2 Process Steps in the Manufacturing Sector

Table 4-2 Data Analysis Using BWM Method

Sta ges	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	Avg.	Ra nk
S1	0.18 4237	0.33 0425	0.18 8106	0.16 8798	0.29 5385	0.33 9223	0.33 0951	0.33 9223	0.29 7214	0.33 4495	0.19 8675	0.17 6619	0.31 2695	0.21 0383	0.18 9949	0.18 9003	0.31 068	0.19 4175	0.18 782	0.31 773	0.31 773	0.25 7786	1
S2	0.12 2825	0.08 7879	0.12 5404	0.11 2532	0.12 3077	0.14 1343	0.10 3903	0.14 1343	0.18 5759	0.10 453	0.07 947	0.11 7746	0.13 0895	0.10 5191	0.09 4974	0.07 5601	0.09 7087	0.09 7087	0.12 5213	0.09 9291	0.09 9291	0.11 2878	4
S3	0.28 6592	0.21 9697	0.31 0784	0.16 8798	0.12 3077	0.08 4806	0.20 7806	0.08 4806	0.07 4303	0.20 9059	0.13 245	0.26 7452	0.19 6343	0.14 0255	0.12 6632	0.30 3551	0.12 945	0.31 068	0.30 1651	0.13 2388	0.13 2388	0.18 776	2
S4	0.12 2825	0.14 6465	0.12 5404	0.27 11	0.18 4615	0.21 2014	0.13 8538	0.21 2014	0.12 3839	0.06 9686	0.31 7881	0.17 6619	0.13 0895	0.32 5137	0.12 6632	0.12 6002	0.19 4175	0.12 945	0.12 5213	0.19 8582	0.19 8582	0.17 4079	3
S5	0.07 3695	0.02 4606	0.02 7262	0.05 6266	0.02 7692	0.02 8269	0.05 9373	0.02 8269	0.09 2879	0.08 3624	0.02 649	0.05 0463	0.02 9088	0.07 0128	0.04 7487	0.07 5601	0.02 9126	0.02 9126	0.07 5128	0.06 6194	0.06 6194	0.05 0808	7
S6	0.09 2119	0.07 3232	0.09 4053	0.11 2532	0.09 2308	0.07 0671	0.06 9269	0.07 0671	0.12 3839	0.08 3624	0.09 9338	0.11 7746	0.06 5448	0.02 8689	0.30 8666	0.12 6002	0.07 767	0.09 7087	0.02 8458	0.09 9291	0.09 9291	0.09 6667	5
S7	0.09 2119	0.06 2771	0.07 5242	0.08 4399	0.09 2308	0.07 0671	0.05 9373	0.07 0671	0.07 4303	0.08 3624	0.07 947	0.07 0648	0.07 8537	0.06 0109	0.07 5979	0.07 5601	0.09 7087	0.07 767	0.09 391	0.05 6738	0.05 6738	0.07 5618	6
S8	0.02 5589	0.05 4924	0.05 3745	0.02 5575	0.06 1538	0.05 3004	0.03 0786	0.05 3004	0.02 7864	0.03 1359	0.06 6225	0.02 2708	0.05 6098	0.06 0109	0.02 9679	0.02 8637	0.06 4725	0.06 4725	0.06 2607	0.02 9787	0.02 9787	0.04 4404	8

4.3.3 Quantitative analysis

According to the survey results, as shown in Figure 4-3, 36 (45%) respondents stated that they are behind schedule in becoming more digital. Moreover, 27 (33.7%) respondents state that they have not even started planning to become more digital. This emphasises the importance of a comprehensive digital transformation process for the manufacturing sector in developing economies such as Egypt.

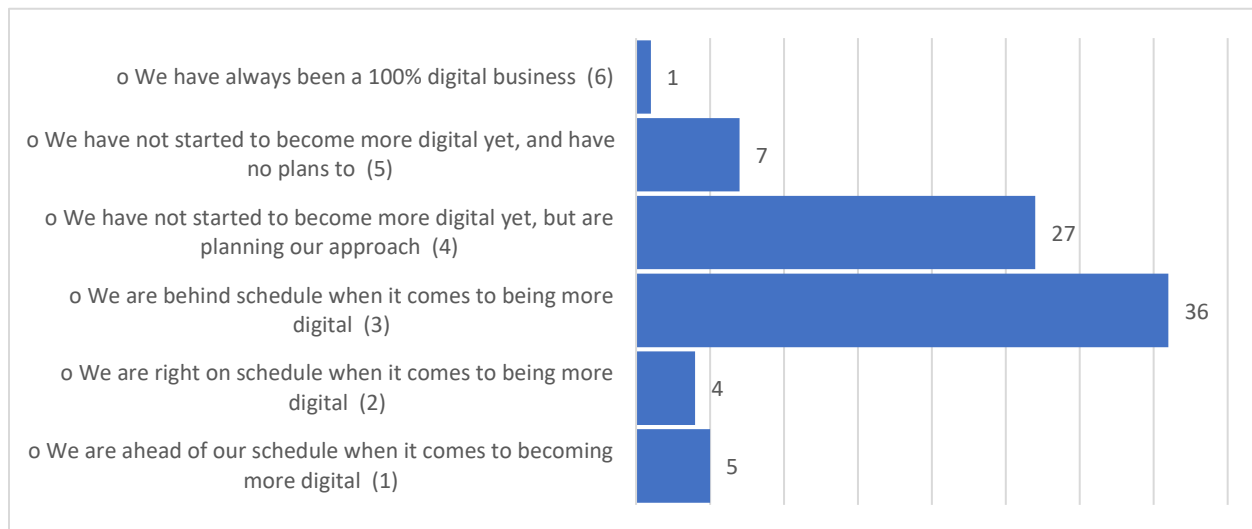


Figure 4-3 Organisation Digital Efforts

Another interesting insight from the survey results is that most respondents state the failure of implementation of change projects, as the mean of the results was 1.81 and the standard deviation was 0.929 on a scale of 1–5, as shown in Table 4–3. Moreover, the respondents state that digital technology implementation has been unsuccessful in the past because of the major challenges stated earlier in this study, with a mean of 1.86 and standard deviation of 0.896.

Table 4-3 Descriptive analysis of the organisation's performance background

	N	Minimum	Maximum	Mean	Std. Deviation
Overall, the organisation is being successful in achieving its strategic objectives. (1)	80	1	5	2.34	0.775
Overall, the previous business change projects in the organisation have been successful. (2)	80	1	5	1.81	0.929
Digital technology implementations in the organisation have been successful. (3)	80	1	5	1.86	0.896
Valid N (listwise)	80				

The survey results show a clear need for an integrated assessment model for innovation and managing change through digital initiatives. As in Table 4-4, the results indicate a poor implementation of innovation initiatives because of the lack of an organisational strategy and its communication across all departments in the organisation. With a mean of 1.88, most of the respondents indicate that their organisation has failed to generate new ideas. This is supported by a mean score of 1.89, indicating that their organisations have already successfully implemented several digital initiatives.

Table 4-4 Descriptive analysis of Strategy & Innovation Through Digital Initiatives

	N	Minimum	Maximum	Mean	Std. Deviation
The organisation is good at generating new ideas to improve performance. (1)	80	1	5	1.88	0.933
The organisation is good at implementing new ideas to improve performance. (6)	80	1	5	2.15	0.873
The organisation has already successfully implemented several digital initiatives that improve or adapt its products and services	80	1	5	1.89	0.941

(2)					
There are well-defined metrics to measure the impact of each innovation on the organisation's bottom line. (3)	80	1	4	1.89	0.811
The organisation business strategy focuses on consumers and their needs. (4)	80	1	5	2.05	0.87
The organisation business strategy is shared at all levels of the organisation. (5)	80	1	4	1.85	0.781
The organisation business strategy is understood at all levels of the organisation. (7)	80	1	5	2.24	0.958
Valid N (listwise)	80				

Moreover, the results obtained for the culture dimension show a clear need for a roadmap for implementing digital transformation successfully. As shown in Table 4-5, most of the organisation does not have a clear roadmap for using digital technologies, with a mean of 1.93, and has a weak response to change initiatives, with a mean of 2.13. However, there is a clear understanding of the crucial need for a digital transformation in a competitive market with a mean of 4.2, and there is a moderate vision of how the digital transformation initiatives can shape the future of the new organisation with a mean of 3.1.

Table 4-5 descriptive statistics of organisation vision and culture

	N	Minimum	Maximum	Mean	Std. Deviation
There is an inspiring vision of how the new digital era can create a new future with shared value for the organisation. (1)	80	1	5	3.1	0.891
The organisation has a clear understanding of how the competitive landscape is changing due to digital	80	1	5	4.2	0.838

trends. (2)					
The organisation has a clear roadmap to use digital technologies to help the employees deliver their business objectives. (3)	80	1	5	1.93	0.925
The organisation has an open, blame-free and collaborative culture. (4)	80	1	4	1.89	0.811
The organisation responds well to change. (5)	80	1	5	2.13	0.891
The organisation communicates effectively internally and externally. (6)	80	1	5	1.86	0.853
The organisation learns from previous experience. (7)	80	1	5	2.13	0.891
Valid N (listwise)	80				

Moreover, when emphasising the need for robust business processes to enhance and implement digital transformation initiatives, most respondents again state a lack of solid business process systems. As in Table 4-6, Survey results show a lack of effective technology platforms (mean 2.14) and the usability of these technology platforms in gaining new collaborators (mean 1.86) or increasing the efficiency of the employees (mean 2.13)

Table 4-6 Descriptive analysis of business processes

	N	Minimum	Maximum	Mean	Std. Deviation
The business units and functions are well connected to each other via digital platforms. (1)	80	1	5	2.21	0.853
The organisation's technology platforms are effective. (2)	80	1	5	2.14	0.902
The organisation's technology platforms easy to use (5)	80	1	5	2.05	0.831

The organisation's technology platforms have improved employee engagement (i.e., Technology adoption rate). (6)	80	1	5	2.19	0.82
The organisation is using digital technologies to improve the efficiency of employees. (3)	80	1	5	2.13	0.891
The organisation is using digital technologies to expand its network of collaborators. (4)	80	1	5	1.86	0.853
Valid N (listwise)	80				

There is poor implementation when it comes to technology and automation. As in Table 4-7, the results show that there is a lack of usage of new technologies like AI or big data (mean 2.13), and there is a significant lack of opportunities to automate business processes (mean.193) due to the significant challenges that were stated earlier in chapter 2. While the results show that there is significant resistance to implementing new technologies by employees (mean 3.9),

Table 4-7 descriptive analysis of technology and automation

	N	Minimum	Maximum	Mean	Std. Deviation
The organisation is using new digital technologies like AI, Big Data and Robotic Process Automation. (1)	80	1	5	2.13	0.891
The organisation has an innovative approach to the assessment and application of new digital technology. (2)	80	1	5	1.88	0.862
Opportunities to automate business processes have been identified where appropriate. (3)	80	1	5	1.93	0.965

Opportunities to automate business processes have been implemented where appropriate. (5)	80	1	4	1.89	0.811
The organisation is resisting new digital technologies. (4)	80	1	5	3.9	0.853
Valid N (listwise)	80				

4.4 Formulating DT Process Stages in the Manufacturing Industry

This section will discuss the implementation stages and best practices of DT in the manufacturing sector after the readiness assessment of an organisation. Assessing the readiness of the organisation's capabilities helps the decision-maker get an overall insight into the DT processes needed for the organisation to move forward in the DT journey. As mentioned earlier, this process needs to be continuous and needs to be further updated regularly to cope with the advancement of digital technologies and the shift in customer needs and wants. Figure 4-4 summarises all the stages in the DT process, ranked based on the BWM after conducting the interviews.

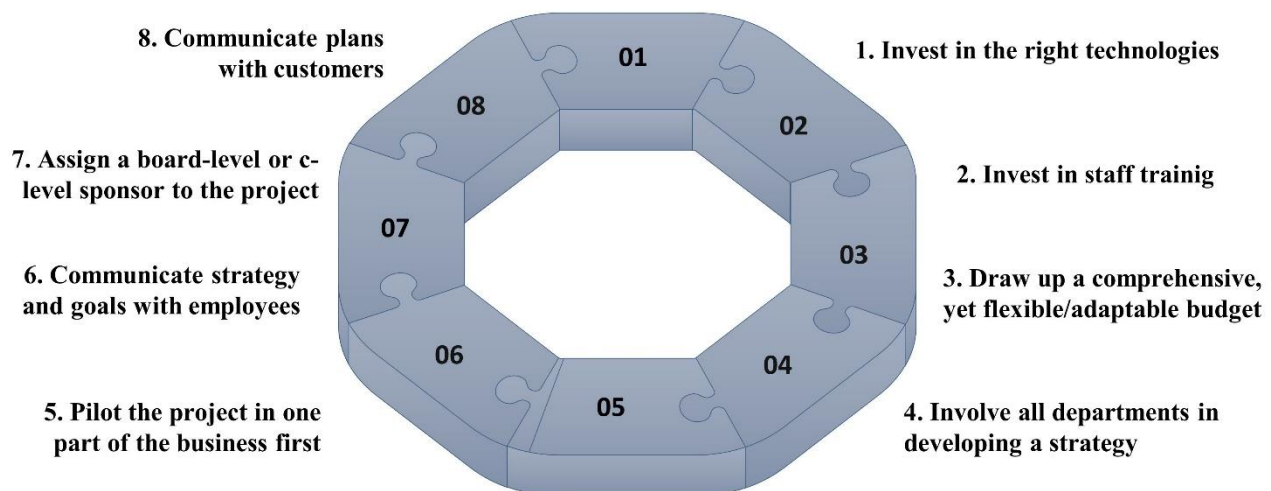


Figure 4-4 DT process in the manufacturing industry

4.4.1 Invest in the Right Technologies and Tools

The right understanding of these technologies and how the manufacturing organisation could use them properly in their daily activities is crucial to the success of any DT process. These digital technologies range from artificial intelligence (AI), the Internet of Things (IoT), big data analytics, robots, and many other tools. Investing in the right technologies that suit an organisation's structure and size will help the organisation best utilise these technologies to get the most return on investment in the shortest period of time (Benitez et al. 2020). This practice will differ from one manufacturing sector to another and will depend on many factors, such as the organisation's financial and human capabilities (Dalmarco et al. 2019). It is very important to emphasise investing in technologies that are right for the organisation, not the best technologies existing in the market, as these best technologies may not be Suitable for the organisation.

Investing in the right technologies and tools is an important part of any digital transformation process. By choosing the right tools and technologies, you can improve efficiency, reduce costs, and gain a competitive advantage. Data analysed from the interviews suggested the following to consider when choosing technologies and tools for your business:

1. Identify business needs: Before starting to look at specific technologies, it's important to identify the specific problems or challenges the organisation is trying to solve. This will help to determine which technologies and tools are most relevant to the business.
2. Research the technological options: There are many different technologies and tools available, so it's important to research and compare the options to find the ones that are the best fit for business. Organisations should consider factors such as cost, functionality, compatibility with their existing systems, and ease of use.
3. Consider scalability: As the business grows and evolves, it should choose technologies and tools that can scale with it. This will help to avoid the need to constantly reinvest in new tools as the business grows.

4. Keep an eye on the future: Technology is constantly evolving, so it's important to choose technologies and tools that are likely to remain relevant and useful for the long term. Look for technologies that are backed by strong development teams and have a track record of success.

By carefully selecting the right technologies and tools for your business, you can ensure that your digital transformation efforts are successful and help drive your business forward.

4.4.2 Invest in Staff Training

One of the main challenges of DT is the lack of skills necessary to cope with this transformation, either intellectual skills or technical skills (Butt 2020b). This is due to a lack of training programs provided by an organisation to their employees as well as the demographic nature of the workforce in some economies. Investing in training to build technical skills to cope with the advancement of digital technologies is crucial to the success of the DT process. Figure 4-5 summarises the essential digital skills needed for implementing DT.

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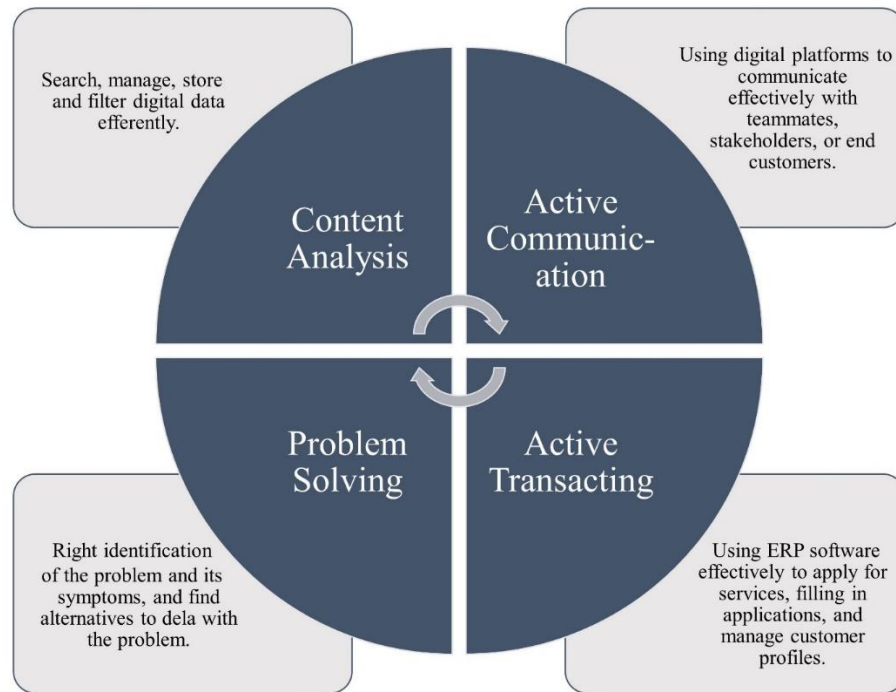


Figure 4-5 Essential Digital Skills for DT

Not only are technical skills necessary, but intellectual and human skills are also very important in the DT process (Chirumalla 2021). Investing in training programs such as innovation management or managing change, especially for middle managers, is of great importance to help managers understand the resistance of change for their employees and know ways to cope with this resistance and overcome it.

Investing in staff training is an important part of any digital transformation project. By providing training to your employees, you can help ensure that they have the skills and knowledge they need to effectively use new technologies and tools and contribute to the success of the project. Most of the respondents in the interviews suggested the following guidelines to consider when planning staff training for a digital transformation project:

1. Identify training needs: It's essential to start by identifying the specific skills and knowledge that the employees will need to use the new technologies and tools

effectively. This will help to focus the training efforts and ensure that the business is providing the most relevant and useful training.

2. Choosing the right training method: There are many different methods for delivering training, including in-person classes, online courses, and hands-on training. Choosing the method that is the best fit for employees and the technologies they are using
3. Make training convenient: When possible, organisations should try to make training as convenient as possible for their employees. This might involve offering training at different times of the day or providing online training options that can be accessed from anywhere.
4. Providing ongoing support: Training shouldn't end when the initial training period is over. Provide ongoing support to the employees to help them continue learning and improving their skills. This might involve providing additional training sessions, online resources, or one-on-one coaching.

By investing in staff training, the business can help ensure that its employees are able to effectively use the new technologies and tools and contribute to the success of the organisation's digital transformation project.

4.4.3 Draw Up a Comprehensive Yet Flexible and Adaptable Budget.

Financial capabilities are one of the main criteria for a decision-maker to take into consideration when setting a DT strategy. Developing a budget that suits the needs of the manufacturing organisation to achieve its goals from DT is of great importance. This will also determine the level of digital technology advancement that the organization should invest in (Ing et al. 2019). When setting a budget for DT, several factors need to be considered—for example, the cost-benefit analysis, the expected return on investment, and the project payback period. Every manufacturing organization should allocate a specified percentage of its profits to DT processes each year to cope with digital technologies' developments, as this is a continuous process.

Creating a budget for a digital transformation project is an important step to ensure that you have the resources you need to succeed. Respondents suggested these few tips for drawing up a comprehensive yet flexible budget:

1. Identify all costs: Make a list of all the costs associated with the digital transformation project, including the cost of new technologies and tools, training, consulting fees, and any other expenses.
2. Determine a budget: Based on the costs that have been identified, determine how much the organisation can afford to spend on the digital transformation project. Be sure to consider the overall business budget and any other financial commitments it has.
3. Leave room for flexibility: While it's important to have a solid budget in place, it's also important to leave room for flexibility. Things may come up during the project that the organisation didn't anticipate, so it's a good idea to have a little extra money set aside for unexpected expenses.
4. Review and adjust the budget on a regular basis. As the digital transformation project progresses, you may find that the budget needs to be adjusted. Review the budget to ensure that it is on track and then make any necessary adjustments.

By following these steps, the organization can create a comprehensive yet flexible budget that will help ensure the success of your digital transformation project.

4.4.4 Involve All Departments in Developing a Strategy.

As mentioned above, DT is not only about the operation or production departments; it should also happen across all departments of an organisation (Chirumalla 2021). When developing a strategy for DT, the decision-makers should involve all departments in the organization and the stakeholders most affected by this change—for example, the suppliers. Many organisations go beyond that and develop a co-strategy with their leading suppliers or main distributors to ensure that their DT efforts are well organised so they get the most out of this change (Ciano et al., 2021).

Involving all departments in developing the strategy will significantly reduce the resistance to change when implementing these change strategies. This will enhance the efficiency of the processes and reduce any efforts to make this change fail (Horváth and Szabó 2019).

It's important to involve all departments in the development of a strategy for a digital transformation project. Here are a few reasons why:

1. Different departments have different perspectives. Each department in the organisation has a unique perspective and expertise that can be valuable in developing a digital transformation strategy. Involving all departments enables a more well-rounded and comprehensive view of the challenges and opportunities you are facing.
2. Encourages buy-in: When all departments are involved in the development of a strategy, it can help encourage buy-in and support for the project. This is especially important if the digital transformation project affects how different departments work.
3. Helps identify potential challenges: By involving all departments in the strategy development process, the organization can identify potential challenges or roadblocks that it may need to address. This can help ensure that the project is successful.
4. Improves communication: Involving all departments in the strategy development process can help improve communication and collaboration within the organisation. This can be especially valuable if the digital transformation project involves significant changes to how the organization operates.

By involving all departments in the development of a digital transformation strategy, you can get a more comprehensive and well-rounded view of the organisation's challenges and opportunities and help ensure the success of the project.

4.4.5 Pilot The Project in One Part of The Business First.

DT is a huge project in terms of scale and scope. Implementing the project in all of an organisation's businesses in the early stages would be fraught with danger, both financially and administratively. For this reason, one of the best tactics to initiate a DT project is to pilot it first in one of the business units of the organisation. This pilot may take place in one of the production lines or one of the production processes inside the production line. The scale of the piloting will be determined by the organisation's financial capabilities as well as the skills already available in its workforce. Moreover, it will depend on how far the organization wants to go in adapting DT projects and processes.

In addition, the results obtained from the survey indicate that most respondents prefer to implement their pilot projects in IT projects first, followed by implementing them in the marketing department. Figure 4-6 shows the list of business units for which they would implement this pilot project.

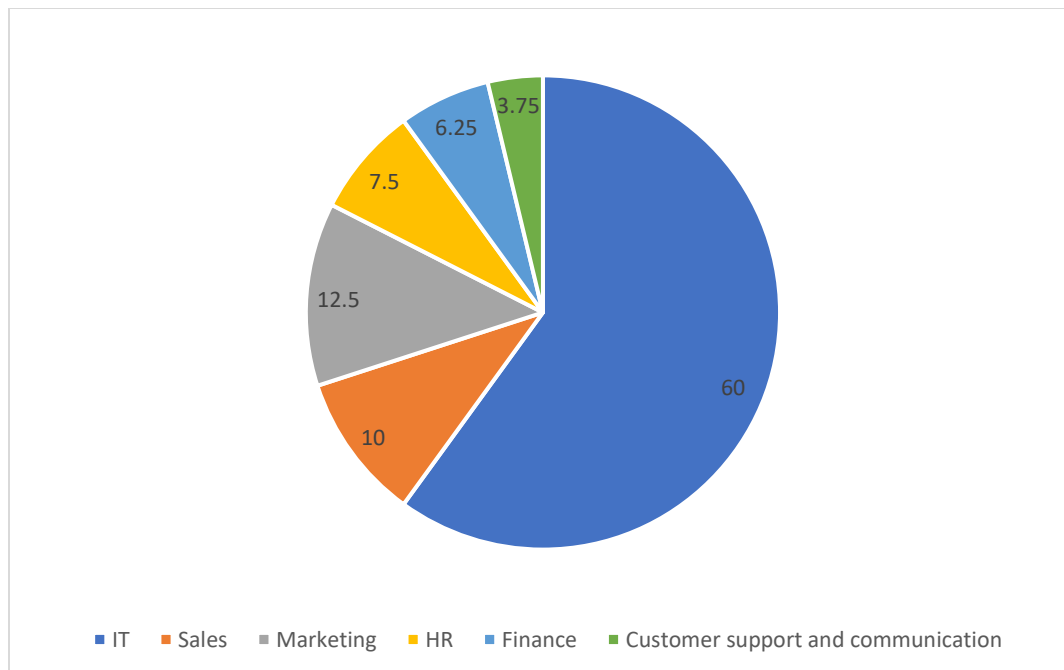


Figure 4-6 Pilot Project business units implementation

Piloting a digital transformation project in one part of the business first can be a useful way to test and refine the project before rolling it out more widely. Here are a few benefits of piloting a digital transformation project:

1. Allows you to test and refine the project: Piloting the project in one part of the business first gives the opportunity to test and refine the project before rolling it out more widely. This can help ensure that the project is successful when it is implemented more widely.
2. Identifies challenges and opportunities: Piloting the project in one part of the business can help the organisation identify any challenges or opportunities that it may not have anticipated. This can be valuable information that can help you improve the project before rolling it out more widely.
3. Builds support: Piloting the project in one part of the business can help build support and buy-in for the project among employees and stakeholders. This can be especially important if the digital transformation project involves significant changes to how your organisation operates.
4. Manages risk: By piloting the project in one part of the business first, this can minimize the risk of the project not being successful. If there are any problems with the project during the pilot phase, the organisation will have an opportunity to address them before rolling it out more widely.

Overall, piloting a digital transformation project in one part of the business can be a useful way to test and refine the project before rolling it out more widely and can help ensure the success of the project.

4.4.6 Communicate Strategy and Goals with Employees

Communication is one of the most important procedures in any project that aims to make significant change (Kovait et al. 2020). Top management should communicate the goals of implementing DT to the working members of the organisation. This will help reduce any fear from the employees that digital technologies will eliminate their jobs and convince them that applying digital technologies will reshape their jobs, not replace

them (Horváth and Szabó 2019). Another benefit of communication is that it opens up space to invite any innovative ideas that employees might have for implementing these kinds of projects. This will increase their sense of participation in forming this strategy and make them more committed to achieving the goals of this strategy.

Effective communication is key to the success of any digital transformation project. Here are a few strategies for communicating the strategy and goals of a digital transformation project with employees:

1. Clearly articulate the purpose and benefits of the project. It's essential to clearly explain the purpose and benefits of the digital transformation project to the employees. This will help them understand why the project is important and how it will impact their work.
2. Involve employees in the development of the strategy: Involving employees in the development of the strategy can help ensure that they feel invested in the project and understand its goals and objectives.
3. Use multiple communication channels: Different employees may prefer different communication channels, so it's a good idea to use a variety of channels to reach as many people as possible. This might include email, in-person meetings, team updates, and more.
4. Keep employees informed of progress: Regularly update employees on the progress of the project and any changes or updates to the strategy. This will help keep them informed and engaged in the project.
5. Offer support and resources: Provide employees with the support and resources they need to succeed during the digital transformation project. This might include training, additional support, or other resources.

By following these tips, you can help ensure that your employees are informed and engaged in the digital transformation project and that it is successful.

4.4.7 Assign a Board-Level or C-Level Sponsor to the Project.

Top management support is one of the key success practices from previous experiences in manufacturing organisations (Krishnan et al., 2021). This support has a great influence on reshaping the organisational culture to be more digital-oriented and helping the workforce understand the significance of DT in their daily activities. This support also encourages middle managers to take the initiative in this direction and showcase their digital processes within their departments to achieve a more digital-oriented workflow.

Assigning a board-level or C-level sponsor to a digital transformation project can be an effective way to ensure that the project has the support and resources it needs to be successful. Here are a few reasons why:

1. Provides leadership and guidance: A board-level or C-level sponsor can provide leadership and guidance to ensure that the project stays on track and meets its goals.
2. Shows commitment: Assigning a board-level or C-level sponsor to the project demonstrates the importance of the project to the organisation and helps ensure that it receives the resources and attention it needs.
3. Helps remove roadblocks: A board-level or C-level sponsor has the authority to remove any roadblocks or barriers that may be hindering the progress of the project. This can help ensure that the project stays on track and is successful.
4. Increases visibility: Having a board- or C-level sponsor can increase the visibility of the project and help ensure that it receives the support it needs from other stakeholders in the organisation.

Overall, assigning a board-level or C-level sponsor to a digital transformation project can be an effective way to ensure that the project has the support and resources it needs to be successful.

4.4.8 Communicate Plans with Customers

The final best practice is to communicate your plans with the customers. As the customers are the heart of any organisation, they should be aware of any change in the plans of a company, especially if it relates to the user experience or communication channels with the customers (Zaoui and Souissi 2020). For example, making the customer more aware of the new chatbot feature on the organisation's website and how to use it will maximize the use of this feature.

It's important to communicate your digital transformation plans with customers to ensure that they are aware of any changes that may affect them. Data analysed from interviews suggested the following tips for communicating your digital transformation plans with customers:

1. Clearly articulate the purpose and benefits of the project. It's important to clearly explain the purpose and benefits of the digital transformation project to the customers. This will help them understand why the project is important and how it will impact them.
2. Use multiple communication channels: Different customers may prefer different communication channels, so it's a good idea to use a variety of channels to reach as many people as possible. This might include email, social media, website updates, and more.
3. Keep customers informed of progress: Regularly update customers on the progress of the project and any changes or updates that may affect them. This will help keep them informed and engaged in the process.
4. Address any concerns or questions: It's important to be responsive to any concerns or questions that customers may have about the digital transformation project. This can help ensure that they feel supported and that the project is successful.

By following these tips, the organisation can help ensure that its customers are informed and engaged in the digital transformation process and that it is successful.

4.5 Data Reliability and Validity

4.5.1 Data Reliability of the BWM Analysis

Based on the preferences provided by the consulted stakeholders for each step, as provided in Table 4-1, further calculations were done to ascertain the weights for the various factors. A Ksi* value (CR) of 0.079 was determined, close to zero. According to Rezaei (2015), in the BWM, the closer the CR is to zero, the more consistent the experts' comparisons. That makes the data statistically reliable, and the weighted steps are accurately prioritised according to the methods adopted in the interview. Other steps are taken to ensure the data is valid and will be thoroughly discussed in the data validation chapter.

4.5.2 Data Reliability of the Survey Results

The values of Cronbach's alpha are presented against all the variables, which can be found below. A generally accepted rule is that α of 0.6-0.7 indicates an acceptable level of reliability, and 0.8 or greater a very good level. However, values higher than 0.95 are not necessarily good, since they might be an indication of redundancy (Hulin, Netemeyer, and Cudeck, 2001).

First, Cronbach's alpha of variables in the survey study is shown in Table 4-8. All the variables has a value of reliability obtained greater than 0.7 hence it is significantly high and valid for acceptance.

Table 4-8 Reliability Test of Survey Variables

Item	Cronbach's Alpha	N of Items
organisational performance background	0.820	3
Strategy & Innovation Through Digital Initiatives	0.867	7
Organisation Vision & Culture	0.893	7
Business Processes	0.869	6
Technology & Automation	0.836	5

Overall, all of the survey results are reliable and have a strong consistency percentage among them. Another layer of validation will be discussed later in the validation chapter.

4.6 Implications of the results

4.6.1 Theoretical Implications

Although there is extensive literature on DT implementation, few have given a detailed process for DT implementation in the manufacturing sector (Anderson and Ellerby 2018; Luthra et al. 2020; Stoianova et al. 2020; Balog and Knapčíková 2021; Jafari-Sadeghi et al. 2021). This research adds to the literature by developing a prioritised DT implementation process specifically tailored for the manufacturing industry using data collected from top experts in the manufacturing field in an evolving economy focused on the manufacturing industry like the Egyptian economy. Moreover, this research considers most of the aspects of the DT process's implementation, from technology to human factors and leadership support.

4.6.2 Practical Implications

The suggested model can help manufacturing firms in the developing world formulate a comprehensive strategy to implement DT, especially for those firms that are at the beginning of their digital transformation journey. By offering this process, manufacturing firms can understand and prioritise their business objectives to suit their capabilities in order to achieve a successful digital transformation. As stated earlier, digital transformation is not only a one-time process, but rather a continuous one that needs the integration of all aspects of the organisation. That is why organisations must adapt their processes and prioritise them according to the dynamic factors that can affect their digital transformation journey. That is why this suggested framework for a DT process offers the most important eight steps of the DT and the flexibility to prioritise them according to the manufacturing firm's capabilities and their surrounding business environment.

4.7 Chapter Summary

This chapter aims to identify and determine the most important stages for DT implementation in the manufacturing sector after assessing the readiness of the manufacturing organisation to begin this process. After studying the literature review, we determined eight stages and ranked them according to their importance. Twenty-one semi-structured interviews with manufacturing experts in the Egyptian economy were held and analysed using the BWM to rank the stages according to the interviewees' perspectives. The stages in the DT process are as follows, according to importance: (1) invest in the right technologies and tools, (2) invest in staff training, (3) draw up a comprehensive yet flexible/Adaptable budget, (4) involve all departments in developing a strategy, (5) pilot the project in one part of the business first, (6) communicate the strategy and goals with employees, (7) assign a board-level or C-level sponsor to the project, and (8) communicate plans with customers. Understanding the dimensions and factors of each of these eight stages will help manufacturing organisations implement DT successfully, especially when they have yet to start their DT process.

5 DIGITAL TRANSFORMATION READINESS ASSESSMENT MODEL FOR THE MANUFACTURING INDUSTRY

5.1 Introduction

In the manufacturing industry, Digital Transformation is critical for organisations to stay competitive because the only way to ensure sustainability in today's competitive markets is to digitise corporate processes. Moreover, with the exponential evolution of digital native manufacturing organisations, the competition has become fiercer, and the need to begin digital transformation processes for manufacturing organisations is a necessity (Schniederjans *et al.*, 2020).

Although academic research has placed significant emphasis on DT in recent years, there is controversy surrounding the term's definition, context, and problems, particularly in the manufacturing industry (Bibby and Dehe, 2018; Culot, Nassimbeni, *et al.*, 2020). Furthermore, there is a lack in the literature review to address this idea in the manufacturing industry or elucidate how manufacturing organisations assess their needs and capabilities to begin this transformation journey (Mahmoud *et al.*, 2020; Mokhtar *et al.*, 2020).

To fill this gap, the present chapter proposes a DT Readiness Assessment model for manufacturing companies to help them identifying their readiness level and the following steps to be implemented to continue improving their DT processes. The proposed model serves as a beginning step in the planning phase of DT processes in the manufacturing organisation through a macro-level analysis of the organisation's capability to implement DT processes. Section 5.2 outlines the research methodology. Sections 5.3 and 5.4 present the digital transformation readiness assessment model and tool. Finally, Section 5.5 highlights the implications of the model and the chapter summary.

5.2 Research Methodology

The research methodology, as shown in Figure 5-1, consists of five steps. First, analyse the literature review to find the most important and valid criteria for assessing digital

transformation successfully in the manufacturing industry. Second, conducting a qualitative analysis of the interviews held with 21 experts in the field to determine the most important criteria for the new model Third, the business/technology integration model was formulated, and fourth, an assessment tool was developed to support the model based on a weighted average methodology. Finally, a validation of the model was conducted by experiencing the new model and the assessment tool in three case studies from different manufacturing sectors, which will be discussed later in the validation chapter. Each step will be discussed in the following sections.

5.2.1 Analysing the Literature

After studying the models already existing in the literature and the articles discussing DT in general, an in-depth literature analysis was conducted to determine the factors that affect DT inside the manufacturing industry. The research has focused on sources from manufacturing literature to maintain a certain degree of consistency with regard to the specific topics of interest while ensuring that our sample size would remain considerable. Web of Science (WoS), EBESCO (business source complete), ScienceDirect, and Scopus were chosen to filter our research. WoS has the leading journals in the "digital manufacturing" theme. Business Source Complete was included to add other journals that are not focused on manufacturing but have journals that talk about digital transformation from a business perspective. ScienceDirect and Scopus for validation, as well as ensuring that all journals that are not in WoS or EBESCO will be considered for our research.

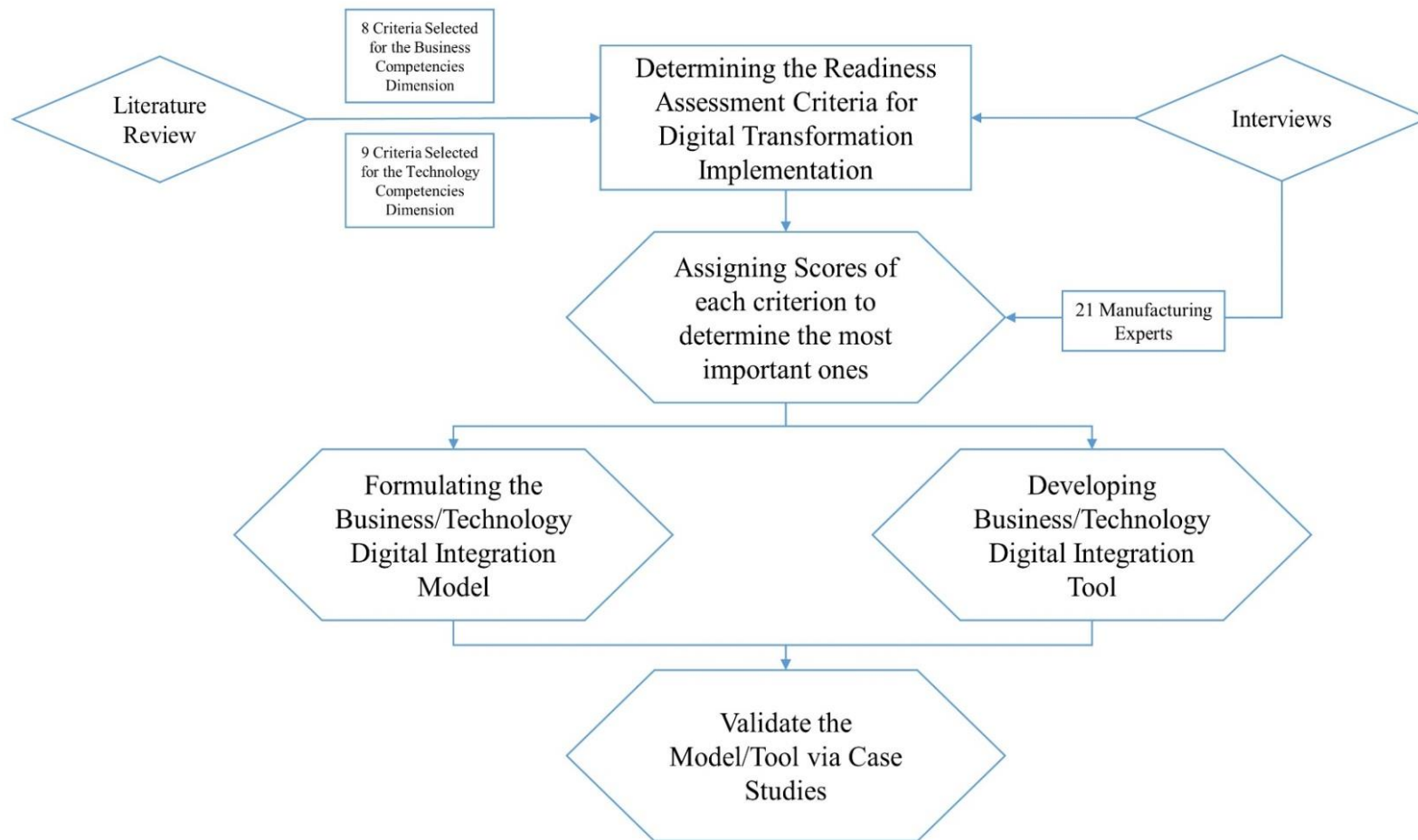


Figure 5-1 The Methodology Adopted in the Chapter

Criteria for exclusion included: works in progress; panel introductions; sources not available in English; unavailable full papers; papers before 2005. The reason for the time frame of this study was to address digital transformation in its present and future directions. In our initial search, we found papers from the '80s and '90s that talk about digital transformation but use old or obsolete technology. So, we decided to make our research more reliable by addressing papers from the past 15 years. Furthermore, we excluded papers that had nothing to do with the manufacturing industry in order to keep the scope of this field as broad as possible. The reason for this is that digital transformation has different meanings according to the sector in which it is applied. For example, digital transformation in the banking sector has a different perspective and is more service-focused than when applying the same concept in the manufacturing industry.

The main keywords used in this search were critical success factors of DT, drivers of DT, and determinants of DT. The outlined research databases were then searched using a combination of these keywords. The list was then refined to remove duplicates, and the titles were checked to ensure the consistency of the paper with this review. Then the abstract was also checked before selecting the publication for a full review. Ninety articles were found that matched the criteria of the literature review search. This number reflects the growing academic interest in DT and its successful implementation.

A summary of the factors included in the literature is shown in Table 5-1. According to the literature, DT will not succeed solely through digital technologies; it will also require business competencies (Abdallah et al., 2021; Bongomin, Nganyi et al., 2020; Butt, 2020; Ciano et al., 2021; KMPG, 2015; Krishnan et al., 2021; Kulba and Medennikov, 2020; Rojko, 2017; Rumyantseva et al. This will range from leadership support to incorporating this transformation into the organisation's culture. Therefore, this model includes two dimensions with sub-criteria: the business competencies dimension and the technology competencies dimension.

Table 5-1 Factors Identified in the Literature

Main Criteria	Factors	No. of Mentions	References
Business Competencies Criteria	Organisational Strategy Vision	17	(Hartley and Sawaya, 2019; Ismagilova <i>et al.</i> , 2019; Jafari-Sadeghi <i>et al.</i> , 2021; Kusmiarto <i>et al.</i> , 2021; Preindl <i>et al.</i> , 2020)
	Organisational Culture	17	(Chirumalla, 2021; Ismagilova <i>et al.</i> , 2019; Lam and Law, 2019; Mohelska and Sokolova, 2018; Schumacher <i>et al.</i> , 2016)
	Innovation Practices	7	(Benitez <i>et al.</i> , 2020; Halpern <i>et al.</i> , 2021; Ismagilova <i>et al.</i> , 2019; Jafari-Sadeghi <i>et al.</i> , 2021; Mihardjo <i>et al.</i> , 2019)
	Financial Support	8	(Bahlooq <i>et al.</i> , 2020; Mittal <i>et al.</i> , 2018; Rupp <i>et al.</i> , 2021; Schumacher <i>et al.</i> , 2016)
	Leadership Support	56	(Hizam-Hanafiah <i>et al.</i> , 2020; Kusmiarto <i>et al.</i> , 2021; Mihardjo <i>et al.</i> , 2019; Oberer and Erkollar, 2018; Tekic and Koroteev, 2019)
	Digital Talent	48	(Büchi <i>et al.</i> , 2020; Črešnar <i>et al.</i> , 2020; Mohelska and Sokolova, 2018; Rojko <i>et al.</i> , 2020)
	Supply Chain Management	8	(Ardito <i>et al.</i> , 2019; Ivanov <i>et al.</i> , 2019; Moldabekova <i>et al.</i> , 2021)
	Customer Relationship Management	4	(Ciano <i>et al.</i> , 2021; Fernández-Rovira <i>et al.</i> , 2021)
Technology Competencies Criteria	Internet of Things (IoT)	58	(Ing <i>et al.</i> , 2019; Kiel <i>et al.</i> , 2017; Osterrieder <i>et al.</i> , 2020; Sader <i>et al.</i> , 2019; Schumacher <i>et al.</i> , 2016)
	Big Data Analytics	61	(Fernández-Rovira <i>et al.</i> , 2021; Frank <i>et al.</i> , 2019; Ivanov <i>et al.</i> , 2019; Llopis-Albert <i>et al.</i> , 2021; Tao <i>et al.</i> , 2019)
	Enterprise Resource	28	(Abdallah <i>et al.</i> , 2021; Sidorenko

	Planning Software (ERP)		and Khisamova, 2020)
	Artificial Intelligence	30	(Ahmad <i>et al.</i> , 2021; Bongomin, Yemane, <i>et al.</i> , 2020; Črešnar <i>et al.</i> , 2020; Hartley and Sawaya, 2019)
	Virtual Reality/Augmented Reality (VR/AR)	39	(Brozzi <i>et al.</i> , 2020; Butt, 2020; Halpern <i>et al.</i> , 2021)
	Robots	37	(Bongomin, Yemane, <i>et al.</i> , 2020; Črešnar <i>et al.</i> , 2020; Kulba and Medennikov, 2020)
	Cloud Computing	43	(Ahmad <i>et al.</i> , 2021; Ardito <i>et al.</i> , 2019; Mokhtar <i>et al.</i> , 2020)
	Vertical and Horizontal Integration	27	(Butt, 2020; Culot, Orzes, <i>et al.</i> , 2020; Santos <i>et al.</i> , 2020)
	Data-Driven Services and Smart Products	10	(Frank <i>et al.</i> , 2019; Kusmiarto <i>et al.</i> , 2021)
	Digital Product Development	11	(De Carolis <i>et al.</i> , 2017; Črešnar <i>et al.</i> , 2020; Kovrigin and Vasiliev, 2020)

After studying the literature, it is noted that most of the research focuses on the technological factors of DT, whereas little research focuses on the business aspects of the process. This has been identified as one of the main reasons why DT processes fail in the United Kingdom, as presented in the Made Smarter report by the UK government (Abdallah *et al.*, 2021).

5.2.2 Data Collection and Analysis

To determine the key criteria included in both dimensions, 28 interviews were aimed at being conducted to gain richer insights and diverse experiences about DT from different backgrounds and expertise. However, due to the COVID-19 pandemic and imposing travel restrictions during the previous year, only 21 expert interviews were conducted with professionals working in the digital technology sector for more than five years in emerging and developing economies. All the experts agreed that DT should have two

dimensions—business and technology—as suggested by the experts during interviews. The semi-structured interviews concentrate on including the key factors that should be included in the dimensions of business and technological competencies.

5.2.2.1 Qualitative Analysis

According to the studies of El Sawy et al. (2020), Gerald (2015), and Ghobakhloo (2018), DT implementation has reached its peak following COVID. One of respondents who works as a productions manager said that;

".....Due to the increase in need for remote working and socially dispersed workplaces, DT has greatly increased after COVID, resulting in a reduced communication barrier with international clients....."

Organisations all over the world are still taking advantage of DT to gain money because they have suffered big financial losses after COVID. The study of Abdallah et al. (2022) defined the importance of the DT process and its massive implementation after COVID-19. It means Covid has given us the fastest way to implement the DT process in different operations all over the world. It is true that to successfully implement a digital transformation, an environment where risk is everyone's concern and technological literacy is a prerequisite must be fostered.

Leaders at the top levels of an organisation may convey this message consistently. Respondents have answered that the readiness of the DT process is necessary for the manufacturing sector of Egypt. Readiness for DT includes certain models of DT, as also defined in the literature review part. These models bear much importance for implementing DT in the manufacturing sector of Egypt. According to 12 respondents, there is a lack of awareness about the readiness of DT among employees of manufacturing sector organisations in Egypt. Another key highlighting stated by one of the respondents who work as a plant manager is:

".....Digital Maturity Model and 4.0 Technological development Model are key players to maintain customer strategy, the culture of the organisation, Big Data, Cloud Technology, Cyber Systems, AR and AI in organisation operations....."

There are different models for DT readiness that are vital for the awareness and preparation of the DT process in organisations. Indeed, Egypt is a developing country, which needs research efforts on the readiness of the DT process and much other information about DT, such as its challenges, skills necessary for DT, and enablers of DT in developed countries. In this way, Egyptian manufacturing sector organisations can become successful in the achievement of proper DT processes for business competitiveness. According to a research study by Abdallah (2022), it is vital to assess the readiness of the organisation's capabilities. This activity helps decision makers put overall insights into the DT process. It is vital to ensure that either organisation is investing in the right digital tools to move forward in business. For the readiness of DT, it is also important to investigate the training of employees, communication with employees, and relationships with customers. One of the respondents highlighted this key aspect and stated that:

".....It is necessary to train employees about latest technologies related to DT, give awareness of latest applications to compete with globalised nature of business, for competing with the organisations of the manufacturing sector in this world....."

According to various research studies such as El Sawy et al. (2020), Gerald (2015), and Ghobakhloo (2018), it has been noticed that social media has transformed the nature of business. Global business goals are taking place with the help of social media tools and applications, which include DT. It involves different tools, such as social media websites and applications like Facebook and LinkedIn.

Organisations all over the world are using the social media tool Facebook for the promotion of any new product, and any type of promotion is possible through this social media application. People from all over the world are drawn to Facebook promotion. It creates a large pool of customers in different markets. As a result, investors and

stakeholders in Egypt's manufacturing sector should use this type of DT to promote their businesses in various market segments.

"..It is the power of social media with DT that enhances communication with customers; it is largely fulfilling business needs and goals, building the trust of customers."

According to the information provided by respondents as a result of interview questions about readiness for the DT process,

".....Readiness about DT improves awareness about the implementation of latest DT tools, it helps to make correct decisions about financial investments about required DT technology for the industry...."

According to the study by Phung (2022), social media had become popular due to the emergence of digital processes that supported customer interactions. Companies all over the world, both developed and developing, have shifted to digital ambitions for business growth by utilizing this tool (Phung, 2022). Organisations all over the globe realised that they needed digital teams to manage social media, mobile channels, and other digital technologies for business. One of the respondents who works as a production line manager stated that:

".....Adoption of new technologies is giving full access to implement DT processes in all working operations of the manufacturing industry; investing in terms of robotics thus replaces human interactions and reduces working time, resulting in achieving milestones....."

The enablers of technology are increasing costs and decreasing functionality. During this modern era of globalisation, organisations are focusing on creating opportunities. It is helping to optimize resources (Jimeno-Morenilla et al., 2021). The management of organisations is making efforts to improve return on investment with the help of technology; thus, reducing the cost of resource utilisation. The application of various technologies, such as data processing, data analysis, AI, and machine learning, is

assisting in increasing the potential of existing resources. An increase in technology is also increasing the functionality and features of existing platforms.

From the data and information of respondents, it has been determined that different enablers of the digital transformation process have altered or changed business patterns. It has improved the customer retention rate, relationships with customers, and many more (Jones et al., 2021).

The digital transformation process in every aspect of work has shifted the work of the manufacturing sector to improved procedures. It is extremely beneficial to organisations in the manufacturing sector all over the world. However, there is a lack of some aspects of DT, but these gaps are different according to countries and their implementation of DT processes. According to the study of Abdullah et al., 2021, there is a skills gap in digital skills for the successful implementation of digital transformation in Egypt.

A score for each criterion was given based on the expert view of its importance, ranging from 1 (least important) to 5 (most important), and the model uses the criteria that most of the experts thought were most important in each dimension. As shown in Figure 5-2, the most important business competency dimensions, with a total score of 80 or more, to make sure that this dimension is considerably important in all of the views of the interviewees, comprised leadership, business strategy and vision, innovation practices, and organisational culture.

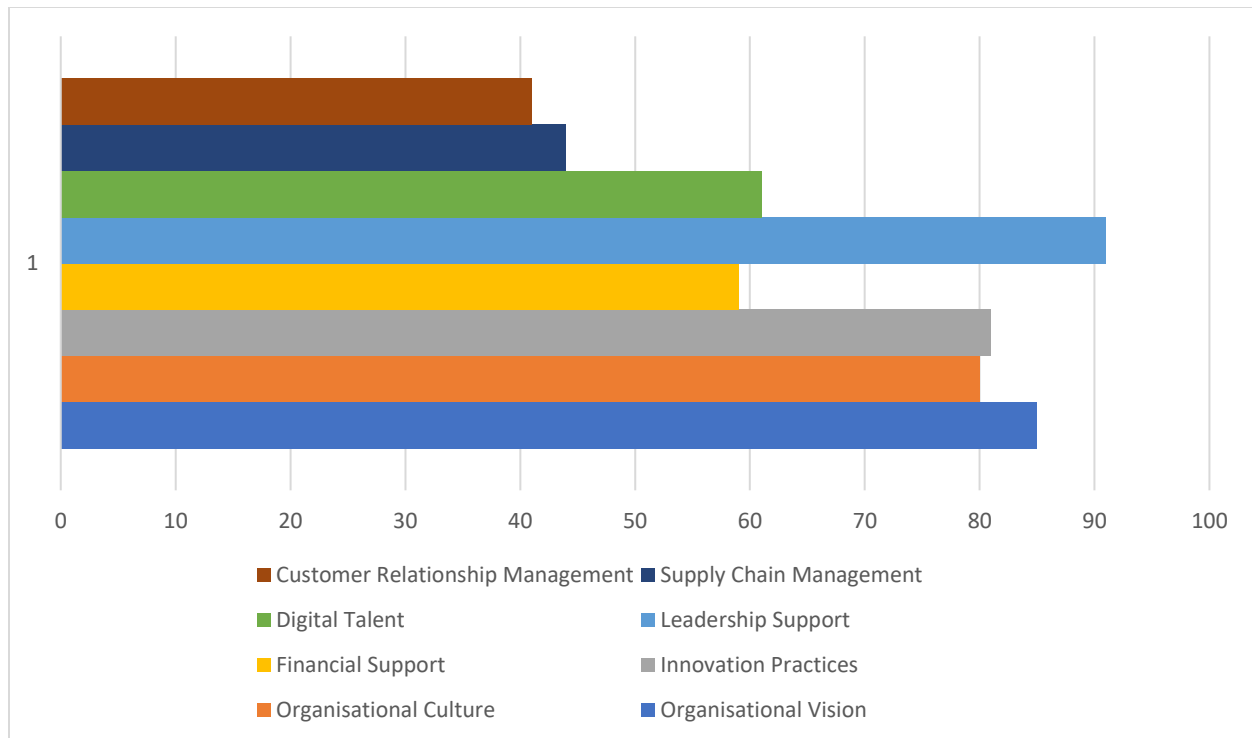


Figure 5-2 Experts' Scoring of Business Competencies Dimension

In this research, "technological competencies" are defined as the adoption of the right advanced digital technologies in all aspects of the organisation. This could range from adopting simple digital technology like a simple ERP system to using more complicated digital technology like robotics. Business competencies are defined as the management practices that are done to support the ease of adopting digital technologies in the organisation's processes. This will range from formulating a digital strategy and inheriting a digital component in the organisation's culture to the top management support and leadership style used to implement DT successfully.

As shown in Figure 5-3, the Technology Competencies dimension included Digital Technologies Adopted and Digital Business Processes. As illustrated in the model, digital technology factors are gathered in one dimension, as the digital technologies used will be different from one manufacturing industry to another and will depend on the size and scale of manufacturing operations within the organisation. To increase the suitability of the model so that it can be used in any manufacturing industry and in any size organisation, in this model, "Digital Technologies Adopted" will combine all the

digital technologies used in the organisation for its manufacturing processes and include them in the same items in the assessment tool. The same is true for the Digital Business Processes dimension.

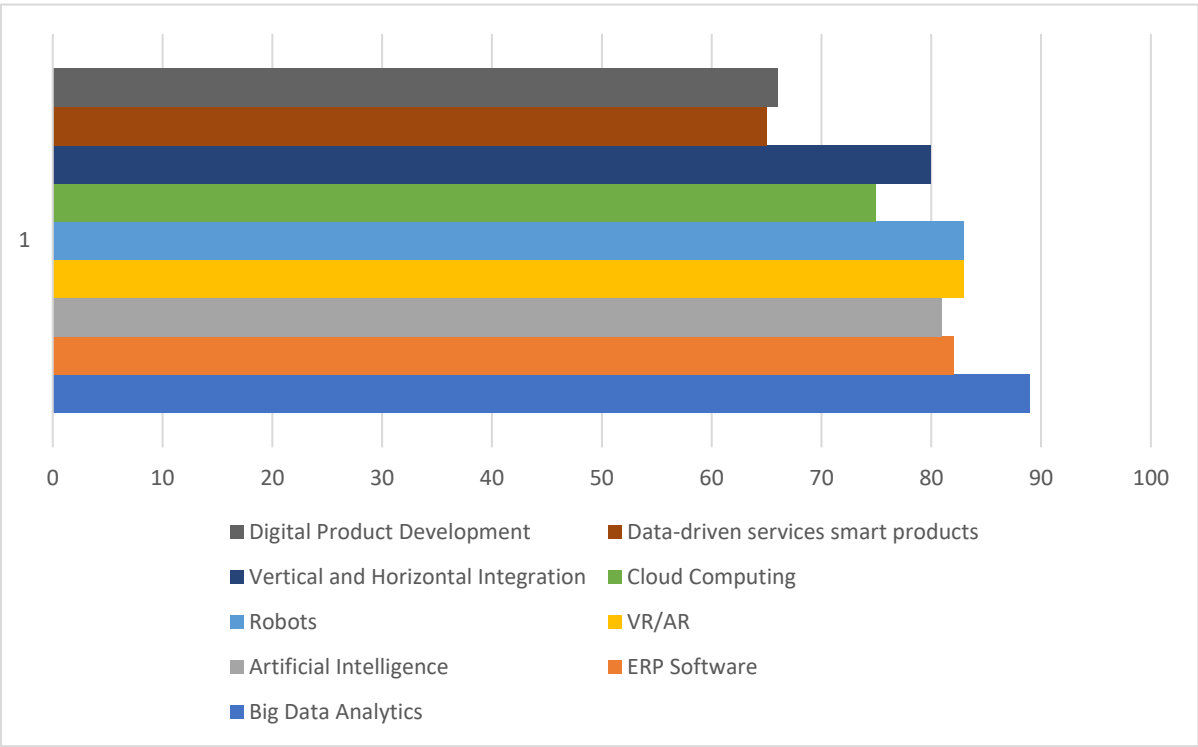


Figure 5-3 Experts’ Scoring of Digital Competencies Dimension

5.3 Business Technology Digital Integration Model

This model provides the organisation with a broad assessment of its level in its DT journey. It is designed to be among the first steps the organisation may take in assessing their digital operations. This should be followed by a range of more detailed and complicated analyses of both business and technological aspects. Table 5-2 summarises the factors used in the model after the expert interviews’ validation of the factors.

Table 5-2 Criteria Used in the Model after the Expert Interviews

Main Criteria	Factors
Business Competencies Criteria	Organisational Vision

	Organisational Culture
	Innovation Practices
	Leadership Support
	Digital Technologies Adopted (Internet of Things [IoT], Big Data Analytics, Enterprise Resource Planning (ERP) Software, Artificial Intelligence [AI], Virtual Reality/Augmented Reality [VR/AR], Robots, Cloud Computing)
Technology Competencies Criteria	Digital Business Processes (Vertical and Horizontal Integration, Data-Driven Services, Digital Product Development)

After calculating the score of each dimension, the model proposes the current readiness level for the organisation and a generic roadmap for the next steps to continue the organisation journey to become digitally transformed. For example, as Figure 5-4 shows, the model proposed nine readiness levels from Low Digitalisation to Digital Hero, which is briefly described in this section.

After calculating the score for each dimension, the model proposes the current readiness level for the organisation and a generic roadmap for the next steps to continue the organisation's journey to become digitally transformed. For example, as Figure 5-4 shows, the model proposes nine readiness levels, from low digitalisation to digital hero, which are briefly described in this section. Generally. The terminology starter (e.g., business starter or technology starter) means that the manufacturing organisation have done some efforts in this specific direction which is highlighted as a medium efforts in their designated action. The term adopter (e.g., business adopter or technology adopter) means that this specific competency has been tested and adopted in this direction, which is highlighted in a high competency because of this adoption.

The arrows in the figure represent how the organisation could move from its current level to the next advanced level in the DT journey. The development of the 3 by 3 model has been chosen to highlight the importance of each step taken in developing both competencies, even if it is a slight development. Developing other models such as 2 by

2 or 4 by 4 or 5 by 5 could either not include the possible competencies or the model could be too complicated to be used in industry.

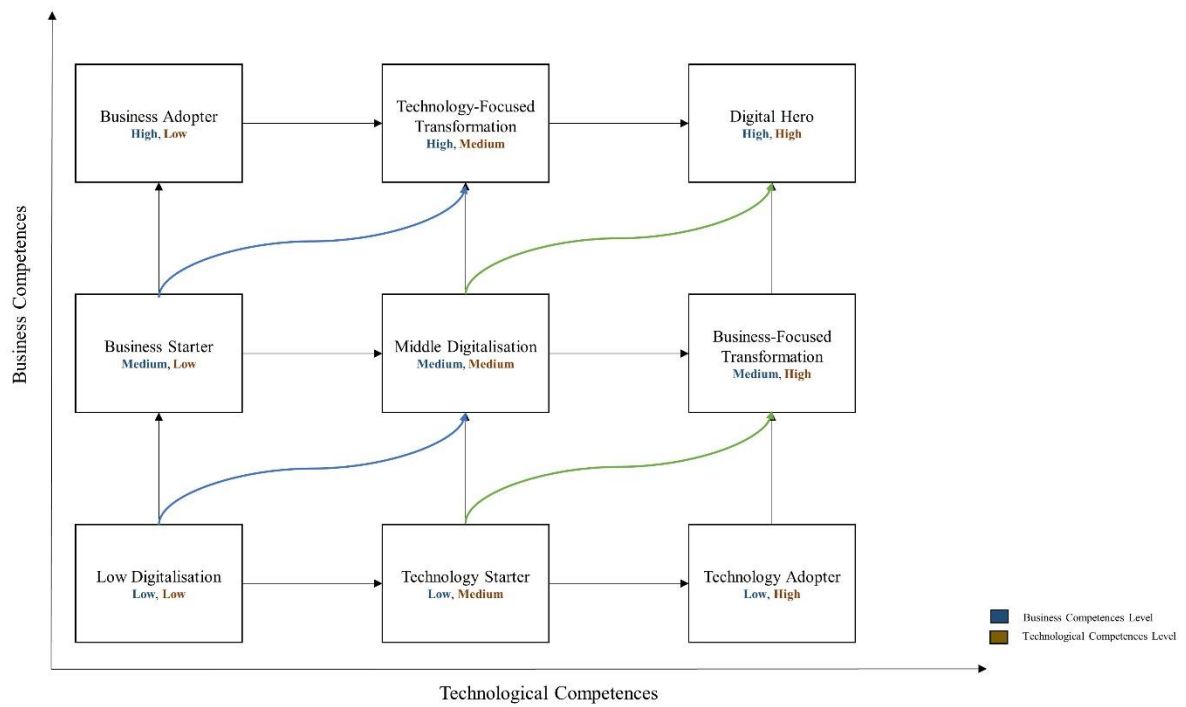


Figure 5-4 Business Technology Digital Integration Model Levels

5.3.1 Low Digitalisation

This level is the elementary level for any organisation. It represents a low technology, low business assessment. This means that the organisation has a low use of digital technologies and little support from the leadership to facilitate the transformation process. The organisation needs to increase its use of digital technologies to move to the next level in the technology direction (Technology Starter) or have digital initiatives incorporated into its leadership practices and business strategies to move to the next level in the business direction (Business Starter). Alternatively, if the organisation's resources and capabilities could work in both directions in the same way, as represented by the blue arrow in the Figure, it could advance to the Middle Digitalisation level.

Studies have shown that small and medium enterprises, some big companies, and state-owned enterprises are some of the firms that belong to this stage. These organisations are not very responsive to technological changes because of the dynamics of their businesses, their stage of development or infancy, or because they are operating in markets with low competition. These companies may not have activities that require advanced technologies such as big data analytics and AI, or they may require such tools but their internal structures and support systems do not allow them to implement them as needed. In some state-owned enterprises, the lack of initiative and low productivity level may discourage innovation, thereby creating an environment that is not conducive for new technologies (Plekhanov and Netland, 2019).

5.3.2 Technology Starter

An organisation that is at the technology starter level uses basic digital technologies in its operations, whether internally or externally. This means that the organisation has a basic enterprise resource planning (ERP) system, uses information technology (IT) systems, and has digital communications with the supply chain. For the business part, this level still has low support from the leadership, and there are few digital initiatives inside the organisation. Leadership support should increase and have more change management practices incorporated into the corporate culture to move to the next competence level (middle digitalisation); otherwise, if the organization moves in the old direction and invests only in technology, it will advance to the next technological level (technology adopter). Again, the movement could be in both directions and directly get the hybrid way to the Business-Focused Transformation level.

Businesses or organisations from low-tech industries are some of the examples of firms in this bracket. These companies have taken various initiatives and formulated objectives to drive their organisations towards transforming their enterprises from manual to digitally enabled processes. Companies at this level face the risk of stiff competition from firms that are in the advanced stages of digitalisation. Thus, there is a growing need to exploit their internal capabilities to implement digital technologies at a deeper level. These companies can consider new technologies such as advanced

analytics and other relevant tools to attain their digital transformation goals. However, it can be argued that the adoption of digital technologies by these firms is still in its infancy stages and needs to advance (Plekhanov and Netland, 2019).

5.3.3 Business Starter

This level is the opposite of the Technology Adopter level. At this level, the organisation has increased leadership and a risk-taking culture that encourages it to try new things. However, the organisation does not have the technological capabilities needed to make these initiatives a complete transformation. The next step is to invest more in some basic digital technologies to integrate their business efforts with the right capabilities and then move to the next competence level (middle digitalisation) or the next business level (business adopter) if the organisation moves in the old direction. Moreover, if the organisation has the financial and human capabilities, it can directly jump to the level of technology-focused transformation if it moves in both directions.

Organisations that are at this level of digitalisation have embraced the right culture and have the required leadership support to oversee the digitalisation activities. The digitalisation process will affect the culture of the organisation, as the supporting structures will be the leadership's risk-taking behaviours, effective error management, and active learning from past failures. These companies need to define and assign clear roles and responsibilities and be ready to welcome radical changes to improve business efficiency (Berghaus and Back, 2016).

5.3.4 Middle Digitalisation

The moderate level of both directions is referred to as middle digitalisation. Here, the organisation is in the middle of business efforts related to changing management practices and uses a moderate level of digital technologies. An organisation assessed at this level has significant potential to complete its transformation process. On the one hand, it can invest in more advanced digital technologies like advanced ERP systems, advanced use of IoT, and augmented reality (AR) business applications. This investment will push the organisation toward the next technological process (business-

focused transformation). On the other hand, it can foster an open innovation culture and extensive support from the senior leadership for the transformation process and implementing procedural steps for transforming the day-to-day operations into a more digitalised approach. These management practices will push it to the next business level (technology-focused transformation). Again, if the organisation has enormous resources and business capabilities, it can work in both directions together and advance directly to the Digital Hero level (green arrow in the Figure).

5.3.5 Technology Adopter

The Technology Adopter category represents a high technology, low business assessment level. Most of the organisation's heavy investment capital may be placed at this level. The use of digital technologies is intense and significant. The organisation may have used digital twin technologies, robots/cobots, and similar advanced digital technologies. However, the business level is not on the same page. The corporate culture has a significant resistance to change, and there are no leadership initiatives to encourage the workforce to become more agile in this transformation process. Here, the organisation has only one option not to fail its DT process: it needs to overcome this resistance to change and have incentives for the workforce to become more digitally skilled and aware that this transformation process will not take their jobs, for example. These practices will move the organisation to the next level (a business-focused organisation).

5.3.6 Business Adopter

The business adopters category is the opposite of the technology adopters category, involving a low technology, high business level. The organisation has a strong, innovative culture and strong support from senior management at this level. However, it has fundamental digital technologies that do not allow it to complete the transformation process. Again, the only option here is to invest in digital technologies, such as replacing old IT software with an integrated ERP system or even using sensors and IoT technology to enhance the manufacturing processes. This push towards advanced

technologies will move the organisation to the next level (technology-focused transformation).

5.3.7 Business-Focused Transformation

This is a high technology, medium business level. The organisation located at this assessment level still needs a straightforward push to complete its readiness for DT. Here, the organisation needs to bring its work forward by encouraging innovation and increasing senior leadership support in this regard. This push will move the organisation to the most advanced level (Digital Hero).

5.3.8 Technology-Focused Transformation

This is a high business, medium technology level. Here, the focus should be on investing in advanced digital technology to reach the level of "Digital Hero. Companies embracing this approach implement different digital technologies across various departments, units, or sections of their businesses to increase operational efficiency and productivity.

5.3.9 Digital Hero

Digital Hero is the most advanced level in this model, representing a high business and high technology level. Here, the organisation achieves a high score in using advanced digital technologies and using business practices in the right way to achieve the transformation process. However, as discussed above in the definition of DT, it is a continuous process that never ends as long as the organisation is still in business. Thus, to remain at this level, the organisation should work to promote digital technology and have the same support from management and business practices.

An example of a digital hero is a data-driven business that has embraced the use of advanced digital tools such as data analytics technologies that ensure real-time analysis, the collation of data from multiple sources, and enhanced customer interactions. Since no other company can use this data despite its availability, only firms

with advanced technologies have known how to exploit its advantages. These companies usually have the requisite internal expertise to use bid data, the right technological infrastructure, and appropriate procedures for data governance. In these enterprises, digitalisation has advanced and demonstrated clear results (Berghaus and Back, 2016).

5.4 Business/Technology Digital Integration Tool

A five-point Likert-style questionnaire was created to assess each criterion in relation to both the business and technological aspects of the organisation on these dimensions. The questionnaire was collected and validated by experts to enhance its reliability. The final version of the questionnaire considered the inclusivity of each criterion and was short and straightforward. The questionnaire respondents were expected to be from senior-level management, with their work related to operations and manufacturing processes. Typical respondents should be the Chief Operations Officer, Operations Manager, or Plant Manager. Table 5-3 lists the statements used in the assessment tool.

Table 5-3 Items Used in the assessment tool

Dimension	Criteria	Statements
Business	Strategy	The business strategy is shared at all levels of the organisation.
		The business strategy is understood at all levels of the organisation.
		Overall, the organisation is succeeding in achieving its strategic objectives.
		Overall, the previous business change projects in the organisation have been successful.
		There is an inspiring vision of how the new digital era can create a new future full of business opportunities.
		The organisation clearly understands how the competitive landscape is changing because of digital trends.
		The organisation has a clear roadmap to use digital technologies to help the employees deliver their business objectives.
	Innovation Practices	The organisation is good at generating new ideas to improve performance.
		The organisation is good at implementing new ideas to improve performance.

		The organisation has already successfully implemented several digital initiatives that improve or adapt its products and services.
		The organisation business strategy focusses on consumers and their needs.
	Organisational Culture	The organisation has an open, blame-free and collaborative culture.
		The organisation responds well to change.
		The organisation communicates effectively, both internally and externally.
		The organisation learns from previous experience.
	Leadership	Leaders act as a role models by facilitating the transformation to a digital-centric organisation.
		Senior individuals in the organisation are held accountable for digital initiatives.
		Senior managers outside the information technology (IT) department are involved in defining, designing and implementing digital initiatives.
		Leaders encourage new initiatives toward digital platforms.
Technology	Digital Business Processes	The business units and functions are well connected to each other via digital platforms.
		The organisation's technology platforms are effective.
		The organisation's technology platforms are easy to use
		The organisation's technology platforms have improved employee engagement (i.e., technology adoption rate).
		The organisation is using digital technologies to improve the efficiency of employees.
		The organisation is using digital technologies to expand its network of collaborators.
	Digital Technologies Adopted	The organisation is using new digital technologies, such as artificial intelligence (AI) and Robotic Process Automation.
		Opportunities to automate business processes have been implemented where appropriate.
		The organisation is resisting new digital technologies.
		The organisation has an innovative approach to the assessment and application of new digital technology.
		The organisation uses updated intranet and extranet software.
		The organisation uses sensor technology in its manufacturing processes.

Using a weighted average method and giving 1 point to each statement and each criterion, a weight represents the number of items used in this criterion. The total score for both dimensions was calculated from 1 to 5, where scores of 1 to 2 are consider low, 2+ to 4 are considered medium and 4+ to 5 are considered high. The level is determined through the scoring in each dimension, as explained in Figure 5-5.

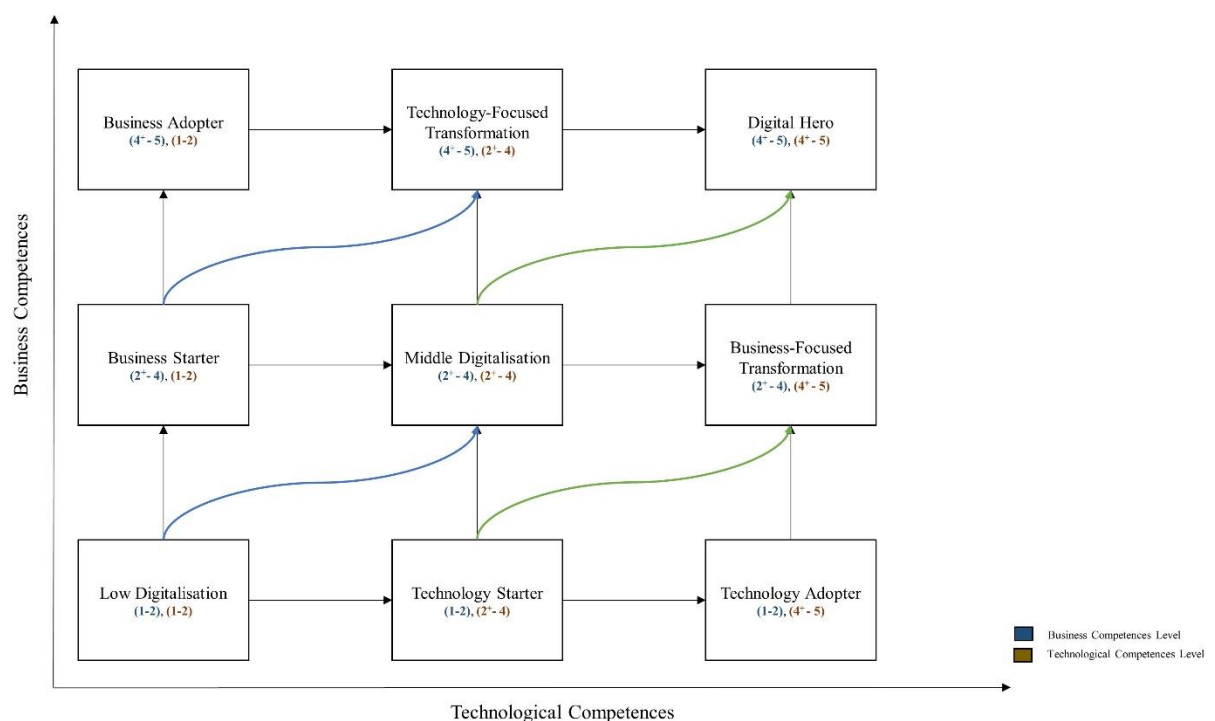


Figure 5-5 Business Technology Digital Integration Model Scoring

An online tool was developed to support the organisation in adopting the readiness model (<https://form.jotform.com/210913339170046>). At the end of the survey, which was intended to be answered by one of the top management teams related to operations management and digital technologies in the manufacturing firm, a total score for both competencies was forecasted. The level of the organisation was briefly

described. For example, if the organisational score was 1.5 in business competencies and 3.5 in technological competencies, this means that the organisation had reached the Technology Adopter level.

5.5 Research Implications

5.5.1 Theoretical Implications

This research proposes a new readiness assessment and maturity model for DT processes focussing on the manufacturing industry in developing economies. The model was generated by capturing the best practices found in the previous models and then modified and validated by experts in the field to determine the degree of suitability of this model for manufacturing operations. This model adds to the literature in this regard by developing a link between business practices and technological competencies and determining the sub-dimensions that can be used to measure each dimension (Kellner et al., 2020; Lezina et al., 2019; Makki and Xie, 2020).

Although there are a number of digital maturity models in the literature, few of them focus on the manufacturing industry and even fewer that integrates both business and technological aspects of the DT as a whole (Črešnar *et al.*, 2020; Denicolai *et al.*, 2021; Makki and Xie, 2020). This model is different to the models previously found in the literature that it gives the decision maker in the manufacturing organisation a strategic overview of the business and technological capabilities of the organisation to implement DT processes. The model then locates the organisation on one of the nine levels and suggests ways to improve its location.

The model adds to the theory of digital maturity in the manufacturing industry as it introduces a new and easy way to assess the DT readiness in the manufacturing industry which can be suitable to any manufacturing organisation as the model is not industry-specific or technology-specific. Nevertheless, it gives a clear view of the DT readiness in the manufacturing organisation.

5.5.2 Practical Implications

The suggested model measures the degree of readiness for a manufacturing organisation to begin or proceed with DT processes. The importance of the model comes from the disruption that most economies have experienced because of the COVID-19 pandemic and its sizeable effect on the way of doing business. This is why all organisations, big or small, should begin their DT journey now. The model is a macro-level model that gives general insight into DT practices and should be followed by another detailed analysis for each technology used in the organisation. The model is easy to use and can be implemented within a one-hour timeframe.

The model is tailored to manufacturing organisations in the developing economies which try to begin their DT journey to cope with the changes made by digital technologies all over the world. This is particularly important as most of the digital readiness models have focused on the developed countries.

5.6 Chapter Summary

A new readiness model for measuring DT in the manufacturing industry was proposed. By investigating the literature and conducting interviews with experts in the manufacturing industry in a developing economy like the Egyptian economy, the model proposed two main dimensions: Business Competencies and Technological Competencies. Each main dimension has sub-dimensions that measure the readiness level. For Business Competencies, the sub-dimensions are Leadership, Strategy, Innovation Management Practices and Organisational Culture. For Technology Competencies, the sub-dimensions are Digital Business Processes and Digital Technologies Adopted.

A nine-level scale was introduced in this model. The levels are Low Digitalisation, Technology Starter, Business Starter, Middle Digitalisation, Technology Adopter, Business Adopter, Business-Focussed Transformation, Technology-Focussed Transformation and Digital Hero. The score was calculated using the weighted average method for both dimensions. Moreover, using three case studies to validate the model

implemented in manufacturing companies in the Egyptian economy were analysed, and a lack of using advanced digital technologies was found, where many manufacturing operations still rely on manual work. However, there is strong support from senior leaders and strategy makers for adopting DT initiatives inside their plants. Three main case studies were introduced in this research to highlight the use of the model, and each case study was located in the model.

6 LEAD-19 - THE DIGITAL LEADERSHIP ATTRIBUTES TO FOSTER DIGITAL TRANSFORMATION IN THE MANUFACTURING INDUSTRY

6.1 Introduction

The literature review has revealed that current leaders require various skills, knowledge, and qualifications to meet the demands of the digital age. A digital leader must have certain qualities or behaviours necessary to oversee the digital transformation process. For example, digital leaders should act as enablers, pioneers, mentors, managers, and innovators in the current digital age.

These qualities will help them create sustainable solutions and develop strategic goals for implementing digital tools in their organisations. Leadership is often described as a shared and dyadic process that leads to the attainment of strategic goals. The modern view of leadership is not limited to a single concept, but rather a collection of ideas that define what influential leaders should be and how they should behave in various contexts. Some of the words used to describe leadership in the modern era include transformational, transactional, innovative, authentic, and inspirational, among others. These concepts describe various types of leadership that have been cited as appropriate in various contexts (Weber, Krehl, and Büttgen, 2022).

Given the findings of this study, a framework that examines what digital leadership in the manufacturing sector entails has been developed. This framework contains four main attributes that define the appropriate leadership for DT. These include an inspirational mindset, an innovation mindset, a digital business mindset, and a transformational mindset.

6.2 Research Methodology

As shown in Figure 6-1, this study followed an integrated approach to determining the key digital leadership attributes necessary for DT in Egypt's manufacturing industry, including interviews and literature reviews. The research methodology, as shown in Figure 6-1, consists of four steps. First, analyse the literature review to find the most important and valid attributes of digital leadership that can help develop a successful DT process in the manufacturing industry in Egypt. Second, conducting a qualitative analysis of the interviews held with 21 experts in the field to determine the most important steps using the BWM as a critical multi-criteria decision-making (MCDM)

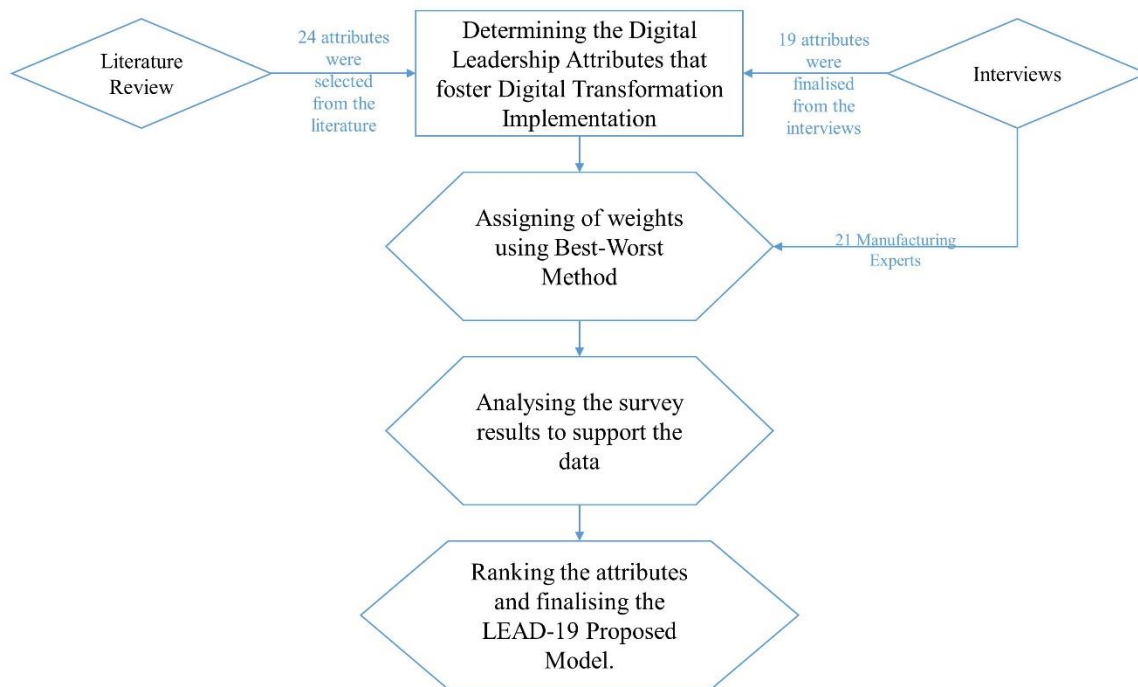


Figure 6-1 Research Methodology

approach. Third, a quantitative analysis was conducted for the survey results using descriptive statistics to support the data collected from the interview and increase the model's reliability. Finally, the final prioritisation of these attributes has been discussed,

and a new model called the LEAD-19 Model for digital leadership attributes has been introduced. Each step will be discussed in the following sections.

6.3 Data Analysis

As mentioned in chapter two, the most common digital attributes mentioned in the literature were discussed. In the second step, factors collected in the previous steps were finalized to determine the most relevant digital leadership attributes that foster DT implementation in the manufacturing industry in Egypt. The shortlisting process was completed via personal interviews with twenty-one participants. As stated previously, the details of the participants can be found in Chapter 3. Respondents' selection was performed using a combination of purposive sampling and self-selection sampling techniques rather than statistical sampling techniques (Moktadir et al., 2018; Suhi et al., 2019). Therefore, participants using digital technologies in their business, having information and knowledge about the subject of the study, as well as having the desire and willingness to participate in the study, were selected. At the beginning of each interview, the aim and procedures of the study were presented to each respondent. After that, each participant was asked to answer a simple "Yes" or "No" short questionnaire (Almeida et al., 2021; Randall, 2014) to determine whether each attribute is relevant or not to the usage of DT in Egyptian Manufacturing Industry. Also, each participant has the option to add any new attributes. Attributes that received fewer than four "yeses" were discarded from the list. No further factors were added. At the end of this step, nineteen attributes were finally recognised as important and relevant for this study. The final attributes generated from the literature review and participants' opinions are presented in Table 6-1.

Table 6-1 Digital Leadership Attributes

Main Attribute	Sub-Attribute	Supporting Literature
Inspirational Mindset (INSM)	Motivator (INSM1)	(Abbu, Mugge, Gudergan, et al., 2022; Ehlers, 2020; Oberer & Erkollar, 2018; Zupancic et al., 2017)
	Openness (INSM2)	(Alos-Simo et al., 2017; Gaikwad, 2013; Khatri et al.,

		2022; Ratajczak, 2022)
	Decisive Courageous (INSM3)	(Beyaz Hüseyin Furkan and Yldrm, 2020; Garzoni et al., 2020; Heavin & Power, 2018)
	Trustworthy (INSM4)	(Abbu, Mugge, & Gudergan, 2022; Trubetskaya, 2021)
	Enthusiastic (INSM5)	(Alos-Simo et al., 2017; Jagadisen et al., 2022a; Khatri et al., 2022; Niu et al., 2022; Walden et al., 2019)
Innovation Mindset (INNM)	Risk Taker (INNM1)	(Bongiorno et al., 2017; Ivanov et al., 2019; Zupancic et al., 2017)
	Agile (INNM2)	(Abbu, Mugge, Gudergan, et al., 2022; Jagadisen et al., 2022a; Kandler et al., 2020; Kuehnel & Au-Yong-oliveira, 2022)
	Anticipatory (INNM3)	(Mihardjo, Sasmoko, Alamsjah, et al., 2019b; Wasono & Furinto, 2018)
	Collaborative (INNM4)	(Jagadisen et al., 2022b; Lusiani et al., 2020)
Digital Business Mindset (DBM)	Digital Intelligence (DBM1)	(Bordeleau et al., 2018; Brock & von Wangenheim, 2019)
	Complexity Master (DBM2)	(Allen, 2019; Loonam et al., 2018)
	Digital Savvy (DBM3)	(Almeida et al., 2021; Hilton, 2010; Mihardjo, Sasmoko, Alamsjah, et al., 2019; Mihardjo, Sasmoko, Alamsyah, et al., 2019)
	Digital talent Scout (DBM4)	(Bongiorno et al., 2017; Ehlers, 2020; Zupancic et al., 2017)
	Ambidexterity (DBM5)	(Alos-Simo et al., 2017; Ehlers, 2020; Oberer & Erkollar, 2018; Zulu & Khosrowshahi, 2021)
	Lobbyist (DBM6)	(Frick et al., 2021; Gaffley & Pelser, 2021; Weber et al., 2022)

Transformational Mindset (TM)	Diversity Champion (TM1)	(Bongiorno et al., 2017; Strljic et al., 2019; Zupancic et al., 2017)
	Encouraging (TM2)	(Almeida et al., 2021; Randall, 2014; Weber et al., 2022)
	Visionary (TM3)	(Ismagilova et al., 2019; Kruglyakova et al., 2019; Tolstykh et al., 2018)
	Accountable (TM4)	(Alos-Simo et al., 2017; Bongiorno et al., 2017; Ratajczak, 2022)

6.3.1 Qualitative Analysis

This section outlines the key highlights generated from the discussion throughout the interviews. It is necessary to train employees about innovation. Employees need training sessions about different fields of the DT process, namely, robotics, cloud robotics, big data analytics, cloud computing, the internet of things, artificial intelligence, etc. (Mhlanga and Moloi, 2020). 14 out of 21 respondents said that leadership plays an essential role in the DT process in organisations. One of the respondents said:

".....Transformational leadership style is the prominent factor in achieving DT and changing the business environment; the biggest organisations in the world have succeeded through the implementation of transformational leadership for any change; it will produce a productive working environment..... "

The study of Purwanto et al. (2021) has also indicated the importance of a transformational leadership style for innovative working and quality work. Transformational leaders allow their employees to take part in the decision-making process. Employees in organisations where leaders allow open access to anything can become much more productive. It reduces stress and anxiety related to work. It creates a comfortable and flexible working atmosphere for employees. Abou-El-Fadl (2018) defined the importance of leadership characteristics that leaders must have. These

traits are traits of digital leaders who employ disruptive technologies to increase productivity, value creation, and social welfare. Leadership plays an essential role. Leaders in any organisation inspire, motivate, and set an example so that their respective employees follow them. Leaders are, therefore, necessary to accomplish any positive change in the organisation. For example, to make changes in the organisation's structure or to bring any other change Leaders are responsible for providing a plan for certain actions, and they also maintain a positive relationship with their workforce to accomplish their vision.

According to research studies by Jimeno-Morenilla et al. (2021), Jones et al. (2021), and Junge (2019), change cannot occur naturally and requires the perfect move of a leader. For example, if an organisation wishes to change its structure in order to implement DT in various business operations, employees can efficiently adopt such a change by leading a change. Furthermore, if a leader is effective, it can generate a good personal connection with everyone in the organisation. Such leaders can fulfil all the needs of their employees, for which a leader must understand the feelings of their employees. He is liable to generate feelings of comfort and security on the employees' side. A leader can easily resolve conflicts because he can resolve any conflict in the organisation. Leaders should listen to the concerns of others and also address them quickly. Leaders engage themselves in conflict resolution by adopting conflict resolution skills. They resolve challenges that employees face in the organisation. When a leader adopts a transformational style, employees feel flexible to talk with and work with such a leader (Jimeno-Morenilla et al., 2021; Jones et al., 2021; Junge, 2019). They can easily discuss anything with their leaders. Employees always need some encouragement from their leaders to take certain actions and to determine the solution to some work-related problems. Leaders use their skills to attain a certain vision and mission for the organisation. So, to implement DT practices and ensure their successful implementation, a leader needs to engage employees on one platform. A leader can guide employees about the importance of DT processes. Enablers of DT, its challenges, readiness for DT, readiness models of DT, and much other meaningful information can help employees in the achievement of DT in business-related functions.

The overall literature on leadership for digital leadership tactics has shown that the role of any leader is of great importance (Kane et al., 2019). It primarily addresses leadership style in order to become an effective leader. A leader needs to possess some characteristics to enhance the skills of every individual in the organisation, and those leadership skills include being open to change, which means a leader should allow employees to take part in the decision-making process. It improves different skills among employees, such as problem-solving and critical thinking. A leader must possess ownership and responsibility because he is responsible for the efforts of employees and their actions (Lee et al., 2021). Employees always follow the leader's orders to act in any way. It means employees follow the personality of their leaders, as also defined in the literature. It has been determined that in order to bring about a change in digitalisation in every business process, employees must be led using a digital leadership style. It includes developing digital skills in employees, such as new technological trends innovation and digital transformation enablers. According to the literature, innovation is critical for the success of DT processes in the manufacturing industry. Many firms in this world lack an innovation strategy; there is a lack of sufficient innovative decisions in manufacturing sectors. Employees need training from their leaders about innovative trends in the DT process. Employees must be trained for digital transactions in countries such as Egypt. Employees need programs called incubators or accelerators that may work properly to digitalise the manufacturing industry (Li et al., 2022).

6.3.2 Application of the Best-Worst Method (BWM)

As stated earlier in Chapter 4, various MCDM techniques exist, such as "Analytic Network Process" (ANP), "Multi-Attribute Utility Theory" (MAUT), "Simple Multi-Attribute Rating Technique" (SMART), "Analytical Hierarchy Process" (AHP), and "Multi-Objective Optimisation Ratio Analysis" (MOORA) (Malek & Desai, 2019; Suhi et al., 2019; Van de Kaa et al., 2019) All of these strategies are based on doing a pairwise comparison between multiple factors in order to determine the most influential component by weighing each factor. However, the majority of these MCDM techniques have been constrained by the complexity and inconsistency of the pairwise comparison

of alternatives, which can produce confusing findings (Rezaei, 2015). The Best–Worst Method (BWM) can be used to solve multi-criteria problems to overcome these drawbacks. The BWM is a recently developed method introduced by Rezaei (2015) that may be used to address the complexities of pairwise comparisons and produce accurate findings (Gupta & Barua, 2016; Kusi-Sarpong et al., 2019; Malek & Desai, 2019; Suhi et al., 2019). In comparison to other MCDM approaches, the BWM offers the following benefits: Less sophisticated (concerning the requisite datasets, decision-maker inputs, and pairwise comparisons), a systematic approach to data collection saves specialists time, facilitates implementation, and yields more reliable and consistent findings (S. Ahmad et al., 2021; Ahmadi et al., 2017; Kusi-Sarpong et al., 2019; Malek & Desai, 2019; Suhi et al., 2019).

Furthermore, numerous researchers have extensively used the BWM in a variety of domains, such as innovation and technology (e.g., Gupta & Barua, 2016; Moktadir et al., 2018; Orji et al., 2020; Salimi & Rezaei, 2018; Sobota et al., 2020; Tarei et al., 2021; Van de Kaa et al., 2019)

Therefore, the BWM will be utilised in this study to determine the relative importance of different digital leadership attributes that can foster the successful implementation of digital transformation in the manufacturing sector in Egypt. This section outlines all the steps required to apply the BWM, as stated by Rezaei (2015), to derive the relative importance (weights) of the critical digital leadership attributes and their corresponding sub-attributes for successful digital transformation in the Egyptian manufacturing industry.

Step 1: Creating a set of criteria for making a decision

By performing an extensive literature review, a set of decision-making criteria was initially determined as the main criteria in this step. The literature analysis led to the extraction of 25 digital leadership attributes that impact successful digital transformation. Next, using comments and feedback from the 21 respondents described in the

preceding section, these criteria were finalized and reduced to 19, as previously given in Table 6-1.

Step 2: From the set of criteria created in step 1, identify the best (most desirable, most important) and worst (least desirable, least important) criteria.

In this step, every participant was prompted to select the most important digital leadership attribute and sub-attribute, as well as the least important attribute and sub-attribute, from the list established as provided in Table 6-2.

Every respondent select the best attribute and sub-attribute as a first step to compare it relatively with other attributes and sub-attributes in the next steps. The numbers in the table represents the respondent coding for the 21 interviews. For example, Inspirational Mindset (INSM) was chosen as worst main attribute by respondents 1,3,5,6,8,9,12,14,19, and 21.

Table 6-2 Best and worst factors decided by Respondents

Digital Leadership Criteria	Determined as Best by respondents	Determined as Worst by respondents
Inspirational Mindset (INSM)		1, 3, 5, 6, 8, 9, 12, 14, 19, 21
INSM1	1, 9, 10, 11	4, 13, 14, 18, 19
INSM2	2, 3, 5, 6, 7, 8, 12, 15, 16, 17, 20, 21	
INSM3		1, 5, 9, 10, 11
INSM4	4, 13, 14, 18, 19	
INSM5		2, 3, 6, 7, 8, 12, 15, 16, 17, 20, 21
Innovation Mindset (INNM)	1, 4, 5, 7, 11, 16, 18, 21	17
INNM1	1, 2, 5, 6, 7, 9, 10, 13, 16, 19	15
INNM2		1, 3, 6, 7, 9, 11, 16, 21
INNM3	3, 4, 8, 11, 12, 14, 15, 17, 18, 20,	5, 13, 19

	21	
INNM4		2, 4, 8, 10, 12, 14, 17, 18, 20
Digital Business Mindset (DBM)	2, 6, 10, 13, 14, 15, 17, 20	4, 7, 11, 18
DBM1	2, 6, 12, 17, 19	
DBM2	3, 4, 7, 9, 10, 11, 20, 21	12, 17
DBM3	5, 8, 18	1, 11, 13, 14
DBM4	13, 14	7, 21
DBM5	1, 15, 16	4, 6
DBM6		2, 3, 5, 8, 9, 10, 15, 16, 18, 19, 20
Transformational Mindset (TM)	3, 8, 9, 12, 19	2, 10, 13, 15, 16, 20
TM1		1, 2, 4, 5, 6, 7, 12, 13, 19, 20
TM2	1, 2, 5, 9, 10, 11, 15, 16, 17, 19, 21	
TM3	3, 6, 7, 12, 13, 20	8, 9, 10, 11, 14, 16, 18
TM4	4, 8, 14, 18	3, 15, 17, 21

Step 3: Comparing the best criterion with the other criteria in pairs.

In this step, by using a "9-point linguistic scale from 1 to 9," as shown in Table 6-3, the participant evaluates the most important criterion's preference above all other criteria. By conducting this pairwise comparison, the best-to-other (BO) vector is identified and can be expressed as follows:

$$A_B = (a_{B1}, a_{B2}, a_{B3}, \dots, a_{Bn}),$$

Where a_{Bj} denotes the importance of the best criterion B over criterion j , making $a_{BB} = 1$.

Table 6-3: 9-point linguistic scale

9-point linguistic attributes	Scores
“Equal importance”	1
“Somewhat between Equal and Moderate”	2
“Moderately more important than”	3
“Somewhat between Moderate and Strong”	4
“Strongly more important than”	5
“Somewhat between Strong and Very strong”	6
“Very strongly important than”	7
“Somewhat between Very strong and Absolute”	8
“Absolutely more important than”	9

By applying this step, each respondent was requested to identify the preference for the most important digital leadership attribute over every other attribute. As indicated in Table 6-4, all the answers from the respondents have been transformed into a “Best-to-Others vector”.

Table 6-4 Best-to-Others vector

	Best	INSM	INNMM	DBM	TM
R1	INNMM	7	1	4	5
R2	DBM	5	3	1	6
R3	TM	7	4	2	1
R4	INNMM	6	1	8	3
R5	INNMM	6	1	2	4
R6	DBM	6	2	1	4

R7	INNM	6	1	8	3
R8	TM	8	4	6	1
R9	TM	6	4	3	1
R10	DBM	4	2	1	6
R11	INNM	5	1	8	4
R12	TM	7	3	5	1
R13	DBM	4	3	1	6
R14	DBM	6	4	1	2
R15	DBM	4	2	1	7
R16	INNM	5	1	3	8
R17	DBM	4	8	1	5
R18	INNM	6	1	8	4
R19	TM	6	3	5	1
R20	DBM	5	4	1	7
R21	INNM	5	1	3	4

Step 4: Comparing the worst criterion with the other criteria in pairs.

Utilising the same “9-point linguistic scale” as in step 3, the decision-maker evaluates which criteria are preferred over the worst one. This pairwise comparison reveals the others-to-worst (OW) vector, which is expressed as:

$$A_W = (a_{1W}, a_{2W}, a_{3W} \dots, a_{nW})^T,$$

Where a_{jW} denotes the preference of criterion j over the worst criterion W , making $a_{WW} = 1$.

By applying this step, each respondent was required to determine the preference of all other digital leadership attributes over the least desirable attribute. All the respondents' answers have been transformed into an "Others-to-Worst vector", as provided in Table 6-5.

Table 6-5 Others-to-Worst vector

	Worst	INSM	INNМ	DBM	TM
R1	INSM	1	8	5	3
R2	TM	4	6	8	1
R3	INSM	1	5	7	8
R4	DBM	3	8	1	6
R5	INSM	1	8	7	5
R6	INSM	1	8	8	5
R7	DBM	3	8	1	6
R8	INSM	1	5	3	8
R9	INSM	1	5	6	8
R10	TM	6	7	8	1
R11	DBM	4	8	1	5
R12	INSM	1	6	4	8
R13	TM	5	7	8	1
R14	INSM	1	5	8	6
R15	TM	4	7	8	1
R16	TM	4	8	6	1
R17	INNМ	5	1	8	4
R18	DBM	3	8	1	5
R19	INSM	1	6	4	8

R20	TM	4	4	8	1
R21	INSM	1	8	6	5

Step 5: Computing optimal weights of the criteria.

After conducting the pairwise comparisons as stated in step 3 and step 4, the final step is to calculate the optimal weights. To calculate the optimal weights of the criteria $(w_1^*, w_2^*, w_3^*, \dots, w_n^*)$, it is necessary to:

First, minimise the maximum absolute differences $\{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$ for all j . Therefore, mathematical (6-1) is applied

$$\min \max_j \{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$$

Subject to:

$$\sum_j w_j = 1,$$

$$w_j \geq 0, \text{ for all } j \quad (6-1)$$

Second, transform (6-1) into the next linear programming formula:

$$\min \xi^L$$

Subject to:

$$|w_B - a_{Bj}w_j| \leq \xi^L, \text{ for all } j$$

$$|w_j - a_{jW}w_W| \leq \xi^L, \text{ for all } j$$

$$\sum_j w_j = 1, \quad (6-2)$$

$w_j \geq 0$, for all j

Finally, use (6-2) to obtain the optimal weights of the criteria $(w_1^*, w_2^*, w_3^*, \dots, w_n^*)$, as well as the optimal consistency value ξ^L .

By utilising (6-1), the optimal weights for the major digital leadership attributes and their associated sub-attributes have been determined. After that, the aggregate weights for each of the major digital leadership attributes and their respective sub-attributes have been calculated for each of the 21 respondents using (6-2). Lastly, the simple average technique has been used to produce a single weight vector for each of the key digital leadership attributes and their relevant sub-attributes. The calculated average weight for each of the main digital leadership attributes and the average consistency ratio (ξ^L) derived for all respondents are displayed in Table 6-6.

Table 6-6 Main attributes' optimal weights

	INSM	INNMM	DBM	TM	ξ^L
R1	0.065502	0.600437	0.18559	0.148472	0.141921
R2	0.14248	0.237467	0.55409	0.065963	0.158311
R3	0.053571	0.151786	0.303571	0.491071	0.116071
R4	0.117647	0.588235	0.058824	0.235294	0.117647
R5	0.057692	0.480769	0.307692	0.153846	0.134615
R6	0.056338	0.309859	0.478873	0.15493	0.140845
R7	0.117647	0.588235	0.058824	0.235294	0.117647
R8	0.0625	0.1875	0.125	0.625	0.125
R9	0.133333	0.2	0.266667	0.4	0.4
R10	0.157895	0.315789	0.473684	0.052632	0.157895
R11	0.146341	0.609756	0.060976	0.182927	0.121951
R12	0.061425	0.233415	0.140049	0.565111	0.135135

R13	0.176471	0.235294	0.529412	0.058824	0.176471
R14	0.057692	0.153846	0.480769	0.307692	0.134615
R15	0.148936	0.297872	0.496454	0.056738	0.099291
R16	0.137931	0.574713	0.229885	0.057471	0.114943
R17	0.182927	0.060976	0.609756	0.146341	0.121951
R18	0.125	0.625	0.0625	0.1875	0.125
R19	0.065963	0.237467	0.14248	0.55409	0.158311
R20	0.145985	0.182482	0.603406	0.068127	0.126521
R21	0.068729	0.522337	0.233677	0.175258	0.178694
Final Wt.	0.108667	0.352059	0.304866	0.234409	0.147754

The same steps were applied to gain the weights of the sub-attributes in each main attribute as in Tables 6-7,6-8,6-9, and 6-10 . Table 6-11 highlights the final results from the utilisation of the BWM and lists the key digital leadership attributes and their corresponding sub-attributes in order of final ranking based on their relative importance. The results obtained will be fully described in the section 6-5.

Table 6-7 Weights of INSM sub-attributes

	INSM1	INSM2	INSM3	INSM4	INSM5	ξ^L
R1	0.421965	0.17341	0.040462	0.260116	0.104046	0.098266
R2	0.2	0.5	0.1	0.15	0.05	0.1
R3	0.206186	0.515464	0.123711	0.103093	0.051546	0.103093
R4	0.051282	0.274725	0.10989	0.454212	0.10989	0.095238
R5	0.132124	0.534326	0.05829	0.165155	0.110104	0.126295
R6	0.198641	0.48092	0.148981	0.119185	0.052274	0.115003

R7	0.206186	0.515464	0.123711	0.103093	0.051546	0.103093
R8	0.2	0.5	0.1	0.15	0.05	0.1
R9	0.441088	0.271903	0.042296	0.135952	0.108761	0.102719
R10	0.48092	0.198641	0.052274	0.148981	0.119185	0.115003
R11	0.48092	0.119185	0.052274	0.198641	0.148981	0.115003
R12	0.255924	0.398104	0.170616	0.127962	0.047393	0.113744
R13	0.045496	0.259327	0.172884	0.418562	0.103731	0.100091
R14	0.05137	0.136986	0.273973	0.428082	0.109589	0.119863
R15	0.198641	0.48092	0.119185	0.148981	0.052274	0.115003
R16	0.275676	0.445946	0.091892	0.137838	0.048649	0.105405
R17	0.25641	0.42735	0.17094	0.102564	0.042735	0.08547
R18	0.052274	0.198641	0.148981	0.48092	0.119185	0.115003
R19	0.053333	0.202667	0.101333	0.490667	0.152	0.117333
R20	0.206186	0.515464	0.123711	0.103093	0.051546	0.103093
R21	0.202667	0.490667	0.152	0.101333	0.053333	0.117333
Final Wt.	0.219871	0.363815	0.117972	0.215639	0.082703	0.107907

Table 6-8 Weights of INNМ sub-attributes

	INNМ1	INNМ2	INNМ3	INNМ4	ξ^L
R1	0.5	0.05	0.3	0.15	0.1
R2	0.625	0.125	0.1875	0.0625	0.125
R3	0.229885	0.057471	0.574713	0.137931	0.114943
R4	0.235294	0.117647	0.588235	0.058824	0.117647

R5	0.588235	0.235294	0.058824	0.117647	0.117647
R6	0.578616	0.062893	0.238994	0.119497	0.138365
R7	0.578616	0.062893	0.238994	0.119497	0.138365
R8	0.229885	0.137931	0.574713	0.057471	0.114943
R9	0.515464	0.051546	0.309278	0.123711	0.103093
R10	0.515464	0.123711	0.309278	0.051546	0.103093
R11	0.235294	0.058824	0.588235	0.117647	0.117647
R12	0.229885	0.137931	0.574713	0.057471	0.114943
R13	0.636364	0.109091	0.063636	0.190909	0.127273
R14	0.229885	0.137931	0.574713	0.057471	0.114943
R15	0.058442	0.185065	0.633117	0.123377	0.107143
R16	0.578616	0.062893	0.238994	0.119497	0.138365
R17	0.229885	0.137931	0.574713	0.057471	0.114943
R18	0.229885	0.137931	0.574713	0.057471	0.114943
R19	0.636364	0.109091	0.063636	0.190909	0.127273
R20	0.229885	0.137931	0.574713	0.057471	0.114943
R21	0.229885	0.057471	0.574713	0.137931	0.114943
Final Wt.	0.386707	0.109356	0.400782	0.103155	0.118117

Table 6-9 Weights of DBM sub-attributes

	DBM1	DBM2	DBM3	DBM4	DBM5	DBM6	ξ^L
R1	0.230769	0.153846	0.038462	0.115385	0.384615	0.076923	0.076923
R2	0.386297	0.16035	0.080175	0.240525	0.09621	0.036443	0.094752

R3	0.162822	0.379919	0.081411	0.244233	0.097693	0.033921	0.108548
R4	0.163934	0.393443	0.081967	0.245902	0.032787	0.081967	0.098361
R5	0.156863	0.117647	0.376471	0.235294	0.078431	0.035294	0.094118
R6	0.417423	0.127042	0.101633	0.254083	0.036298	0.063521	0.090744
R7	0.16185	0.404624	0.242775	0.040462	0.069364	0.080925	0.080925
R8	0.183246	0.137435	0.451571	0.109948	0.078534	0.039267	0.098168
R9	0.248815	0.408768	0.124408	0.099526	0.082938	0.035545	0.088863
R10	0.12	0.4	0.24	0.08	0.12	0.04	0.08
R11	0.228916	0.391566	0.036145	0.15261	0.114458	0.076305	0.066265
R12	0.454545	0.045455	0.090909	0.181818	0.136364	0.090909	0.090909
R13	0.176909	0.106145	0.041899	0.453911	0.132682	0.088454	0.076816
R14	0.182442	0.078189	0.04321	0.468107	0.136831	0.091221	0.079218
R15	0.156057	0.117043	0.078029	0.234086	0.38193	0.032854	0.086242
R16	0.378788	0.151515	0.113636	0.227273	0.090909	0.037879	0.075758
R17	0.454545	0.045455	0.090909	0.181818	0.136364	0.090909	0.090909
R18	0.119243	0.238486	0.370978	0.158991	0.068139	0.044164	0.105994
R19	0.386297	0.16035	0.080175	0.240525	0.09621	0.036443	0.094752
R20	0.162822	0.379919	0.081411	0.244233	0.097693	0.033921	0.108548
R21	0.242775	0.404624	0.16185	0.040462	0.069364	0.080925	0.080925
Final Wt.	0.246446	0.228658	0.143239	0.202343	0.120848	0.058466	0.08894

Table 6-10 Weights of TM sub-attributes

	TM1	TM2	TM3	TM4	ξ^L
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R1	0.055249	0.596685	0.116022	0.232044	0.099448
R2	0.055249	0.596685	0.232044	0.116022	0.099448
R3	0.116022	0.232044	0.596685	0.055249	0.099448
R4	0.05949	0.226629	0.135977	0.577904	0.101983
R5	0.057471	0.574713	0.137931	0.229885	0.114943
R6	0.05	0.25	0.575	0.125	0.175
R7	0.049822	0.302491	0.52669	0.120996	0.078292
R8	0.117647	0.235294	0.058824	0.588235	0.117647
R9	0.254237	0.540254	0.052966	0.152542	0.222458
R10	0.212177	0.562731	0.055351	0.169742	0.285978
R11	0.310559	0.484472	0.049689	0.15528	0.136646
R12	0.05	0.25	0.575	0.125	0.175
R13	0.057078	0.239726	0.559361	0.143836	0.159817
R14	0.231618	0.099265	0.064338	0.604779	0.090074
R15	0.320513	0.5	0.128205	0.051282	0.141026
R16	0.18559	0.600437	0.065502	0.148472	0.141921
R17	0.320513	0.5	0.128205	0.051282	0.141026
R18	0.117647	0.235294	0.058824	0.588235	0.117647
R19	0.055249	0.596685	0.232044	0.116022	0.099448
R20	0.057078	0.239726	0.559361	0.143836	0.159817
R21	0.320513	0.5	0.128205	0.051282	0.141026
Final Wt.	0.145415	0.398244	0.23982	0.21652	0.138004

Table 6-11 Aggregate weights and the final ranking of the main digital leadership attributes and their corresponding sub-attributes

Major dimensions	Weights of major dimensions	Sub-dimensions	Weights of sub-dimensions	Global Weights	Rank
Inspirational Mindset (INSM)	0.10866699	INSM1	0.219870839	0.02389270	15
		INSM2	0.363814783	0.03953466	10
		INSM3	0.117971667	0.01281963	18
		INSM4	0.215639467	0.02343289	16
		INSM5	0.082703244	0.00898711	19
Innovation Mindset (INNM)	0.35205884	INNM1	0.386707129	0.13614366	2
		INNM2	0.109356056	0.03849977	11
		INNM3	0.400782034	0.14109886	1
		INNM4	0.103154781	0.03631655	13
Digital Business Mindset (DBM)	0.30486564	DBM1	0.246445683	0.07513282	4
		DBM2	0.228658063	0.06970999	5
		DBM3	0.143239166	0.0436687	9
		DBM4	0.202342508	0.06168728	6
		DBM5	0.120848313	0.03684250	12
		DBM6	0.058466266	0.01782436	17
Transformational Mindset (TM)	0.23440853	TM1	0.145415228	0.03408657	14
		TM2	0.398244318	0.093351866	3
		TM3	0.239820227	0.056215907	7
		TM4	0.216520227	0.050754189	8

6.3.3 Quantitative Analysis

This section outlines the data gathered from the survey concerning leadership that can support the data gathered from interviews as well. For the leadership variable, a set of questions was composed of three scale questions ranging from 1 (strongly disagree) to 5 (strongly agree) to capture the need for a digital leadership model and one drop-down question about who is currently leading the digital initiatives in the organisation to capture top-management's support for the organisation's digital transformation initiatives. The results of the analysis of these questions are in Table 6-12.

Table 6-12 Descriptive Statistics of the leadership variable

	N	Minimum	Maximum	Mean	Std. Deviation
Leaders act as a role model by facilitating the transformation to a digital-centric organisation. (1)	80	1	5	1.88	.862
Senior individuals in the organisation hold accountable for digital initiatives. (2)	80	1	5	1.93	.965
Senior managers outside IT department get involved in defining, designing and implementing digital initiatives. (3)	80	1	4	1.89	.811
Valid N (listwise)	80				

The values obtained indicate that the mean ranges between 1.88 and 1.93, while the standard deviation ranges between 0.811 and 0.965. The mean below 2 in all of the items gives an indication that most of the respondents indicate a poor leadership style existing in their manufacturing organisation and the failure of previous digital initiatives because of the lack of accountability as well as the vision of those leaders.

Moreover, the answer to the "Who is currently leading your organisation's digital initiatives?" question is quite interesting. As most of the respondents indicate, there is top-level management support for the digital initiatives implemented in the manufacturing firms, as in Figure 6-2.

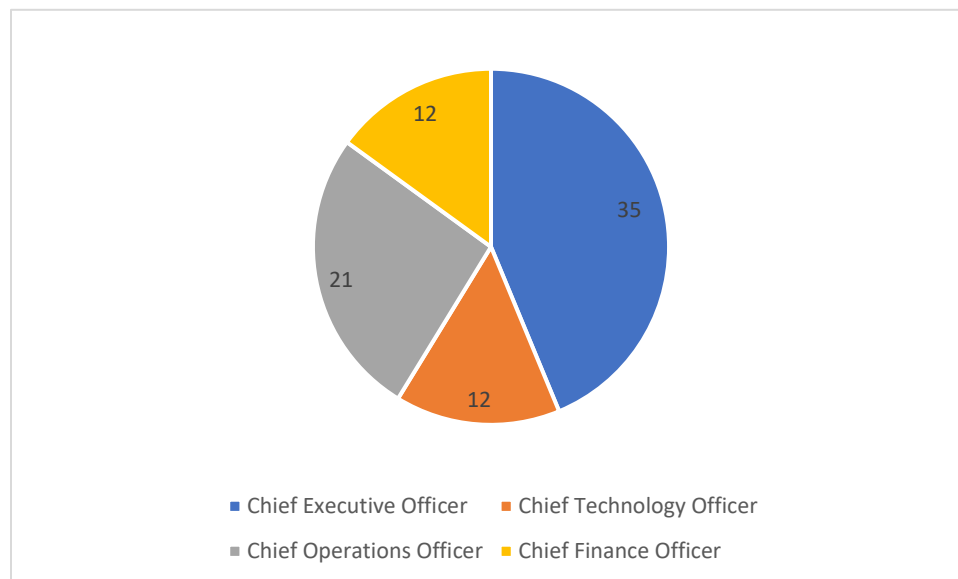


Figure 6-2 Executives responsible for digital initiatives in the organisation

According to the results, the organisation is led by the CEO (35), COO (21), and the same numbers have been reported for the CTO and CFO (12). This means that there is at least one responsible person at the top executive level, as this is very important, as indicated in Chapter 4 as well.

6.4 LEAD-19 Model: The top digital leadership attributes

The proposed model prioritises and categorises the digital leadership attributes according to the results obtained from the BWM and the interviews held. The final ranking of the model is shown in Figure 6-3. The following section describes the results in detail.

6.4.1 Ranking of the Main Attributes of LEAD-19

According to the results obtained from the application of the BWM, it is evident that the innovation mindset (INNM) is the most influential attribute for digital leadership characteristics for a successful implementation of digital transformation initiatives in the manufacturing industry in Egypt, with the highest global weight of 0.352259. This indicates that an innovation mindset's attributes are critical when thinking of a leader adopting digital change projects in the manufacturing industry. The following important main attribute for a digital leader is the "digital business mindset" (DBM), with a global weight of 0.304866. This reveals the important role that business strategy and digital competencies play in determining the success of digital transformation initiatives in the manufacturing firm. Based on the respondents' evaluations, the transformational mindset (TM) is the third most crucial attribute in driving successful leadership, with a global rank of 0.234409. Finally, the least significant attribute is the inspirational mindset (INSM), which has a global weight of 0.108667.

6.4.2 Ranking of the Sub-Attributes of LEAD-19

Two factors (INNM3 and INNM1) out of the top three factors are indicated in the innovation mindset, which is consistent with the ranking of the main dimension discussed before. Agile (INNM3), with a global weight of 0.14109886, is ranked first, which indicates the importance of this attribute as a driving attribute of the innovation mindset of a digital leader. As agility means responding quickly to change and responding promptly to emerging needs, special attention should be paid to this attribute as a major player in the mindset of digital leadership. This finding is consistent with earlier research (Bongiorno et al., 2017; Ibrahim et al., 2022; Oberer & Erkollar,

2018; Zupancic et al., 2017) that highlighted the same attribute as a major factor in the digital leadership mindset.

Another highly ranked factor that comes in second in the ranking and connects with the innovation mindset as well is the risk-taker attribute (INN1), with a global weight of 0.14109886. This reveals the understanding that digital transformation is a risky project that involves a lot of risky decisions that must be taken in the short run to reap its benefits in the long run. Again, this is consistent with previous literature (Alos-Simo et al., 2017; Khatri et al., 2022; Oberer & Erkollar, 2018).

Visionary (TM2), with a global weight of 0.093351866, comes third in the ranking of the most important digital leadership attributes when it comes time to implement digital transformation. Given the new digital competencies demonstrated in the last five years, this reflects the need for a digital vision in the medium and long term strategy of manufacturing organisations to reshape the business. This is consistent with earlier literature that emphasises the need to build a digital vision and culture among manufacturing organisations to successfully implement digital transformation (Bharadwaj et al., 2013a, 2013b; Gobble, 2018; Ismail et al., 2017).

However, the transformational mindset (TM) comes in third in the main attribute ranking, and the visionary mindset (TM2) has a high ranking compared to its main attributes. This indicates the importance of building a digital culture and strategy with a digital vision in the manufacturing organisation. Furthermore, the incorporation of Egypt Vision 2030, which emphasises digital transformation, draws special attention to this attribute among leaders in manufacturing organisations.

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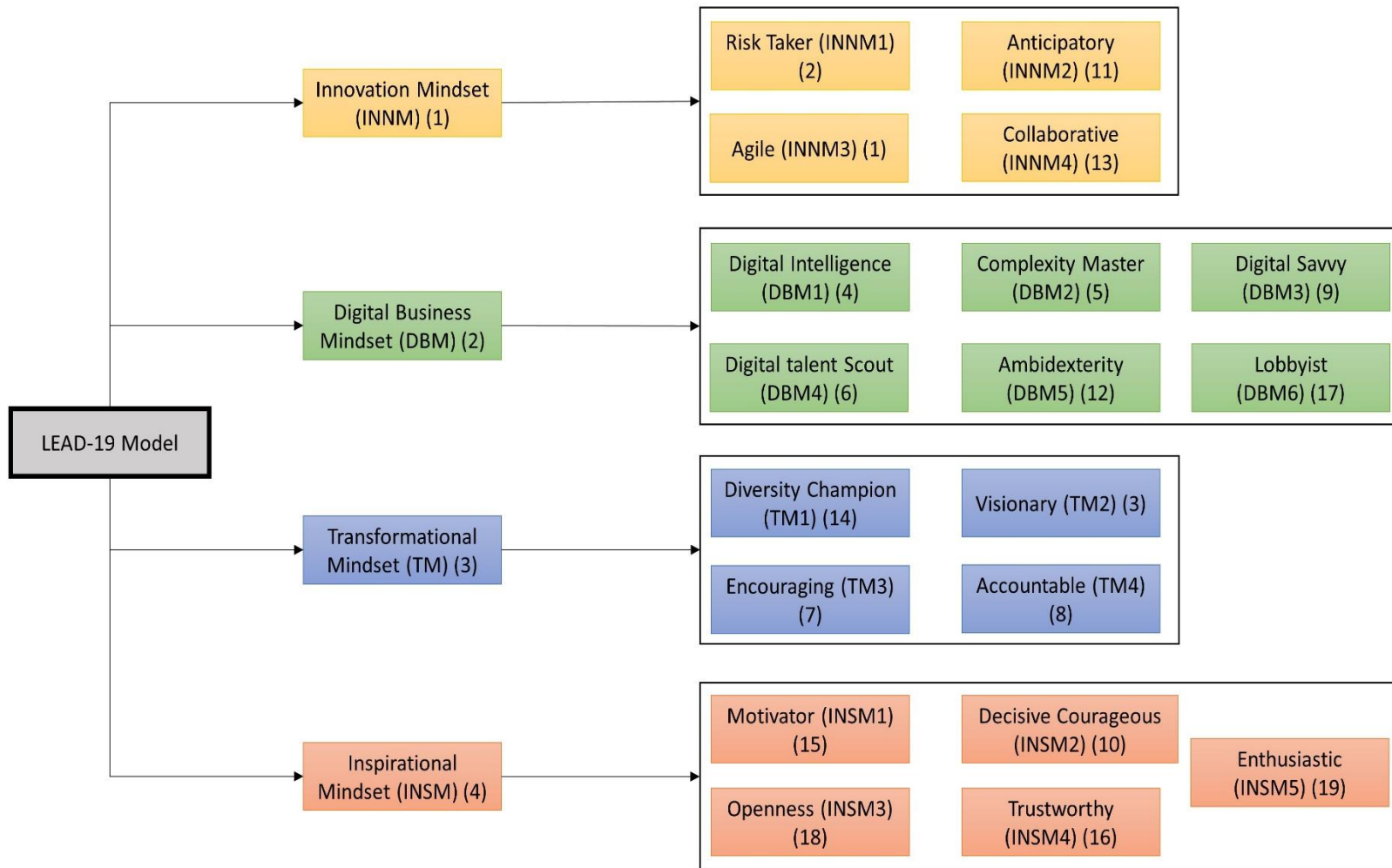


Figure 6-3 LEAD-19 Model

Digital intelligence (DBM1), complexity master (DBM2), and digital talent scout (DBM4) come in fourth, fifth, and sixth, respectively, with global weights of (0.075132821), (0.069709987), and (0.061687278), respectively. This is consistent with the main attributes ranking, as they all fall below the digital business mindset, which comes next after the innovation mindset. Leaders with a digital business mindset can prepare employees and workers to get ready for change and make sure that all of the complexities are handled professionally regarding major change projects like digital transformation projects (Allen, 2019; Caruso, 2018; Radovic-Markovic, 2008).

Moreover, the leader with the digital talent scout trait has the skills necessary to attract and retain employees with the appropriate digital skills needed to successfully implement digital transformation (Garca-Castilla & Vrseda-Sanz, 2016; Khatri et al., 2022; Kokolek et al., 2019). This trait is crucial in a developing economy like the Egyptian one because of the shortage of employees with these digital skills.

With global weights of (0.056215907) and (0.050754189), respectively, Encouraging (TM3) and Accountable (TM4) rank seventh and eighth. This reflects the need for a good rapport and informal relationships with the leader and their employees to keep them enthusiastic about the process and how digital transformation could shape their future jobs, not just take their jobs away (Dwivedi et al., 2022; James et al., 2022; Srivastava et al., 2022). Furthermore, accountability is critical in any medium- to long-term change project. As mentioned earlier, these types of projects come with higher risks, and digital leaders should hold them Accountable (Almeida et al., 2021; Arumugam et al., 2022; Purba, 2021).

It is worth noting that motivator (INSM1), trustworthiness (INSM4), openness (INSM3), and enthusiasm (INSM5) are among the lowest ranking attributes with a ranking of the fifteenth, sixteenth, eighteenth, and nineteenth, respectively, with global weights of (0.023892702), (0.023432892), (0.012819626), and (0.008987113). This is consistent with the experts' responses, which rank an inspirational mindset as the least important of the main attributes. This means that leaders in the manufacturing organisation in

Egypt pay less attention to personal attributes than to inter-relational attributes with other stakeholders, both internally and externally, given the bureaucratic nature of the Egyptian economic system. Decisive courage (INSM2) is the only attribute under this category that falls under the top ten sub-attributes and ranks tenth with a global weight of (0.039534657). This is consistent with the previous results of risk-taking and accountability traits. A risk taker must have the courage to take tough and sometimes harmful decisions in the short run to reap the benefits of digital transformation in the long run.

Also, it is worth noting that all of the main attributes are represented in the top ten sub-attributes with at least one sub-attribute. This indicates the relative importance of the main attributes and emphasises the importance of a digital leader possessing the majority of these characteristics in order to successfully implement digital transformation in their manufacturing organisation in Egypt or a similar developing economy, taking cultural and environmental differences into account.

6.5 Research Implications

6.5.1 Theoretical Implications

This study has several important implications for the literature on digital leadership and its role in shaping the digital transformation. First, this study proposes a model that shapes the most significant attributes of digital leadership discussed in the literature and prioritises them according to their relative importance, with a focus on the manufacturing sector. According to the literature, most earlier studies did not consider the entire range of factors. They have focused on more generic personality traits. Second, to the best of the authors' knowledge, this study is among the first to use multi-criteria decision-making (MCDM), particularly the Best-Worst Method (BWM), in the field of digital leadership and how this can foster digital transformation. As most of the literature uses survey results, the BWM provides more consistent and reliable results as it comes from purposive sampling, which is conducted by people who have the experience necessary to take part in this research and eliminates the risk of respondents being vague. Finally,

most of the studies focusing on digital leadership in the manufacturing industry come from developed economies with advanced technology applications. Very few studies focus on developing economies and the challenges they face with many cultural and environmental changes compared to developed countries.

6.5.2 Practical Implications

Apart from the theoretical implications mentioned above, this research has several practical implications. First, this research gives senior managers and top leaders in manufacturing organisations a specific model with clearly identified attributes categorised into four main attributes. It clarifies the most important attributes to focus on and develop their leadership skills based on. Second, this study gives the owners of these manufacturing organisations, especially in developing countries, a model that can be used in capacity building programs and training workshops to enhance their top management's performance regarding implementing digital transformation. Finally, this model will enhance owners' and top management's awareness of digital leadership attributes and the importance of fostering digital transformation in their operations as a necessary step to still compete in this changing world.

6.6 Data Reliability and Validity

Based on the preferences provided by the consulted experts for each step, as provided in Tables 6–6, further calculations were done to ascertain the weights for the various factors. A Ksi* value (CR) of 0.147754 was determined, close to zero. According to Rezaei (2015), in the BWM, the closer the CR is to zero, the more consistent the experts' comparisons. That makes the data statistically reliable, and the weighted attributes and sub-attributes are accurately prioritised according to the methods adopted in the interview. Other steps are taken to ensure the data is valid and will be thoroughly discussed in the data validation chapter.

6.7 Chapter Summary

This chapter aims to identify the key digital leadership attributes that can foster successful digital transformation implementation in the manufacturing industry in a developing economy like the Egyptian economy. An extensive literature analysis was undertaken to specify the most frequently mentioned attributes and sub-attributes in previous studies to achieve this aim. Next, these factors were refined based on participants' opinions, yielding a total of 4 main attributes and 19 sub-attributes. After that, the BWM was applied using inputs from twenty participants to rank and prioritise the main dimensions and their relevant factors.

The results indicated that innovation mindset is the most important attribute for becoming a successful digital leader, followed by digital business mindset, then transformational mindset, and finally inspirational mindset. Moreover, the BWM ranks and categorises the sub-attributes, identifying the top 10 sub-attributes that need closer attention in developing digital leadership skills. These are: agile, risk-taking, visionary, digital intelligence, complexity mastery, digital talent scouting, encouraging, accountability, digital savvy, and decisive courage.

Overall, this study brings new knowledge to the literature of digital leadership in developing countries by highlighting the significant attributes that a digital leader should possess to foster digital transformation operations in the manufacturing industry.

7 Validation of the Developed Digital Transformation Framework

7.1 Introduction

The research findings based on data analysis from both qualitative and quantitative methods are presented in Chapters 4,5, and 6. Twenty one interviews were analysed, and 80 respondents from the survey results were collected and analysed. As discussed in earlier chapters, a DT process with detailed steps was discussed to ensure the successful implementation of DT in the manufacturing industry in a developing economy like the Egyptian ecosystem. Secondly, a readiness assessment model was developed to assess the degree of readiness of the manufacturing firms to begin their DT journey, and a tool was formulated to support this model. Finally, the results discussed the major digital leadership attributes and their prioritisation of them to ensure the support of senior management in a distributed change process like digital transformation.

This chapter discusses the procedures and measures adopted to ensure the quality and rigour of this research's findings as mixed research and the usefulness of the developed findings, as shown in Figure 7-1. This is done by discussing some of the well-known strategies that confer rigour on qualitative analysis and how they are adopted in this research. These strategies are purposive sampling, multiple coding, triangulation, expert validation, and case studies (Barbour, 2001).

The rest of this chapter is organised as follows: after this brief introduction, the basics of each of the technical strategies will be discussed in a separate section, where Section 7.2 explains Expert Validation. Finally, 7.3 presents the case studies conducted to validate the DT readiness assessment model/tool. Also, an explanation of how these strategies were used, particularly in this research, is given. Due to its relative importance, experts' validation and case studies have been given particular emphasis in this research. There will be a discussion of the validation sessions held with different experts, consultants, advisors, project managers, and academics.

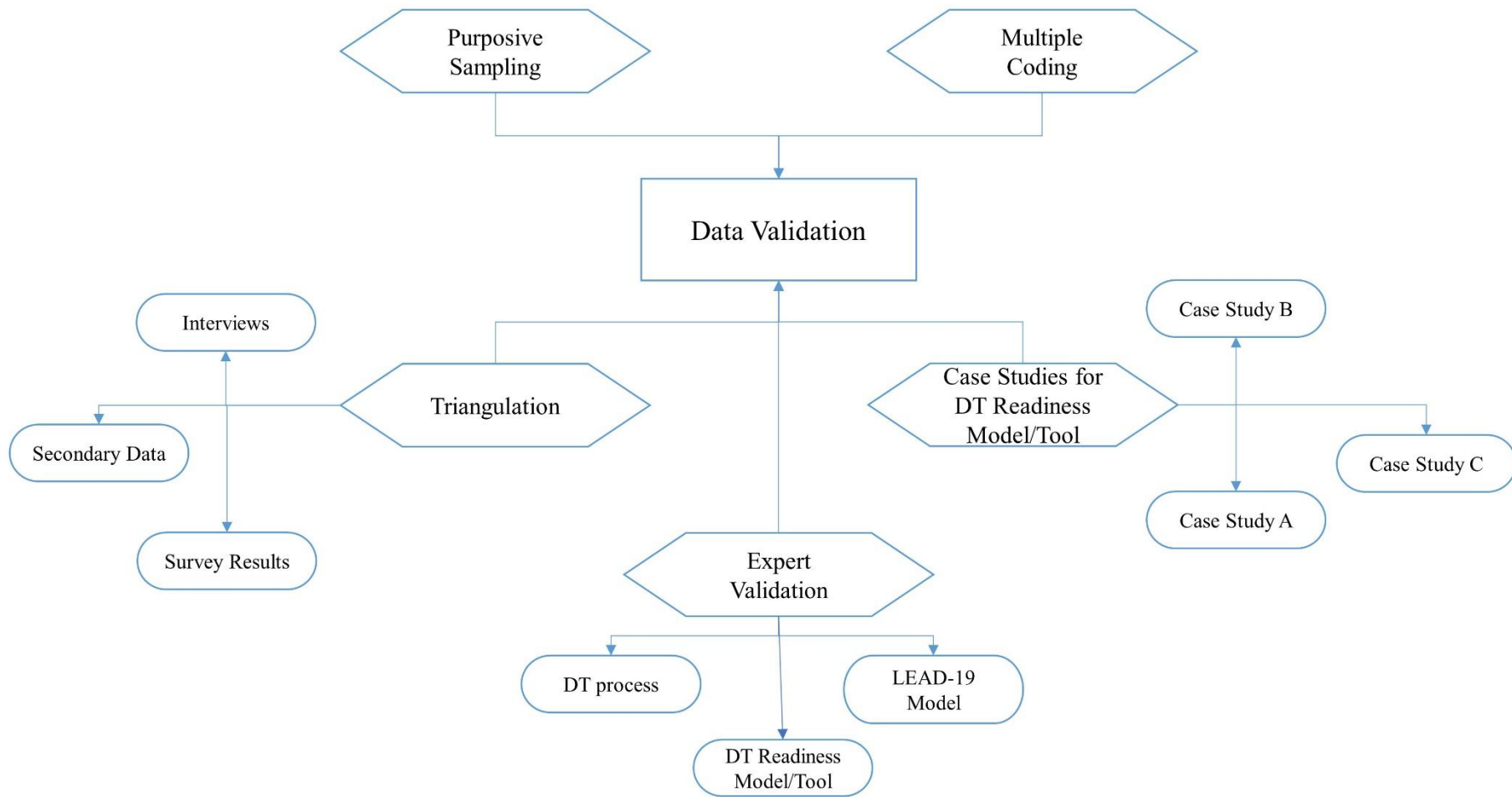


Figure 7-1 Research Framework Validation

7.2 Expert validation

Expert validation is the first strategy utilised to validate the findings of this study. Expert validation guarantees reliability. Checking the results at the completion of data collection or of the entire study with experts would satisfy the validity standards (Long and Johnson, 2000). Using this methodology, the researcher double-checked the research findings with manufacturing industry experts, as well as other consultations and senior legislative leaders, whose reactions helped refine explanations—as did key informants. The researcher did not invalidate his own interpretations in favour of respondent interpretations. However, their perspectives were treated as additional interpretations and suggestions for enhancing the findings' explanations.

It is important to emphasise that the obtained data does not consist primarily of interviews. Significant components of raw data consist of field notes, observation of non-verbal indications, recognition of unconscious shifts in tone and emphasis, as well as documents collected from numerous informants, some of which were not obtained directly from interviewees. Therefore, there was no hesitation to revisit some of the same interviewers, but this time to check the data analysis's conclusions. This is supported by research that defines respondent validation as confirming the accuracy of the findings with members of the investigated group (Long and Johnson, 2000). This is backed by experts who did not participate in the data collection as well.

The expert validation process was conducted once this research's findings were developed. As soon as the data analysis and formulation of the findings were complete, the researcher attempted to contact the respondents in order to avoid issues of lack of access or modification of the respondents' circumstances and perspectives.

Ten interviews were conducted for validation purposes in total. It should be emphasised that all of these interviews were performed online, as the researcher was unable to return to Egypt to conduct them in person. Table 7-1 shows all interviewees who participated in the validation process, as well as their positions, companies, industries, and total years of work experience.

Table 7-1 Expert involved in the Data Validation Process

No.	Organisation Manufacturing Sector	Role	Years of Experience
E1	Home Appliances	Production Planning Manager	15 Years
E2	Food Processing	Production Line Supervisor	9 Years
E3	Food Processing	Plant Manager	15 Years
E4	Home Appliances	Quality Control Director	10 Years
E5	Furniture	Product Design and Innovation Manager	11 Years
E6	Industrial Modernisation Centre (Governmental Support Organisation)	Director of the Centre	10 Years
E7	The Senate House (Legislation Body)	Senator	4 Years
E8	Manufacturing Consultancy Organisation	Senior Digital Consultant	8 Years
E9	Pharmaceuticals	Plant Manager	12 Years
E10	Textiles	Production Line Manager	9 Years

As mentioned in Table 7-1, there is a diverse range of experts that have been involved in the validation process, as five manufacturing sectors were presented in this process to ensure the generalisability of the findings to the whole manufacturing industry. Another aspect was the governmental aspect represented by the Manufacturing Modernization Centre (IMC) in the Ministry of Industry, Egypt, which is responsible for providing consultation and logistics services and helping manufacturing organisations, especially small and medium enterprises, rely on advanced and digital technologies. where the feedback from the director of the center was important to capture the reality of the digital infrastructure in the Egyptian economy. Another piece of feedback was

gathered from one of the senators in the senate house who is a member of the senate house's industrial committee to capture the legislative viewpoint of the findings and if there are any supportive laws and regulations for DT in Egypt's industrial economy and how the findings can shape the bottom line for these laws.

Two independent types of validations—qualitative and quantitative—were conducted to assess the veracity and applicability of the acquired results. These two methods of validation have been used in numerous past research settings (e.g., Almutairi et al., 2019; Elnadi & Shehab, 2016, 2021; Vinodh & Chintha, 2011).

Each interviewee received a package three days ahead of their respective interviews. This package comprised all validation-related information, including the DT Process, readiness assessment models, the digital leadership model, case studies, and overall findings. The goal of distributing this package before each interview was to provide interviewees with sufficient time to evaluate all pertinent information so they could provide their feedback and evaluation. Another objective was to save time during the interviews by quickly discussing the participants' perspectives. At the beginning of each interview session, the researcher provided a brief introduction to the research context, the subject to be validated, and the session's objectives.

As stated previously, several of the respondents for the validation procedure were also interviewed for the initial data collection for this study. The remaining validation interviewees were identified using the snowball technique. For instance, some of them were initially nominated by key informants, and after each interview session, the researcher asked the interviewees to propose individuals who they believed would have the time and experience to engage in the process.

Regarding the qualitative validation, online meetings with the experts named in Table 7-1 were held. The results of this study were presented to each participant throughout the discussion. Each participant was asked to provide input on the following:

- The extent to which the DT process is comprehensive and encompasses all the steps influencing the successful implementation of DT in the Egyptian manufacturing organisation.
- any missing step in the DT process or in the readiness assessment model that must be added to or excluded from them,
- The extent to which the calculated ranking and relative importance of the attributes and sub-attributes of the LEADE-19 proposed model reflect reality and are relevant to promote DT implementation in the manufacturing industry in developing economies like Egypt.

Participants indicated that the processes in the DT process presented in Chapter 4 of this study are exhaustive and account for all factors influencing DT implementation in Egypt. In addition, the majority of practitioners were pleased with the level of detail collected by the readiness assessment model and instrument described in this study's fifth chapter. In addition, all participants concurred with the ranking and relative relevance of the principal qualities and sub-attributes described in Chapter 6 of this study.

After the group discussion, the 10 experts were asked to complete a validation questionnaire independently. The validation questionnaire consists of three sections, each composed of four questions: In each question, experts were asked to choose from a Likert scale ranging from 0 to 10. The responses of the experts are presented in Table 7-2. The analysis of the experts' responses revealed that they all agreed on the results obtained with an average mean greater than 8.

Case studies were used to add another layer of validation to the readiness assessment model and tool, as discussed in the following section.

Table 7-2 Respondents of Experts Validation

1- DT Process Validation Items	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Mean
To what extent do you believe that the DT process is comprehensive and covers all the steps impacting the successful implementation of DT in the manufacturing industry?	9	8	8	7	8	8	9	8	8	8	8.1
To what extent do you believe that the calculated ranking (the relative importance) of the main steps reflects the reality of digital transformation implementation in the manufacturing industry in Egypt?	10	9	9	8	9	9	8	9	8	9	8.8
To what extent do you believe the proposed process provides useful guidelines to manufacturing organisations wishing to implement DT in their operations?	8	9	10	8	7	7	9	6	8	8	8
To what extent do you believe that the proposed DT process and its steps can be generalised to the manufacturing industry's different sectors?	9	8	9	9	9	8	7	8	8	7	8.2
2- Readiness Assessment Model Validation Items	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Mean
To what extent do you believe that the proposed assessment model is comprehensive and covers all the competencies impacting the successful implementation of DT in the manufacturing industry?	10	9	10	6	7	6	8	8	10	9	8.3
To what extent do you believe that the proposed 9-level model reflects the reality of digital transformation implementation in the manufacturing industry in Egypt?	9	8	9	8	9	8	7	7	9	8	8.2
To what extent do you believe the proposed assessment tool provides useful	10	9	10	7	7	9	8	9	10	10	8.9

guidelines to manufacturing organisations wishing to implement DT in their operations?											
To what extent do you believe that the proposed assessment model/tool and its steps can be generalised to the manufacturing industry's different sectors?	9	10	9	8	9	6	7	7	8	7	8
3- LEAD-19 Model Validation Items	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Mean
To what extent do you believe that the LEAD-19 model is comprehensive and covers all the digital leadership attributes impacting the successful implementation of DT in the manufacturing industry?	6	9	8	8	7	8	9	8	10	9	8.2
To what extent do you believe that the calculated ranking (the relative importance) of the main attributes and sub-attributes of the LEAD-19 model reflects the reality of digital transformation implementation in the manufacturing industry in Egypt?	9	10	8	6	9	7	8	8	8	8	8.1
To what extent do you believe the proposed LEAD-19 model provides useful guidelines to manufacturing organisations wishing to implement DT in their operations?	8	8	8	9	9	9	8	6	9	9	8.3
To what extent do you believe that the proposed LEAD-19 model and its attributes can be generalised to the manufacturing industry's different sectors?	9	9	9	8	9	7	7	8	10	8	8.4

7.3 Case Studies

In this section, three case studies are highlighted using the model. After gaining a general insight from the collected data, these case studies were chosen because of their importance for the economy. This was of great interest to these organisations, as they viewed digital transformation as a crucial step in the emerging economic context, especially in relation to how the COVID-19 pandemic has affected their manufacturing processes. The case studies were chosen from various manufacturing sectors to ensure generalisation and application of the model, as well as to enrich the diversity of the proposed model in order to truly assess Egypt's digital readiness to successfully implement digital transformation.

7.3.1 Case Study A: Home Appliances Company

The first case study is a manufacturing company in the home appliances business that has been in operation for more than 15 years and has three manufacturing locations all over Egypt. The survey was completed by the plant manager, who has been in the factory for 10+ years and has more than 20 years of experience in manufacturing operations.

The survey was conducted using a face-to-face approach to ensure that every item was understandable in its manner and to gain insights into the industry in relation to the model. The survey took about one hour to complete; the score for this company is explained in this section and shown in Figure 7-2.

As highlighted in the Figure, the organisation focuses more on technology capabilities, with a minor focus on management and strategy aspects. The score for the overall business competencies is 2.46; this was calculated by determining the score for the business competencies criteria. These criteria are strategy (2.57), innovation management (2.50), organisational culture (2.25), and leadership (2.50).

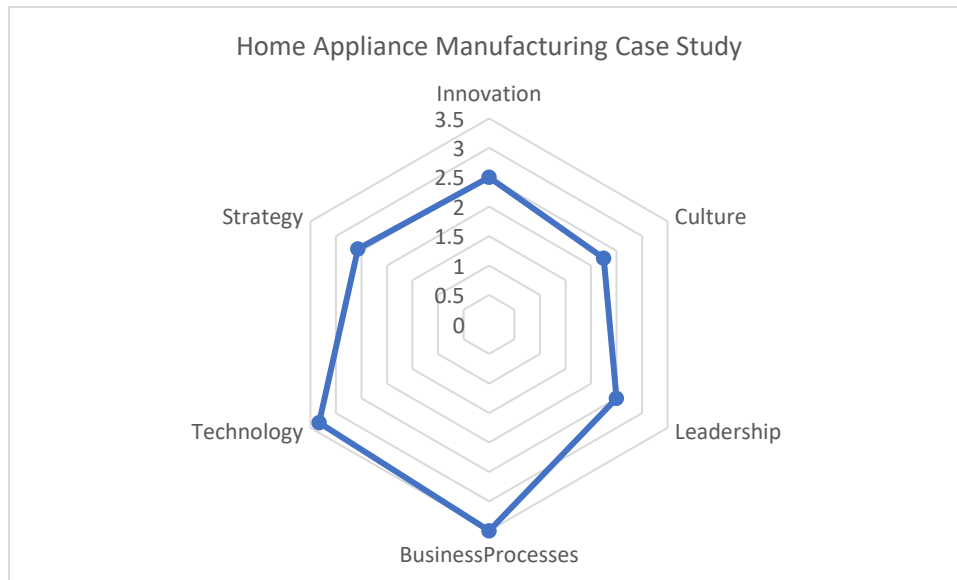


Figure 7-2 Home Appliance Manufacturing Case Study Score

The scores show that the manufacturing organisation is at the medium level of business competencies that should exist to implement DT successfully. Senior leadership support for digital initiatives exists, but not in enough capacity. Moreover, the organisation faces resistance to change, which affects organisational behaviour in the transformation process. The strategy and innovation pillars are still at the medium level.

The score for the overall technological competencies is 3.42; this was calculated by determining the score for the criteria of the technological competencies. These criteria are digital business processes (3.50) and digital technologies adopted (3.33). This score shows that the technology used in manufacturing operations is good, considering the organisation's size and business capital. The digital technologies employed are of a medium level. The organisation uses advanced ERP software with some automated production processes, but many operations are still handled manually.

From this brief analysis, it can be stated that this organisation is at the middle digitalisation level. The organisation has moderate technological capabilities and moderate management support in line with the size of its operations. According to their investment and working capital, the next steps to be taken are investing in capacity building via training programs and professional development initiatives that support the

DT processes to move from the middle digitalisation level to the technology-focused transformation level.

7.3.2 Case Study B: Food Processing Company

The second case study is a food processing manufacturing company that has been in business for 20+ years with millions of dollars in working capital and a variety of product lines; this scope allows the company to have different manufacturing plants all over Egypt. The survey was completed by the Chief Operations Officer for the holding company as a whole; this executive has 20+ years of experience in production and operations management. The survey was conducted face to face and took about an hour.

The score for this company is shown in Figure 7-3. The Business Competencies dimension score is 1.68, and it was calculated from the following sub-dimensions: strategy (1.71), innovation management (1.25), organisational culture (2.00), and leadership (1.75). The results show poor management practices in terms of innovation and encouraging transformational processes. The resistance to change in this manufacturing company is so great that the current strategy cannot deal with it.

The Technological Competencies dimension score is 4.33, which was calculated using the Business Process (4.17) and Digital Technologies Adopted (4.50) criteria. Like most food processing manufacturing organisations, this manufacturing company uses extensive automation processes for quality control and hygiene. The level of technology in this manufacturing operation is high, with advanced robotics and extensive uses of IoT technology. In addition, the ERP system in the organisation is advanced and uses cloud services to integrate with suppliers in real-time.

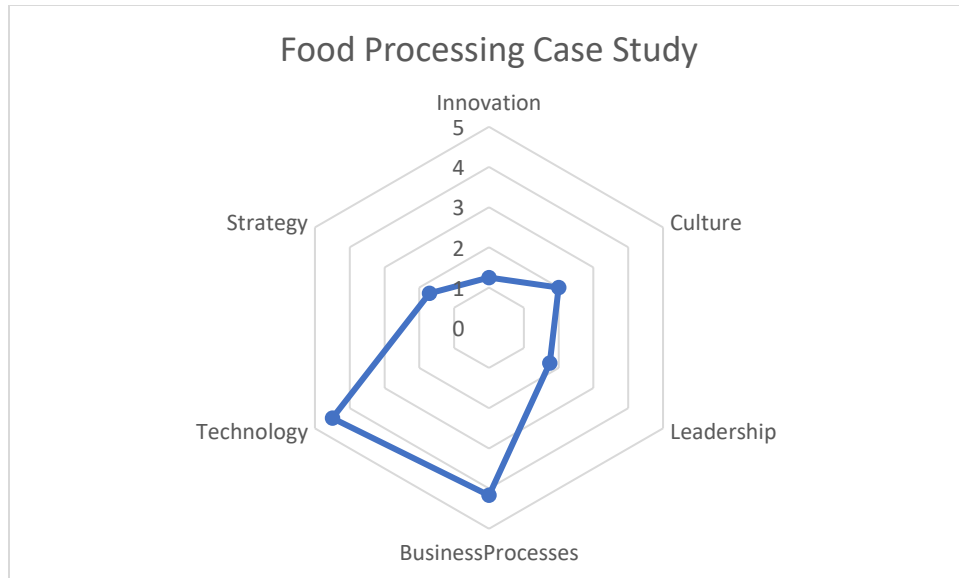


Figure 7-3 Food Processing Manufacturing Case Study Score

Summing up the score, this organisation is at the technology adopter level. As the literature has shown, most big corporations with extensive capital focus only on technology and neglect business processes and the organisational culture that supports adopting these technologies. For this organisation to proceed in the DT journey, it needs to focus extensively on changing its organisational vision to become more digital and making the organisational culture more agile to change by advocating and encouraging change initiatives and receiving strong support from senior leadership in this regard. As shown in the previous case, capacity building and training programs are crucial at this stage. To advance one more level in the readiness model for business-focused transformation, more advanced business practices and more agile strategic management will be needed.

7.3.3 Case Study C: Pharmaceuticals Company

The third case study involved a significant pharmaceutical manufacturing company. The company has already existed in the Egyptian economy for more than five years and has global accreditation for most of its products. This industry has become of major importance in any economy, especially after the COVID-19 pandemic. The company has been investing millions of dollars in its manufacturing processes in the past 18 months to produce one of the COVID-19-authorized vaccines, which will be

disseminated all over the world. The survey was completed by the Quality and Inspection Manager at one of the organisation's plants. The survey was conducted face to face, and the researcher sought to uphold the confidentiality of the organisation's manufacturing processes, especially in this critical moment of their operations.

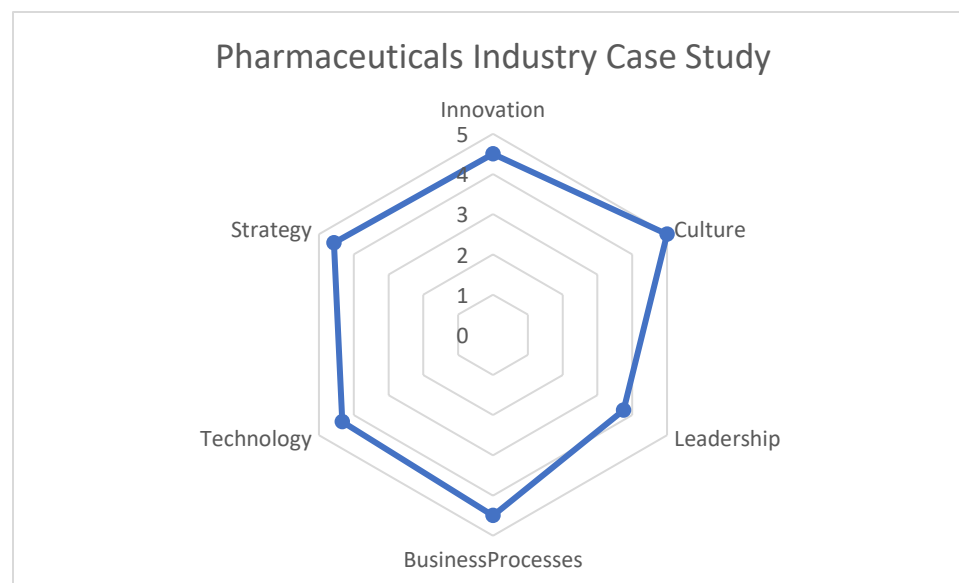


Figure 7-4 Pharmaceuticals Industry Case Study Score

The score is highlighted in Figure 7-4. The Business Competencies score is 4.21, which was calculated from the sub-dimensions of strategy (4.57), innovation management (4.5), organisational culture (4.00), and leadership (3.75). The organisation is already in one of the most transformational periods of its operations—expanding its manufacturing processes. This is being done with significant support from senior leadership to encourage innovation and the adoption of digital technologies, which are necessary in the industry to ensure quality. The organisation adopts an agile manufacturing strategy that allows for flexible adaptation to the dynamic changes in organisational processes. The organisation invests a lot in training programs, especially in digital leadership and change management practices for senior leadership.

The score for technological competencies is 4.42, which was calculated from the sub-dimensions of digital business processes (4.5) and digital technologies adopted (4.33).

The technology used in manufacturing organisations is advanced, with many robots and artificial intelligence systems in place.

The overall level of this manufacturing company is Digital Hero. The organisation is at the most advanced level of the suggested model. The organisation has both the business and technological capabilities to pursue the DT process. As mentioned above, DT is a continuous process that requires ongoing efforts to adopt new technologies and innovate new strategies to cope with technological advancements. Any organisation at the top level, like in this case study, that stops making any efforts in the transformation journey will eventually fail and shift backwards to a lower readiness level.

7.3.4 Results Affirmation

After calculating the business/technology integration score and identifying areas for improvement for each of the three organisations, a presentation was given to the experts who participated in the evaluation process for each business. The purpose of this presentation was to analyse each firm's computed score and areas for improvement, as well as examine if the results accurately reflect the situation in each organisation.

In each company's group discussion, the five experts were asked whether:

1. The calculated score represents reality.
2. The improvement areas represent the company's current position.
3. Were there any missing components or components that should be excluded?

The experts asserted that the score computed for their company reflects the current digital transformation practices in their company. Also, there was an agreement among them on the improvement areas identified for each company. Finally, they did not suggest any modifications to the model and mentioned that the model is comprehensive and covers all the required elements.

For example, the **plant manager of company (A)** mentioned:

"I am quite pleased with how we undertake projects for digital transformation. There is always room for improvement, but I believe we performed quite well. Identifying the gap between the current level of digital transformation and the next stages is one of the tool's most attractive features. The instrument can indicate areas for improvement. "We will look for ways to improve."

Also, the **Chief Operating Officer of Company B** said:

"I am proud. The tool is relatively straightforward, comprehensive, and quick to implement. All of the recommendations and suggestions are acceptable. Our strengths and weaknesses are now much more apparent. Our performance in several areas was below expectations, but it will improve. The index demonstrates that we are on the correct path."

Finally, the **Quality and Inspection Manager of Company (C)** stated:

"This tool is quite helpful. It allows us to evaluate our performance in various areas. The instrument is useful for locating and diagnosing problems. It has the benefit of analysing our performance in each domain by slicing difficulties into manageable pieces. "We now have a comprehensive understanding of what is occurring and how to effect change. "

7.4 Chapter Summary

In this chapter, the researcher explained what has been done to ensure the quality and rigor of this research's findings as mixed research and the usefulness of the developed findings. This was done first by discussing the strategies and measures adopted to conduct such validation and explaining what their output was. The validation strategies used in this research are purposive sampling, multiple coding, triangulation of data sources, respondent validation, and case study applications.

Concerning the respondent validation strategy, an explanation of its process was given in addition to the details of the validation sessions and interviews. These sessions aimed to validate the DT process steps and their prioritisation, the digital leadership attributes and their positioning, and finally, the overall findings.

Regarding the case study application, a selection of three case studies was adopted to validate the DT readiness assessment model from various manufacturing sectors. Finally, the approval of the results of this application was discussed.

8 DISCUSSION AND CONCLUSIONS

8.1 Introduction

This chapter provides an overview of the research findings and their implications for the digital transformation process in the manufacturing industry. It discusses both the theoretical and practical implications of the research, detailing how the findings can be used to influence digital transformation processes in manufacturing organisations. This section also discusses how the research process helped fulfil the specific objectives that the researcher sought to attain. It concludes by summarising the key points and with a discussion of what future research studies should focus on, recommending areas that researchers should further examine to expand this area and contribute to its advancement.

8.2 Discussion of the Study Key Findings

A discussion of the key findings of the research is presented in this section in the same order as the results presented in previous chapters.

8.2.1 The Literature Review Process

As discussed in chapter 2, the literature review focused on a variety of issues surrounding the DT process, such as finding a working definition of digital transformation as it applies to the manufacturing industry as in section 2.3. In addition, the literature review section also explored past studies on factors related to digital transformation, especially with regard to the elements of DT that contribute to its successful adoption and implementation. In order to develop a concept of how the DT process may be undertaken to help organisations, it examined the results of earlier research projects and the opinions of other authors on the subject.

After a thorough review of existing literature in this area, it was determined that the definition of "digital transformation" has changed over time. In the 1970s and 1980s, it used to refer to the employment of computing technologies in companies to enhance

production processes. In the 1970s and 1980s, it used to refer to the employment of computing technologies in companies to enhance production processes. It now has a new definition that is more general. Furthermore, research demonstrates that this term has undergone a number of stages in its development, which include going from the point where the term used was "digitalisation" to "digitalisation," and finally to the current stage where the term "digital transformation" is being used. These concepts were examined and extensively described to help come up with a comprehensive understanding and definition of the DT process in the manufacturing industry.

The literature review revealed that there are different ways of defining the DT process. While some researchers view this as a process, others believe it is a strategy or a disruptive process. The study found that these definitions have shed light on what the DT process is, and thus the existing literature offers a deep understanding of the concept. After reviewing these varied definitions, a conceptual definition of the digital transformation process as it relates to the manufacturing industry was developed. Based on the literature reviewed, the adopted definition consists of various elements that consider the customer, continuity, digital technologies, and organisations.

Through the literature review process, it was determined that many scholars have also identified and discussed the challenges facing the digital transformation process. These challenges are summarised in section 2.4 and affect both small and large companies, but their impacts may vary from one industry to the next. The main challenges identified by most studies include the skills gap, difficulties in adopting new technology, problems with change management, and companies' innovation policies.

The literature review process also focused on the enabling technologies for DT as in section 2.7. It was determined that many studies have explored this aspect and identified several technologies that lead to DT in various industries. These include the latest technologies such as AI, IoT, cloud computing, the digital twin, robotics, and ERP systems. Many studies in this area have explored how these technologies drive the digital transformation process and some of the skills and capabilities that organisations must possess to make effective use of them.

The study also focused on the benefits of the digital transformation process in the manufacturing sector, coming up with different findings from various studies on the effects of DT in various industries as seen in section 2.5. The reviewed literature revealed that the DT process has significant impacts on internal and external business processes, leading to several benefits for companies that implement digital technologies to transform their business processes. Some of the identified positive outcomes include enhanced productive operations, competitive advantage, profitability, and innovativeness. Others include a unique focus on customers and the continued growth of businesses.

Moreover, the researchers also reviewed literature focusing on digital transformation and the manufacturing ecosystem. The existing studies in this area revealed that the manufacturing sector is one of the most complex ecosystems due to its production and supply chain activities (Abdallah et al. 2021a). This complexity comes from the nature of adopting complicated digital technologies, not only in their productions processes, but also when integrating with different supply chain partners and providers (Agrawal et al. 2018). Digital technologies enhance communication between these networks, making it easy for the entire ecosystem to operate and communicate in real time. Most studies in this area have identified how different firms use various technologies, such as the digital twin and robotics, to enhance their manufacturing activities. Others have also focused on transformative processes enabled by tools such as customer relationship management (CRM) to enhance communication. Most studies agree that new digital tools have enabled the manufacturing sector to connect to both local and external markets, which shows how the new communication tools benefit this sector.

The literature review section also explored the importance of digital leadership in the DT process. Most studies in this area have tried to come up with a definition of "digital leadership," trying to differentiate between "leadership in the digital age" and "digital leadership." Various definitions of these aspects were reviewed and noted in the literature review section. Most of the studies in this area have determined that these two styles of leadership can assist businesses from many industries in embracing digital tools and connecting with their clients and other stakeholders. All business executives

must possess the kind of leadership necessary to guarantee the effective adoption of digital technology in their organisations in today's evolving digital world.

Scholars in this area also believe that there will be a need for new digital leadership skills to deal with the challenges brought about by new digital technologies, such as adopting artificial intelligence in the production operations, or incorporating advanced robotics system in the manufacturing system. Since the workplace environment is also undergoing a series of transformations, digital leaders will play a significant role in helping guide employees and making the workplace more flexible for the current crop of workers. Some scholars believe that leaders in the digital age require different leadership styles to enable the DT process to take place. They believe that transactional, empowering, and transformational leadership styles can be equally important for digital leadership. Given that digital leaders need to possess unique talents and characteristics, a variety of ideas and concepts have been used to explain this style of leadership. There have been numerous descriptions of digital leadership that focus on traits like innovation, vision, critical thinking, and inquisitiveness.

The literature review also examined the existing digital transformation readiness models, which led to the identification of various frameworks like the Five Digital Business Aptitude Domains, McKinsey's Framework, Deloitte's Digital Maturity Model, Pacchini's Industry 4.0 Model, and the Digital Readiness Assessment Maturity Model. Others included the UMPULS Maturity Model, the Smart Manufacturing Maturity Models for SMEs, and the System Integration Maturity Model for Industry 4.0. It was determined that, despite the recent surge in academic interest in this field of study, there are currently no effective and comprehensive assessment tools available to gauge how prepared manufacturing organisations are for the digital transition. Additionally, some of the current models addressed in the literature consider DT as a whole, although most of them only concentrate on industry 4.0 practices.

The literature review process then concluded with the identification of various research gaps as per its findings. It was determined that there are areas that have still not been effectively examined by researchers. There is a need to focus on how manufacturing

firms can assess their DT readiness, the connection between technology and business aspects that can help businesses realise a successful DT process, as well as the development of new roadmaps for the DT process in the manufacturing industry. On the basis of these concerns, it may be argued that there are not enough frameworks for guidance and evaluation to guarantee the correct adoption of digital transformation technologies in the manufacturing sector. Future research should fill this vacuum by investigating this topic and developing useful roadmaps, plans, and strategies to enable digital transformation in this industry, which is what this study sought to do.

8.2.2 The Research Methodology

As discussed in Chapter 3, the research methodology adopted was primarily a mixed method of qualitative and quantitative techniques, given the complex nature of the phenomenon studied and its relative newness in developing economies. The data collection phase consists of conducting interviews and surveys to collect the views of industry experts and the experiences of different firms with regard to implementing digital tools to improve their businesses. In addition, the author used observation, the companies' documentation, and secondary reports. The information captured from different sources was triangulated to minimize bias. The findings of these exercises revealed that for a digital transformation process to take place, companies must follow the right procedures and processes.

Moreover, the author triangulated the data collected by employing semi-structured and structured interviews with different experts from different organisations. In addition, the questionnaires used in this research have always been piloted by a subject expert to ensure their quality and applicability. After collecting and analysing the required data from different sources, the key findings were summarised and presented to the participants in order to reduce the researcher's bias.

8.2.3 DT Processes in the Manufacturing Sector and the Proposed Process Model for DT Implementation

As described in chapter 4, after interviewing various experts derived from Egypt's manufacturing industry, eight (8) steps were identified as critical in the digital adoption and implementation process. These steps were used to propose a model for guiding DT implementation processes. By following these eight steps, the decision-maker can gain a comprehensive understanding of the DT procedures required for the organisation to move forward in the DT journey. As has been noted throughout this study, this process must be ongoing and updated frequently to keep up with the development of digital technologies and the change in clients' needs and preferences.

The first thing to consider is that organisations must invest in the right technologies to ensure an effective digital transformation process. The study found that the effectiveness of any DT process depends on how well these technologies are understood and how the manufacturing organisation can implement them in their regular operations. Artificial intelligence (AI), the Internet of Things (IoT), big data analytics, robotics, and numerous other tools are examples of these digital technologies. When an organisation invests in the technologies that are most suited to its structure and size, it will be able to use them to maximize return on investment in the shortest amount of time. This procedure will vary depending on the type of manufacturing involved and a variety of other criteria, including the organisation's people and financial resources. It is crucial to stress the importance of investing in technologies that are appropriate for the organisation rather than the finest ones currently on the market, as the best ones might not be appropriate for the organisation.

Secondly, organisations must train their employees to equip them with the right skills and knowledge for digital transformation. The lack of technical or intellectual abilities required to handle this change is one of the key problems with DT (Butt 2020b). This is a result of both the workforce demographics in some economies and the absence of training programs offered by an organisation to its personnel. The development of technical abilities to deal with the evolution of digital technologies requires investment

and doing so is essential for the DT process to be successful. In the DT process, intellectual and interpersonal abilities are just as crucial as technical skills. Investing in training programs in innovation management or managing change is crucial to assisting managers in understanding how their people react to change and learning how to deal with and overcome resistance to change.

The third step is to have a flexible and Adaptable budget for the digital transformation process. One of the primary factors a decision-maker should take into account while establishing a DT strategy is financial capability. It is crucial to create a budget that works for the manufacturing organisation in order to accomplish its DT objectives. This will also define how much the organisation should invest in the evolution of digital technologies. A number of things need to be taken into account when creating a budget for DT, including the cost-benefit analysis, estimated return on investment, and project payback duration. To keep up with the advancement of digital technologies, every industrial organisation should set aside a specific portion of its profits each year for DT procedures.

The fourth step is to bring everybody on board, including all departments, when implementing new digital technologies. DTP should take place throughout all divisions of an organisation. The decision-makers should consult with all organisational departments and the parties most impacted by the change, such as suppliers, while formulating a DT strategy. Many businesses go further than that and create a cost-effective strategy with their primary distributors or suppliers to make sure their DT efforts are well-organised and they maximize the benefits of this transition. Employees' resistance to change will be greatly reduced when all departments are included in the strategy's development, which will improve process efficiency and lessen attempts to make the new program fail.

The fifth step involves piloting the project in one part of the organisation first before moving to other areas. In terms of magnitude and breadth, DT is a huge project. It would be extremely risky, both financially and administratively, to implement the project in its early phases across all departments of an organisation. As such, one of the best

ways to start a DT project is to pilot it first in one of the organisation's business units. One of the production lines or a production process inside a production line may be the location of this pilot. The organisation's financial resources and the labour force's existing skill set will determine the scope of the piloting.

The sixth step is to communicate strategy and goals with employees. One of the most crucial steps in every project that seeks to bring about major change is communication. The top management of the organisation should inform the workforce of DT's objectives. This would assuage employees' fears that adopting digital technology will result in the loss of their jobs and persuade them that doing so will transform their jobs rather than replace them. Another advantage of communication is that it creates a venue for the inclusion of any creative suggestions staff members may have for carrying out these kinds of tasks. By doing so, they will feel more involved in the development of this approach and more motivated to carry it out.

The seventh step involves assigning a board-level or C-level sponsor to the project. One of the main success strategies from prior experiences in manufacturing organisations is top management assistance. This support plays a significant role in changing the organisational culture to be more digitally focused and in educating the workforce about the importance of DT in their everyday tasks. In order to create a workflow that is more digitally oriented, this support also encourages middle managers to take the initiative in this direction and promote their digital processes within their departments.

Lastly, the eighth step is to share plans with clients. This last recommended practice is to let your customers know what you are planning. Since consumers are the lifeblood of every business, they should be informed of any changes to the company's plans, especially if they affect customer service or avenues for contact. For instance, increasing client awareness about the organisation's website's new chatbot function and how to use it will maximize its use.

8.2.4 The Proposed Digital Readiness Assessment Model

Extensive literature research was carried out to identify the variables affecting DT within the manufacturing industry after reviewing the models currently present in the literature and the articles covering DT in general as a major finding of this research described in chapter 5. To retain some degree of consistency regarding the particular themes of interest while ensuring that our sample size would stay sizable, the research has concentrated on sources from manufacturing literature. According to the elements addressed in the literature, DT will not thrive alone through the use of digital technologies; it also requires business competencies. This will include everything from leadership support to integrating this transition into the organisation's culture. Consequently, the business competencies dimension and the technology competencies dimension are two critical factors in this model.

As described in Chapter 5 of this dissertation, the suggested model determines an organisation's present level of DT and provides a general roadmap for the organisation's journey toward digital transformation that can be applied to a variety of manufacturing sectors not tailored to a specific industry . For example, the model proposed nine levels of readiness ranging from low to high digitalisation. An organisation can advance from its current level to the advanced level of the DT journey by following the recommended steps.

8.2.5 LEAD-19: The Proposed Digital Leadership Attributes Model

After extensive analysis of the literature review to identify the key attributes of a digital leader to foster digital transformation in the manufacturing industry, a proposed model of four main attributes and 19 sub-attributes was developed to determine the most important attributes regarding digital leadership given the special nature of developing economies and cultural and environmental changes in the Egyptian economy.

As discussed in chapter6, the results indicated that an innovation mindset is the most important attribute for becoming a successful digital leader, followed by a digital business mindset, then the transformational mindset, and finally the inspirational

mindset. Moreover, the BWM ranks and categorises the sub-attributes, identifying the top 10 sub-attributes that need to be given closer attention in developing digital leadership skills. These are: agility, risk-taking, visionary leadership, digital intelligence, complexity mastery, digital talent scouting, encouragement, accountability, digital savvy, and decisive courage.

8.3 Contribution to Knowledge

This research contributes to the body of literature by creating a prioritised DT implementation method that is specifically customised for the manufacturing industry in Egypt. Additionally, this study takes into account the majority of DT process implementation factors, including leadership support, human factors, and technology. The key research contribution to knowledge theoretically and practically are as follows:

- In this study, an innovative readiness evaluation and maturity framework for digital transformation activities is proposed, with a particular emphasis on the manufacturing sector in emerging markets. The system was created by incorporating the best practices discovered in the other models, and it was adjusted and validated by subject-matter experts to ascertain its level of applicability for manufacturing processes. This model contributes to the body of research in this area by establishing a connection between company operations and technological capabilities and identifying the sub-dimensions that can be used to measure each factor.
- This developed digital maturity model provides the decision-maker in the manufacturing organisation with a strategic perspective of the organisation's capabilities in terms of business and technology for implementing DT procedures. The methodology then places the organisation on one of the nine levels of technology adoption and makes recommendations for how to make that location better.
- The proposed framework contributes to the notion of digital maturity, especially as it applies to the manufacturing sector, by offering a fresh and simple method to evaluate the DT readiness of the sector. Since the model is neither industry-

specific nor technology-specific, it may be used by any manufacturing organisation. However, it provides a clear picture of the industrial organisation's DT readiness.

- For the digital readiness assessment model, the proposed methodology assesses how prepared a manufacturing organisation is to start or continue DT activities. The COVID-19 pandemic's significant impact on business practices and the disruption it caused to most economies are what give the model its significance. Due to this, all businesses, regardless of size, should start their DT journey right away. The model, which provides a macro-level overview of DT processes, should be followed by a more in-depth review of each technology employed by the organisation. The approach is simple and easy to use.
- This research adds to the literature by developing a prioritised DT implementation process specifically tailored for the manufacturing industry using data collected from top experts in the manufacturing field in an evolving economy focused on the manufacturing industry like the Egyptian economy. Moreover, this research considers most of the aspects of the DT process's implementation, from technology to human factors and leadership support.
- The suggested approach aids manufacturing companies in emerging economies in formulating a thorough DT implementation strategy, particularly for those manufacturing companies that are just starting out on their digital transformation path. Offering this approach enables manufacturing companies to comprehend and prioritise their company goals in accordance with their resources in order to successfully undergo a digital transformation. The developed framework for a DT process includes the eight DT factors that are most crucial to the process. These factors also give managers the flexibility to place orders in accordance with the capabilities of the manufacturing firm and their surrounding business environment.
- Regarding digital leadership, this study has several important implications for the literature on digital leadership and its role in shaping the digital transformation. First, this study proposes a model that shapes the most significant attributes of digital leadership discussed in the literature and prioritises them according to

their relative importance, with a focus on the manufacturing sector. Second, to the best of the authors' knowledge, this study is among the first to use multi-criteria decision-making (MCDM), particularly the Best-Worst Method (BWM), in the field of digital leadership and how this can foster digital transformation. As most of the literature uses survey results, the BWM provides more consistent and reliable results as it comes from purposive sampling, which is conducted by people who have the experience necessary to take part in this research and eliminates the risk of respondents being vague. Finally, most of the studies focusing on digital leadership in the manufacturing industry come from developed economies with advanced technology applications.

- The new framework is designed for manufacturing companies in emerging economies that are attempting to start their DT journey in order to deal with the changes brought about by digital technology globally. Given that the majority of digital preparedness models have concentrated on rich nations, this new model will be significant for many companies in the developing world.

8.4 Fulfilment of the Research Objectives

After conducting an extensive literature review and survey to examine the digital transformation process in the manufacturing sector, the researcher came up with various research findings on the topic. This section reviews how these research activities led to the fulfilment of research objectives as outlined in Chapter 1.

Objective 1 of this study was to analyse and capture the good practices of the current digital transformation processes via an extensive literature review. To fulfil this , a thorough literature review was conducted to study the digital transformation process in the manufacturing sector. The study found that:

1. Companies operating in the manufacturing sector adopt various techniques and strategies to incorporate digital tools in their activities and production processes, which have largely helped improve their productivity levels. Some of the

companies aim to transform their entire processes, while others only focus on a few sections, units, or departments.

2. The literature review also helped in identifying various types of technologies driving the DT process as well as how companies use them to digitise their activities. These include cloud computing, the Internet of Things, big data analytics, and the digital twin.
3. Most DT activities aim to enhance customer experiences and a company's innovativeness. The study also found that DT is embraced to increase profitability, enhance productive operations, increase a company's competitive advantage, and ensure continual growth.
4. The study also found that companies employ the right leadership to ensure the success of their DT processes, as digital leaders are encouraged to have the right qualities and skills to lead the digital transformation process.
5. Companies also use various digital transformation readiness assessment models to assess their readiness for digital transformation. Some of the models identified include McKinsey's Framework, Pacchini's Industry 4.0 Model, the Deloitte Digital Maturity Model, the Five Digital Business Aptitude Domains, and the Digital Readiness Assessment Maturity Model. Others included the UMPULS Maturity Model, the Smart Manufacturing Maturity Models for SMEs, and the System Integration Maturity Model for Industry 4.0.

Objective 2 of the study was to capture, via a field study, the industrial perspectives of digital transformation processes and their implementation challenges. To accomplish this aim, a systematic literature review was conducted to identify factors related to the digital transformation process, especially the business and technology related issues that enable DT activities to take place. A survey was also conducted to collect information from industry experts and companies operating in the manufacturing sector to validate these findings. This process helped gather first-hand information concerning the experiences of managers or companies that have adopted digital technologies, leading to a deeper understanding of the digital transformation process in the manufacturing sector. The study found that:

1. Many industry experts identified various business competencies, such as leadership, business strategy and vision, innovation practices, and organisational culture, as important factors in the DT process.
2. The respondents also believed that the Technology Competencies dimension, which comprises Digital Technologies Adopted and Digital Business Processes, was also important to ensure the success of the DT process. The industry experts interviewed felt that some of the digital competencies required include knowledge of digital product development, the ability to adopt data driven services and produce smart products, the adoption of vertical and horizontal integration, and the ability to implement various digital tools such as cloud computing, robotics, AI, ERP systems, and big data analytics.
3. As discussed in the literature review section, various challenges affecting the implementation of DT in organisations were identified, which include a skills gap, difficulties in adopting new technology, difficulties in managing change, and inadequate innovation policies.

Objective 3 of the study was to analyse the current digital transformation needs, challenges, and enablers in the Egyptian manufacturing sector. Studying Egypt's manufacturing sector through case studies and interviews helped fulfil this aim. It was determined that:

1. It was determined that the DT process required leaders with the right skills, qualities, and vision to ensure the successful implementation of digital technologies. Since new digital tools come with various challenges and requirements, current leaders should have the requisite technical competencies, attitudes, and abilities to drive the digital transformation process. A comprehensive analysis of digital leadership is described in Chapter 6 of this dissertation.
2. For successful implementation of DT in the manufacturing sector, businesses must have various competencies and capabilities. This relates to various business and technological competencies as described in objective 2.

3. The challenges facing the manufacturing sector were also identified as described under objective 2, as it was learned that the implementation of new technological tools cannot go without challenges.

Objective 4 is concerned with the development of an assessment tool to measure the readiness of the manufacturing organisation to ensure digital transformation. An assessment tool was created to provide an effective approach to assessing and measuring an organisation's readiness to implement digital technologies. The model was developed based on various best practice factors identified in the previous models. It was then modified and validated through peer reviews to determine its relevance for the manufacturing sector.

The model covers both the digital and business competencies dimensions, hence offering a broad and comprehensive assessment framework for examining an organisation's level in the DT implementation process. It offers a framework that outlines the first steps an organisation should take to assess its digital readiness and maturity level, which is followed by a detailed and extensive analysis of the business and technological aspects of the organisation.

The model can be used to assess an organisation's current readiness level and offers a roadmap to guide its next steps as it attempts to implement new digital tools. As described in Chapter 5 of this dissertation, the roadmap consists of nine readiness levels, which range from low digitisation to digital hero. It offers guidelines on how an organisation can move from its current level to the top-most digital hero level.

Objective 5 was about developing an innovative process to support digital transformation in the manufacturing sector, which was fulfilled by developing a digital transformation model to guide the adoption and implementation of various digital technologies by manufacturing firms. This model is described in Chapter 4 of this dissertation. This model was designed in accordance with various findings concerning the digital transformation process in the manufacturing industry. As described in the findings section, the model consists of eight main steps that leaders must follow to

ensure a successful digital transformation process. The summary of the 8 steps is as follows:

- Invest in the right technologies.
- Invest in staff training.
- Draw up a comprehensive yet flexible and Adaptable budget.
- Involve all departments in developing a strategy.
- Pilot the project in one part of the business first.
- communicate strategy and goals with employees.
- Assign a board-level or C-level sponsor to the project.
- communicate plans with customers.

If followed correctly, these steps can effectively guide the digital transformation process and help businesses successfully implement new digital tools to improve their business operations and production processes.

Objective 6 of this study was to identify the key digital leadership attributes that can foster the successful implementation of digital transformation in the manufacturing industry. This is fulfilled by proposing the LEAD-19 model, as described in Chapter 7. This model describes the main and sub-attributes of digital leadership that should be embodied by the top management of the manufacturing organisation to help successfully implement digital transformation as an ongoing process.

The results indicated that an innovation mindset is the most important attribute for becoming a successful digital leader, followed by a digital business mindset, then the transformational mindset, and finally the inspirational mindset. Moreover, the BWM ranks and categorises the sub-attributes, identifying the top 10 sub-attributes that need closer attention in developing digital leadership skills. These are: agility, risk-taking, visionary leadership, digital intelligence, complexity mastery, digital talent scouting, encouragement, accountability, digital savvy, and decisive courage.

Objective 7 of this study was to validate the work via a case study in the Egyptian manufacturing sector and evaluate the work via expert judgment. Case studies were

conducted among various companies drawn from different sub-sectors in the manufacturing industry. The case studies helped to validate the proposed digital transformation readiness assessment model by evaluating how these companies approached their DT processes and how their practices reflected what was contained in the proposed model. The work was then evaluated by industry experts to gain their views on the proposed model.

During the interviews, all the industry experts interviewed concurred that the two elements of DT—business and technology—should be equal in importance and thus were considered in the proposed assessment model. Through the interviews, it was determined that the most crucial business competency components included organisational culture, leadership, business strategy, and vision. The Technology Competencies dimension included both Digital Business Processes and Adopted Technologies. As shown in the model, the factors related to digital technologies, which are grouped into one dimension, will vary depending on the type of manufacturing business as well as the organisation's size and scope of manufacturing operations. This model will include all of the digital technologies used in the organisation's manufacturing processes and include the same elements in the assessment tool in order to increase the adaptability of the model so that it can be used in any manufacturing industry and in any size organisation. The digital business process dimension is no different. The organisation can use this model to get a general assessment of where it is in the DT process.

8.5 Conclusions

This study has looked at the influence of digital transformation on company activities across a range of sectors in the manufacturing industry. In conclusion, digital transformation (DT) is a mechanism focused on the needs of the customer that enables sustainable growth of manufacturing processes through the use of cutting-edge digital technologies like cloud computing, the Internet of Things, big data analytics, and the digital twin in every aspect of the organisation. Academics studying information systems have contributed the most to the development of this area of research. The literature

has a wide range of insights into digital transformation, some of which highlight the advantages of embracing the process in the manufacturing sector. The adoption of digital technologies is, however, hampered by certain significant issues, such as a lack of training and a skills gap in the industrial sector.

The results demonstrate that digital transformation tools can revolutionize manufacturing organisations by boosting employee productivity and improving customer engagement. The concerns brought up in this paper offer an excellent foundation for additional research. For manufacturers, the idea of digital transformation holds considerable advantages and importance. It provides ways for businesses to advance through the value chain and capitalize on Profitable ventures.

One of the key findings of this research is to identify and determine the most important stages for DT implementation in the manufacturing sector after assessing the readiness of the manufacturing organisation to begin this process. After studying the literature review, we determined eight stages and ranked them according to their importance. Twenty-one structured interviews with manufacturing experts in the Egyptian economy were held and analysed using the BWM to rank the stages according to the interviewees' perspectives. The stages in the DT process are as follows, according to importance: (1) invest in the right technologies and tools, (2) invest in staff training, (3) draw up a comprehensive yet flexible/Adaptable budget, (4) involve all departments in developing a strategy, (5) pilot the project in one part of the business first, (6) communicate the strategy and goals with employees, (7) assign a board-level or C-level sponsor to the project, and (8) communicate plans with customers. Understanding the dimensions and factors of each of these eight stages will help manufacturing organisations implement DT successfully, especially when they have yet to start their DT process.

Moreover, this study led to the development of a new readiness model for DT measurement in the manufacturing sector. The model has two primary characteristics: business competencies and technological competencies. These dimensions were determined by reviewing the literature and interviewing manufacturing experts in Egypt,

a developing country. The level of readiness is measured by sub-dimensions under each main dimension. The sub-dimensions of business competencies are organisational culture, leadership, strategy, and management practices. The sub-dimensions for technology competencies are "digital business processes" and "digital technologies adopted." This model introduced a nine-level scale: low digitalisation, technology starter, business starter, middle digitalisation, technology adopter, business adopter, business-focused transformation, technology-focused transformation, and digital hero.

The weighted average approach was used to determine the score for both dimensions. In addition, an analysis of three case studies used to validate the model used in manufacturing firms in the Egyptian economy revealed a dearth of the use of cutting-edge digital technologies, with many manufacturing activities still relying on human labour. Senior leaders and decision-makers do, however, strongly support DT projects being implemented inside their facilities. This study included three key case studies, each of which was located in the model, to illustrate how the model was used.

In addition, this study aims to identify the key digital leadership attributes that can foster successful digital transformation implementation in the manufacturing industry in a developing economy like the Egyptian economy. An extensive literature analysis was undertaken to specify the most frequently mentioned attributes and sub-attributes in previous studies to achieve this aim. Next, these factors were refined based on participants' opinions, yielding a total of 4 main attributes and 19 sub-attributes. After that, the BWM was applied using input from twenty participants to rank and prioritise the main dimensions and their relevant factors.

The results indicated that innovation mindset is the most important attribute for becoming a successful digital leader, followed by digital business mindset, transformational mindset, and finally inspirational mindset. Moreover, the BWM ranks and categorises the sub-attributes, identifying the top 10 sub-attributes that need closer attention in developing digital leadership skills. These are: agility, risk-taking, visionary

leadership, digital intelligence, complexity mastery, digital talent scouting, encouragement, accountability, digital savvy, and decisive courage.

Overall, this study brings new knowledge to the literature of digital leadership in developing countries by highlighting the significant attributes that a digital leader should possess to foster digital transformation operations in the manufacturing industry.

8.6 Research Limitations and Future Research

Despite its strengths, this research has limitations that need to be further investigated in future research. These include the following: First, this study was applied to the Egyptian economy, which is a developing economy with different characteristics from the developed economies, even in terms of adopting different digital technologies. Second, the purpose of this research is to address the implementation phase of the DT process; other post-implementation phases may include measurement and control, feedback, and improvement.

DT is an inclusive term that involves both management and technical perspectives. This research focused on the organisation at the macro level. Thus, it can provide a general guideline for manufacturing organisations to assess their readiness and maturity level for DT activities. Future research can go deeper and build on this model to assess each digital technology's readiness or open innovation practice. This was recommended during the validation phase of the model when adopting the case studies.

The main focus of this research was on manufacturing organisations. However, future research may adopt the model in other industries, considering that "design thinking" has different meanings in different industries.

The research was applied to a developing economy—namely, the Egyptian economy. Future research may use the model to assess the readiness of manufacturing companies in other developed economies with different resources and capabilities.

Future research may include applying the same process to a specific manufacturing industry and seeing how changing the manufacturing industry impacts the process.

Other future research should look at additional issues, such as applying the same DT process in a developed economy and making a comparative analysis between both processes or applying the same process in a different sector and measuring the differences in the process.

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Appendices

Appendix A Semi-Structured Interview Questions

Appendix A Semi-Structured Interview Questions

I am very grateful you kindly agree to take part in this interview. My research is aimed to develop an innovative framework and processes to successfully implement Digital Transformation in The Manufacturing Industry. The required time to conduct this interview will take approximately 90 minutes.

I would like to confirm that all information and names gathered from the interview will be kept confidential, and the researcher is responsible for confidentiality.

The major topics to be discussed during this interview are as follows:

- The previous and current work experience and roles of the interviewee.
- Perception of interviewee of digital transformation and current initiatives in Egypt.
- The interviewee's opinion about main barriers and challenges of Digital Transformation implementation in the manufacturing industry. Particularly, the barriers related to political, organisational, resources, cultural, legislative, regulatory and technological aspects
- The interviewee's view on how and why these barriers are occurring, and how they can be overcome.
- The factors that motivate development, the motives and benefits which can make the most gain of the Digital Transformation Projects
- Suggestions and future plans for future planning of digital transformation in the manufacturing ecosystem in Egypt.

Thank you very much once again for your participation and cooperation!

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Open Discussion Questions:

- ✓ First, please tell me briefly about your current and previous work experience and roles, regarding manufacturing and operations management, particularly the use of digital technologies
- ✓ Could you give me a brief description of any digital transformation project you are involved in (if applicable) and what was the idea behind the project?
- ✓ In your own words, what is your definition of digital transformation in the manufacturing industry?
- ✓ In your own words, why do you think the Digital transformation in the manufacturing industry in Egypt is important?
- ✓ In your opinion, what are the main barriers to digital transformation development and or implementation? In other words, according to your knowledge, what are the problems that could be encountered during a digital transformation project implementation? I mean the barriers that could stop these projects.
- ✓ What are the most important enablers of implementing digital transformation initiatives successfully in your manufacturing organisation?
- ✓ Speaking of Enablers, what is the most influential technology for digital transformation to you and what seems most applicable for your manufacturing firm?
- ✓ From your experience, what does the starting point that manufacturing organisations should begin with to begin their digital transformation successfully?
- ✓ If there is a digital transformation plan already in place, what were the things that went according to the plans and what went wrong?
- ✓ Tell us how the organisation can cultivate the culture to deliver the promise of the technology.
- ✓ How important do you think it is for the teams to collaborate across functions?
- ✓ What role does the budget play in the digital transformation plan?
- ✓ According to your experience, how can we assess digital transformation readiness in any manufacturing organisation?

Digital Transformation Process Questions:

According to your experience and your thoughts, please answer the following questions

1. Select the most important step (best) to implement Digital Transformation successfully in the manufacturing industry in Egypt

- ☐ Invest in the right technologies and tools
- ☐ Involve all departments in developing a strategy
- ☐ Invest in staff training
- ☐ Draw up a comprehensive, yet flexible/adaptable budget
- ☐ Assign a board-level or c-level sponsor to the project
- ☐ Pilot the project in one part of the business first
- ☐ Communicate strategy and goals with employees
- ☐ Communicate plans with customers

2. Now, select the least important (worst) step from the same list

- ☐ Invest in the right technologies and tools
- ☐ Involve all departments in developing a strategy
- ☐ Invest in staff training
- ☐ Draw up a comprehensive, yet flexible/adaptable budget
- ☐ Assign a board-level or c-level sponsor to the project
- ☐ Pilot the project in one part of the business first
- ☐ Communicate strategy and goals with employees
- ☐ Communicate plans with customers

3. Next, please give each step a relative importance rank compared to the best step you chose. Rank from 1 to 9, where 1 is the same importance as the best and 9 is least important compared to the best

Best to Others	Invest in the right technologies and tools	Involve all departments in developing a strategy	Invest in staff training	Draw up a comprehensive, yet flexible/adaptable budget	Assign a board-level or c-level sponsor to the project	Pilot the project in one part of the business first	Communicate strategy and goals with employees	Communicate plans with customers
The chosen best step ----- -----								

4. Finally, please give each step a relative importance rank compared to the worst step you chose, the rank is from 1 to 9, where 1 has the same worst importance compared to the worst and 9 is most important compared to the worst.

Others to the Worst	The chosen worst step -----
Invest in the right technologies and tools	
Involve all departments in developing a strategy	
Invest in staff training	
Draw up a comprehensive, yet flexible/adaptable budget	
Assign a board-level or c-level sponsor to the project	
Pilot the project in one part of the business first	
Communicate strategy and goals with employees	
Communicate plans with customers	

Digital Readiness Assessment Questions

1. Please give each business competency of the following a score from 1 to 5, where 1 is least important, and 5 is most important, to assess digital transformation business readiness capabilities

Business Criterion	Your rank (from 1 to 5)
Customer Relationship Management	
Supply Chain Management	
Digital Talent	
Leadership Support	
Financial Support	
Innovation Practices	
Organisational Culture	
Organisational Vision	

2. Please give each technology competency of the following a score from 1 to 5, where 1 is least important, and 5 is most important, to assess digital transformation technology readiness capabilities

Technology Criterion	Your rank (from 1 to 5)
Digital Product Development	
Data-Driven Systems	
Vertical/Horizontal Integration	
Cloud Computing	
Robots	
VR/AR	
Artificial Intelligence	
ERP Software	
Bid Data Analytics	

Digital Leadership Attributes Questions

Main Attributes

According to your experience and your thoughts, please answer the following questions

1. Select the most important (best) Digital Leadership Mindset that can foster the successful implementation of digital transformation initiatives
 - ☐ Inspirational Mindset
 - ☐ Innovation Mindset
 - ☐ Digital Business Mindset
 - ☐ Transformational Mindset
2. Now, select the least important (worst) mindset from the same list
 - ☐ Inspirational Mindset
 - ☐ Innovation Mindset
 - ☐ Digital Business Mindset
 - ☐ Transformational Mindset
3. Next, please give each mindset a relative importance rank compared to the best mindset you chose. Rank from 1 to 9, where 1 is the same importance as the best and 9 is least important compared to the best

Best to Others	Inspirational	Innovation	Digital Business	Transformational
Chosen best mindset -----				

4. Finally, please give each mindset a relative importance rank compared to the worst mindset you chose. The rank is from 1 to 9, where 1 has the same worst importance compared to the worst, and 9 is most important compared to the worst.

Others to the Worst	Chosen worst mindset -----
Inspirational	
Innovation	
Digital Business	
Transformational	

Digital Leadership Sub-Attributes

We will repeat the previous steps for each mindset to rank the relative importance of sub-attributes inside each mindset

Transformational Mindset

1. Select the most important (best) Transformational Mindset sub-attribute that can help in the successful implementation of digital transformation initiatives
 - ☐ Diversity Champion
 - ☐ Visionary
 - ☐ Encouraging
 - ☐ Accountable
2. Now, select the least important (worst) sub-attribute from the same list
 - ☐ Diversity Champion
 - ☐ Visionary
 - ☐ Encouraging
 - ☐ Accountable

3. Next, please give each sub-attribute a relative importance rank compared to the best mindset you chose. Rank from 1 to 9, where 1 is the same importance as the best and 9 is least important compared to the best

Best to Others	Diversity Champion	Visionary	Encouraging	Accountable
Best chosen sub-attribute -----				

4. Finally, please give each sub-attribute a relative importance rank compared to the worst mindset you chose. The rank is from 1 to 9, where 1 has the same worst importance compared to the worst, and 9 is the most important compared to the worst.

Others to the Worst	Chosen Worst sub-attribute -----
Diversity Champion	
Visionary	
Encouraging	
Accountable	

Inspirational Mindset

1. Select the most important (best) Inspirational Mindset sub-attribute that can help in the successful implementation of digital transformation initiatives

- ☐ Motivator
- ☐ Decisive Courageous
- ☐ Openness
- ☐ Trustworthy
- ☐ Enthusiastic

2. Now, select the least important (worst) sub-attribute from the same list

- ☐ Motivator
- ☐ Decisive Courageous
- ☐ Openness
- ☐ Trustworthy
- ☐ Enthusiastic

3. Next, please give each sub-attribute a relative importance rank compared to the best mindset you chose. Rank from 1 to 9, where 1 is the same importance as the best and 9 is least important compared to the best

Best to Others	Motivator	Decisive Courageous	Openness	Trustworthy	Enthusiastic
Best chosen sub-attribute -----					

4. Finally, please give each sub-attribute a relative importance rank compared to the worst mindset you chose. The rank is from 1 to 9, where 1 has the same worst importance compared to the worst, and 9 is the most important compared to the worst.

Others to the Worst	Worst Chosen Sub-Attribute -----
Motivator	
Decisive Courageous	
Openness	
Trustworthy	
Enthusiastic	

Innovation Mindset

- Select the most important (best) Innovation Mindset sub-attribute that can help in the successful implementation of digital transformation initiatives
 - ☐ Risk Taker
 - ☐ Anticipatory
 - ☐ Agile
 - ☐ Collaborative
- Now, select the least important (worst) sub-attribute from the same list
 - ☐ Risk Taker
 - ☐ Anticipatory
 - ☐ Agile
 - ☐ Collaborative

3. Next, please give each sub-attribute a relative importance rank compared to the best mindset you chose. Rank from 1 to 9, where 1 is the same importance as the best and 9 is least important compared to the best

Best to Others	Risk Taker	Anticipatory	Agile	Collaborative
Best Chosen Sub-Attribute -----				

4. Finally, please give each sub-attribute a relative importance rank compared to the worst mindset you chose. The rank is from 1 to 9, where 1 has the same worst importance compared to the worst, and 9 is the most important compared to the worst.

Others to the Worst	Worst Chosen Sub-Attribute -----
Risk Taker	
Anticipatory	
Agile	
Collaborative	

Digital Business Mindset

- Select the most important (best) Digital Business Mindset sub-attribute that can help in the successful implementation of digital transformation initiatives
 - ☐ Digital Intelligence
 - ☐ Complexity Master
 - ☐ Digital Savvy
 - ☐ Digital talent Scout
 - ☐ Ambidexterity
 - ☐ Lobbyist
- Now, select the least important (worst) sub-attribute from the same list
 - ☐ Digital Intelligence
 - ☐ Complexity Master
 - ☐ Digital Savvy
 - ☐ Digital talent Scout
 - ☐ Ambidexterity

☐ Lobbyist

3. Next, please give each sub-attribute a relative importance rank compared to the best mindset you chose. Rank from 1 to 9, where 1 is the same importance as the best and 9 is least important compared to the best

Best to Others	Digital Intelligence	Complexity Master	Digital Savvy	Digital talent Scout	Ambidexterity	Lobbyist
Best Chosen Sub-Attribute						

4. Finally, please give each sub-attribute a relative importance rank compared to the worst mindset you chose. The rank is from 1 to 9, where 1 has the same worst importance compared to the worst, and 9 is the most important compared to the worst.

Others to the Worst	Worst Chosen Sub-Attribute
Digital Intelligence	
Complexity Master	
Digital Savvy	
Digital talent Scout Ambidexterity Lobbyist	

Thank you very much for your participation in this interview!

Appendix B Digital Transformation Implementation Survey

Digital Transformation Implementation Survey

Dear Sir/Madam

Thank you for participating in this survey. This 15–20-minute survey is developed to assess the readiness of the manufacturing companies in Egypt to adopt and implement Digital Transformation strategies and processes. It is part of ongoing research at Cranfield University, England.

This survey is directed to the company's senior executives or members of staff directly related to digital technology implementation in a manufacturing facility.

Your responses are voluntary and will be confidential. We sincerely respect your privacy. All answers will be compiled together and analysed as a group. By participating in this questionnaire, you will receive a summary of the results of this questionnaire if you kindly agree to provide your email address.

If you have any questions or inquiries regarding this questionnaire, please do not hesitate to contact Yasser Abdallah, a PhD researcher at Cranfield University at +44 (0) 7463 852 998 or via email (Yasser.Abdallah@cranfield.ac.uk).

Thank you again for your time in participating in this survey.

Q1 Nature of the Organisation

Q1.1 Please Select your organisation category:

- ☐ Public / Government sector (1)
- ☐ Private sector (2)

Q1.2 Which manufacturing sector does your organisation belong to?

- ☐ Textiles (1)
 - ☐ Food processing (2)
 - ☐ Chemicals (3)
 - ☐ Electrical Machines (4)
 - ☐ Pharmaceuticals (5)
 - ☐ Hydrocarbons (6)
 - ☐ Cement (7)
 - ☐ Iron and Steel (8)
 - ☐ Oil and Gas Industry (9)
 - ☐ Home Appliances (10)
 - ☐ Other: (11) _____
-

Q1.3 How long is your organisation in operation ?

- ☐ less than one year (1)
- ☐ 1 year - 5 years (2)
- ☐ 5 -10 years (3)
- ☐ 10+ years (4)

Q1.4 How many employees does your organisation have?

- ☐ 1-50 (1)
- ☐ 50-100 (2)
- ☐ 100-250 (3)
- ☐ 250-500 (4)
- ☐ 500-1000 (5)
- ☐ 1000+ (6)

Q2.1 Organisation Performance Background

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Overall, the organisation is being successful in achieving its strategic objectives. (1)	☐	☐	☐	☐	☐
Overall, the previous business change projects in the organisation have been successful. (2)	☐	☐	☐	☐	☐
Digital technology implementations in the organisation have been successful. (3)	☐	☐	☐	☐	☐

Q2.2 Where do you see your own organisation currently when it comes to becoming more digital?

- ☐ We are ahead of our schedule when it comes to becoming more digital
- ☐ We are right on schedule when it comes to being more digital
- ☐ We are behind schedule when it comes to being more digital
- ☐ We have not started to become more digital yet, but are planning our approach
- ☐ We have not started to become more digital yet, and have no plans to
- ☐ We have always been a 100% digital business

Q2.3 What are the biggest challenges that your organisation has actually experienced in trying to undertake a successful digital transformation? Rank your top 3 challenges from this list.

- _____ Over reliance on legacy technology (1)
- _____ Internal politics (2)
- _____ Lack of dedicated budget (3)
- _____ Lack of the right in-house skills (4)
- _____ Lack of the right technology/tools (5)
- _____ Cultural resistance (6)
- _____ Lack of formal strategy/plan (7)
- _____ Lack of senior management sponsorship (8)
- _____ Other (9)
- _____ There are no challenges to digital transformation (10)

3 Strategy & Innovation Through Digital Initiatives

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
The organisation is good at generating new ideas to improve performance. (1)	☐	☐	☐	☐	☐
The organisation is good at implementing new ideas to improve performance. (6)	☐	☐	☐	☐	☐
The organisation has already successfully implemented several digital initiatives that improve or adapt its products and services (2)	☐	☐	☐	☐	☐
There are well-defined metrics to measure the impact of each innovation on the organisation's bottom line. (3)	☐	☐	☐	☐	☐
The organisation business strategy focuses on consumers and their needs. (4)	☐	☐	☐	☐	☐
The organisation business strategy is shared at all levels of the organisation. (5)	☐	☐	☐	☐	☐
The organisation business strategy is understood at all levels of the organisation. (7)	☐	☐	☐	☐	☐

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4 Organisation Vision & Culture

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
There is an inspiring vision of how the new digital era can create a new future with shared value for the organisation. (1)	☐	☐	☐	☐	☐
The organisation has a clear understanding of how the competitive landscape is changing due to digital trends. (2)	☐	☐	☐	☐	☐
The organisation has a clear roadmap to use digital technologies to help the employees deliver their business objectives. (3)	☐	☐	☐	☐	☐
The organisation has an open, blame-free and collaborative culture. (4)	☐	☐	☐	☐	☐
The organisation responds well to change. (5)	☐	☐	☐	☐	☐
The organisation communicates effectively internally and externally. (6)	☐	☐	☐	☐	☐
The organisation learns from previous experience. (7)	☐	☐	☐	☐	☐

5 Leadership

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
Leaders act as a role model by facilitating the transformation to a digital-centric organisation. (1)	☐	☐	☐	☐	☐
Senior individuals in the organisation hold accountable for digital initiatives. (2)	☐	☐	☐	☐	☐
Senior managers outside IT department get involved in defining, designing and implementing digital initiatives. (3)	☐	☐	☐	☐	☐

Q5.2 Who is currently leading your organisation's digital initiatives? (If they are a team, check all that applied)

- ☐ Chief Executive Officer (1)
- ☐ Chief Information Officer (2)
- ☐ Chief Technology Officer (3)
- ☐ Chief Operations Officer (4)
- ☐ Chief Data Officer (5)
- ☐ Chief Digital Officer (6)
- ☐ Head of Digital Transformation (7)
- ☐ Chief Finance Officer (8)
- ☐ Chief Marketing Officer (9)

- ☐ Chief Strategy Officer (10)
- ☐ Other C-Level Officer (please specify) (11)
-
- ☐ Other Role (please specify) (12)
-
- ☐ No one in particular is/was leading it (13)

Q5.3 What are the most critical steps to enable a successful digital transformation? Rank your top 3 steps from this list.

- _____ Invest in the right technologies and tools (1)
- _____ Involve all departments in developing a strategy (2)
- _____ Invest in staff training (3)
- _____ Draw up a comprehensive, yet flexible/adaptable budget (4)
- _____ Assign a board-level or c-level sponsor to the project (5)
- _____ Pilot the project in one part of the business first (6)
- _____ Communicate strategy and goals with employees (7)
- _____ Communicate plans with customers (8)
- _____ Other (9)
- _____ I don't know (10)

Q5.4 In your opinion as a leader in your organisation, what are the most effective tactics to implement digital transformation? Rank your top 3 from the list.

- _____ Pilot programs (1)
- _____ Culture change led from the top (2)
- _____ Clear digital strategy/roadmap with Well-determined priorities (3)
- _____ Outside help from consultants (5)
- _____ Educating and training employees (6)
- _____ Impact assessments to understand changes in technology, processes, and people (7)
- _____ Other (8)

Q5.5 In which business unit would you implement this pilot project? (If applicable)

- ☐ IT (1)
- ☐ Sales (2)
- ☐ Marketing (3)
- ☐ HR (4)
- ☐ Finance (5)
- ☐ Customer Support & Communication (6)
- ☐ Product (7)
- ☐ I don't know (8)

6 Business processes

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
The business units and functions are well connected to each other via digital platforms. (1)	☐	☐	☐	☐	☐
The organisation's technology platforms are effective. (2)	☐	☐	☐	☐	☐
The organisation's technology platforms easy to use (5)	☐	☐	☐	☐	☐
The organisation's technology platforms have improved employee engagement (i.e. Technology adoption rate). (6)	☐	☐	☐	☐	☐
The organisation is using digital technologies to improve the efficiency of employees. (3)	☐	☐	☐	☐	☐
The organisation is using digital technologies to expand its network of collaborators. (4)	☐	☐	☐	☐	☐

7 Technology & Automation

	Strongly disagree (1)	Somewhat disagree (2)	Neither agree nor disagree (3)	Somewhat agree (4)	Strongly agree (5)
The organisation is using new digital technologies like AI, Big Data and Robotic Process Automation. (1)	☐	☐	☐	☐	☐
The organisation has an innovative approach to the assessment and application of new digital technology. (2)	☐	☐	☐	☐	☐
Opportunities to automate business processes have been identified where appropriate. (3)	☐	☐	☐	☐	☐
Opportunities to automate business processes have been implemented where appropriate. (5)	☐	☐	☐	☐	☐
The organisation is resisting new digital technologies. (4)	☐	☐	☐	☐	☐

8 Participant Background

Q8.1 What is your job title?

Q8.2 What is your professional experience field? (Check all that applied)

☐ Top Executive Management (1)

☐ Marketing and Public Relations (2)

☐ Operations and Manufacturing (3)

☐ Human Resources (4)

☐ Information Technology (5)

☐ Financial Management (6)

☐ Strategic Management (8)

☐ Sales and Customer Service (9)

☐ Other: (7) _____

Q8.3 How many years of experience do you have?

- ☐ 1 year to 5 years (1)
- ☐ 5 years to 10 years (2)
- ☐ 10 years to 15 years (3)
- ☐ 15+ years (4)

8.4 Would you like to receive the results of this questionnaire?

- ☐ Yes (1)
- ☐ No (2)

If yes, what is your Email?

Q8.5 Would you like to be contacted for further discussion about the results of the research?

- ☐ Yes (1)
- ☐ Maybe (2)
- ☐ No (3)

If yes, What is your phone number?

Q8.6 Would you recommend someone else to take this survey?

☐ Yes (1)

☐ No (3)

If yes, what is his/her name?

If yes, What is his/her email?

Thank You very much for your participation in this survey!