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**The role of the Fourth Industrial Revolution technologies’
adoption on the competitiveness of companies in the South
Durban Basin**

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Thesis

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Declaration

I, Livingstone Smith, here declare that:

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Date: 17 May 2024

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Abstract

This research addresses the critical issue of how companies in the South Durban Basin have embraced Fourth Industrial Revolution (4IR) technologies and the implications for their operations and the local economy. The South Durban Basin is a significant industrial hub in South Africa, and the adoption of the 4IR technologies has both practical and theoretical implications. The purpose of this study is to assess the extent to which companies in the South Durban Basin have integrated 4IR technologies into their operations and the potential impact on their competitiveness and the broader community. The research also investigates the associated challenges and opportunities for businesses in this context. To accomplish this research objective, a mixed-method approach was employed. Data was collected from forty (40) small and medium-sized companies in qualitative research and hundred and sixty (160) small and medium-sized companies using quantitative research. Data was collected through semi-structured interviews and questionnaires, and analysis encompassed coding, labelling, and descriptive and inferential statistics to derive meaningful insights from the gathered information. The analysis revealed that companies in the South Durban Basin have made significant strides in adopting 4IR technologies, particularly in areas such as automation, data analytics, and the Internet of Things. The research also found that these technologies have positively impacted operational efficiency, product quality, and competitiveness. However, challenges such as the digital divide, skills gaps, and infrastructure limitations have been identified as barriers to more widespread adoption of the 4IR technologies. Notably, the study encountered various limitations, including disruptions caused by major events such as the July 2021 unrest in KwaZulu-Natal and other parts of South Africa, as well as devastating floods in April 2022, leading to the closure of some businesses. Despite these challenges, the study remains valuable to various stakeholders seeking insights into the 4IR 's impact in the region. Companies that have successfully integrated these technologies into their operations have experienced tangible benefits. The findings of this study contribute to the broader discussion on technology adoption in industrial regions and provide insights into the South Durban Basin's unique context.

Keywords: Adoption, Automation, Competitiveness, Digital Technology, Fourth Industrial Revolution.

Acronyms and abbreviations

4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
CFA	Confirmatory Facto Analysis
EFA	Exploratory Facto Analysis
GPS	Global Positioning Systems
HMT	Human machine technology
ICT	Information, Communication, and Technology
IoT	Internet of Things
IS	Information Systems
IT	Information Technology
KZN	KwaZulu-Natal
MLA	Maximum Likelihood
NDP	National Development Plan
NLP	Natural Language Processing
RFI	Radio Frequency Identification
SEM	Structural Equation Modelling
SME	Small and Medium Enterprises
STEM	Science, Technology, Engineering, and Mathematics
TTF	Task-Technology Fit

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CHAPTER 1

Introducing the study

1.1 Introduction

According to Scherrer (2022) the world has undergone three (3) significant industrial revolutions over the last 250 years, each of which brought about profound socio-economic changes. The Fourth Industrial Revolution (4IR) is no exception to the earlier revolutions and is characterized by the integration of smart, interconnected systems encompassing cyber, physical, and biological domains, along with innovative business models that are reshaping our social, economic, and political landscapes. Ndzendze, Singh, Timm, Meyers, Malatji, Malatji, Sundani, Shange, Matshidze, Rugunanan, and Brokensha (2024) express reservations about South Africa's ability to actively take part in the 4IR, citing that South Africa did not fully take part in the earlier three revolutions, the current global environment, characterised by the reduction of global boundaries and the rapid pace of technological advancement, offers greater access to the opportunities presented by this revolution. The focus of this study is on evaluating the ability of companies in the South Durban Basin to harness the potential of the 4IR. The 4IR has brought disruptive technologies, trends, and robotics that have disrupted the way people live and work. The President of the Republic of South Africa, Mr. Matamela Cyril Ramaphosa, emphasised the need for South Africa to position itself as a critical contributor to the development of the 4IR.

In his 2019 State of the Nation address, the President referred to the digital compact, with economic justice, social benefit, and innovation at its heart, as a vital part of the new social compact brought about by the 4IR. According to Schwab (2017), this followed the 2016 World Economic Forum in 2016 declaring that the entire world was currently coming to terms with the digital transformation accelerated by smart technologies' growth. Similarly, Peters (2017) argues that companies and industrial processes need to adapt to this rapid change and exponential growth so as not to be left behind by developments in their sector and their competitors. Peters (2017) further suggests that due to this revolution's scale, scope, and complexity, there will be increasing ambiguity, volatility, chaos, disruptive innovation, and uncertainty in its nature and form. Naude (2017) posits that as much as computer technology is progressing at a very high speed, breaching all facets of society and humans, South Africa has a geographical advantage to capitalize on the benefits of the 4IR. South Africa is diverse and hence a narrower observation of the 4IR is necessary which is why the study on the South Durban Basin area becomes necessary.

The study is primarily aimed at examining how companies in the South Durban Basin area used the 4IR technologies for competitive advantage. The World Economic Forum in 2016 said that the 4IR was unquestionably resulting in significant changes in the workforce landscape, technological advancements, and industry relations which affect all aspects of society and the economy. The study looks at how the challenges of the 4IR were overcome by the companies in the South Durban Basin to achieve a competitive advantage.

1.2 The research problem

The advent of the 4IR poses unique challenges to competitive advantage, particularly in the South Durban Basin area. Companies in the South Durban Basin have been slow to adopt 4IR technologies, which has significantly impeded their ability to remain competitive in a rapidly evolving market. Unlike previous industrial revolutions, 4IR technologies are more likely to replace lower-skilled workers while complementing higher-skilled workers. This shift brings into question whether economies, including South Africa's, have the requisite skills to participate effectively in economic activities within the 4IR context. The World Economic Forum (2016) highlighted that many low-skilled, routine jobs in manufacturing, which are prevalent in South Africa, are increasingly subject to automation. This trend reduces the incentive for organizations to offshore manufacturing or assembly operations to South Africa solely based on low-cost labour. Compounding this issue, is the imminent closure of SAPREF's operations, as reported by Business Day (2022), following the earlier shutdown of the Engen refinery in December 2020. These closures have led to significant job losses, directly impacting the economy of the South Durban Basin. Ngwane and Mabuya (2020) have also noted the threat to job security and economic stability due to the potential reduction in offshore manufacturing operations.

This research aims to unpack the competitive advantage and its measurement within this context by examining the impact of the 4IR on the labour market, particularly the displacement of lower-skilled workers and the adequacy of South Africa's current skill set to meet the demands of the 4IR. The reduced economic activities, job losses, closure of some of the businesses, the shift in global business trends away from low-cost labour advantages will also be examined. Addressing these issues is crucial for developing strategies to enhance competitive advantage in the South Durban Basin area amidst the transformative pressures of the 4IR. Despite the global trend towards 4IR integration, there is a notable gap in research addressing how the adoption of these technologies could enhance the competitiveness of companies within this region. The lack of comprehensive studies on this subject further complicates efforts to understand and overcome the

challenges that companies face in implementing 4IR innovations. This highlights both the current lag in technology adoption and the lack of relevant research on the issue.

1.3 Contribution of the study

The study aims to contribute to the growing body of knowledge on the implementation of 4IR strategies by companies in the South Durban Basin and their role in achieving competitive advantage. It will offer insights into how these companies have navigated the challenges associated with 4IR adoption to enhance their market positioning. The research will also explore the theoretical frameworks that underpin the effective use of 4IR as a strategic tool for competitiveness. Moreover, the study will provide companies with practical guidance on adopting the right strategic initiatives to manage automated operations. This will include an emphasis on leadership skills that are adaptable to the evolving demands of 4IR, fostering new ways of thinking and behaviour. By expanding knowledge of 4IR, this research has the potential to serve as a catalyst for increased productivity, market expansion, and strategies to mitigate job displacement.

Additionally, the findings of this study will be valuable to institutions of higher learning by informing the development of curricula focused on smart learning, equipping future leaders with the necessary skills to thrive in a 4IR-driven economy. Finally, this research will enhance understanding of the broader impact of 4IR on human lives and economic activity, while offering practical, theoretical, and methodological contributions to sustaining competitive advantage in the digital age.

1.4 Research objectives

1. To examine how companies in the South Durban Basin area use the 4IR technologies for competitive advantage
2. To evaluate if the companies in the South Durban Basin can embrace the 4IR opportunities to overcome challenges
3. To analyse how the personnel skills were able to ensure that companies in the South Durban Basin used the 4IR strategy to remain competitive
4. To develop a theoretical framework for effective use of the 4IR technologies for companies in the South Durban Basin to achieve a competitive advantage.

1.5 Research questions

1. How was the 4IR implemented to ensure a competitive advantage?
2. To what extent did the South Durban Basin embrace the opportunities of the 4IR, and overcome its challenges, and how did that affect its competitiveness?
3. What personnel skills were able to ensure the successful implementation of the 4IR?
4. How can a theoretical framework for effective use of the 4IR as a competitive advantage for the South Durban Basin be developed?

1.6 Significance of the study

The significance of this study lies in its exploration of how companies in the South Durban Basin are navigating the challenges and opportunities presented by the 4IR. As noted by the United Nations Environment Programme (2021), the ability to adapt and evolve quickly is essential for the survival of organizations. This study, therefore, assesses the readiness and adaptability of these companies in embracing 4IR technologies and strategies. By examining the experiences of companies in this industrial hub, the study provides insights into their understanding of 4IR concepts and the degree to which they are prepared to implement necessary changes. Furthermore, it draws on lessons from earlier industrial revolutions, offering valuable benchmarks for measuring the effectiveness of 4IR strategies.

The findings of this research are highly significant for business owners and managers. In a rapidly changing technological environment, the ability to lead organizations through the complex demands of 4IR is crucial for sustained competitiveness. The study's conclusions will assist in guiding companies on how to successfully implement 4IR strategies, which is vital not only for their own growth but also for the broader advancement of the South African economy. By equipping businesses with insights on adapting to this new era, the study contributes to the national goal of leveraging 4IR for economic progress.

1.7 Delimitation of the study

The study was limited to the area of the South Durban Basin in Durban and not to the rest of South Africa. There are various business sectors in the South Durban Basin and because of the red tape in some organizations that falls outside of the control of the researcher, such companies

even if they were in the sample, had to be omitted. Due to the recent unrest which was followed by the flooding in Durban and particularly the South Durban Basin, the sampling technique had to consider the companies that were affected by the unrest and flooding, dropping those that were forced to shut down. As much as that had the potential to negatively affect the sampling frame, the researcher made every effort to ensure that respondents had an equal chance of taking part in the study to ensure the study's validity and reliability.

1.8 Limitations

The limitation of the study was the fact that some organizations considered the subject under investigation to be intellectual property and felt uncomfortable disclosing some of their trade secrets. To mitigate this limitation, the researcher made all attempts to assure the respondents of the confidentiality of the information they gave. The second limitation was that most companies if not all companies in the area were affected by the July 2021 unrest and vandalism followed by the severe floods in April 2022. The researcher had to find the companies that have recovered and are in operation and left out those that are still closed.

1.9 Summary of the research procedures

The study used a mixed-method study approach. According to Creswell and Plan-Clark (2018), the mixed-method approach involves collecting and analysing data using qualitative and quantitative methods within a single study to integrate the strengths of both methods. The researcher used mixed methods in the three (3) stages of the research: (a) data collection, (b) data analysis, and (c) data interpretation. In the data collection stage, the researcher used qualitative and quantitative methods to collect data. In the data analysis stage, the researcher used a statistical technique to analyse the quantitative data and used thematic analysis to analyse the qualitative data. In the interpretation stage, the researcher integrated the findings from both quantitative and qualitative analysis to arrive at a more comprehensive understanding of the research question or problem leading to a more informed understanding and better outcomes.

1.9.1 Research design

Sekaran and Bougie (2016) define a research design as a blueprint or plan for collecting, measuring, and analysing data, created to answer the research questions. According to Kheider (2017), human beings by their nature have the vital instinct of inquisitiveness for, when the unknown confronts them, they probe further to reach a full understanding of the unknown.

Consequently, Letchford (2020) suggests that this curiosity is the foundation of all knowledge and the method that staff employs for obtaining knowledge of whatever the unknown can be termed research. Furthermore, Hosier (2019) states that research is an academic activity and as such the term research should be used in a technical sense, and it should be used both as a source of knowledge and a systematic method of finding a solution to a problem. In a quest to find solutions, research uses a scientific and different approach to discover answers to existing problems. The study can be classified as an explanatory study as it is intended to build on both exploratory and descriptive research to explain how companies embraced the 4IR as a competitive strategy. Lelisa (2018) argues that explanatory research is conducted to discover and report some relationships among various aspects of the study. The study aims to supply evidence to support the relationship between the companies' use of the 4IR and how that has resulted in their competitive advantage, hence the explanatory research design.

According to Leavy, (2017), mixed methods research involves collecting, analysing, and in some way integrating both quantitative and qualitative data in a single project. In line with this assertion, the researcher employed both the quantitative and the qualitative methods in the study. The phases of a research project are integrated or synchronised, with the quantitative phase influencing the qualitative phase or vice versa. In this case, the mixing took place in all three stages of the study such as data collection, data analysis, and interpretation, called concurrent mixing. In other words, the mixed methods helped the researcher to answer questions that would not have been answered using qualitative or quantitative methods alone.

1.9.2 Research context

The context of the research is the area of the South Durban Basin which is found South of Durban from the Durban harbour stretching down to the Amanzimtoti in the South. EThekweni Metro (2020) argues that the area of the South Durban Basin area is an economic hub of the City in that it is highly industrialised with major petroleum companies and various manufacturing plants. It is also closer to residential areas such as Lamontville, Umlazi, Wentworth, Kwamakhutha, Umbumbulu, and other areas supplying the labour force. Below, is a map of the industrial area of the South Durban Basin together with the residential areas that supply it with labour and the economic landmarks such as major roads, railways, and the location of the major industries:

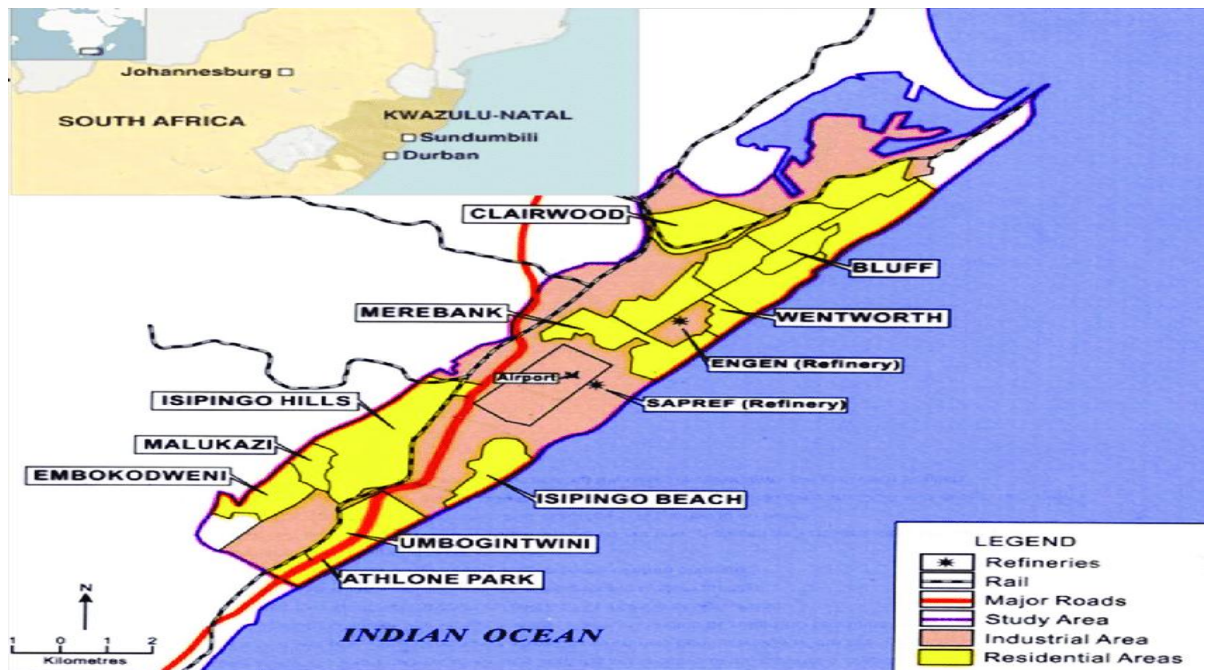


Figure 1:1 Map of the study area

Source: Researchgate (2022)

As illustrated in the map above, the area has residential areas as well as industrial activities such as a paper mill, a sugar refinery, two oil refineries, and chemical industries. The fact that the area is characterised by residential areas that can supply labour to the industrial processes, and flowing traffic makes the area more susceptible to industrial development. The interest of the study is on the effect of the 4IR on employment, how businesses conduct their operation using 4IR as a competitive strategy, and the direct impact on human lives.

1.9.3 Target population

Saunders, Lewis, and Thornhill (2019) argue that when conducting research, the data must be collected from a defined group, referred to as the population. In this study, the target population comprised small and medium-sized companies situated in the South Durban Basin area, with a total population of 320 participants. From this population, 200 participants were selected, with 160 involved in the quantitative study and 40 in the qualitative study. The nature of the study and the questions posed made it appropriate for individuals in senior management to provide responses, given their authority to comment on the strategic direction of their companies. Therefore, the respondents consisted of senior management from the selected companies.

1.9.4 Sampling techniques

Taherdoost (2020) argues that sampling techniques can be divided into probability sampling and non-probability sampling. Considering both types of sampling techniques, the researcher used the probability sampling technique. According to Maree (2017), the probability sampling technique is an objective sampling method where all elements in the target population have an equal chance of being selected to become part of the sample. Rahi (2017) further suggests that probability sampling is further divided into four categories such as simple random sampling, systematic random sampling, stratified random sampling, and cluster sampling. According to Saunders et al. (2019) a sample design must be representative, reliable, and proper for the research study hence the selection of systematic random sampling which is a type of probability sampling where the first sampling point is selected at random, and the rest of the participants are selected at regular intervals. Taherdoost (2017) believes that the advantage of this type of sampling technique is its simplicity. Systematic random sampling was selected in the study because it is simpler, more convenient, and quicker than the use of random numbers in simple random sampling.

1.9.5 Chosen sample and sample size

Maree (2017) argues that the type of research decides the sample size. Due to the nature of the study, the sample for the qualitative approach is a total of forty (40) medium companies based in the South Durban Basin area south of Durban. The study is a mixed method study and therefore the sample size for the quantitative method is a total of one hundred and sixty (160) respondents. A preliminary study revealed that there are three hundred and twenty (320) SMEs in the area under investigation. Taherdoost (2017) states that what is considered an adequate sample depends on the sample selected compared to the complexity of the population, the aims of the researcher, and the kinds of statistical manipulation that will be used in data analysis. Saunders et al. (2019) further suggest that the choice of sample size is governed by the confidence you need in your data, the margin of error that you can tolerate, the types of analyses you are going to undertake, and the size of the total population from which your sample is being drawn. Using systematic random sampling the sample size for the qualitative method is set at forty (40) companies being the sample size and hundred and sixty (160) companies being the sample size for the quantitative study. The respondents for both qualitative and quantitative methods was the senior managers who handle the strategic direction of the companies being investigated.

For a quantitative study, the researcher used a questionnaire to collect data from 160 senior managers or supervisors, one from each selected organization to gather the quantitative data. The

formula to select the quantitative research respondents was 320 divide by 160 equals 2. This means that every second member of the sample frame was chosen for the study. The motivation for using systematic random sampling is to end the element of bias in the selection of participants. The systematic random sampling technique guarantees representability, reliability, and simplicity and as such is proper for the research study. Bryman, Bell, and Hirschsohn (2021) caution that when systematic sampling is employed, it is important to ensure that there is no inherent ordering of the sampling frame, since that may bias the resulting sample. This caution was taken into account when conducting the sampling process.

1.9.6 Research Instruments

Having considered all the alternatives available and the need for more reliable conclusions, the researcher used semi-structured, face-to-face interviews where the researcher asked a set of predetermined questions to collect the qualitative data. According to Sekaran and Bougie (2016), the main advantage of face-to-face or direct interviews is that the researcher can adapt the questions as necessary, clarify doubts, and ensure that the responses are properly understood, by repeating or rephrasing the questions. When this method is employed, the researcher can also pick up nonverbal cues from the respondent. Any discomfort, stress, or problems that the respondent experiences can be detected through non-verbal signals such as frowns, nervous tapping, and body language unconsciously shown by the respondent. The non-verbal cues make it possible to detect meanings that would have been impossible to detect in a telephone interview.

In addition to the above, Leavy (2017) states that successful interview research is dependent on building rapport with the participants through active listening. Eye contact and gestures can go a long way to showing participants that the interviewer is interested in what the respondents are saying, and that the interviewer wants them to continue. In the study, face-to-face interviews was chosen because it enables the interviewer to interpret the non-verbal signals and ease the discomfort that might arise during the interview while clarifying any confusion that might need clarity during the process of data collection. It also makes the interviewer adapt the interview and make follow-up questions for clarity as and when the need arises. The electronic questionnaires with closed-ended questions were used to collect the quantitative data. The questionnaires were emailed to 160 companies in the South Durban Basin. The questionnaire was designed to capture demographic information, and organizational classification such as type of organization, size of an organization, and the Likert scale questions to rate the attitude of the employees towards the 4IR.

1.9.7 Data collection techniques

Paradis, O'Brien, Nimmon, Bandiera, and Martimianakis (2016) argue that data can be collected using interviews, surveys, focus groups, and observations. According to Ndukwu (2020), the choice of a data collection technique depends on the goal of the research and the tools available for analysis and any research is as good as the data that drives it, so choosing the right technique of data collection is the determining factor in the strength of the study. Consequently, due to the limited time, the researcher employed a mixed method and a mixed instrument to collect data. The researcher used a semi-structured type of interview for the respondents to answer predetermined types of qualitative questions. This was done in the face-to-face interview to manage all other factors that are relevant to the research, including non-verbal signs from the respondents. Because this is a mixed-method study and encompasses both qualitative and quantitative methods, questionnaires were also emailed to the respondents to collect quantitative data. Creswell and Plano Clark (2018) state that the mixing of the two types of data might occur at several stages of the research process, i.e. data collection, data analysis, or interpretation, or all three, and in the study, the mixing took place in all three stages of the study.

1.9.8 Data analysis

Considering that the researcher was faced with loads of data that needed a great deal of sorting and the process of data reduction necessary to convert data into information, the researcher used Busetto, Wick, and Gumbinger's (2020) suggestion to transcribe interviews verbatim with annotations for behaviour, followed by coding, labelling, and tagging the transcripts into paragraphs or sentences. The researcher used SPSS version 29.0 to analyse quantitative data and used NVivo version 20 to analyse the qualitative data. As soon as the data was coded the researcher returned to the research questions to see if the responses were responding to the research questions. Where the answer was negative, this meant that the data collection or analysis was not yet complete, and the researcher gathered more data to fill out the emerging theoretical contribution until such time that the codes and emerging analysis were theoretically saturated.

Tracy (2013) states that early in the research process, researchers often do not know why they are taking notes or what they are looking for. Similarly, Creswell and Plano Clark (2018) suggest that the researcher might have a primary aim to collect one form of data and have the other form of data supply supportive information. In line with this view, the study used quantitative data to support qualitative data. The researcher constantly turned back to the literature review section as often as possible to show issues not yet found in the data. By testing the propositions against the data, the researcher was able to move towards the development of valid and sound conclusions.

This process enabled the researcher to interpret the data and be able to draw reliable conclusions from the study.

1.10 Organisation of the study

The subsequent chapters of this thesis are meticulously structured to provide a comprehensive exploration of the research undertaken. This section delineates the roadmap followed in delineating the multifaceted dimensions of the study.

Chapter 1

This chapter presents an overview of the research undertaken. That included the introduction, background to the study, problem statement, research objectives, research questions, the significance of the study, scope, and justification of why the study was necessary. A summary of the research method together with an explanation of why such a method was employed, was presented. The chapter provides an overview of all the chapters.

Chapter 2

This chapter presents a literature review by various authors on the research problem. The researcher examines the extent to which the previous authors have tried to answer the research questions.

Chapter 3

This chapter presents a theoretical framework that underpins the study. It delves into various theoretical perspectives, models, and concepts relevant to the subject matter, providing a comprehensive understanding of the theoretical landscape within which the study operated.

Chapter 4

This chapter deals with the research method employed in the study such as research design, research approach, research paradigm, research philosophy, data sources, data collection techniques, and sampling techniques. The chapter also discusses how data was interpreted.

Chapter 5

This chapter presents the quantitative data analysis and results of the study. It outlines the methods employed to analyse the data collected, such as statistical tests or modelling techniques. The chapter delves into the results obtained from the analysis, highlighting key trends, patterns, and correlations identified within the data.

Chapter 6

This chapter gives the qualitative data analysis and discussion. The chapter delves into the process of analysing qualitative data collected during the research, exploring themes, patterns, and insights derived from the data. Additionally, it engages in a comprehensive discussion of the findings, connecting them to relevant literature, theories, and research questions.

Chapter 7

This chapter presents the results of the research study and serves to elucidate the main discoveries of the study and their implications for the field of research. It also outlines the key findings discovered during the research process and delves into the significance of these findings within the broader context of the study's objectives.

Chapter 8

This chapter presents the conclusions and recommendations of this study. The final chapter typically serves as the culmination of a thesis. It summarises the key findings and insights derived from the preceding chapters or sections. In this chapter, the researcher provides a concise summary of the main conclusions drawn from the study or analysis conducted, including highlighting the significant results, trends, patterns, or insights uncovered through the research process. Additionally, the chapter includes recommendations based on the conclusions reached. These recommendations suggest further research directions, propose practical applications of the findings, and offer suggestions for policy and future research.

1.11 Chapter Summary

This chapter introduces the study. It supplies an understanding of the concept of the 4IR and defines the research problem underpinning the research questions and aims that the study tries to answer. The methodological stance and the justification for such are discussed together with the

expected contribution of the study to the new body of knowledge. The organization of the study is also explained. The study focuses on the impact of the 4IR on the South African economy with reference to the South Durban Basin area in Durban, South Africa. Presidential commission (2020), describes the South Durban Basin as the industrial hub of Durban, KwaZulu-Natal, stretching from the Port of Durban in the North to Amanzimtoti in the South. According to the eThekweni Metro (2020), the area is the economic hub of the region with the following sub-sectors; fuel, sugar industries, petroleum, rubber and chemical industries, food, beverages and tobacco, transport equipment, metal products, machinery, household appliances, petroleum refineries, a paper mill, and motor manufacturers.

This chapter sets the tone for the entire study by giving a background to the study, giving a rationale for the study, giving the research problem, providing the research aims and research questions that attempt to answer the research problem, and outlining the rationale of the study. It also dealt with issues such as how ethical considerations were seen and handled. This chapter gave a clear methodological position of the study and justification of those decisions. Based on the nature of the study, the researcher employed both quantitative and qualitative methods of the study, and that choice is justified in the study. The study area, target population, sampling size, and techniques are explained. Research instruments, together with how they were operationalised are discussed. The researcher has also argued that validity and reliability were ensured while ensuring that ethical consideration was also ensured in the study. The next chapter looks at the secondary data on the 4IR to find the gaps that might be necessary for the current study to fill.

CHAPTER 2

Literature review

2.1 Introduction

The literature review in this chapter serves as a comprehensive exploration of the Fourth Industrial Revolution (4IR) and its implications on companies, with a particular focus on the South Durban Basin. The purpose is to contextualise the various viewpoints raised by various writers and narrow them down to the South African context for the benefit of the broader South African economy. The review is structured to provide a thorough understanding of the historical context of industrial revolutions, leading up to the current 4IR. Additionally, it delves into the opportunities created and challenges posed by the 4IR, drawing insights from various writers. The chapter begins with an examination of the history of industrial revolutions, emphasising the transitions from the first to the fourth. This historical overview sets the stage for understanding the evolutionary path that led to the 4IR and highlights the transformative nature of technological advancements in each revolution. The literature review then engages with a variety of perspectives from different writers, elucidating the opportunities and challenges introduced by the 4IR. Insights from experts and scholars contribute to a broader understanding of how technological advancements impact businesses globally and shape their competitive landscape.

The central focus of the literature review is to analyse the views of various writers regarding how the 4IR can contribute to companies' competitive advantage. It explores strategies and frameworks proposed by scholars for effectively managing the challenges associated with the rapid changes brought about by the 4IR. The review transitions from a general perspective to the specific context of South Africa. It highlights the unique challenges and opportunities presented by the 4IR in the South African business landscape, addressing economic, social, and technological aspects. The literature review narrows down its focus to the South Durban Basin, examining the implementation of the 4IR in this particular region. It scrutinizes the readiness and willingness of key stakeholders in the South Durban Basin to embrace the 4IR, exploring the implications for local businesses and industries. Several key topics are discussed within the South Durban Basin context, including the implementation of the 4IR technologies, the willingness of stakeholders to adopt these technologies, and the roles of government and higher education institutions in fostering a conducive environment for the 4IR. The literature review concludes by examining the broader implications of the 4IR on the future of jobs. It also explores the general

understanding of the 4IR concept among stakeholders in the South Durban Basin, shedding light on the perceptions and challenges associated with workforce transitions in the face of technological advancements. This detailed literature review provides a robust foundation for the subsequent chapters, offering a comprehensive overview of the historical, global, and localized dimensions of the 4IR, ultimately guiding the exploration of the South Durban Basin's specific dynamics in the context of this transformative industrial era.

2.2 The history of industrial revolutions

The term “industrial revolution” has become a fundamental concept in understanding the trajectory of modern human history. According to Olaitan, Issah, and Wayi (2021), the term industrial revolution generally describes a period where technological transformations culminate in dramatic and tremendous changes in a socio-economic situation of people and countries. In their view, for any change to be termed revolutionary in nature, it must encapsulate periods marked by profound technological advancements that catalyse significant socio-economic transformations. Other scholars such as Gleason (2018) and Levin (2018) have delved into the origins and implications of this concept, shedding light on its historical significance and ongoing relevance in contemporary discourse. Gleason (2018) traces the terminology of the industrial revolution back to Arnold Toynbee's work in 1884, specifically his “Lectures on the Industrial Revolution”. Toynbee's insights provided a framework for understanding the sweeping changes that occurred during this epoch, laying the groundwork for subsequent scholarly analysis and debate. By labelling this period as a “revolution”, Toynbee emphasized the transformative nature of the technological innovations and societal upheavals that characterized it.

Building upon Toynbee's foundation, Levin (2018) expands the discourse by delineating three distinct industrial revolutions that have shaped the global economy. This conceptualization has gained widespread acceptance, finding resonance in forums such as the World Economic Forum. Levin (2018) outlines a chronological progression, identifying key technological breakthroughs and their socioeconomic ramifications. The First Industrial Revolution, spanning the period from approximately 1760 to 1840, was characterized by the harnessing of steam power and the mechanization of textile manufacturing. This era witnessed the emergence of factories and the mechanization of labour, fundamentally altering the economic landscape and social fabric of society. The Second Industrial Revolution, occurring from the late 19th century to the early 20th century, introduced electricity, mass production techniques, and the division of labour. Innovations such as the assembly line revolutionised manufacturing processes, leading to unprecedented levels of productivity and economic growth. The Third Industrial Revolution

unfolded during the early 1970s with the advent of electronics, information technology, and automated production. This era witnessed the proliferation of computers, telecommunications networks, and robotics, reshaping industries and labour markets on a global scale.

According to Schwab (2017) each industrial revolution represents a paradigm shift propelled by technological innovation, impacting not only the means of production but also social relations, cultural practices, and geopolitical dynamics. These revolutions are not isolated events but interconnected stages in a broader narrative of human progress and transformation. Moreover, the concept of industrial revolutions serves as a lens through which to analyse contemporary developments and anticipate future trajectories. As we stand on the cusp of the fourth industrial revolution, characterised by advancements in artificial intelligence, biotechnology, and renewable energy, understanding the lessons of history becomes imperative for navigating the complexities of the present moment.

The discourse surrounding the industrial revolution is multifaceted, encompassing historical, technological, economic, and socio-political dimensions. Scholars like Gleason (2018) and Levin (2018) have contributed to this discourse by elucidating its origins, delineating its stages, and contextualising its implications within broader historical narratives. By grappling with the complexities of industrial revolutions past and present, we gain insight into the dynamics of innovation, progress, and societal change that continue to shape our world. The discourse surrounding the 4IR has gained significant traction in recent years, particularly in academic and business circles. Serumaga-Zake and Van der Poll (2021) provide a comprehensive analysis of the foundations and implications of the 4IR, building upon the ideas put forth by Klaus Schwab, the founder of the World Economic Forum. Schwab (2017) posits that the 4IR represents a departure from previous industrial revolutions due to its integration of physical, digital, and biological technologies, thereby transforming various aspects of business and industry.

Figure 1.1. below shows the progression of the four industrial revolutions that have happened in the world. These are referred to as the “First Industrial Revolution,” “The Second Industrial Revolution,” “The Third Industrial Revolution”, and the “Fourth Industrial Revolution.” A diagram reflecting the progression of the four industrial revolutions (4IR) is highly relevant in the study of the 4IR. By providing a visual representation of the progression of the industrial revolutions, a diagram allows individuals to quickly grasp the key concepts and understand the chronological evolution of industrialization. A diagram allows for easy comparison between the

different industrial revolutions, facilitating a comparative analysis of their characteristics, drivers, and outcomes.

A diagram reflecting the progression of the four industrial revolutions is highly relevant in the study of the 4IR as it provides a visual framework for understanding the historical context, comparing different stages of industrial development, informing strategic decision-making, facilitating education, and fostering awareness and discourse about the ongoing digital transformation and its implications for society and the economy.

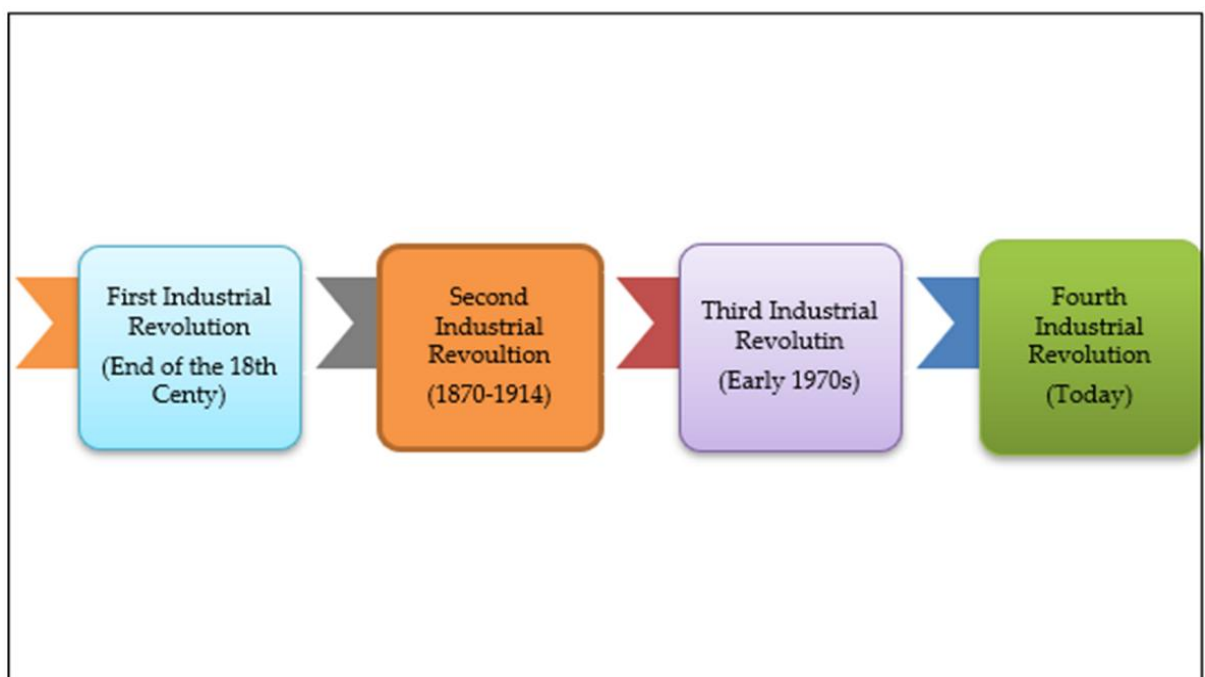


Figure 2:1 The four Industrial Revolutions

Source: Mhlanga (2022)

One of the key contributions of Serumaga-Zake and Van der Poll (2021) is their identification of four main spheres of business affected by the 4IR: customer expectations, product enhancement, collaborative innovation, and organizational forms. These spheres encapsulate the multifaceted impact of the 4IR on businesses, from reshaping consumer behaviour and demands to fostering new modes of collaboration and organisational structures. This analysis underscores the profound changes that the 4IR brings about in the way businesses operate and compete in the global marketplace. Moreover, Serumaga-Zake and Van der Poll (2021) emphasise that the ramifications of the 4IR extend far beyond the realm of business, profoundly altering how humans relate, live, and work. This observation aligns with Schwab's assertion (2017) that the 4IR represents a

fundamental shift in the human experience, driven by the convergence of various technological domains. As such, the 4IR heralds not only technological advancements but also socio-economic and cultural transformations on a global scale.

To contextualise the emergence of the 4IR, Waghid, Waghid, and Waghid (2019) draw parallels with previous industrial revolutions, elucidating how each revolution has shaped human civilisation. The First Industrial Revolution, characterized by the harnessing of steam power and the proliferation of railroads, marked a significant departure from agrarian societies, enabling rapid urbanisation, population growth, and advancements in transportation and communication. Subsequent revolutions, propelled by electricity and computing technologies, further accelerated human progress, facilitating mass production and enhancing connectivity on a global scale. By comparing the historical trajectory of industrial revolutions with the advent of the 4IR, Waghid, Waghid, and Waghid (2019) underscore the evolutionary nature of technological innovation and its transformative impact on human society. The 4IR, they argue, represents the culmination of previous revolutions while introducing unprecedented levels of integration and complexity across technological domains.

The academic discourse surrounding the 4IR encompasses a range of themes, including its foundational principles, its implications for business and industry, and its broader socio-economic and historical context. By synthesising insights from scholars such as Schwab, Serumaga-Zake, Van der Poll, and Waghid, a comprehensive understanding of the 4IR emerges, highlighting both its disruptive potential and its capacity to reshape the fabric of human civilization. Peters (2017) offers a chronological perspective, delineating the progression from the First Industrial Revolution characterized by steam and mechanical production to the contemporary era of cyber-physical systems. This evolution signifies not only technological advancements but also shifts in the nature of production, management, and governance, indicating a transformative impact on global systems. Gleason (2018) contributes to this discussion by emphasising the foundational role of technology in driving industrial revolutions. He traces the origins of the First Industrial Revolution to the harnessing of water and steam power, highlighting the quest for systematic and efficient manufacturing processes. This historical perspective underscores the notion of continuity and progression in technological innovation, culminating in the contemporary discourse on the 4IR. In contrast, Schwab (2017) presents a more radical interpretation of the 4IR, emphasising its distinctiveness from previous revolutions. He contends that the fusion of physical, digital, and biological technologies constitutes a paradigm shift that transcends disciplinary boundaries, impacting economies and industries on a global scale. This characterisation underscores the

disruptive potential of the 4IR, suggesting a departure from linear models of technological advancement towards more complex and interconnected systems.

The perspective offered by the South African Presidential Commission on the 4IR (2020) adds a novel dimension to the discourse by highlighting pre-colonial industrial capabilities in regions like Mapungubwe (modern-day Zimbabwe, Botswana, and South Africa). By contextualising the 4IR within a broader historical narrative, the Commission emphasises the potential for leveraging technology to address contemporary developmental challenges. This perspective underscores the transformative potential of the 4IR not only in terms of economic competitiveness but also in addressing social and human development issues such as health, education, and food security. The discussion surrounding the 4IR encompasses historical, technological, and socio-economic dimensions. While differing perspectives exist regarding its nature and significance, there is a consensus on its transformative potential and the need for proactive engagement to harness its benefits for global progress. This discourse underscores the importance of understanding the 4IR not merely as a technological phenomenon but as a complex interplay of historical legacies, contemporary innovations, and future possibilities.

Furthermore, Schwab (2017) argues that the 4IR is not merely about smart and connected machines, but encompasses a wide range of technologies and fields, including gene sequencing, nanotechnology, renewables, and quantum computing. This revolution involves the fusion of these technologies and their interaction across physical, digital, and biological domains, distinguishing it fundamentally from earlier industrial revolutions. However, Gastrow (2018) raises concerns about South Africa's potential inability to fully capitalize on the 4IR, attributing this to the country's historical disengagement from earlier industrial revolutions. He provides a historical analysis to explain why South Africa did not participate in the previous three revolutions. According to Berg and Hudson (2023) during the First Industrial Revolution, Africa, including South Africa, was significantly impacted by the slave trade. They argue that this exploitation and suffering hindered the region's ability to engage with the transformative technological developments occurring elsewhere in the world. Reid (2020) further suggest that in the Second Industrial Revolution, while the world experienced rapid industrialisation and technological advancement, Africa was undergoing colonisation and partitioning. This colonial subjugation stifled indigenous development and innovation, further marginalising the continent from global technological progress. The Third Industrial Revolution coincided with Africa's struggle for decolonisation. The emergence of independent nations was often fraught with

challenges such as proxy governments, dictatorships, conflicts, and instability, diverting attention and resources away from technological advancement.

Gastrow's historical narrative underscores the significance of the present moment for Africa. He warns that failing to position itself within the 4IR could perpetuate the continent's marginalization in the global development process. As the most technologically advanced and industrialised nation on the continent, South Africa bears a collective responsibility to lead Africa into the 4IR. To address the challenges, South Africa must prioritise investment in education, research and development, infrastructure, and innovation. Collaboration with international partners and leveraging existing strengths in sectors such as mining, agriculture, and information technology can facilitate the country's integration into the 4IR. The statements provided by the Presidential Commission on 4IR (2020), Andreoni and Anzolin (2019), and Xing and Marwala (2017) offer valuable insights into the role of governance, industrial policies, and societal readiness in navigating the complexities of this technological revolution. Firstly, the Presidential Commission on 4IR (2020) underscores the opportunity for South Africa to leverage targeted industrial development strategies and technological innovation to drive economic value and enhance societal well-being. This assertion aligns with the broader narrative that the 4IR presents unprecedented opportunities for countries to leapfrog into new economic paradigms by embracing emerging technologies and fostering innovation ecosystems. Furthermore, Andreoni and Anzolin (2019) advocate for the proactive role of industrial policies in shaping technological change within sectors and across society. Historically, industrial policies have played a crucial role in guiding countries through previous industrial revolutions, and the 4IR is no exception. By formulating strategic policies that incentivise investment in key technological domains, South Africa can position itself to harness the transformative potential of emerging technologies while mitigating the risks of exacerbating existing inequalities.

Moreover, Xing and Marwala (2017) highlight the converging nature of the 4IR, where advancements in technology blur the traditional boundaries between disciplines such as humanities, social sciences, and STEM (Science, Technology, Engineering, and Mathematics). This interdisciplinary convergence necessitates a holistic approach to governance and policy formulation that transcends ordinary thinking and embraces cross-disciplinary collaboration. By fostering synergies between different fields of knowledge, South Africa can foster a more inclusive and interdisciplinary approach to tackling the complex challenges posed by the 4IR. However, it is essential to recognize that governance and policies alone are not sufficient to ensure the successful implementation of the 4IR initiatives. As emphasised in the discussion, creating a

conducive environment with a willingness to implement policies is equally critical. This underscores the importance of political will, stakeholder engagement, and institutional capacity-building in driving forward the 4IR agenda. Without a collaborative effort from government, industry, academia, and civil society, the full benefits of the 4IR may remain elusive.

The arguments presented highlight the pivotal role of governance, industrial policies, and interdisciplinary collaboration in enabling South Africa to harness the opportunities presented by the 4IR. By embracing targeted industrial development strategies, shaping technological change through proactive policies, and fostering interdisciplinary convergence, South Africa can position itself as a frontrunner in the global 4IR landscape while advancing societal well-being and inclusive economic growth. Understanding the historical trajectory of industrial revolutions provides valuable insights and lessons that can inform the effective implementation of the 4IR.

2.3 Legal services in the South Durban Basin

In the context of the South Durban Basin, legal services serve as a critical linchpin in shaping industrial activities, especially within the framework of the 4IR. The integration of big data and 4IR technologies in this region not only opens new avenues for industrial growth but also introduces a multitude of legal complexities, particularly in areas such as environmental regulation, labour laws, and compliance with evolving regulatory frameworks. The South Durban Basin, characterised by its concentration of heavy industries, faces unique environmental and social challenges, which are exacerbated by its industrial landscape. Leonard and Lidskog (2021) underscore that these challenges necessitate robust legal interventions to mitigate environmental harm, ensure regulatory compliance, and safeguard the rights of communities adversely affected by industrial activities. Legal professionals, therefore, play an indispensable role in guiding industrial entities through the regulatory landscape, particularly in areas such as pollution control, waste management, and emission regulation, which are critical in this heavily industrialised region.

The legal challenges within the South Durban Basin are further complicated by the reliance of its industries on a large labour force from the surrounding residential areas. The advent of 4IR technologies, such as automation and artificial intelligence, presents significant implications for labour law, particularly in terms of job displacement, worker rights, and adherence to fair labour practices. As industrial processes become increasingly digitised, legal professionals must ensure that companies uphold regulations designed to protect workers from unfair dismissals and unsafe

working conditions. The intersection of legal services and labour law is crucial in balancing the benefits of technological advancement with the protection of workers' rights, a task that becomes even more significant in a region as heavily industrialised as the South Durban Basin.

Moreover, stakeholder participation is fundamental to the successful implementation of 4IR strategies in this region, as highlighted by Reed (2019). Legal services are essential in facilitating negotiations and establishing agreements between various stakeholders, including businesses, labour unions, and local communities. Issues such as land use, compensation for displaced residents, and the establishment of public-private partnerships are deeply intertwined with legal frameworks. Legal practitioners provide the guidance needed to navigate these often-contentious issues, ensuring that all parties' rights are protected and that the 4IR technologies are integrated in a manner that promotes sustainable industrial growth.

Intellectual property law is another domain where legal services in the South Durban Basin have become increasingly significant. The integration of 4IR technologies has heightened the need for businesses to protect their innovations, whether through patents, copyrights, or licensing agreements. Legal professionals ensure that companies are aware of and comply with intellectual property laws, thus fostering innovation while safeguarding the competitive interests of industrial entities in the region. As 4IR technologies reshape the industrial landscape, effective legal services ensure that companies in the South Durban Basin can fully harness these technologies while mitigating the legal risks associated with them.

The convergence of big data and 4IR technologies also presents transformative opportunities for addressing the region's environmental and social challenges. These technologies can be leveraged to optimize industrial processes, improve sustainability initiatives, and promote inclusive economic development. Padayachee and Mukomana (2019) note that Durban's strategic location has established it as an economic hub in South Africa, but failure to capitalise on 4IR technologies risks leaving the region's potential untapped. The Department of Trade and Industry (DTI) has identified the manufacturing sector as a cornerstone of the South African economy, owing to its strong employment linkages, contributions to the balance of payments, and generation of export earnings. The South Durban Basin, home to two of South Africa's four oil refineries and Africa's leading chemical storage facilities, is a vital industrial center contributing 8% of the country's GDP (Leonard & Lidskog, 2021; Serafini, 2018).

However, despite its industrial significance, the South Durban Basin faces persistent challenges, including high levels of income inequality and social discontent, exacerbated by the impact of industrial activities on the local population. The Prosperity Fund (2019) emphasizes that the region's economic growth, driven by its highly industrialised nature, is accompanied by socioeconomic disparities, with migrants providing labour to industries while living in informal settlements. Legal services are crucial in addressing these disparities, ensuring that industries comply with both environmental and labour laws, and protecting the rights of the most vulnerable populations.

The implementation of 4IR strategies also necessitates a broad-based participation process involving all stakeholders. Reed (2019) advocates for long-term stakeholder involvement, emphasising that inclusive participation is key to the successful adoption of 4IR technologies. Public participation in decision-making processes can help address challenges that arise from the implementation of 4IR strategies, ensuring that the interests of all stakeholders including industries, labour organisations, and local communities are adequately represented. This broad participation is particularly important in addressing the concerns of industries and communities affected by the transition to e-hailing systems and other 4IR-driven innovations that may disrupt existing forms of transportation and employment.

Hallward-Driemeier and Nayyar (2018) highlight the evolving symbiotic relationship between manufacturing and services in the context of the 4IR, suggesting that services are becoming an integral component of industrial value creation. By integrating advanced technologies such as artificial intelligence, automation, and the Internet of Things (IoT) into manufacturing processes, industries can enhance efficiency and productivity, while unlocking new avenues for market expansion. This shift toward a service-centric model of manufacturing holds significant implications for the South Durban Basin, where legal services will be instrumental in facilitating this transition, ensuring that businesses not only embrace new technologies but also comply with the regulatory frameworks governing their implementation.

Lastly, legal services in the South Durban Basin are fundamental to navigating the complex legal challenges posed by the 4IR. By ensuring compliance with environmental and labour laws, facilitating stakeholder participation, and addressing intellectual property concerns, legal professionals contribute to creating an industrial environment that maximises the opportunities presented by 4IR technologies while minimising the associated risks. As the region continues to

embrace 4IR innovations, the role of legal services in fostering sustainable and inclusive industrial growth will become even more critical.

2.4 Implementation of the Fourth Industrial Revolution

The implementation of the 4IR in South Africa undoubtedly holds immense potential for the country's economic growth and development. However, amidst the enthusiasm for technological advancements, it's crucial to acknowledge and address the significant challenges that stand in the way of its successful implementation. One of the foremost challenges facing South Africa is its persistent levels of inequality. While 4IR technologies have the capacity to revolutionise various sectors and improve living standards, they also have the potential to exacerbate existing inequalities if not managed properly. Schwab's assertion that technology should serve people, not enslave them, underscores the importance of ensuring that the benefits of technological advancement are equitably distributed across society.

According to Mamokhere (2019), in South Africa, a considerable proportion of the population lacks access to basic services such as electricity, water, healthcare, and education. This lack of access not only hampers individuals' ability to fully participate in and benefit from the digital economy but also widens the gap between the technologically empowered and the technologically marginalized. Thus, any meaningful implementation of the 4IR in South Africa must prioritise addressing these foundational issues of access and inequality. Moreover, beyond access to basic services, there are broader socio-economic challenges that need to be navigated. For instance, there is a pressing need to address unemployment, particularly among the youth, who are expected to bear the brunt of technological disruptions in the job market. The government must invest in upskilling and reskilling programs to ensure that the workforce is equipped with the necessary skills to thrive in an increasingly digitalised economy.

Additionally, there are concerns about the potential loss of traditional jobs as automation and artificial intelligence become more prevalent. Jacobs (2023) suggests that South Africa's transition to 4IR must be accompanied by robust policies that support job creation and ensure a just transition for those whose livelihoods are at risk of being displaced by technology. Furthermore, there are infrastructure challenges that need to be overcome to fully harness the potential of the 4IR. This includes expanding access to high-speed internet connectivity, upgrading digital infrastructure, and enhancing cybersecurity measures to safeguard against potential threats.

While the implementation of the 4IR in South Africa holds promise for driving economic growth and innovation, it is imperative that the government and other stakeholders take proactive steps to address the significant challenges that stand in the way. By prioritising equity, inclusivity, and sustainability in the adoption of the 4IR technologies, South Africa can ensure that technology serves as a tool for empowerment rather than further entrenching existing inequalities. Schwab (2017) emphasises an understanding and analysing of the challenges posed by technology and also underscores the importance of adopting a thoughtful and people-centered approach to 4IR implementation in South Africa.

According to Kegel (2019), the 4IR is a concept that focuses on production automation using cyber-physical systems and advanced manufacturing technologies. Additionally, Schultz, Aurik, Zuazua, and Blaylock (2018) state that 4IR enables companies to capitalise on production opportunities, mitigate risk and challenges, and be resilient and agile in responding to unknown future shocks. In line with the above arguments Peters (2017), argues that 4IR is the result of the integration and compounding effects of multiple exponential technologies, such as artificial intelligence (AI), biotechnologies, and nanomaterials. Therefore, based on this understanding, the 4IR extends the industrial revolution paradigm into a future where many of the elements of what we might consider industry-fixed and centralised factories, and massive labour forces within large corporations will no longer exist.

Cunningham (2018) argues that the 4IR stands as a hallmark of transformative change in contemporary society. Such a paradigm shift is not merely incremental but rather revolutionary, impacting the very fabric of society and economy. Cunningham (2018) emphasises that the 4IR has the potential to elevate digitally advanced nations to unprecedented levels of economic prosperity. This assertion is grounded in the notion that countries embracing digital transformation are better poised to harness the opportunities presented by 4IR technologies. By leveraging automation, artificial intelligence, Internet of Things (IoT), and other innovations, nations can enhance productivity, efficiency, and competitiveness across industries. Consequently, this could lead to significant economic growth and the creation of new market opportunities. Similarly, Olaitan et al. (2021) highlight the transformative impact of the 4IR on the nature of work and human relations in production. As new technologies emerge, they disrupt traditional job roles and necessitate the acquisition of novel talents and skills.

Automation and AI, for instance, may replace certain manual tasks, requiring workers to upskill or reskill to remain relevant in the labour market. Moreover, the integration of human and machine

capabilities can foster new modes of collaboration, potentially enhancing productivity and innovation in the workplace. However, the realisation of these potential benefits is contingent upon widespread engagement and discussion regarding the implementation of the 4IR technologies. As Cameron, Bashor, and Collins (2014) caution, the urgent need to address challenges such as population growth and climate change underscores the importance of leveraging 4IR advancements to enhance food production efficiency. With arable land becoming scarcer due to climate change, there is a pressing need to develop innovative solutions that can sustainably increase agricultural productivity.

Nonetheless, the successful adoption and integration of the 4IR technologies require more than just technological advancement; it necessitates comprehensive societal, regulatory, and ethical considerations. Gillwald (2021) cautions that without broad engagement and dialogue, there is a risk of significant lag time in realising the full potential of the 4IR. Issues such as data privacy, job displacement, and socio-economic inequality must be addressed through collaborative efforts involving governments, businesses, academia, and civil society. However, realising this potential requires proactive engagement, discussion, and collaboration to address the multifaceted challenges and opportunities associated with 4IR technologies. Only through inclusive and responsible implementation can societies harness the full benefits of this revolution while mitigating potential risks and ensuring equitable outcomes for all stakeholders.

South Africa stands at a crossroads, grappling with multifaceted challenges such as high unemployment rates, pervasive crime, and inadequate infrastructure. However, scholars like Alexander (2022) and Morsy (2020) offer a compelling perspective that reframes these challenges as potential opportunities for innovation and development. These papers delve into the academic discussion surrounding the notion that by harnessing its abundant human capital and leveraging technology, South Africa can transform its challenges into opportunities for progress and leapfrog many development hurdles. Alexander (2022) highlights the vast pool of unemployed individuals in South Africa who remain disengaged from the formal economy. Traditionally perceived as a liability, these individuals represent an untapped resource that could drive innovation and economic growth if incorporated into existing or new businesses. By providing education, skills training, and entrepreneurship opportunities, South Africa can harness this human capital potential. Furthermore, Morsy (2020) underscores the urgency of equipping the country's youthful demographic population with the requisite skills for future employment. Investing in education and vocational training programs tailored to emerging industries can empower the workforce and align their skills with market demands.

The prevailing challenges in South Africa, including crime, unemployment, and infrastructure deficiencies, present fertile ground for innovative solutions. Alexander (2022) posits that addressing crime could catalyse the growth of security technology companies, stimulating economic activity while enhancing public safety. Furthermore, by integrating unemployed individuals into these ventures, South Africa can simultaneously reduce crime rates and foster entrepreneurship. Similarly, infrastructure gaps provide opportunities for investment in technology-driven solutions, such as renewable energy and digital connectivity initiatives, which can spur economic development and enhance quality of life. Morsy (2020) emphasises the transformative potential of technology in overcoming development barriers. With its burgeoning youth population, South Africa possesses a demographic dividend that can be leveraged through technology-enabled education and skills training. By embracing digital platforms and innovative pedagogies, the country can democratize access to learning and prepare its workforce for the digital economy. Additionally, technology-driven initiatives can facilitate the delivery of essential services, mitigate logistical challenges, and bridge urban-rural divides, thereby accelerating progress across various sectors.

The perspectives offered by Alexander (2022) and Morsy (2020) underscore the importance of reframing challenges as opportunities for innovation and development in South Africa. By unlocking the potential of its human capital, harnessing technology, and fostering an ecosystem conducive to entrepreneurship, the country can chart a course towards inclusive growth and prosperity. However, realising this vision requires concerted efforts from policymakers, businesses, and civil society to invest in education, infrastructure, and technology-driven solutions that empower individuals and catalyse socio-economic transformation. Through strategic interventions and collaborative endeavours, South Africa can navigate its developmental challenges and emerge as a beacon of innovation and resilience on the African continent.

The discourse surrounding the impact of the 4IR on production systems and manufacturing efficiency has garnered significant attention in academic and industrial circles. The cited works by Raj Dwivedi, Sharma, Jabbour, and Rajak (2020), Lekhanya (2019), and Anand (2022) provide valuable insights into the transformative potential of the 4IR technologies on workflows, efficiency, and overall competitiveness in the manufacturing sector. Raj et al. (2020) assert that the advanced technologies associated with the 4IR, such as artificial intelligence, Internet of Things (IoT), robotics, and big data analytics, are reshaping traditional production systems. These technologies enable the digitization and decentralization of production processes, leading to enhanced effectiveness and efficiencies. The digitisation of workflows allows for real-time monitoring, data-driven decision-making, and seamless integration across various stages of

production. Furthermore, decentralisation facilitates distributed manufacturing and agile responses to market demands, thereby improving overall operational efficiency. Central to the discussion is the notion that efficiency in manufacturing translates directly to profitability. By leveraging 4IR technologies, manufacturers can optimize resource utilization, minimize waste, and streamline operations, ultimately maximising revenue growth. This aligns with conventional wisdom within the manufacturing domain, where cost reduction and productivity enhancement are primary objectives for sustainable business success.

Building upon this premise, Lekhanya (2019) emphasises the broader societal implications of the 4IR beyond mere efficiency gains. The integration of advanced technologies not only transforms production processes but also redefines the nature of work and human interactions within the manufacturing ecosystem. Automation and digitisation lead to shifts in job roles, skill requirements, and organizational structures. Additionally, the interconnectedness facilitated by 4IR technologies enables greater collaboration, knowledge sharing, and innovation, thereby enhancing the quality of life for individuals involved in the manufacturing sector. Anand (2022) extends this discussion by highlighting the critical role of operational intelligence in achieving efficiency within the 4IR paradigm. Real-time performance monitoring, predictive analytics, and adaptive control systems enable manufacturers to optimise resource allocation, mitigate risks, and respond swiftly to dynamic market conditions. By harnessing these capabilities, manufacturers can achieve tangible benefits such as reduced manufacturing costs, increased flexibility, and enhanced agility in adapting to changing customer preferences and market disruptions.

The cumulative arguments put forth by these scholars underscore the multifaceted impact of the 4IR technologies on manufacturing efficiency and competitiveness. From improving operational effectiveness to enhancing the overall quality of life for stakeholders, the transformative potential of the 4IR is vast and profound. However, Anand (2022) asserts that the realization of these benefits hinges upon the willingness of all stakeholders to embrace change is crucial. Adoption barriers such as technological inertia, skill gaps, and organisational resistance must be addressed through proactive policies, investments, and collaborative efforts to fully realise the promise of the 4IR in manufacturing. Ultimately, the effective deployment of the 4IR technologies holds the promise of delivering a sustainable competitive advantage by optimising efficiency, fostering innovation, and driving economic growth in the manufacturing sector.

Kupe (2019) argues that higher education institutions worldwide have a responsibility to contribute to the progress and development of their societies. This assertion aligns with the

broader societal role often attributed to universities, which goes beyond imparting knowledge to fostering innovation, critical thinking, and societal engagement. Kupe emphasises the importance of investing in graduates. This investment goes beyond traditional academic education to encompass the development of skills and competencies that are pertinent to the demands of the 4IR. In an era characterised by rapid technological advancements, graduates need to possess a versatile skill set that enables them to adapt to evolving job markets. This underscores the necessity of collaboration among various stakeholders, including governments, the private sector, and students themselves, in cultivating human capital. Such partnerships are crucial for aligning educational outcomes with the needs of the labour market and ensuring that graduates are adequately equipped to navigate the complexities of the 4IR.

The World Economic Forum (2018) suggest that the skills required for success in this era are dynamic and constantly evolving, driven by technological innovations such as artificial intelligence, robotics, and automation. Therefore, educational curricula must be designed to equip students with the skills necessary to thrive in an increasingly digitised and interconnected world. Andreoni (2019) introduces a critical perspective by highlighting the sector and country-specific nature of the challenges associated with harnessing the opportunities presented by the 4IR. While digital technologies offer potential benefits to firms across various sectors, the extent to which these benefits can be realised depends on factors such as sectoral characteristics, regulatory frameworks, and institutional capacities. Capturing the opportunities presented by the 4IR requires specific capabilities and incentives. These may include investments in digital infrastructure, workforce upskilling and reskilling initiatives, supportive policy environments, and incentives for innovation and entrepreneurship. However, the distribution of these capabilities and incentives is uneven across sectors and countries, posing a significant challenge to widespread adoption and adaptation to the 4IR. This necessitates a multifaceted approach involving collaboration among stakeholders, a focus on skill development, and an awareness of the sector and country-specific dynamics shaping the 4IR landscape. Addressing these challenges requires concerted efforts to ensure that educational systems remain responsive to the evolving needs of society and the economy.

Based on this philosophical viewpoint, there is a growing emphasis on reskilling and upskilling employees to keep up with the technological changes of the 4IR. Furthermore, Lent (2018), argues that adaptability under uncertain fluctuating conditions requires the most critical skills, and that requires the education sector to mirror the knowledge requirement of the work environment relevant to the 4IR. Wessels (2020) cautions that many current qualifications that are currently offered by tertiary institutions prepare the workforce for jobs that will be non-existent within five

years, or that, at the very least, will be drastically different. To avert the risk of losing jobs in the era of the 4IR, Marwala (2019) states that the best strategy to stay ahead of the changing needs of the labour market is to retrain, up-skill and transform the workforce. A lack of an adequately trained workforce leads to organizations not getting the returns they had hoped for on their digital investments. It is crucial that organisations not only focus on keeping up with the digital advancements in the 4IR but also understand the correlation human skills have on the success of their digital investments. As organisations invest in their human skills through education and training, they need to allow employees to maximise their usage of innovative applications. This will help in reducing costs, improving efficiencies, enhancing the client experience, and potentially increasing organisational growth while supplying a best return on digital investments.

The argument presented highlights the critical role of education in preparing individuals and societies for the challenges and opportunities presented by the 4IR. This discussion will explore various aspects of this statement, drawing on insights from academic literature. The assertion that education forms the basis for effective implementation of the 4IR aligns with scholarly perspectives on the transformative potential of education. As noted by the Presidential Commission on the Fourth Industrial Revolution (2020), a well-educated population is crucial for harnessing the benefits of technological advancements. Education serves not only to impart technical skills but also fosters critical thinking, creativity, adaptability, and problem-solving abilities – all of which are essential in navigating the complexities of the 4IR landscape.

Olaitan et al. (2021) underscore the issue of skill inadequacy in South Africa to support the demands of the 4IR. This perspective resonates with broader discussions on skill shortages and mismatches observed in many countries undergoing rapid technological changes. The gap between the skills demanded by emerging technologies and those possessed by the workforce poses a significant challenge for economic development and competitiveness. Menon and Castrillon (2019) advocate for a shift in education paradigms to address the evolving needs of the 4IR. They argue that traditional qualifications may not adequately equip individuals with the diverse skill sets required in the modern workplace. This highlights the necessity for educational institutions to adapt their curricula to emphasize interdisciplinary learning, technological literacy, and lifelong learning to ensure graduates are prepared for the dynamic nature of the 4IR economy.

Wuttaphan (2020) identifies various factors that impact human skills development, such as job type, gender, turnover, and organisational performance. Understanding these dynamics is crucial for designing effective educational interventions and workforce development strategies tailored

to the demands of the 4IR. For instance, promoting diversity and inclusion in education and employment practices can enhance innovation and productivity in the era of rapid technological change. The discussion emphasises the importance of investing in human skills for organisational success in the 4IR. Organisations must recognise the value of nurturing a skilled workforce capable of leveraging technological tools effectively. This requires not only recruiting individuals with the right skills, but also providing continuous training and development opportunities to adapt to evolving technologies and market demands. This academic discussion underscores the pivotal role of education in preparing individuals and organisations for the challenges and opportunities presented by the 4IR. Addressing skill gaps, fostering flexibility in education systems, understanding factors influencing human skills development, and prioritising investment in human capital are essential for thriving in the 4IR era. By embracing lifelong learning and prioritising human skills development, societies can harness the transformative potential of technology to drive inclusive growth, innovation, and sustainable development.

The implementation of the 4IR in South Africa is an ongoing process that requires sustained effort and investment from the government and private sector. While there have been several initiatives and strategies put in place, challenges such as inequality and job displacement need to be addressed to ensure that the benefits of the 4IR are shared equitably across society. The discussion on the use of the 4IR technologies is intrinsically linked to the discussion of willingness to embrace the 4IR, as individuals' and societies' receptiveness and adaptability to advanced technological innovations determine the pace and success of this transformative era.

2.5 Willingness to embrace the Fourth Industrial Revolution

Olaitan et al. (2021) present a nuanced perspective, highlighting both the potential benefits and challenges associated with the adoption of the 4IR technologies in addressing issues such as poverty, unemployment, and inequality. One of the central concerns raised by critics, as noted by Olaitan et al. (2021), is the fear of significant job losses resulting from the adoption of emerging technologies. This fear is not unfounded; as historical precedent suggests that technological advancements often lead to the displacement of certain types of labour. In the context of South Africa, where unemployment and inequality are already pressing issues, such concerns hold particular significance. The resistance to embracing 4IR technologies among some stakeholders underscores the need for a comprehensive understanding of the implications of these technologies on various sectors of society. The disruptive nature of the 4IR technologies necessitates careful consideration of their impact on government, businesses, employees, and consumers alike.

Effective policymaking and stakeholder engagement are crucial in navigating these complexities and ensuring that the benefits of the 4IR are equitably distributed across society.

The study conducted by the Kagiso Trust, as reported by the Mail and Guardian (2019), sheds light on the readiness of South Africans to embrace 4IR technologies. The findings of this study serve as a valuable resource for policymakers and stakeholders in formulating strategies to address the challenges and opportunities presented by the 4IR. Importantly, the study highlights the need for a multi-disciplinary and multi-faceted approach to education, awareness, and up-skilling to prepare individuals and institutions for the demands of the 4IR. However, as emphasized by Olaitan et al. (2021), the inevitability of the 4IR requires a shift in mind-set among all stakeholders. Whether South Africa is fully prepared to embrace 4IR technologies or not, the reality remains that these technologies are shaping the future of work, economy, and society. Consequently, there is a pressing need for proactive measures to harness the potential of the 4IR technologies while mitigating potential risks such as job displacement and exacerbation of inequality.

The discussion surrounding the adoption of the 4IR technologies in South Africa is complex and multifaceted. While there are legitimate concerns regarding job losses and inequality, there are also significant opportunities for socio-economic development and inclusive growth. Effective policymaking, stakeholder engagement, and investment in education and skills development are essential in realising the transformative potential of the 4IR while ensuring that its benefits are shared equitably across society. As noted by the World Bank (2019), businesses operating in this era encounter multifaceted challenges, ranging from the imperative to reskill their workforce, to managing the ethical implications of modern technologies, and navigating the intricate regulatory environment. These challenges not only impact the operational strategies of businesses but also have profound implications for stakeholders such as employees and consumers. One of the foremost challenges faced by businesses in the 4IR is the necessity to reskill their workforce. The advent of automation, artificial intelligence, and other disruptive technologies has reshaped job roles and skill requirements across industries. Consequently, many employees are apprehensive about the potential threat of job displacement due to automation. Addressing these concerns necessitates proactive measures by businesses to facilitate lifelong learning and skill development among their employees. This includes investing in training programs, fostering a culture of continuous learning, and promoting adaptability to technological changes. Moreover, businesses must collaborate with educational institutions and government agencies to design comprehensive reskilling initiatives that equip workers with the competencies required in the evolving job market.

In addition to workforce reskilling, businesses must grapple with the ethical implications inherent in the adoption of modern technologies. Li (2024) asserts that the proliferation of AI, big data analytics, and biotechnologies raises concerns regarding data privacy, algorithmic bias, and the potential for technological misuse. To mitigate these risks, businesses are increasingly called upon to adhere to ethical principles and regulatory frameworks that safeguard the rights and well-being of individuals. This entails incorporating ethical considerations into the design, deployment, and governance of technology-driven solutions. Furthermore, businesses must engage in transparent communication with stakeholders regarding the ethical dilemmas posed by emerging technologies, fostering trust and accountability in their operations. Navigating the complex regulatory environment constitutes yet another challenge for businesses operating in the 4IR. The rapid pace of technological innovation often outpaces the development of regulatory policies, leading to legal ambiguities and compliance challenges. To ensure regulatory compliance, businesses must proactively monitor and adapt to evolving regulatory landscapes, engaging with policymakers and industry associations to advocate for conducive regulatory frameworks. Moreover, businesses should implement robust internal governance mechanisms to ensure adherence to legal requirements and mitigate regulatory risks effectively.

Beyond the organisational realm, employees and consumers emerge as pivotal stakeholders in the 4IR ecosystem. Employees, apprehensive about the impact of automation on their livelihoods, advocate for initiatives that promote lifelong learning and career adaptability. Businesses must heed these concerns by investing in employee development programs and fostering a supportive work environment conducive to skill enhancement and career advancement. Similarly, consumers, increasingly cognisant of the risks and benefits associated with the 4IR, demand greater transparency and accountability from businesses and governments alike. This necessitates businesses to adopt practices that prioritise consumer welfare, ethical conduct, and environmental sustainability, thereby fostering trust and loyalty among consumers. The challenges outlined by the World Bank (2019) underscore the complex interplay between technological innovation, organisational dynamics, and stakeholder expectations in the 4IR era. Businesses must adopt a multifaceted approach to address these challenges, encompassing strategies for workforce reskilling, ethical governance, regulatory compliance, and stakeholder engagement. By embracing these imperatives, businesses can navigate the complexities of the 4IR landscape while fostering sustainable growth and societal prosperity.

According to Business Report (2022), South Africa with abundant rural resources has a huge advantage in industrialisation to increase its African trade, as the country is the biggest importer of consumer goods and industrial and mining goods. However, this advantage can only be fully

realised if leadership is willing to create a clear vision that will be understandable by all key stakeholders, which will lead to fostering and instilling confidence in the domestic business environment in the short to medium term for investors to buy into the new growth prospects and market competitiveness in the manufacturing industry and related sectors. Accordingly, Bai, Dallasega, Orzes, and Sarkis (2020) suggest that the 4IR leads to carbon emissions reduction, resulting in superior performance which consequently addresses the ecological and social limitations of traditional industrial practices and technologies translating into long-term organisational competitiveness. These are some of the factors that appeal to industry stakeholders such as labour and investors to embrace the 4IR technologies, especially in the South Durban Basin which has always been engulfed by ecological issues.

Pombo-van-Zyl (2019) states that the 4IR provided a major opportunity for the South African economy to level up to the first-world countries and that if professionally managed it has the potential to improve the quality of life for the people of South Africa. However, contrary to this view, Tarifa-Fernandez (2019) cautions that the 4IR brought various technologies too complex for companies to understand and embrace with ease, and as a result, most companies prefer to wait and watch the other companies that have embraced the 4IR to see how they respond in the market. The concept of sustainability is particularly important to the study of the 4IR as companies face the uncertainty of whether to embrace the 4IR or wait until they can see benefits from the companies that embrace it. This means that those companies that play a wait-and-see approach might wake up extremely late to catch up because of the speed of change in 4IR technologies. Emphasizing the point of companies that play a wait-and-see approach, Tarifa-Fernandez (2019) explains the concept of sustainability as a realization of benefits over a lengthy period. The emphasis on time in this matter might be of critical importance as companies might miss real opportunities while watching the advantages of those that adopt the 4IR technologies. Looking at the opportunities of embracing the 4IR technologies, Padayachee and Mukomana (2019) look at how information and communication technologies and automation technologies were effectively used in Durban and how the customers, as the biggest stakeholders, embraced the use of the modern technologies and automation. Their findings reveal that the acquiring and correct use of these modern technologies have a direct influence on the competitiveness of the organisations in Durban.

The need to study technology acceptance is because it is impossible to generalise the level of acceptance across all sectors as technology appeals differently to different demographic groups. There is also a need to look at the availability of the relevant skills suitable for the acceptance of

the 4IR technologies. In line with this thinking, Brown (2020) suggests that as the world entered the era of the 4IR, of artificial intelligence, robotics, and the Internet of Things (IoT), the challenge for Africa is providing its youth with skills relevant to the emerging world of work. Brown (2020) further argues that issues such as growth in unemployment, lack of proper infrastructure, and mismatch between the skills-set of those entering the job market and the skills required by the industries present a serious shortcoming in the use of the 4IR as a competitive advantage. In response to the shortcomings highlighted above, the Presidential Commission on the 4IR (2020) recommends the revival of South Africa's manufacturing sector by investing in human capital through incorporating the 4IR infrastructure such as 3D printing and digital economy into the existing economic and social infrastructure. The fears and uncertainties caused about using the 4IR technologies brought discomfort amongst some role players. As such, correct positioning, and alignment of the resources to support the effective use of the 4IR technologies as a competitive advantage is necessary to alleviate some of the fears and ensure acceptance by all stakeholders.

Marwala (2019) highlights the importance of proactive national strategies in South Africa to address the risks and uncertainties associated with the 4IR and harness its potential benefits. This discussion will critically evaluate Marwala's perspective, examining the significance of national strategies in navigating the challenges and opportunities presented by the 4IR. Firstly, Marwala emphasizes the need for sound energy, IT infrastructure, and education policies to mitigate risks associated with 4IR adoption. This assertion resonates with scholarly literature, which underscores the crucial role of infrastructure and human capital development in facilitating technological transformation. According to the World Bank (2019), effective energy policies can ensure reliable power supply to support digital infrastructure, while investments in IT infrastructure enhance connectivity and enable the deployment of emerging technologies. Moreover, education and skills development are imperative to equip the workforce with the capabilities required to thrive in a digital economy. Secondly, Marwala advocates for stakeholder collaboration to address the challenges and opportunities of the 4IR. This aligns with the concept of multi-stakeholder governance, which emphasises the involvement of diverse actors, including governments, businesses, civil society, and academia, in decision-making processes related to technology adoption. By fostering collaboration, stakeholders can collectively identify priorities, allocate resources efficiently, and develop inclusive policies that consider diverse perspectives and interests.

Furthermore, Marwala's assertion reflects a recognition of the transformative potential of the 4IR in driving economic growth, social progress, and environmental sustainability. However, Schwab (2017), states that realizing these benefits requires proactive efforts to address potential risks, including job displacement, inequality, and environmental degradation. Marwala's call for sound national strategies and stakeholder collaboration in South Africa to navigate the 4IR reflects a nuanced understanding of the challenges and opportunities inherent in technological transformation. By prioritising investments in infrastructure and human capital, fostering multi-stakeholder partnerships, and promoting inclusive policies, governments can harness the potential of the 4IR to drive sustainable development and inclusive growth.

Embracing the 4IR technologies is essential for navigating the evolving landscape of the workforce. As we stand at the precipice of unprecedented technological advancement, understanding and harnessing the potential of the 4IR technologies will not only drive innovation but also redefine the future of work. By embracing automation, artificial intelligence, machine learning, and other transformative technologies, businesses and individuals can adapt and thrive in an increasingly digital and interconnected world. However, it is imperative that we also address the potential challenges and disruptions these technologies may pose to the workforce, such as job displacement and skill gaps. Thus, by actively embracing and shaping the integration of the 4IR technologies, we can pave the way for a future workforce that is agile, skilled, and equipped to thrive in the era of the 4IR and beyond.

2.6 The Fourth Industrial Revolution and the future of the workforce

The landscape of work is undergoing profound transformations driven by technological advancements. Gastrow (2018) underscores the imperative for South Africa to adapt to these changes by integrating both technological imperatives and human values. However, the path forward is not straightforward, as highlighted by Raj et al. (2020), who emphasize the necessity for strong internal capabilities and a culture conducive to innovation to harness the benefits of Industrial Revolution 4.0. Moreover, Morsy (2020) warns of a growing mismatch between the evolving demands of businesses and the skills offered by the South African education system, necessitating urgent measures to bridge this gap. This academic discussion delves into the challenges and opportunities presented by the evolving nature of work in South Africa and proposes strategies to effectively navigate this transition.

The advent of modern technologies, including artificial intelligence, automation, and digitalisation, is revolutionising business operations globally. In South Africa, these

advancements are met with mixed reactions, reflecting uncertainties about the future of work. While technological innovation promises efficiency gains and enhanced productivity, it also raises concerns about job displacement and the erosion of traditional employment models. Consequently, there is a pressing need for organisations to adapt their internal capabilities and cultivate a culture conducive to embracing technological change. Raj et al. (2020) highlight the importance of strong internal capabilities and an innovation-driven culture in leveraging the benefits of the 4IR. As technological disruptions reshape industries, firms must equip their teams with the skills and mind-set necessary to thrive in this dynamic environment. This entails investing in continuous learning and development initiatives to upskill employees and foster a culture of experimentation and risk-taking. Moreover, companies must embrace diversity and inclusivity, leveraging expertise from diverse fields to drive innovation and problem-solving.

Despite the potential of modern technologies to drive economic growth and prosperity, Morsy (2020) identifies a significant gap between the skills demanded by businesses and those provided by the South African education system. To address this disparity, urgent reforms are needed to align educational curricula with the evolving needs of the labour market. This requires a multifaceted approach, encompassing curriculum redesign, teacher training programs, and partnerships between academia and industry to ensure relevance and practical applicability of skills taught. To navigate the complexities of the future of work in South Africa, policymakers, educators, and businesses must collaborate to develop holistic strategies that integrate technological advancements with human-centric values. These include reforming the education system, promoting lifelong learning, fostering innovation ecosystems, and enhancing digital literacy to ensure equitable access to opportunities and mitigate the risk of technological exclusion.

The future of work in South Africa is intricately linked to its ability to harness technological advancements while upholding human values and inclusivity. By investing in internal capabilities, fostering an innovation-driven culture, and addressing skills mismatches through education reform, South Africa can position itself to seize the opportunities presented by the 4IR. However, concerted efforts and collaboration between government, industry, and academia are essential to navigate this transition effectively and ensure inclusive and sustainable economic growth. According to the World Economic Forum (2018), the current core curriculum content in 50 percent of all subject disciplines taught in a four-year technical qualification will be redundant by the time students graduate. Consequently, with the impending skillset disruption and a substantial proportion of subject discipline knowledge at the risk of being outdated in a few years,

higher education institutions are under increased pressure to ensure that their graduates will be able to function effectively within society.

Consequently, the World Economic Forum (2018) suggests that future jobs within the 4IR technology sectors, AI, machine learning, robotics, nanotechnology, 3D printing, genetics, and biotechnology, are expected to dominate in the coming decades. Contrary to the above, the International Monetary Fund (2018), states that there is substantial uncertainty on the extent to which jobs may be displaced because of the 4IR. Against this backdrop of uncertainty, South Africa must develop new forms of manufacturing that would trigger a period of valuable growth. These new forms of manufacturing refer firstly to new business models of bringing goods and services to the consumer. In line with the above, the South African government through its politico-economic policy, the National Development Plan (NDP) 2030 is quite intent on addressing a major barrier to cultivating higher education in the 4IR by providing greater access to the internet. The NDP 2030 states that all South Africans should be able to acquire and use knowledge effectively through increased connectivity.

Raj et al. (2020), believe that the challenge of the 4IR is the displacement of jobs resulting in potential challenges in social and organisational contexts resulting in the increase in inequality which would disrupt the labour market. The Future of Jobs Report (2016) specifically highlights complex problem-solving skills as one of the most important skills required to be enacted by graduates. Additionally, social skills (persuasion, emotional intelligence, teaching others), cognitive abilities (creativity and mathematical reasoning), and processing skills (critical thinking) will also be in high demand. Although the Future of Jobs Report outlines the key skills demand in 2020, higher education institutions are under increased pressure to expect the skills they should equip their graduates with to function within the 4IR environment. The social sustainability aspect that the 4IR technologies bring is employee health and safety as it tends to take over monotonous and repetitive tasks resulting in higher employee satisfaction and motivation. To this end, the institutional arrangements to manage the information, communications, and technology (ICT) environment need to be better structured to ensure that South Africa does not fall victim to a digital divide. If the opportunities of the 4IR are not exploited, South African companies face the possibility of lagging behind in innovation and digital growth thereby worsening the possibility of the digital divide and giving away their global competitiveness.

Morsy (2020) suggests that considering that South Africa did not take part in the earlier three (3) revolutions, to catch up with other nations, it will have to adopt national strategies for education and skills development plans. Such strategies should not only focus on youth but also on adult workers, dropouts, informal-economy workers, and those from economically and socially disadvantaged groups. Employers often cite inadequately prepared workers as a major constraint on their business growth. Furthermore, Waghid, Waghid, and Waghid (2019) state that South African universities are now being challenged by the Ministry of Higher Education to embark on the pursuit of shaping their academic activities considering the demands of the 4IR because such educational efforts would hopefully contribute towards economic prosperity, job creation, and empowerment of marginalized communities.

In addition to the above, Kupe (2019) states that this shift in the offerings by the institutions of higher learning needs to be underpinned by teaching and learning strategies that create well-educated, socially conscious citizens who are equipped with skills for their era, in this case, the 4IR. This is because the manufacturing industry already requires automation solutions to be highly cognitive and highly autonomous. According to Kupe (2019), this will enhance the role of artificial intelligence (AI) to save time and cost in supply chain management processes while at the same time enhancing the cooperation between humans and machines across the whole value chain up to the point of services. This is because artificial intelligence can connect machines, people and processes, a game changer, to get data to make more informed decisions when it comes to data acquisition and analysis toolsets allowing organizations to achieve efficiencies never dreamed of before. Similarly, Mpofu and Nicolaidis (2019) argue that businesses are increasingly faced with potential conflicts of interest arising from what shareholders expect and other stakeholders desire. This is because technology shifts present opportunities to create new business models that also disrupt existing systems. To this end, the technology requires a lot of investment from the companies without a guarantee for returns, which contradicts the interests of the shareholders.

According to Mpofu et al. (2019), the interest of the shareholders is to see any business making a profit while employees as the biggest stakeholders want to preserve jobs. Despite all the contradictions, Naude (2017) argues that the 4IR indeed holds opportunities for African industrialisation, and among the opportunities are new business models that are bringing goods and services to consumers. These include products-as-services, the sharing (collaborative) economy, digital services, and exports. These are all markets that are currently underdeveloped in Africa but have substantial potential given Africa's geography, demography, and ongoing

urbanization. Figure 2.2 below shows different digital tools relevant to the effective implantation of the 4IR technologies.

The use of the 4IR digital tools is particularly relevant in the study of the South Durban Basin due to the potential benefits and challenges associated with these technologies in the context of the region. 4IR technologies can enhance the efficiency and productivity of industries in the South Durban Basin. Automation, data analytics, and IoT devices can optimise processes, reduce downtime, and improve overall operational performance. Digital tools enable advanced monitoring and management of environmental factors. In the South Durban Basin, where industrial activities may impact the environment, 4IR technologies can facilitate real-time monitoring of air and water quality, helping to mitigate environmental risks. The implementation of smart infrastructure, including smart grids, transportation systems, and waste management, can contribute to sustainable development in the South Durban Basin. These technologies can improve resource utilization, reduce energy consumption, and enhance overall urban sustainability.



Figure 2:2 4IR digital tools

Source: jobPRO (2022)

Some of the 4IR tools illustrated above include blockchain, Robotics, Internet of Things (IoT), and artificial intelligence (AI) and those tools are reshaping the way we live and work and are

likely to have a profound impact on society in the coming years. Henama and Sifolo (2017) suggest that digital tools also bring opportunities in South Africa and one of those opportunities is an e-hailing mode of taxis which has grown in popularity in many cities due to its customer experience driven by an end-to-end approach, from service acquisition to delivery. This has brought the 4IR at a faster pace and is aggressively disrupting the market. The disruption introduced by the e-hailing system offers a glimpse of what could happen in manufacturing, fuelling the fear that robots will take low and semi-skilled jobs, resulting in an unemployed youthful, and growing population, which brings with it a host of socio-economic challenges. Despite the discourse around robots being driven by fear, robots could also be driven by innovation being a different type of leapfrogging in the job market.

Lekhanya (2019) argues that technology is embedded in all we do, and more than half of the world's population is now connected to the internet, and the global economy is being digitized. However, Pillay (2020) cautions that many South African manufacturers still face major talent challenges when organising their businesses for the digital transformation towards 4IR considering that to effectively use the benefits of the 4IR, different IT skill sets, better skills blend, and realignment of skills are necessary. Some of the challenges of the 4IR are illustrated in Figure 2.3 below. The choice of a framework for the implementation of the 4IR technologies in the South Durban Basin was carefully considered, taking into account various challenges associated with this technological transition. The framework addresses the challenges of inequality, job displacement, cybersecurity, and ethical concerns, and explain the relevance of a suitable framework to address these issues. Implementation of the 4IR technologies may exacerbate existing social and economic inequalities, creating a digital divide between those who can access and benefit from these technologies and those who cannot.

The chosen framework should prioritise inclusive policies and strategies that ensure widespread access to and benefits from 4IR technologies. This may involve community engagement, digital literacy programs, and targeted initiatives to bridge the gap. The chosen framework should prioritise inclusive policies and strategies that ensure widespread access to and benefits from 4IR technologies. This may involve community engagement, digital literacy programs, and targeted initiatives to bridge the gap. Automation and advanced technologies in the 4IR may lead to job displacement, particularly in traditional industries, potentially causing unemployment and economic instability. A comprehensive framework should include strategies for reskilling and upskilling the local workforce, creating new opportunities for employment, and supporting a smooth transition for those affected by job displacement. Zhou and Wang (2023) suggest that collaboration between industry, government, and educational institutions is crucial. The increased

reliance on interconnected technologies in the 4IR introduces new cybersecurity threats and vulnerabilities that can have severe consequences for individuals, businesses, and critical infrastructure. A robust cybersecurity framework should be an integral part of the overall strategy. It should encompass measures such as secure-by-design principles, regular cybersecurity assessments, and the development of a skilled cybersecurity workforce to protect against potential threats. Ethical considerations surrounding the use of the 4IR technologies include issues such as privacy concerns, biased algorithms, and the ethical use of data. The chosen framework should include clear guidelines and principles for ethical technology development and deployment.

This involves ensuring transparency, fairness, and accountability in algorithmic decision-making, as well as protecting individuals' privacy rights. The South Durban Basin, being an industrial hub, may experience unique challenges and opportunities in the adoption of the 4IR technologies. The framework should be tailored to the local context, considering the specific industries, demographics, and economic conditions of the region. Community engagement and collaboration with local stakeholders are essential to ensure that the benefits of the 4IR technologies are shared inclusively and that the implementation aligns with the specific needs and priorities of the South Durban Basin.

Figure 2.3 below illustrates the challenges posed by the Fourth Industrial Revolution (4IR) and its implications for the future workforce. The 4IR has the potential to exacerbate existing inequalities, as technological advancements may widen the gap between those who have access to and can benefit from these technologies and those who do not. Automation and AI technologies may lead to job displacement, as routine tasks become automated, impacting traditional job roles and requiring new skills for employment. The increased reliance on digital technologies in the 4IR introduces new cybersecurity risks, such as data breaches and cyberattacks, which can have significant consequences for businesses and individuals. The rapid pace of technological advancement in the 4IR raises ethical concerns regarding privacy, autonomy, and the responsible use of AI and other emerging technologies.

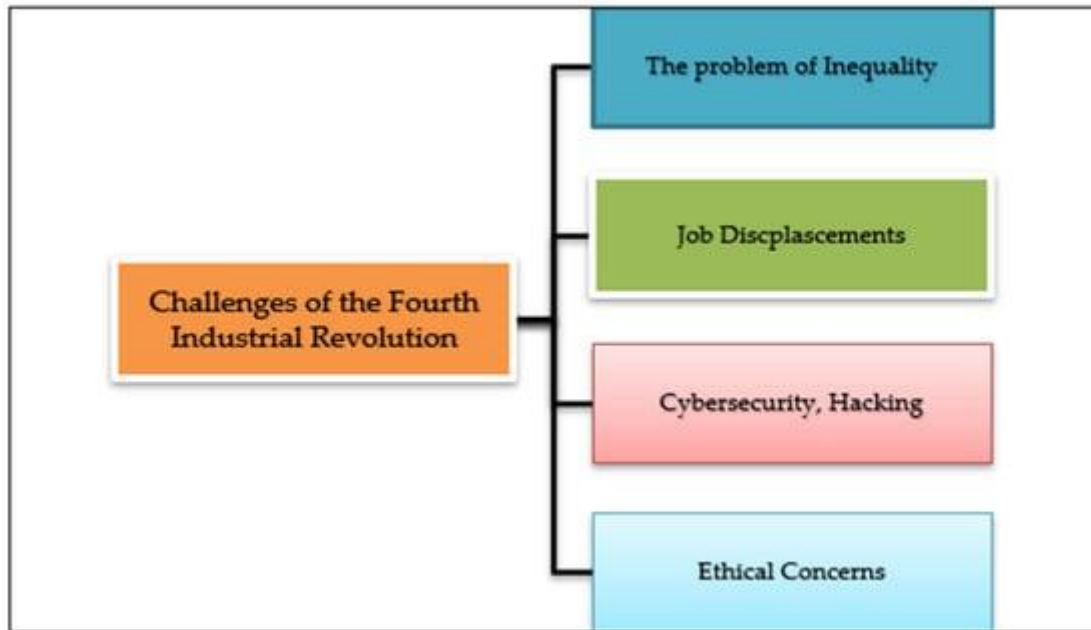


Figure 2:3 Challenges of the Fourth Industrial Revolution

Source: Mhlanga (2022)

Understanding these challenges is crucial for anticipating and preparing for the future of the workforce. It highlights the need for policies and strategies that address issues of inequality, promote reskilling and upskilling initiatives, prioritize cybersecurity measures, and establish ethical guidelines for the development and deployment of emerging technologies. This understanding helps stakeholders navigate the complexities of the evolving labour market and foster a more inclusive and sustainable future for the workforce. Job displacement is involuntary job loss because of economic factors such as structural change. In mitigation of the fears of job displacements, Lekhanya (2019), suggests that the challenge of technical skills can be addressed through social re-skilling, infrastructural adjustments, technology upscaling of human resources, as well as economic re-capitalization. On the other hand, Pillay (2020) suggests that the reality is that there is not only a local but also a global talent shortage for 4IR skills. This argument places importance on the study of the future of jobs from a global perspective. The study will identify the skills required in the era of the 4IR to supply the skills relevant for the successful implementation of the 4IR. Velarde (2019) cautions that when designing intelligent machines, it is essential to consider addressing ethics, bias, fairness, privacy, and safety as algorithms can contribute to discrimination in civil rights while also presenting the risk of accidents in real-world applications.

Gastrow (2018) argues that 4IR raises several ethical questions for consideration, including questions related to data privacy, responsibility for autonomous drones and vehicles, the bioethics

of genetic modification, and the societal and developmental impacts of social media and internet use by individuals and populations. On the other hand, Bird, Fox-Skelly, Jenner, Larbey, Weitkamp, and Winfield (2020), believe that robots do not have the capacity for ethical reflection or a moral basis for decision-making, and thus humans must hold ultimate control over any decision-making. This is because humans are certified by their professional standards to uphold certain levels of ethical obligations and the fact that robots do not have certificates or qualifications makes the robots exempt from ethical obligations.

Raj, Dwivedi, Sharma, Jabbour, and Rajak (2020) further suggest that the increased connectivity, such as complex links among value chain partners, creates unanimous concerns about the security risks of sharing information among channel partners. This does not only raise the firms' cybersecurity concerns but also a fear of losing their data to third-party software and service providers in the 4IR. Manda and Blackhouse (2017) further suggest that security and privacy concerns constrain the advancement of digital transformation due to an increase in cyber-crimes and hacking. For the South Durban Basin, the study is even more important to enable companies in the area to capitalize on the opportunities while mitigating the challenges of the 4IR that are highlighted above. The discussion on the 4IR and the future of the workforce underscores the imperative for higher education institutions to adapt and innovate in order to equip students with the necessary skills and competencies demanded by the rapidly evolving technological landscape. As higher education institutions embrace their role in enhancing the 4IR, they play a pivotal role in shaping a workforce that is not only resilient to technological disruptions but also capable of driving innovation and sustainable growth in the digital economy.

2.7 The Role of higher education in enhancing the Fourth Industrial Revolution

In the context of manufacturing companies in the South Durban Basin, higher education plays a vital role in preparing the workforce for the challenges and opportunities presented by the 4IR. The manufacturing sector in this region, which is a hub of industrial activity, requires a skilled workforce that can adapt to emerging technologies like automation, robotics, and the Internet of Things (IoT). Higher education institutions must collaborate with local manufacturers to develop tailored curricula that address the specific needs of these industries, ensuring that graduates are equipped with both technical skills and the ability to innovate and respond to technological disruptions. Gleason (2018) emphasizes that the economic and environmental impacts of 4IR technologies necessitate a drastic shift in educational approaches, particularly in regions like South Durban, where heavy industry plays a critical role. By providing students with an

understanding of how individual technologies interact within broader systems such as supply chains and environmental regulations higher education can support manufacturing companies in navigating the complexities of the 4IR. This shift is essential not only for operational efficiency but also for addressing the environmental challenges unique to industrial zones like the South Durban Basin.

Additionally, higher education should focus on fostering interdisciplinary skills, such as ethical reasoning, problem-solving, and the ability to assess the societal and environmental impacts of industrial technologies. For manufacturers in South Durban, these competencies are crucial as they seek to balance competitiveness with sustainability, particularly in a region that faces significant environmental scrutiny. As Xing and Marwala (2017) point out, institutions must evolve to offer virtual learning environments, which can be particularly beneficial for ongoing employee training in the manufacturing sector, allowing workers to stay updated on the latest technological advancements. Furthermore, the shift from labour-intensive production to knowledge-driven, technology-intensive operations will create a growing demand for digital and technical skills within South Durban's manufacturing companies. By working closely with local industries, higher education institutions can ensure they are producing graduates who not only understand these technologies but can also manage their integration into existing industrial processes.

Lastly, for the manufacturing companies in the South Durban Basin to remain competitive in the 4IR era, higher education institutions must play a proactive role in developing industry-specific skills, promoting innovation, and ensuring that both new entrants to the workforce and current employees are prepared to meet the demands of a rapidly changing technological landscape. Collaborative efforts between higher education, government, and the private sector will be key to fostering an industrial ecosystem that supports sustainable growth and technological advancement.

2.8 The Role of Government in Industrialisation

The statement by Asongu and Odhiambo (2019) underscores the critical relationship between good governance and industrialization, particularly in the context of addressing capital flight. They suggest that when governments are unstable or lack transparency, investors may feel uncertain about the safety of their investments, leading them to move capital out of the country.

Improving political governance involves establishing stable political institutions, ensuring accountability of public officials, and creating an environment conducive to investment. Economic governance reforms are necessary to create a stable and predictable economic environment that encourages investment. This includes implementing sound fiscal and monetary policies, reducing regulatory burdens, and strengthening financial institutions. When institutions are weak and corrupt, investors may perceive higher risks and choose to move their capital elsewhere. Improving institutional governance involves combating corruption, strengthening the rule of law, and enhancing the effectiveness of institutions responsible for enforcing laws and regulations.

To address these challenges, governments should focus on enhancing various aspects of governance, including involving stakeholders in decision-making processes, promoting transparency and accountability, building capacity within government institutions to ensure effective implementation of policies and regulations, providing access to information to enhance accountability and to build trust between the government and investors. Strengthening government institutions improves their ability to enforce laws, regulations, and policies effectively. By addressing political, economic, and institutional governance challenges and implementing reforms to improve transparency, accountability, and effectiveness, governments can create an environment conducive to investment and economic growth.

The discussion surrounding the integration of digital technologies, connectivity, and governmental strategies within the context of the 4IR is crucial for understanding the dynamics of modern societies and economies. Manda and Backhouse (2017) emphasize the interconnectedness of government, citizens, and businesses as a key feature of smart societies in the 4IR era. They underscore the importance of investing in telecommunications infrastructure and broadband technologies to facilitate effective communication, collaboration, and integration across various sectors. This emphasis on connectivity resonates with the broader narrative outlined in the World Economic Forum Report (2018), which highlights the transformative impact of the 4IR on global competition and manufacturing landscapes. The report suggests that nations will need to adapt to this new reality by implementing strategic initiatives to both issue and adopt technology, often through comprehensive national programs. This implies a shift in governmental roles towards more intentional efforts in promoting technological advancements and fostering innovation.

Moreover, Dervojeda and Permatasari (2020) stress the critical role of government in formulating policies and regulations that not only encourage innovation but also ensure fairness and accessibility of modern technologies for all citizens. They advocate for investment in education and training programs to equip individuals with the necessary skills to participate in the evolving digital economy. Additionally, they argue that promoting research and development and innovation is essential for technology adoption and diffusion, particularly among small and medium-sized enterprises (SMEs). However, the case of South Africa introduces a complex challenge where despite the recognition of the importance of investing in infrastructure and fostering innovation, weak economic growth poses significant hurdles in addressing the financing gap required for 4IR technologies. Public capital may be limited, hindering the government's ability to allocate resources towards critical infrastructure projects and research and development initiatives. This underscores the importance of prioritizing economic reforms and seeking alternative sources of funding, such as public-private partnerships or foreign investment. The discourse on digital connectivity, governmental strategies, and economic development within the framework of the 4IR underscores the need for proactive and collaborative approaches. While investment in telecommunications infrastructure and technology adoption are essential, policymakers must also prioritise regulatory frameworks, education, and innovation to ensure inclusive growth and competitiveness in the face of economic challenges.

According to the World Economic Forum (2018), there must be seven types of government-led national efforts to adopt and diffuse new production technologies. These need to be customized for country-specific distinctions and a nation's industrial sector mix and they include:

- Building awareness by communicating the importance of national initiatives and programs to industrial policy, and by sharing success stories and lessons from technology and innovation adoption journeys for pioneering companies;
- Setting up financial incentives, such as tax credits or public loans, that support the acquisition and development of Fourth Industrial Revolution technologies for large, medium, and small enterprises;
- Creating a robust legal framework to regulate areas affected by modern technologies (e.g. intellectual property, data protection, cross-border flows);
- Spurring on accreditation of companies that successfully adopt Fourth Industrial Revolution technologies, nationally and internationally, thus supporting the technology and industry ecosystem;

- Expanding connectivity and data-security protection with specific efforts in production, for example creating dedicated taskforces, institutions, and frameworks on cybersecurity;
- Promoting Research and development and innovation for Fourth Industrial Revolution technologies applied to production;
- Setting up new talent and education programs adapted to the future of the production workforce.

As highlighted by the World Economic Forum in 2018, governments that drive policies aimed at leveraging 4IR technologies often enhance their competitiveness both regionally and globally. This is due to the transformative potential of these technologies to spur on innovation, increase productivity, and drive economic growth. However, as noted by Naude (2017), reaping the benefits of the 4IR requires more than just technological advancement; it necessitates comprehensive strategies that encompass entrepreneurship and education. Indeed, fostering a conducive environment for entrepreneurship and equipping individuals with the necessary skills to thrive in a technology-driven world are essential components of a successful 4IR agenda. Naude's recommendations emphasize the importance of aligning entrepreneurship and education policies with broader 4IR objectives to maximize the potential benefits for society as a whole. Recognizing the transformative impact of the 4IR, the South African government took proactive steps by establishing the 4IR Commission. This commission serves as a platform for coordinating efforts across various sectors to understand and navigate the challenges and opportunities presented by the 4IR. By providing leadership and guidance, the commission plays a crucial role in ensuring that South Africa can effectively adapt to the changing technological landscape and capitalize on emerging opportunities.

Moreover, the recommendations put forth by the Presidential Commission on 4IR in 2020 underscore the multifaceted nature of the challenges facing South Africa in embracing the 4IR. Mobilising capital for 4IR initiatives is crucial to fund research, development, and infrastructure projects necessary for technological advancement. Addressing policy and regulation challenges, such as policy uncertainty, governance issues, and intellectual property laws, is essential to create a conducive environment for innovation and investment. Additionally, reforms in areas such as exchange controls, tax policies, and competition regulation are needed to attract both domestic and foreign investment and foster a vibrant ecosystem for 4IR-driven growth. The discussion highlights the importance of proactive government intervention in driving policies and initiatives to harness the potential of the 4IR. By prioritizing entrepreneurship, education, and strategic policy reforms, countries like South Africa can position themselves as leaders in the global technology landscape and unlock new pathways for sustainable economic development and societal advancement.

The view of the Presidential Commission on the 4IR is that the country's fiscal position is currently weak, with the future growth outlook projected well below the National Development Plan 2030 (NDP) target of 6%. This limits the state's ability to directly invest in and take ownership of the industries it may choose to support. This, however, is a creative challenge requiring the state to rethink its leverage and build long-term negotiating options. According to Manda and Backhouse (2017), political leadership in South Africa has played an important role in setting policy priorities and the significant steps in the journey to digital transformation but the prioritization of policy in some instances is driven by political ambition and populism, which compromises the success of certain policy initiatives that are deemed insignificant for gaining political mileage. Below, is a summary of the policy directives that the government has developed over time to help the digital transformation process:

Table 2:1 Summary of governmental policy directives

Main policies influencing digital transformation in South Africa	
Policy/Strategy document	Relevance
Report of the Presidential Review Commission on the Reform and Transformation of the Public Service in South Africa (1998)	This report has the main findings and recommendations of the Presidential Review Commission (PRC) about the operation, transformation, and development of the South African Public Service, and in particular the creation of a new culture of governance
Electronic government: The digital future: a public service IT policy framework (2001)	Spelled out the e-government vision, defined clearly how progress is to be measured, and set priorities for ICT in government.
National Development Plan (NDP) (2012)	A long-term development plan that provides a broad strategic framework to guide key choices and actions including inclusive digital transformation.
Public Service Corporate Governance of ICT Policy (2012)	To strengthen governance of ICT as a valuable resource in the public service.

National Broadband Policy (2013)	To connect and integrate people, government, and business in the pursuit of inclusive economic growth.
Cyber-security Policy Framework (2015)	To strengthen security and improve trust in the cyber environment by providing a safe and secure space for society, business, and government to thrive.
National Integrated ICT Policy White Paper (2016)	Outlines the overarching policy framework for the transformation of South Africa into an inclusive and innovative digital and knowledge society.
Provincial Growth and Development Strategy (PGDS) (2016)	KZN macro policy instrument that incorporates the Medium-Term Strategic Framework (MTSF) and the government's five-year program of action.
KwaZulu-Natal Digital Transformation Strategy (2020)	It causes the government at a provincial level to redirect its efforts in ensuring that the vision for (NDP 2030) is achieved provincially through harnessing opportunities for digital transformation in the public sector and private sector.

Source: Manda & Blackhouse

As reflected in the table above, South Africa's national and local governments have played an essential role in creating an enabling environment for knowledge development and innovation. The South Durban Basin, as one of the industrial hubs of South Africa, must capitalize on the policy framework to create an environment for industrialization to grow and be sustainable. The successful implementation of the 4IR requires a collaborative effort between the government, the private sector, and citizens. That collaboration needs the government to take a proactive approach to policymaking and investment to ensure that the benefits of the 4IR are widely shared and that potential negative consequences are addressed.

The discussion on the role of government in industrialization lays a foundation for understanding its potential role in shaping the development and deployment of artificial intelligence (AI). Just

as government policies and investments played a crucial role in driving industrialization through infrastructure development, research funding, and regulation, similar considerations are pertinent in the realm of AI. Government intervention can influence AI's trajectory by fostering innovation, ensuring ethical and responsible deployment, and addressing societal impacts such as job displacement and inequality. Thus, understanding historical lessons from industrialisation can inform discussions on crafting effective government strategies for the responsible advancement of AI technologies in today's rapidly evolving digital landscape.

2.9 Artificial Intelligence

Velarde (2019) and Nyagadza et al. (2022) highlight the profound implications of these emerging technologies such as artificial intelligence (AI), advanced computing, and automation on various aspects of society, particularly in terms of labour markets, economies, and political alliances. One of the central themes in discussions surrounding the 4IR is the potential reconfiguration of labour markets. AI and automation technologies have the capability to streamline processes, enhance productivity, and reduce the need for human labour in repetitive or routine tasks. This can lead to significant shifts in the types of jobs available, potentially displacing workers in certain sectors while creating demand for new skills in others. The rise of intelligent machines capable of tasks traditionally associated with human creativity and strategic thinking further complicates this landscape, as it challenges the very notion of what constitutes skilled labour.

Economically, the adoption of AI, machine learning, blockchain, 3D printing, nanotechnology, and self-driving cars can disrupt existing industries and business models. These technologies enable greater efficiency, customization, and cost-effectiveness in production processes, potentially reshaping global supply chains and distribution networks. Moreover, the accumulation and analysis of big data, facilitated by advancements in technology, offer unprecedented insights into consumer behaviour, market trends, and risk management strategies, further influencing economic dynamics.

Politically, the widespread adoption of transformative technologies can also impact the balance of power and alliances between states. Access to and control over critical resources such as data, intellectual property, and technological infrastructure become increasingly important in the digital age. Furthermore, the advent of AI-driven decision-making systems raises questions about accountability, transparency, and governance, particularly in areas such as cybersecurity, autonomous weapons systems, and algorithmic regulation.

However, it is crucial to acknowledge the multidisciplinary nature of these advancements, as highlighted by Nyagadza et al. (2022). The interconnectedness of AI, big data, blockchain, and other technologies makes it challenging to fully comprehend their implications and exploit their potential benefits. Moreover, ethical considerations surrounding issues such as privacy, equity, and social justice must be addressed to mitigate the potential negative consequences of technological disruption. The emergence of the 4IR represents a paradigm shift with far-reaching implications for society, economy, and politics. While the transformative potential of AI and computing technologies is undeniable, it is essential to approach their integration thoughtfully, considering both the opportunities and challenges they present. Collaborative efforts across disciplines and stakeholders are necessary to navigate this complex terrain and harness the benefits of the 4IR while ensuring inclusive and sustainable development.

Olaitan (2021) presents an optimistic view of artificial intelligence (AI), asserting that it imbues machines with human-like intelligence, enabling them to make intelligent decisions autonomously. One of the key points emphasized is the ability of AI to process and store vast amounts of data, enabling machines to interact with their environment and products independently of human intervention. This capacity for independent interaction is seen as a significant advancement, facilitating quicker and more cost-effective task execution based on predefined criteria. The notion that AI enables machines to mimic human intelligence and make decisions independently aligns with the broader discourse surrounding AI development. With advancements in machine learning algorithms and deep learning techniques, AI systems have indeed become capable of processing and analysing large datasets, identifying patterns, and making decisions based on these insights. This capability has led to significant improvements in various fields, ranging from healthcare and finance to manufacturing and transportation. Furthermore, Olaitan's argument underscores the transformative potential of AI in streamlining processes and reducing costs. By automating tasks and decision-making processes, AI can enhance efficiency and productivity while minimizing errors. This can be particularly beneficial in industries where repetitive tasks are common, allowing human workers to focus on more complex and creative aspects of their work.

On the other hand, Marwala (2019) highlights specific developments of AI within the context of South Africa. While the details of these developments are not provided, it is indicative of the global trend of AI adoption and innovation. South Africa, like many other countries, has been investing in AI research and implementation across various sectors. These developments may include initiatives aimed at leveraging AI for economic growth, addressing societal challenges, or improving service delivery. The comparison of these perspectives suggests a broader narrative

of AI's potential impact on society and industry. While Olaitan emphasizes the transformative power of AI in enabling autonomous decision-making and efficient task execution, Marwala's reference to developments in South Africa underscores the global nature of AI innovation and adoption. Together, these viewpoints contribute to a nuanced understanding of the opportunities and challenges associated with AI advancement, both within specific contexts and on a broader scale. Most companies are developing AI or machine learning with a relationship to human resources and will have teams composed of engineers, computer scientists, developers, data scientists, and personnel with mathematical and technical ability.

Furthermore, Velarde (2019) suggests that AI is considered the “new electricity” of the emerging industrial revolution, and deep learning will transform most industries making it indispensable to a wide range of businesses and organizations. This is because of the understanding that computational creativity can boost human intelligence by supplying tools that help to reason, and machines that can learn to describe complex phenomena automatically. As a result of their ability to think and analyse complex tasks, creative machines can also be used to complete tasks such as automatically generating images from human sketches. The point of departure is whether machines can excel in human intelligence with computers and human brains connected to the cloud in a symbiotic enhancement, where humans work only on tasks of their interest and robots take care of the rest of the jobs.

Anifowose (2021) asserts that regarding the key elements of AI encapsulates the diverse array of technologies and capabilities that fall under the umbrella of artificial intelligence. These elements, including natural language processing, expert systems, robotics, intelligent agents, and computational intelligence, collectively represent the multifaceted nature of AI and its potential impact on various domains. Natural language processing stands out as a fundamental component of AI, enabling machines to understand, interpret, and generate human language. Through advancements in natural language processing, AI systems can interact with users more effectively, extract insights from unstructured data, and facilitate communication between humans and machines in a more natural manner. Expert systems, another key element highlighted by Anifowose, involve the development of computer systems that emulate the decision-making capabilities of human experts in specific domains. By encoding expert knowledge into algorithms, these systems can provide valuable insights, recommendations, and solutions across a range of fields, from medicine to finance.

Marwala (2019) suggests that robotics represents the embodiment of AI in physical form,

enabling machines to perceive and interact with their environment autonomously. From industrial robots that automate manufacturing processes to humanoid robots capable of social interaction, robotics continues to push the boundaries of what AI can achieve in the realm of physical tasks and human-machine interaction. Intelligent agents encompass a broad category of AI systems designed to perceive their environment and take actions to achieve specified goals autonomously. These agents can range from simple algorithms that make decisions based on predefined rules to complex systems employing machine learning techniques to adapt and improve their behaviour over time. Computational intelligence refers to the use of algorithms inspired by natural processes, such as neural networks and genetic algorithms, to solve complex problems and learn from data. These techniques enable AI systems to exhibit adaptive behaviour, self-organize, and evolve in response to changing environments and tasks.

Anifowose's (2021) perspective on the potential capabilities of intelligent machines, surpassing even the brightest humans and potentially posing risks if their goals diverge from human interests, reflects ongoing debates and concerns surrounding the ethical and societal implications of AI advancement. While AI holds immense promise in augmenting human capabilities, improving efficiency, and driving innovation across various sectors, it also raises questions about accountability, bias, job displacement, and the potential for unintended consequences. As AI continues to evolve and permeate more aspects of society, it is essential to approach its development and deployment with careful consideration of ethical principles, transparency, and accountability. By fostering interdisciplinary dialogue, collaboration, and responsible stewardship of AI technologies, we can strive to harness their transformative potential while mitigating associated risks and ensuring alignment with human values and well-being.

According to Oosthuizen (2022), digital platforms and AI can shape and underpin the world of work in an unlimited way. This is because, according to Wessels (2020), AI is a rapidly progressing technology that has significance on humans' daily lives through the artificial creation of human intelligence capable of reading, thinking, planning, perceiving, and manipulating natural settings. In support of the importance of AI as a theoretical framework for the 4IR, the World Economic Forum in 2017 pointed out that AI will in the future create more opportunities to apply general capacities translating into multidisciplinary robotic work and more human-conscious software solutions. This means that with assisted intelligence, people and organizations can enhance what they are already doing using AI. Global positioning system (GPS) navigation software, for example, offers drivers directions and informs the driver to adjust to road conditions such as potholes, weather conditions, accidents, or even roadblocks ahead. This means that in the era of augmented intelligence, individuals and organizations can do things that would otherwise

be impossible. Another example is that shuttle services, for instance, would not exist without a combination of programmes that manage them.

People can log shuttle requests and schedule their entire itinerary using a technological device. Furthermore, humans are using AI to process, analyse, and evaluate the massive amounts of data that create today's world, and that allows human beings to spend more time engaged in creative thinking, decision-making, and problem-solving. The above arguments are supported by Commun (2020) in that the emergence of AI is expected to affect global productivity, equality and inclusion, and environmental outcomes. Similarly, Collins, Dennehy, Conboy, and Mikalef (2021) argue that machine learning, automation, and robotics are particularly important in the study of AI due to its ability to perform tasks that historically require human intelligence, such as speech recognition, image analysis, and decision-making. Furthermore, Lee (2019) suggests that AI is also playing a critical role in the development of autonomous systems such as self-driving cars and drones able to perceive their environment, make decisions, and navigate safely. Similarly, AI algorithms can analyse a large amount of data and provide insights that humans may miss leading to better decision-making. The above discussion has shown that AI enables entities and processes to enhance the ability of organizations to use the 4IR as a competitive tool.

Artificial intelligence and big data are intricately linked, as the advancement and application of AI techniques heavily rely on the availability and analysis of vast amounts of data. AI algorithms learn and make decisions based on patterns and insights derived from this data, making the quality and quantity of data crucial for their effectiveness. Conversely, big data technologies and methodologies are often employed to collect, store, process, and analyse the massive datasets required to train and refine AI models. Therefore, discussions surrounding artificial intelligence invariably intersect with discussions about big data, highlighting the symbiotic relationship between the two fields in driving innovation and addressing complex challenges across various domains.

2.10 Big data

Big data analytics has emerged as a transformative technology for manufacturing companies, offering a wide range of benefits, including enhanced competitive advantage, real-time decision-making, process optimization, personalized customer experiences, and service innovation. According to Makkonen (2020), big data analytics refers to the process of examining large and varied data sets to uncover hidden patterns, unknown correlations, market trends, customer

preferences, and other valuable information that can help organizations make informed decisions and gain a competitive edge. Businesses need to continuously process data into prompt and meaningful information for their decision-making and process manufacturing activities. According to Taylor (2023), big data is the large quantity of data collected from various resources that could potentially be analysed to provide valuable insights and patterns. In addition, Oikonomidi (2020) defines industrial big data as the gathering and storing of data from the entire industrial pipeline that can be analysed using proper techniques and reflected in visual presentations to enhance decision-making.

Big data environments can be used to process, manage, and analyse many diverse types of data. Currently, the existing big data solutions have different capabilities depending on what is to be achieved; in general, these solutions could provide real-time analytics or batch processing using statistical techniques or other algorithms such as machine learning. In manufacturing, the impact expectation is high in research and development, production, client relationships, maintenance, and recycling. Andreoni (2019) further suggests that the availability of more and better-quality data lies at the core of today's digital production technologies and is central in product and process design, process control, coding, and the tracking of products within a firm and along its supply chain. Physical robots, for example, can only perform more flexible and intelligent tasks to the extent that the available software can extract the data collected, analyse them, and give orders to robots and other machines connected through integrated systems.

David, Nwulu, Aigbavboa, and Adeboju (2022), explain that big data analytics helps improve and increase the competitive advantage of manufacturing companies, promotes data collection from multiple reliable sources, comprehensive data analytics for real-time decision-making, checks the processes of manufacturing activities, and helps in failure deflection. Makkonen (2020) further suggests that data brings innovative forms of information processing that are cost-effective and cannot be used by traditional processing techniques and algorithms, thus enhancing insight, decision-making, and process automation. According to David et al. (2022), through big data analytics, organisations would be able to acknowledge insights into the purchase behaviour of customers and provide products or suggestions of products that are more personalized for every customer requirement to increase satisfaction and value. Value creation for the customer is the major responsibility of the manufacturers and concerns new products, supply chains, and client relationships. Big data would also make it possible to develop remote diagnostics for the sold items to provide the clients with accurate and better support.

The discussion surrounding the utilisation of big data in the context of the 4IR is crucial in understanding the transformative potential it holds for organisations across various sectors. Frank,

Dalenogare, and Ayala (2019) emphasize the diverse nature of big data, ranging from customer databases and internet clickstream data to social network posts and medical information. This broad spectrum of data types presents organisations with an immense opportunity to derive valuable insights and drive strategic decision-making processes. One of the key benefits highlighted by the authors is the ability of big data analytics to optimize processes within organisations. By harnessing the power of large volumes of data, organisations can identify inefficiencies, streamline operations, and improve overall productivity. This optimization extends beyond internal processes to encompass areas such as supply chain management, where data-driven insights can lead to more efficient logistics and inventory management.

Predictive maintenance is another area where big data plays a significant role in the 4IR landscape. By analysing data from sensors and other sources, organisations can anticipate equipment failures before they occur, thus reducing downtime and minimising costly repairs. This proactive approach to maintenance not only enhances operational efficiency but also contributes to cost savings and improved asset utilisation. Moreover, big data facilitates enhanced product design by providing organisations with valuable insights into customer preferences and market trends. By analysing customer data, organisations can identify emerging needs and preferences, allowing them to tailor their products and services accordingly. This customer-centric approach not only fosters greater customer satisfaction but also enhances brand loyalty and competitiveness in the market.

Furthermore, big data enables organisations to personalise product offerings based on individual customer preferences and behaviour. By leveraging data analytics techniques such as machine learning and predictive modelling, organizations can deliver targeted marketing campaigns and recommendations, thereby increasing the likelihood of conversion and customer retention. The authors also highlight the role of big data in extending the lifecycle of products through after-sales operations. By analysing customer data and feedback, organizations can gain valuable insights into product performance and usage patterns, enabling them to offer tailored support and services. This personalized approach not only enhances the overall customer experience but also fosters long-term relationships and brand advocacy. The utilization of big data in the 4IR era offers organisations unprecedented opportunities for innovation, efficiency, and competitiveness. By leveraging the diverse array of data sources available to them, organizations can optimize processes, drive predictive maintenance initiatives, enhance product design, personalize offerings, and extend the lifecycle of products through after-sales operations. However, it is essential for organisations to invest in robust data analytics capabilities and adhere to ethical guidelines to ensure responsible and effective use of big data resources.

According to Dery (2020), the prediction of future trends in sales and client needs could enhance the marketing strategy through the application of machine learning analytics making it possible to detect the requested products which did not yet reached the clients that belong to other marketplaces to identify the suppliers of these items with strategic proposals for expansion. In the context of the South Durban Basin area, where the focus is on identifying products that have not yet reached clients in different marketplaces and proposing strategic expansion for suppliers, the use of big data frameworks becomes imperative. Big data frameworks, such as Apache Hadoop or Apache Spark, can handle large volumes of diverse data from various sources. This includes transactional data, customer behaviour data, and supply chain data from different marketplaces and suppliers. Big data analytics tools enable the processing and analysis of massive datasets quickly. This allows for the identification of trends, patterns, and anomalies in product distribution and customer behaviour. Utilising machine learning algorithms within big data frameworks can help predict future market trends, customer demands, and potential product shortages or surpluses.

Big data frameworks can facilitate real-time monitoring of inventory levels, sales, and customer preferences. This is crucial for promptly detecting products that have not yet reached clients or identifying emerging market demands. By analysing historical and real-time data, businesses can optimise their supply chain processes. This includes identifying bottlenecks, improving logistics, and streamlining the delivery of products to clients. Analysing data patterns can reveal untapped markets or customer segments, helping businesses tailor their strategies to expand strategically and reach new clients. Big data frameworks are designed to handle large-scale data processing efficiently, making them suitable for the diverse and extensive datasets associated with 4IR and supply chain operations. The multifaceted nature of data in the 4IR context requires advanced processing capabilities, which big data frameworks provide. This is essential for uncovering hidden insights and optimizing operations. Below is an example of big data that would need to be classified, analysed, and processed to make meaning.

Below in figure 2.4 is the presentation of the word cloud representing the key concepts, trends and patterns, importance and relationships. Various concepts are represented visually, with the size of each word indicating its frequency or importance within a given dataset or context. The more frequently a word appears, the larger it appears in the cloud. A word cloud visually represents these concepts, allowing researchers, practitioners, and decision-makers to quickly grasp the most prominent themes and areas of focus within the field. The size and proximity of words in the cloud can also indicate the importance and relationships between different concepts. The word clouds serve as a valuable tool for synthesising and visualising complex concepts and

- The ability to support diverse analytics use cases with the same data sets;
- Operational improvements, such as lower costs and proactive equipment; maintenance; and
- Ensuring that data and analytics platforms can meet future business needs.

At a higher level, big data benefits companies by generating actionable insights that enable them to implement data-driven strategies and decision-making. It can also point organisations toward new business opportunities, potential cost savings, and emerging market trends. In addition, real-time analytics applications fuelled by big data can be used to provide up-to-date information and alerts about problems to operations managers, call centre agents, sales representatives, and other frontline workers. Fortino (2023) explains that data analytics enables the production of insights by using visualisation, mining, or knowledge discovery. The visualisation reports formulate the information into graphs which are helpful for decision-making. Machine learning and data mining are used to process various algorithms such as clustering, classification, and anomaly detection. The role of cloud computing is also significant in facilitating analytics as it provides the possibility to have accessible and interconnected systems that can be managed remotely. The management of the company is responsible for clarifying the goals and the risks that the company is about to undertake due to big data analytics implementations. Organizations should consider acquiring human resources with knowledge of analytics and simultaneously train the existing personnel considering that there is a lack of these skills in the market. By leveraging big data analytics, manufacturing companies can unlock new opportunities for growth, efficiency, and customer satisfaction in an increasingly competitive market landscape.

2.11 Identification of research gaps

The literature review has emphasised the transformative potential of 4IR technologies on South Africa's economy, particularly highlighting opportunities and risks. This analysis outlines key gaps in research that need to be addressed for a comprehensive understanding of the role of 4IR technologies in enhancing the competitiveness of companies within the South Durban Basin. While historical accounts of the industrial revolutions are well documented, especially the 1st through to the 3rd industrial revolution, the transition to the 4IR in the South Durban Basin is inadequately examined. There is a research gap regarding how the evolution of industrial practices in this area has prepared or hindered the adoption of 4IR technologies. Specifically, studies that explore the degree to which past industrial policies and infrastructural developments have laid the groundwork for the integration of 4IR technologies are lacking. Consequently, the historical

narrative of industrial revolutions needs to be localised to address the unique characteristics of the South Durban Basin's economy. A more focused examination of how earlier industrial eras shaped current manufacturing and industrial capacities in the region will inform the readiness and receptiveness to 4IR adoption.

The regulatory landscape governing technological adoption in South Africa has been explored, but there is limited focus on the specific legal challenges and opportunities for the South Durban Basin. Given that the adoption of 4IR technologies involves various legal complexities such as data privacy, cybersecurity, intellectual property, and labour laws there is a critical gap in understanding how existing legal frameworks support or impede 4IR integration in this region. Therefore, research is needed to assess how well the legal services sector in the South Durban Basin is adapting to the requirements of 4IR, and whether regulatory reforms are required to facilitate smoother adoption of technologies such as AI and big data analytics. Moreover, studies should investigate the role of local authorities in creating an enabling environment for 4IR-driven industrialization.

Although the literature suggests that the South Durban Basin is underutilising 4IR technologies, the level of implementation is inconsistent across industries. This presents a major research gap. Empirical studies are needed to investigate how different sectors within the South Durban Basin are adopting 4IR technologies like robotics, automation, artificial intelligence, and IoT, and what barriers are preventing wider implementation. Further research should also explore industry-specific implementation strategies that can enhance competitiveness. Comparative studies between companies that have embraced 4IR technologies and those lagging behind would provide valuable insights into best practices, challenges, and the long-term benefits of technological integration.

Another gap lies in understanding the cultural and organizational willingness to embrace 4IR technologies. While some literature hints at a readiness for change, empirical studies that measure the actual willingness of key stakeholders in the South Durban Basin management, employees, and policymakers are limited. Qualitative research, such as surveys or interviews, can be conducted to assess the attitudes of local business leaders toward the adoption of these advanced technologies. Studies should also explore the influence of socio-economic factors on this willingness, including the impact of historical industrial practices, socio-economic inequalities, and resistance to change in labour-intensive industries.

Existing literature highlights concerns regarding the displacement of labour due to automation and other 4IR technologies, yet there is insufficient research specific to the South Durban Basin. Research is needed to investigate how the adoption of 4IR technologies might reshape the local workforce, particularly in terms of job displacement, skill gaps, and the potential for job creation in new sectors. In addition, future studies should focus on the regional workforce's preparedness to adapt to new technologies and the role of companies in facilitating reskilling and upskilling initiatives. The impact of socio-economic disruptions, like the 2021 unrest and the 2022 floods, on workforce resilience and technological adoption should also be assessed.

The literature underscores the importance of higher education in equipping the workforce with 4IR-relevant skills, but there is a lack of empirical research on the efficacy of these institutions in the South Durban Basin. The gap exists in understanding how aligned higher education curricula are with the skill sets needed for 4IR and whether partnerships between universities and industries are effective in bridging the skills gap. As a result, future studies should explore how higher education institutions in and around the South Durban Basin are integrating 4IR competencies into their programs, and whether there are collaborative frameworks in place between businesses and educational institutions to ensure that graduates possess the necessary skills. While the government's role in facilitating industrialisation through 4IR is acknowledged, more specific research is needed on the role of local and provincial governments in the South Durban Basin. The literature has not thoroughly explored government-driven initiatives for 4IR adoption in the region. Further research is therefore required to assess how government policy, infrastructure investments, and financial incentives are facilitating or hindering the competitiveness of local companies. Additionally, studies should investigate the responsiveness of governmental policies to global 4IR trends and how these policies are being tailored to the unique needs of the South Durban Basin.

While there is substantial literature on the global impact of artificial intelligence (AI) and big data, there is a significant research gap regarding their application in the South Durban Basin. Few studies have focused on how AI and big data are being utilized by manufacturing companies to drive competitiveness. The extent to which these technologies are integrated into decision-making processes, supply chain management, and customer engagement in this region remains underexplored. Further research is required to understand the potential of AI and big data to enhance operational efficiency, product innovation, and market competitiveness for companies in the South Durban Basin. Moreover, studies should investigate the specific challenges of adopting

these technologies in a developing context, including infrastructure limitations, data availability, and skill shortages.

While the literature has provided a foundation for understanding the potential of 4IR technologies in South Africa, key research gaps remain, particularly in the context of the South Durban Basin. These gaps include the efficacy of educational programs, the region-specific implementation of 4IR technologies, and the role of government and legal frameworks in facilitating industrialisation. Addressing these gaps through targeted research will help to provide a deeper understanding of how 4IR can be effectively harnessed to boost competitiveness in the South Durban Basin, ensuring the region's resilience and adaptability in a rapidly evolving industrial landscape.

2.12 Conclusion of the chapter

The chapter looked at the existing literature on the subject under investigation and identified the need for further study on the subject. There are several contradicting arguments on whether the area of Durban South Basin has used the 4IR technologies as a competitive advantage. The chapter has pointed out that the 4IR has brought a lot of economic boosts to South Africa but at the same time cautions that for that to be realised it should not lead to growth in unemployment. The chapter has revealed that for the economy to benefit from the 4IR, institutions of higher learning together with both public and private institutions need to embrace the concept of the 4IR and offer skills that will alleviate job losses through programmes that support opportunities for South African industrialisation. The literature review has pointed out that there are opportunities for industrialisation in South Africa if there is a strategic alignment. There is a need for a study on the effective use of the 4IR as a competitive tool in the South Durban Basin to unpack the opportunities that the area can benefit from to capitalise on the benefits of the 4IR. The following section looks at the theories that are relevant to the study of the 4IR. This will be followed by a discussion of the various concepts relevant to the study. Those concepts will also be shown in a diagrammatical format illustrating how they support the implementation of the 4IR technologies.

CHAPTER 3

Theoretical framework

3.1 Introduction

This chapter delves into the theoretical framework underpinning our study of the 4IR, drawing upon two pivotal theories: technology theory and leadership theory. Technology theory offers insights into the transformative potential of emerging technologies, elucidating how they drive innovation and reshape industries. Concurrently, leadership theory provides a lens through which we can examine the roles, behaviours, and strategies of leaders navigating this complex, dynamic environment. Together, these theories offer a comprehensive understanding of how technology and leadership converge to influence organizational outcomes in the era of the 4IR. To unravel the complex relationship between these theoretical frameworks and the Fourth Industrial Revolution, this chapter also scrutinizes various variables associated with each framework.

Within the realm of technology theory, variables such as innovation diffusion, technological determinism, and the socio-economic impact of technological change are explored. On the leadership theory front, variables may encompass leadership styles, decision-making processes, and the influence of key figures in driving organisational and technological change. Importantly, this chapter serves as a bridge between the literature review and the subsequent empirical investigation, establishing a theoretical foundation that aligns with the historical context presented in the previous chapter. By grounding the study in technology theory and leadership theory, the research aims to unearth the intricate connections between historical industrial transformations and the contemporary landscape of the 4IR. Through a careful examination of these theoretical frameworks and associated variables, the study endeavours to shed light on the enduring impact of the Industrial Revolution on technological and leadership paradigms, contributing to a comprehensive understanding of the evolution of industry and its implications for the present and future.

According to Schwab (2017) the Industrial Revolution, often characterized as the transformative period between the late 18th and early 19th centuries, marked a profound shift in societal and economic structures through technological advancements. This pivotal era witnessed the mechanisation of production processes, the rise of factories, and the widespread adoption of new technologies, fundamentally altering the way goods were manufactured and economies

functioned. Building upon the insights gained from the literature review, which delved into historical perspectives and contextualised the industrial revolution's impact, this chapter delves into the theoretical frameworks essential for comprehending the dynamics of this revolutionary period and its connection to the 4IR. At the heart of this study are two key theoretical frameworks, which are technology theory and leadership theory.

According to Oke, and Fernandes (2020) technology theory provides a lens through which to analyse the evolution and diffusion of technological innovations during the Industrial Revolution. It allows us to understand how these technological advancements influenced industrial activities, altered established patterns of production, and ultimately shaped the economic landscape of the time. Concurrently, leadership theory offers valuable perspectives on the roles played by individuals in guiding and managing enterprises through this transformative phase. Examining the leadership styles and strategies employed during the industrial revolution helps illuminate the human dimension of technological change, providing a nuanced understanding of the interplay between innovation, leadership, and societal transformation.

3.2 Technology Theory

According to Lai (2017), constant technological change simultaneously creates threats to proven business models, while also offering opportunities for novel service offerings resulting in leading firms shaping the evolution of technological applications to their advantage. This theory infuses the consumer adoption of modern technologies, the theory of diffusion of innovations, the theory of task-fit technology, the technology acceptance theory, and the theory of planned behaviour. These are some of the foundations of the understanding and discussion of the technology theory. Nyagadza et al. (2022), further suggest that setting up technological innovation appetite in various emerging economies' industries is meant to address, respond, and navigate within digital disruptive complexities brought about by the new world order or as most call it the new normal. It is their firm belief that the dynamics that are brought by changes resulting from the 4IR to emerging economies' industrial innovation are as old as human settlement. Contrary to the above assertion, Benassi, Grinza, Rentocchini, and Rondi (2022), state that a rampant increase in the development of scientific and technological knowledge about 4IR-related technologies has been seen in recent years.

The 4IR technologies improve new product development design thinking, customer feedback, and market research, and ensure customer satisfaction through powerful, flexible, and fast prototyping features such as 3D printing, CAD camera design, and flexible machining capabilities. Therefore,

Kim (2020), concludes that due to this belief, automation has been and will continue to increase drastically in the coming few years and companies need to keep up with the changing technologies of the 21st century. Andreoni (2019) states that digital production technologies are the result of the integration of hardware, software, and connectivity into an integrated production system where technology is effectively integrated with human resources, leadership, organizational culture, structure, and strategy. This integration is both technological and organizational and often requires the retrofitting of existing production plants. A well-designed and integrated approach that addresses these variables can lead to improved organizational performance.

According to Serumaga-Zake and van der Poll (2021) there is compelling evidence that the 4IR technologies facilitate the complete automation of manufacturing facilities and the integration of an organisation's supply chain partners, which encompass both software and hardware components and those technologies can be used by various manufacturing companies. These technologies are augmented reality, system integration, cloud computing, big data, the Internet of Things, 3D printing, additive manufacturing, cyber security, autonomous robots, and simulation. Additionally, Oztemel and Gursev (2018) argue that the 4IR is a change in technological methodologies by applying 4IR technologies to revolutionise production from dominant machine manufacturing to digital manufacturing. Ali, Mutawa, Amir, and Cui (2017) suggest that performance, technological capabilities, and knowledge management in terms of efficiency are the most important variables that can be used to measure the effectiveness of the use of the 4IR tools as a competitive advantage. These variables will be used to measure the correlation between organisational performance, skills level, and technological change in the South Durban Basin. These variables can be graphically illustrated in the diagram below:

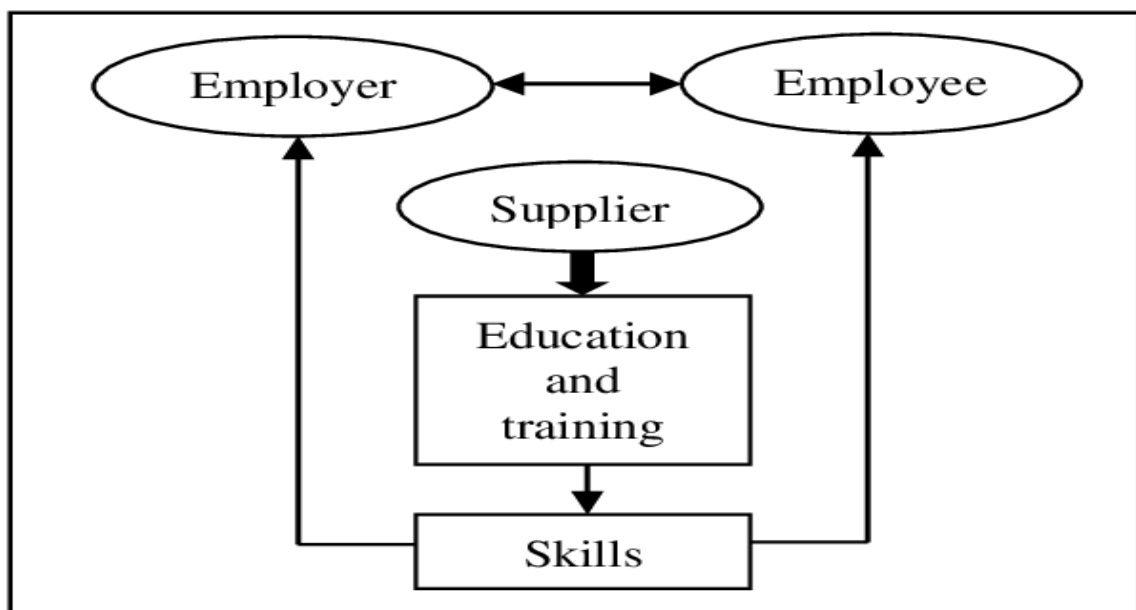


Figure 3.1 Technology Theory

Adapted from Fathiyah, Hamid, Mutalib, and Rasul (2019)

The diagram illustrates a relationship between education as a supplier of skills, employers as users of the skills, and the employees who will require relevant skills to match what the employers are looking for. Wessels (2020) further suggests that automation and artificial intelligence, technical skills, education and training, and robotics are the most important variables in the study of the 4IR. Consequently, Benassi et al. (2022), affirm that technological capabilities are positively associated with customer value and competitive advantage. Technological capabilities are crucial for most organizations to carry as their philosophical stance in achieving competitive goals for their organisations. According to this understanding, those who can successfully implement technological operations are likely to survive the changing environment and those who are stuck in the traditional way of doing things will disappear from the market. Based on this philosophical foundation, Schafer (2018), concludes that innovation, scientific discovery, and the rate at which technology is deployed, adapted, and scaled have all fuelled technological advancement and have a direct impact on the survival of the companies.

Nyagadza et al. (2022) argue that despite all the positives associated with the deployment of technology, the key issue is still ownership and control of the technology which is usually in the hands of a minority owners of corporations. They suggest that many countries are importing capital goods produced abroad with extraordinarily little or no domestic innovation and exporting activity, resulting in limited prospects for moving up the technological ladder. This cautions a call to South Africa to localize the means of production rather than relying on importing and exporting the raw material to other countries. For such to be realized, a significant effort should be on the companies to own the technology rather than get technologies from other countries. Consequently, Luz Tortorella, Cauchick-Miguel, Li, Staines, and MacFarlane (2021) point out that the real story has less to do with technology and more to do with how humans choose to do it and who owns the technology they use. Considering the nature of the skills needed in the era of the 4IR, a complex, changing, and competitive set of forces will determine the shape that the workforce of the future takes.

According to Spies, Grobbelaar, and Botha (2020) in an organisation, technology is typically applied to generate value by improving or supporting individual/s and collective tasks but does require a lot of resources for the acquisition, implementation, and usage of the various technologies. Spies, Grobbelaar, and Botha (2020) refer to this process as the Task-Technology Fit (TTF) which they define as the extent to which technology helps an individual in performing his or her tasks and is thus affected by the interaction between the characteristics of the task and

the functionalities of the technology. Due to the complexity of the interactions between factors such as the technology, users, systems, tasks, and processes it is extremely difficult to directly measure the value that technology creates in a system. According to Spies et al. (2020), the TTF theory provides a means of quantifying the effectiveness of technology in a system by assessing the relationship between the technology and the tasks the technology aims to support. In this context, tasks refer to the totality of physical and/or cognitive actions and processes done by individuals in each environment.

Andreoni and Anzolin (2019) argue that digital production technologies can play a role in making some production processes more environmentally and socially sustainable, affecting the two most traditional profit and capital utilization drivers. While the impact of these sustainability drivers is cross-cutting, they may also have an indirect impact on revenue improvement, cost reduction, and capital utilisation, and they also contribute to achieving a broader driver. This is the extent to which a company can become a major player in the transformation of the economy into a more inclusive and sustainable one. Doric and Roganovic (2021) believe that technological productivity is dependent on the willingness of employees to collaborate and constantly adjust to the changing environment while they exchange knowledge within an organization. It is the key phenomenon of studying the 4IR as the organisational performance can be attributed to the use of the 4IR technologies to improve its competitiveness. Andreoni and Anzolin (2019) suggest that digital production technologies enable companies to respond to their profit driver through digital production technologies that enhance product/service characteristics and functionalities and result in higher revenue improvements, including product innovation, customisation, and time to market, and a more competitive product/service package. In this specific case, digital production technologies impact revenue improvements by enhancing firms' competitiveness, that is, the firm's ability to outperform its competitors with better products and services. Revenue improvements can also result from cost reductions caused by the use of digital production technologies for production and improvements in coordination processes, within the firm and along the supply chain. For example, the use of additive manufacturing can speed up critical stages in the scaling up of the product/technology, while reducing the costs of tooling and re-tooling for new product and process development. The introduction of IoT can also play a role in connecting different control processes, from components' just-in-time inventory to producing predictive maintenance.

Another major driver in the adoption of digital production technologies is the extent to which they affect efficiency in the use of capital investments, both concerning fixed and working capital. Similarly, Lai (2017) emphasizes the individual impact on improved efficiency, effectiveness,

and/or higher quality suggesting that there must be a good fit between task and technology. According to Spies, Grobbelaar and Botha (2020) that is called a task–technology fit which measures the extent to which the emerging technologies meet the task requirement. This is a particularly critical issue for companies operating in developing countries where capital constraints can be a major obstacle in technological upgrading. The tasks expected of modern technologies of the 4IR are (a) stimulating economic growth; (b) improving and enhancing productivity and service delivery; (c) creating new jobs for South Africans and (d) reducing inequality amongst South Africans. In other words, the major task of South Africa is to address its chronic problems of poverty, unemployment, and inequality.

Technology characteristics refer to the attributes of the technology available such as communication support, process structuring, and information processing. Task-technology fit is a critical concept in the field of information systems as it is essential for ensuring that technology is effectively integrated into the organization’s workflow to increase efficiency, productivity, and user satisfaction. The task-technology fit is diagrammatically shown below in Figure 3:2.

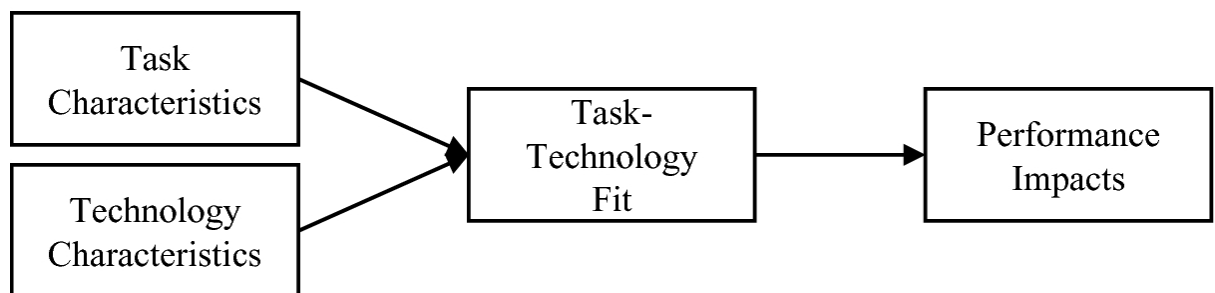


Figure 3.2 The task-technology fit

Source: Theory Hub (2022)

The task-technology fit model illustrated in Figure 3.2 embodies a simple but powerful perspective illustrating that there must be a better fit between technology and task which will result in better performance. In a setting where technology is used by individuals to perform certain tasks or sets of tasks, the model’s premise is that the value/performance of the technology is created by the alignment, or fit, of the task requirements and the technology characteristics that allow a user to perform the tasks. It has been proven that if technology provides a good fit with the task, users will consider the technology to be easy to use, which will affect their intention to use it. The improved performance is typically due to the smooth execution of the task, reducing the cost of performing the task or making the task easier to accomplish. On the other hand, when the technology does not fit well with the task, it can lead to frustration, inefficiency, and decreased

performance. In the South African context, fit measures whether emerging technologies (AI, blockchain, IoT, amongst others) can help address chronic problems of inequality, unemployment, and poverty in South Africa.

According to Rai and Selnes (2019), the task-technology fit refers to the economic feasibility of the adoption and implementation of the new 4IR technologies as well as the financial health of the country. The current downturn in economic growth and productivity in South Africa may affect the adoption of modern technologies. In other words, the country's ability to provide financial support for the implementation of the 4IR across industries and sectors is fundamental. The task-technology fit assesses the economic stability and prosperity of the country and its impact on investments, improvement, and advancement in 4IR technologies. South Africa is currently in an economic recession, so coupled with the severe economic impact of COVID-19 the country may find it difficult to invest adequately in 4IR technologies. This implies that South Africa is currently not financially viable to adopt and utilize 4IR technologies. In the context of the 4IR, understanding technology theory involves exploring key variables such as innovation diffusion, technological determinism, and the socio-economic impact of technological change. These variables are discussed below.

3.2.1 Innovation diffusion

Millar, Lockett, and Ladd (2018) define innovation diffusion as the process through which new technologies and innovations spread across various segments of society and organisations. Maphangwa (2023) further suggests that this concept is rooted in Everett Rogers' diffusion of innovations theory, which outlines how, why, and at what rate new ideas and technology spread. The diffusion of technologies in 4IR is accelerated by factors such as global connectivity, reduced costs of technological adoption, and increasing digital literacy. The rapid spread of innovations affects industries, competitive dynamics, and societal norms, making understanding diffusion patterns crucial for analysing 4IR's impact. In the South Durban Basin, companies that fall into the innovators and early adopters' category are crucial for setting the technological trend. These may include tech-driven manufacturing firms or research-based institutions that are quick to explore 4IR technologies such as artificial intelligence, the Internet of Things, and blockchain. These firms are usually the first to realise the competitive benefits of adopting such technologies. By experimenting with these emerging technologies, they may gain early advantages like increased productivity, enhanced decision-making, and cost-efficiency. These companies are typically positioned to gain a competitive edge by enhancing their production processes,

improving supply chain management, or offering more innovative products. The presence of innovators and early adopters in the South Durban Basin would directly influence the competitiveness of the sector, as they can stimulate other firms to follow their lead.

As 4IR technologies become more mainstream and mature, more companies in the South Durban Basin will begin to adopt them. For example, smart manufacturing systems, automation, and predictive maintenance using Internet of Things might be increasingly adopted by medium-sized companies once these technologies have proven their value. The wider adoption of 4IR technologies creates a broader shift in the industry. This can enhance the overall competitiveness of the region by raising the standards of productivity and operational efficiency. Firms that adopt technology help to diffuse the technologies into the market, contributing to the ecosystem's evolution.

Laggards in the South Durban Basin might include smaller firms or traditional manufacturers who are slower to adopt 4IR technologies due to limited resources, lack of technical know-how, or resistance to change. These companies may rely on outdated methods and be hesitant to make the financial or operational commitment to 4IR adoption. Laggards may face challenges in maintaining their competitive edge as the rest of the industry moves toward 4IR technologies. Their reluctance to adopt can lead to inefficiencies, higher costs, and a potential loss of market share. For competitiveness on a regional scale, lagging firms could either act as a drag or, conversely, serve as late bloomers if they successfully manage a delayed adoption of 4IR technologies.

The diffusion of 4IR technologies in the South Durban Basin will impact the competitive dynamics of the region. Faster technology adoption tends to improve innovation capabilities, reduce costs, and improve operational efficiency. These factors collectively boost the competitiveness of firms, allowing them to position themselves better in both local and global markets. Wang, Wang, and Yang (2010) suggest that the rapid diffusion of 4IR technologies is facilitated by factors like increasing global connectivity, lower technology costs, and rising digital literacy, particularly in industrial areas like the South Durban Basin. Understanding diffusion patterns allows for identifying where interventions (such as government policies or industry support) may be needed to help lagging companies catch up, ensuring that the competitive advantage gained by early adopters does not widen the gap between companies.

Innovation diffusion is a critical concept for understanding how 4IR technologies can enhance the competitiveness of companies in the South Durban Basin. By examining the role of innovators, early adopters, and the different stages of adoption, one can better understand which firms lead the way in adopting 4IR technologies and how this affects the broader industrial ecosystem. The speed and extent of diffusion will determine the overall competitiveness of the region's manufacturing sector in the era of the 4IR.

3.2.2 Technological determinism

The section offers a valuable theoretical framework that is directly relevant to the study of the adoption of 4IR technologies on the competitiveness of companies in the South Durban Basin. According to Hallstrom (2022), technological determinism is a theory that suggests technology develops according to its own logic and has a determinative effect on society. This perspective posits that technological advancements drive societal changes, rather than being shaped by social or cultural factors. By applying concepts such as technological determinism and the socio-economic impact of technological change, the study gains a comprehensive lens through which to analyse the dynamics in the South Durban Basin's manufacturing companies.

Technological Determinism and 4IR Adoption in the South Durban Basin

- **Hard Determinism:** This perspective views technology as an independent force driving social change, which can be applied to how 4IR technologies (AI, robotics, automation) are reshaping the manufacturing sector in the South Durban Basin. As these companies adopt 4IR technologies, the structure of labour markets, job roles, and competitive strategies are likely to change. The drive for increased efficiency, productivity, and cost reduction means companies that adopt these technologies may gain a competitive edge, while those that do not may struggle to keep up.
- **Soft Determinism:** While technology significantly influences change, human and social factors also play a role. In the context of the South Durban Basin, decisions on adopting 4IR technologies are likely to be influenced by regional policy decisions, economic conditions, workforce skills, and the readiness of companies to invest in new technologies. For example, firms may adopt AI and automation not just because it is available but because it aligns with their strategic goals and the prevailing economic environment.

The balance between technology driving change and human agency is central to understanding the adoption patterns of 4IR technologies among manufacturing firms in the South Durban Basin. It raises questions about which firms are more likely to adopt these technologies, how adoption strategies vary, and what external factors (e.g., government support, workforce readiness) facilitate or hinder this process.

Socio-economic Impact of Technological Change

- **Economic Growth and Productivity:** For companies in the South Durban Basin, adopting 4IR technologies is expected to improve productivity through automation, better data analytics, and increased operational efficiency. The effect on competitiveness can be analysed by examining how these technologies reduce costs, increase output, or improve product quality, helping local companies compete both domestically and globally.
- **Employment and Labour Markets:** The introduction of AI and robotics in the South Durban Basin's manufacturing sector could lead to job displacement in certain sectors, while also creating new opportunities in others (e.g., tech support, maintenance of automated systems). For the study, it was important to assess how companies are managing this transition and whether they are investing in upskilling their workforce to remain competitive in a 4IR-driven economy.
- **Inequality and Access:** A critical factor in the study is the uneven adoption of 4IR technologies across different companies. Larger or more resource-rich firms might be better positioned to invest in these technologies, while smaller or less affluent companies could fall behind, exacerbating economic disparities within the region. This could impact the overall competitiveness of the South Durban Basin if a significant portion of its manufacturing base lags in technological adoption.
- **Social Interaction:** With the rise of digital tools, there may be shifts in how workers, managers, and companies communicate and collaborate. The use of digital platforms, virtual reality (VR), or augmented reality (AR) could alter internal company dynamics and external relationships with suppliers and clients, potentially leading to new forms of engagement and competitiveness in the market.

Impact of Innovation Diffusion and Technological Determinism in the South Durban Basin

- **Innovation Diffusion:** This helps explain how and why certain firms in the South Durban Basin might adopt 4IR technologies faster than others. By studying how technologies spread across the region's companies, we are able to gain insights into factors that drive or hinder technology adoption, such as company size, leadership vision, available capital, and the regulatory environment.

- **Technological Determinism:** This offers a theoretical backdrop for understanding the inevitable push of technology, especially in an era like 4IR where innovations such as AI, IoT, and automation are often seen as non-negotiable for firms that want to remain competitive. Analysing the relationship between these technologies and competitiveness reveals how companies in the South Durban Basin are either responding to or being shaped by global technological trends.

By incorporating these theoretical perspectives, the study on the competitiveness of South Durban Basin manufacturing companies focuses on:

- **The drivers and barriers to 4IR technology adoption:** Are companies adopting technology because they must (hard determinism), or are they making deliberate choices based on other factors (soft determinism)?
- **The socio-economic implications:** How does 4IR adoption affect economic performance, labour, and inequality among companies in the Basin? Which firms are benefiting most from these advancements, and what policies or strategies could help others catch up?
- **Strategic competitiveness:** How are companies positioning themselves within a 4IR-driven competitive landscape? By examining the diffusion of these innovations, we are able to understand how some companies leverage technology to outperform others.

This framework provides a multi-dimensional approach to assessing how 4IR technologies are transforming the competitiveness of companies in the South Durban Basin. In the 4IR era, technological determinism highlights how innovations such as automation, big data, and AI are transforming industries, work environments, and social interactions. It provides a framework for understanding how these technologies might drive economic growth, alter job structures, and shift power dynamics within and between organizations.

3.2.3 Socio-economic impact of technological change

According to Bag (2023) the socio-economic impact of technological change examines how technological innovations affect economic structures, social practices, and individual lives. This includes changes in productivity, employment, income distribution, and social interactions.

- **Economic growth and productivity:** Technological advancements in 4IR lead to increased efficiency and productivity. Innovations in automation, data analytics, and machine learning contribute to economic growth by streamlining processes and reducing costs.
- **Employment and labour markets:** The rise of AI and robotics may lead to job displacement but also creates new job categories and opportunities. The challenge is to manage this transition and ensure workers are equipped with the skills needed for emerging roles.
- **Inequality and access:** Technological advancements can exacerbate inequalities if access to technology is uneven. For instance, regions or populations with limited access to advanced technologies may fall behind economically and socially.
- **Social interaction:** Technologies such as social media, virtual reality, and augmented reality alter how people interact, communicate, and form relationships. The socio-economic impact includes shifts in social dynamics and new forms of digital engagement.

Impact on 4IR: The socio-economic impact of the 4IR technologies is multifaceted, influencing economic development, labour markets, and social structures. Understanding these impacts is essential for crafting policies and strategies that harness the benefits of technological advancements while addressing challenges such as inequality and job displacement.

In studying the 4IR, these variables of innovation diffusion, technological determinism, and the socio-economic impact of technological change provide a comprehensive framework for analysing how technological advancements shape and are shaped by society. Innovation diffusion helps us understand the spread and adoption of new technologies. Technological determinism offers insights into how technology drives societal change. The socio-economic impact highlights the broader effects on economic and social systems. Together, these variables offer a robust foundation for exploring the complexities of the 4IR.

3.3 Leadership Theory

Leadership theory provides a crucial lens for examining the dynamics of the 4IR within the realm of information systems (IS) scholarly discourse. Leadership theory emphasizes the role of leaders in setting a strategic vision and driving organizational transformation. In the context of the 4IR, which is characterized by rapid technological advancements such as artificial intelligence, the Internet of Things, big data, and blockchain, leaders play a pivotal role in envisioning the future, driving innovation, and facilitating digital transformation. Leadership theory provides a

comprehensive framework for understanding and guiding the integration of the 4IR technologies within organizations. By emphasising strategic vision, change management, ethical considerations, and interdisciplinary collaboration, leadership theory situates the study of the 4IR firmly within the IS scholarly discourse, highlighting the critical role of leaders in navigating and harnessing the potential of these transformative technologies.

Leadership has always been an area of interest in organizations, societies, communities, and nations. In the dynamic landscape of the 4IR, the study of leadership theory takes on heightened significance as organisations grapple with unprecedented technological advancements and societal transformations. Effective leadership in the context of the 4IR is crucial for navigating complexities, fostering innovation, and ensuring sustainable development. Nowhere is this more relevant than in the South Durban Basin area, a region marked by industrial activity and diverse communities. As the 4IR reshapes industries and economies, leaders in the South Durban Basin must adapt their approaches to maximise the benefits of technological advancements while addressing the unique challenges faced by their communities. This study delves into the intersection of leadership theory and the 4IR, emphasising its practical application and impact on the socio-economic fabric of the South Durban Basin.

Naidoo (2022) suggests that leadership is a very complex and dynamic phenomenon which can be defined in different ways, and explained using a variety of concepts. Pan and Chen (2021) define leadership as a collaborative process between leaders and followers in which the leader motivates and positively influences the followers to achieve short-term objectives which are aligned with long-term vision. Shava (2021) further elaborates that leadership incorporates cognitive abilities, communication skills, emotional intelligence, and ethics. According to Gray (2016), leadership needs to change and adapt to a new set of skills in the 4IR considering that the future of leadership in the era of the 4IR is going to be quite different from the traditional hierarchical structures that many organisations are accustomed to. Consequently, Uys and Webber-Youngman (2019) suggest that a new leadership postulation is required to cope with the challenges related to 4IR and the one that explains leadership in new and rapidly changing contexts, one that balances work and people with leadership impact, one that has a solid foundation of balance between individual leadership and prowess, and finally, one that clearly spells out leadership direction and objectives as a compass to resilience and yet is adaptive and agile.

In line with this view, Deloitte (2019) suggests that four (4) kinds of leaders will thrive in the

4IR: (a) the social superstars; leaders with the capacity to prioritize societal impact initiatives and also generate new revenue streams from socially beneficial products or services; (b) the data-driven deciders; leaders that use meticulous, data-driven approaches to strategize development and have the confidence in their ability to capitalize on the 4IR; (c) the disruption drivers; leaders who demonstrate a willingness to invest in disruptive technologies that upend their markets and who have already made investments that have achieved or exceeded intended business outcomes, and (d) the talent champions; leaders who have gone ahead of the rest in preparing their workforce for the future and have done so continuously. Consequently, Molapo and Khumalo (2018) suggest that leaders must be able to embrace adaptive leadership styles such as transformational leadership which involves inspiring and motivating followers to achieve a shared vision and for them and their companies to survive in the 4IR. They further suggest that the 4IR is forcing leaders to manage employees who are not working in the same physical office or location causing a drastic shift in practice which provides a change for which leaders should be trained to manage themselves remotely. That is why Bunker (2019) suggests that today's leaders must apply an augmented set of leadership competencies to successfully navigate their organizations through rapid change, several types of economies, technology landscapes, cultures, and social values. Leaders need to keep up with the latest trends, technologies, and business practices that are relevant to the 4IR and can make informed decisions and take advantage of emerging opportunities.

According to Alade and Windapo (2020), the need for effective 4IR leadership has placed new demands on organizations to develop and select leaders to effectively lead the organizations in the 4IR era and beyond. In line with this view, Wessels (2020) states that leaders should constantly exploit new opportunities, adapting to the rapid changes brought about by the 4IR technologies with caution, wisdom, and responsibility. Alade and Windapo (2020) further suggest that various leadership traits and leadership styles should be identified while the importance of leadership is emphasised through effective leadership for organisations to be able to deal with the disruptive nature of the 4IR. The interdependency between leadership intelligence, leadership traits, leadership styles, and effective 4IR leadership shows that effective leadership towards 4IR will be provided when the leaders are disruption-prepared to the extent of being able to develop intelligent initiatives that are 4IR-oriented. Though Nawaser (2021) agrees with Alade's view on the importance of leadership, he, on the other hand, argues that there is an increasing demand for a closer look at the relationship between leadership styles, characteristics, and their impact on members and organisations.

In addition to leadership intelligence, leaders need to have certain traits that are relevant to the 4IR. Consequently, Raza (2019) suggests that the kind of leadership style employed in an organization directly affects its overall performance. This is premised on the notion that an organization's leadership style correlates with organizational performance. Adequate motivation, a suitable work environment, compensation, and efficient communication between managers and subordinates play a significant role in promoting excellent organisational performance. In the competitive world with technological changes within the business environment, organizations must employ leadership styles that enable them to survive in a dynamic environment. The diagram below illustrates leadership traits, leadership intelligence, and leadership styles to achieving effective 4IR leadership. Using a diagram to illustrate the relationship between leadership traits, leadership intelligence, and leadership styles in the context of achieving effective leadership in the 4IR can provide a clear and visual representation of the key components. A diagram helps in presenting complex ideas in a simplified and organized manner. It allows leaders to visually grasp the interconnectedness of leadership traits (such as adaptability, vision, and resilience), leadership intelligence (including emotional intelligence and technological acumen), and leadership styles (like transformational or servant leadership) in the context of navigating the challenges and opportunities presented by the 4IR.

A diagram facilitates better communication of the nuanced relationships between different elements of leadership, enabling leaders to understand how their traits and intelligence contribute to the adoption of specific leadership styles for 4IR success. Leaders can use the diagram to align their personal traits and intelligence with the most appropriate leadership style for the demands of the 4IR. This visual representation helps leaders make informed decisions about their leadership approach, fostering strategic alignment with the dynamic and rapidly evolving landscape of the Fourth Industrial Revolution. The diagram can serve as a valuable tool in leadership training and development programs. It provides a framework for aspiring leaders to understand the multifaceted nature of effective leadership in the 4IR, guiding them in developing the necessary traits and intelligence and choosing an appropriate leadership style. Leaders can use the diagram as a reference tool when making decisions related to their leadership approach in the context of technological advancements and societal changes associated with the 4IR. It serves as a visual guide for leaders to assess and adjust their strategies based on the evolving demands of the digital age. A diagram illustrating the interplay between leadership traits, intelligence, and styles enhances understanding, communication, and strategic alignment, making it a valuable tool for leaders aiming to navigate and excel in the 4IR.

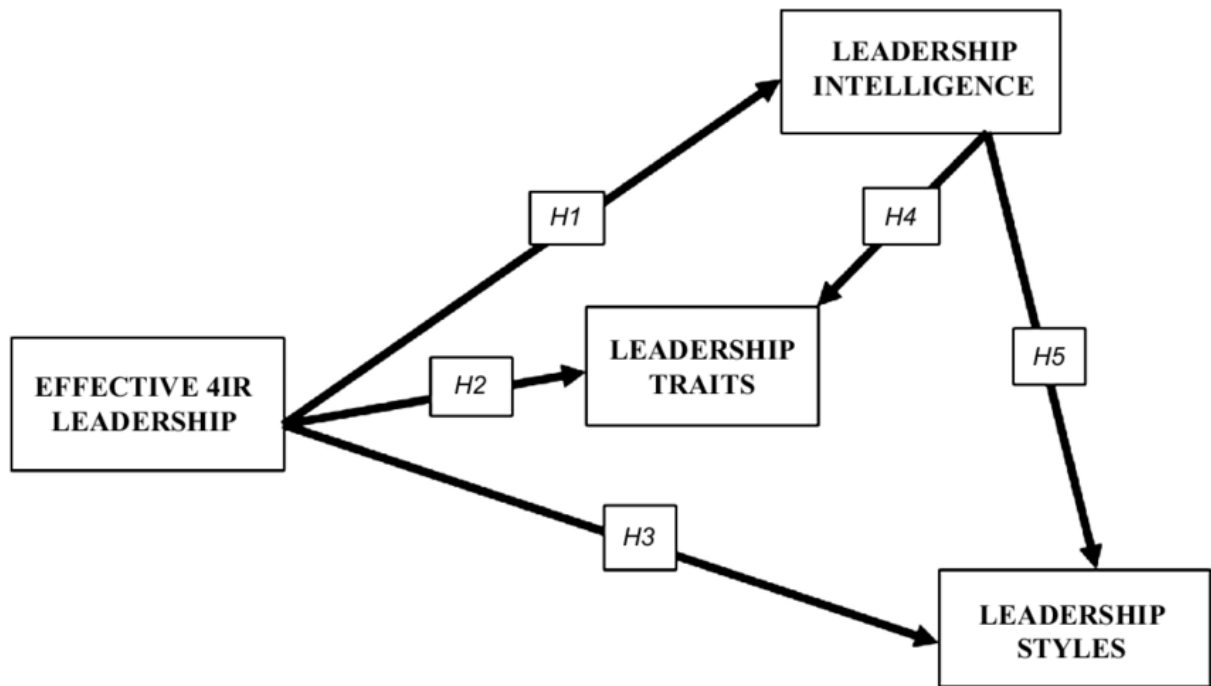


Figure 3.3 Effective 4IR leadership

Source: Alade & Windapo (2019)

The framework shown above illustrates the importance of linking the 4IR leadership to leadership intelligence, leadership traits, and leadership styles to survive the disruptive nature of the 4IR. This ability of a leader to embrace disruption, respond quickly to change, and upskill the existing workforce in line with the requirements of the 4IR is fundamental to organizational success. That is the reason Alade and Windapo (2020) suggest that leadership is the ultimate key to successfully embracing the 4IR initiatives into daily business operations in organizations. According to Alade and Windapo (2020), leadership effectiveness is the extent to which a leader organizes or performs tasks successfully to achieve the goals identified. According to Mdluli and Makhuphe (2017), the elements of leadership effectiveness include two-way communication, a delegation of responsibilities, goals development, a sense of appreciation, generating and maintaining trust, encouraging flexibility in decision-making, the establishment of meaningful identity for the organisation, and the creation of new structures. The implication of this is that effective leaders need to perfect their responses to workload, discipline, stress, goals communication, innovation, and performance of subordinates. According to Doric and Roganovic (2021), leadership enforces corporate culture and is important in industrial performance as it encompasses an organisation's values, ethics, vision, behaviour, and work environment. This means that effective leadership is crucial in meeting the demands of the 4IR to match the demand of the time with the appropriate competencies, influence employees to pursue organizational goals, manage challenges to pursue

organisational goals, manage challenges and conflicts, deliver effective organisational performance, motivate followers, make major changes in organisations, coordinate organisational growth, ensure followers' commitment to organisational objectives, foster positive attributes at work and create a sense of contribution and importance with and among employees. Akbar, Wadood, Bob, and Al-Subari (2020) suggest that the correct leadership leads to the improvement of production efficiency and the improvement of quality strategy is closely related to the improvement of company performance. They also argue that greater efficiency is associated with reductions in pollutant emissions and material and energy consumption per unit of production, which can improve the environmental sustainability of the process. In line with the international calls for environmentally friendly production processes, Agrawal, Schafer, and Funke (2018) state that companies need new product development design thinking, consumer feedback, market research, and customer profile, and those can be implemented through the employment of sophisticated features such as 3D printing, CAD camera design, and flexible machine capabilities. To do this, companies must master management and quality tools, the automation and digitization of processes, continuous improvement, and industrial performance. Berrah, Cliville, Trentesaux, and Chapel (2021), suggest that, in its general sense, performance refers to an exceptional, outstanding, best result and involves expectations that can be translated into goals.

This theoretical framework points to the need for a study to be conducted to assess the kind of leadership that exists in the companies in the South Durban Basin area to conclude on the effectiveness of such companies to use the 4IR technologies. Eblin (2013) states that leadership is about getting things done and that getting things done is dependent on three variables such as time, money, and resources. According to Briker, Walter, and Cole (2021), the time variable is based on the number of hours you spend on a task while money provides options in terms of what to do with your life. The above variables include human resources as people always determine the performance of an organization based on its profitability. The above discussion suggests that the 4IR requires leadership skills such as change management, collaboration, innovation, creative thinking, and analytical skills, and these leadership skills are associated with both skills requirements and skills development.

As a result, Raza (2019) suggests that any organisation that employs right leadership styles and other factors in its operation has a higher probability of achieving its organisational goals. Consequently, Alade and Windapo (2020) suggest that effective 4IR leadership must enhance the motivation and commitment of organisations towards 4IR, create an open communication atmosphere for information-sharing about 4IR developments, and facilitate a change in organisational systems and team dynamics. This implies that organisations that will be successful

in the 4IR era will ideally embrace change, build an innovation ecosystem for all stakeholders, and recognize the importance of human capital. Organisational leadership styles go a long way in influencing the culture of the organisation. This in turn directly or indirectly influences the performance of the organisation.

In conclusion, leaders who want to survive the disruptive nature of the 4IR need to have leadership intelligence, relevant leadership traits, and adaptive leadership styles. This requires a willingness to learn, adapt, and innovate in response to the changing business environment. By developing these qualities, leaders can navigate the complexities of the 4IR and take advantage of emerging opportunities.

3.4 Synthesis of theoretical framework

These theories of technology theory and leadership theory offer complementary perspectives on how technological advancements and leadership dynamics influence the competitive edge of organizations. Technology theory provides a foundation for understanding the role of technological innovations in shaping business environments. Mulaudzi (2020) argues that the adoption of 4IR technologies such as AI, the IoT, big data analytics, and automation reshapes traditional business models and introduces new methods for enhancing operational efficiency and market responsiveness. Within the context of this study, technology theory suggests that companies in the South Durban Basin can significantly improve their competitiveness by integrating 4IR technologies into their processes. This theory argues that technological capabilities are a primary driver of organizational success, and firms that lag in technological adoption risk falling behind their more innovative competitors.

According to Andreoni and Anzolin (2019) the adoption of these technologies facilitates not only process optimisation but also the ability to create new value propositions through advanced analytics, customer personalisation, and real-time decision-making. In competitive industries like those in the South Durban Basin, early adopters of 4IR technologies may benefit from enhanced operational efficiency, cost reduction, improved product and service offerings, and more dynamic supply chain management. Technology theory underscores that firms with a high rate of technology adoption are better positioned to respond to market demands and changes, providing a critical source of competitive advantage. Mulaudzi (2020) asserts that while technology adoption is a key driver of competitiveness, the successful implementation of 4IR technologies

largely depends on effective leadership. Leadership theory helps explain how leaders in companies within the South Durban Basin can influence technology adoption and shape competitive outcomes. Visionary and transformational leaders play a critical role in navigating the complexities of technological change by fostering a culture of innovation, motivating teams to embrace new technologies, and providing strategic direction during periods of transition.

Transformational leadership, in particular, is pivotal in creating an environment that encourages experimentation with emerging technologies, supports continuous learning, and aligns technological advancements with broader business objectives. Leaders must articulate a clear vision for how 4IR technologies integrate into the organization's operations and how they enhance competitiveness. Leadership theory also highlights the importance of leaders in managing resistance to change, ensuring proper alignment of resources, and developing talent capable of leveraging new technologies. Moreover, leadership theory suggests that leaders need to embody both technological competence and an adaptive mind-set. Leaders in the South Durban Basin companies must not only understand the potential of 4IR technologies but also foster collaboration and innovation across their organizations to fully realize these technologies' competitive potential. This underscores the symbiotic relationship between leadership and technology adoption, with leadership driving the strategic direction and creating the organizational conditions necessary for technology-driven competitiveness.

Alade and Windapo (2021) argue that the integration of technology theory and leadership theory offers a comprehensive framework for understanding the role of 4IR technologies in enhancing competitiveness. While technology theory emphasises the transformative power of 4IR technologies, leadership theory underscores the human and strategic elements critical to successful technology adoption. Together, these theories suggest that competitiveness in the South Durban Basin is not solely a function of acquiring advanced technologies but also of the ability of leaders to steer their organisations through the complexities of technological change. Companies that successfully combine technological innovation with strong, adaptive leadership are more likely to sustain long-term competitive advantages.

This synthesis of technology and leadership theories illustrates that competitiveness in the era of the 4IR is both technologically and leadership-driven. Firms in the South Durban Basin can enhance their competitive positioning by adopting cutting-edge technologies, but the effectiveness of these adoptions is contingent on the vision, adaptability, and strategic leadership within the organization. This integrated framework provides a holistic view of how technology

adoption and leadership jointly contribute to the competitiveness of companies operating in a rapidly evolving industrial landscape.

3.5 Gaps in the theoretical frameworks

The study of the adoption of 4IR technologies in the South Durban Basin and their impact on corporate competitiveness draws on a combination of technology adoption theories and leadership frameworks. While these theoretical models offer significant insights, several critical gaps emerge when applied to the specific context of the South Durban Basin. This section identifies these gaps by analysing the limitations in both technology theory and leadership theory as they relate to the adoption of 4IR technologies and the resulting implications for competitiveness. Technology adoption theories provide valuable frameworks for understanding how and why companies adopt new technologies. However, these theories do not fully account for several factors unique to 4IR technologies in the SDB context. Most technology adoption models are based on studies conducted in developed economies where infrastructure, education levels, and financial resources are more robust. The unique characteristics of the South Durban Basin, including infrastructural challenges, economic disparities, and historical socio-political factors, are not adequately captured in existing models. The South Durban Basin's industrial ecosystem, being highly diverse, has varying levels of technological sophistication, which affects the pace and scale of 4IR technology adoption. Traditional models do not sufficiently account for the effects of such disparities.

Current models tend to emphasise the individual's role (e.g., employees or consumers) in technology adoption, focusing on variables such as perceived ease of use and perceived usefulness. In the context of 4IR, however, adoption is more organizationally driven and involves complex, system-wide technological changes such as automation, AI integration, and supply chain digitisation. This systemic nature of 4IR technologies requires a broader, organization-level framework that goes beyond individual perceptions to include strategic imperatives, organizational readiness, and macro-environmental factors (e.g., industry standards, regulation, and infrastructure). The 4IR technologies are often integrated into existing processes and legacy systems, making generalisability a key challenge. Most technology adoption theories are insufficiently equipped to handle the complexity of integrating multiple advanced technologies, such as IoT, AI, and blockchain, into a cohesive system. The South Durban Basin, with its mix of large enterprises and small-to-medium enterprises (SMEs), faces additional challenges in

achieving seamless technological integration. Theoretical models tend to treat technology adoption in isolation, without considering the interoperability challenges that arise when multiple 4IR technologies are adopted concurrently. While many technology adoption models consider efficiency and effectiveness as outcomes, they fall short of explicitly linking technology adoption to broader competitiveness metrics such as market positioning, innovation capability, and long-term profitability. Competitiveness in the context of the South Durban Basin is influenced not only by internal technological efficiencies but also by external factors such as market dynamics, global supply chain integration, and regulatory pressures. The lack of a direct focus on how 4IR technologies contribute to sustainable competitive advantage presents a significant gap in the existing theoretical frameworks.

Leadership plays a critical role in facilitating the adoption of 4IR technologies, yet traditional leadership theories do not fully account for the complexities associated with leading technological change in the context of 4IR. Two prominent leadership theories, Transformational Leadership and Servant Leadership are commonly invoked when discussing technology adoption, but gaps remain in their applicability to the South Durban Basin's industrial environment. Transformational leadership, which emphasises inspiring and motivating employees to embrace change, is often highlighted in discussions of technological innovation. However, in the case of 4IR technologies, visionary leadership alone is insufficient. Companies in the South Durban Basin require leaders who not only inspire but also possess the technical expertise and decision-making capabilities to manage complex technology adoption processes, including stakeholder management, cost-benefit analysis, and risk mitigation. The gap in the theory arises from its focus on abstract motivation and vision, without providing concrete mechanisms for leading the multifaceted processes involved in 4IR technology adoption.

While leadership theories stress interpersonal qualities such as empathy, communication, and trust, they tend to underemphasize the importance of technical competence in managing technology adoption. The adoption of 4IR technologies requires leaders to possess a certain level of digital literacy and technical understanding, which many traditional leadership theories fail to address. This gap is particularly evident in the South Durban Basin, where industries are at varying stages of technological maturity, and the technical know-how required to manage advanced technologies like AI, machine learning, and advanced robotics is critical.

The complexity of 4IR technologies often necessitates cross-functional teams and collaborative decision-making. Traditional leadership models tend to focus on hierarchical structures and

charismatic, top-down leadership styles, which may not be well-suited to the distributed and collaborative leadership required for managing 4IR technology adoption. In the South Durban Basin context, where industries like petrochemicals and manufacturing often have decentralised operations, there is a gap in leadership theories' ability to address the need for collaborative leadership that spans different functions and technical domains.

Adopting 4IR technologies involves significant organizational change, often requiring new workflows, employee reskilling, and even changes in organizational culture. However, many leadership theories underplay the importance of structured change management in the successful adoption of new technologies. The South Durban Basin, with its diverse industrial base, faces unique challenges in this regard, as the rate of technological adoption and the readiness for change vary widely across sectors. Leadership theories must better incorporate change management principles that address both technological and human factors.

Finally, a notable gap exists in how technology and leadership theories intersect when applied to the 4IR context. While both bodies of theory provide valuable insights in isolation, they do not sufficiently address the interplay between leadership practices and technology adoption processes. There is a distinct gap in the literature regarding integrated frameworks that combine both technology adoption and leadership theories. While it is clear that leadership plays a role in shaping organisational readiness for technology adoption, there is insufficient theoretical development around how specific leadership practices can enhance or hinder the adoption of complex 4IR technologies. This is particularly true in the context of the South Durban Basin, where both technological and organisational factors must be aligned for successful adoption.

Both technology and leadership theories tend to focus on internal organizational dynamics, often neglecting the role of external stakeholders such as government, industry regulators, and the local community. In the South Durban Basin, where industrial activity has a significant socio-economic impact, the adoption of 4IR technologies involves balancing competitiveness with social responsibility, environmental sustainability, and compliance with regulatory standards. This gap suggests the need for a more holistic approach that integrates external stakeholder considerations into both leadership and technology adoption theories.

The theoretical frameworks commonly used to study the adoption of 4IR technologies and their impact on competitiveness, while useful, reveal several gaps when applied to the South Durban

Basin. These gaps arise from the limitations of existing technology adoption models in accounting for contextual factors, the complexity of 4IR technology integration, and the metrics of competitiveness. Similarly, leadership theories fall short in addressing the technical, collaborative, and change management aspects of leading 4IR technology adoption. Bridging these gaps requires the development of more comprehensive, context-sensitive, and integrated theoretical models that address the unique challenges faced by companies in the South Durban Basin as they navigate the complexities of the 4IR.

3.6 Chapter Summary

The above theoretical framework shows that South Africa still has low technological capability, economic competency is plummeting and there is a fall in digital technological readiness. The theoretical framework has shown that companies need to review whether the technology used, is the correct fit for the execution of the 4IR ambitions. This can only be achieved through the employment of the correct leadership by the organisation. South Africa seems not to have the financial ability to finance the adoption and utilisation, plus the adoption of modern technologies given its current economic state, coupled with the adverse economic impact of COVID-19. This is due to the rising inflation rate, interest rates hike, and increasing rate of unemployment which affects the economy negatively. The glaring observation here is that South Africa does not have enough digitally skilled workers to manage and use the modern technologies. In addition, South Africa lacks the necessary IT infrastructure and energy security. For South Africa to capitalise on the use of the 4IR technologies the country needs to invest resources in the development of infrastructure and embark on upskilling and reskilling of its workforce.

The conclusion drawn from this discussion is that despite all the shortcomings identified the correct implementation of the 4IR strategies does lead to improved organisational performance. When combined, these theories offer a comprehensive framework for analysing the relationship between the 4IR and competitiveness. By applying these theories, we can understand not only the direct impact of the 4IR technologies on competitiveness but also the complex interplay of choices and diffusion processes that shape competitive outcomes across different sectors. The following chapter will outline the research design and methodology that will be employed to investigate the hypotheses derived from our theoretical foundations. This will include a detailed discussion of the research paradigms, research approach and design, data collection methods, and analytical techniques that guided the study.

CHAPTER 4

Research Design and Methodology

4.1 Introduction

In this chapter, the fundamental framework and approach employed in a study are meticulously examined. This pivotal section serves as the blueprint for the entire research endeavour, outlining the structure, purpose, and methods utilised to address the research questions or hypotheses. According to Dawadi, Shreshta, and Giri (2021) research design elucidates the overall strategy, whether qualitative, quantitative, or a combination of both, guiding the researcher in selecting the most suitable methods for data collection and analysis. Methodology delves into the specific techniques employed to gather and interpret data, emphasising their validity and reliability. As the cornerstone of the research process, this chapter illuminates the path that researchers follow, offering a transparent view of the study's architecture and ensuring the rigor and credibility of the investigation. The chapter captures the research paradigms, research design and approach, location of the study, population and sampling techniques, research instruments, pre-testing, and issues of validity, reliability and trustworthiness. Data collection techniques, data analysis, and interpretation are also discussed. The chapter concludes with a discussion of how ethical considerations were observed in the research process. In this context, this chapter will focus on the research design and method that was used.

4.2 Research paradigms

According to Held (2019) a paradigm can be considered as a constellation of critical beliefs shared by a specific discipline of researchers which serves to direct the content, practice and interpretation of their research. Additionally, Kumatongo and Muzata (2021) suggest that a paradigm can also be considered as a set of shared philosophies of how phenomena are understood as well as how potential problems are addressed and resolved. Kovacs, Kiss, Kassai, Pados, Kalo and Jozsef (2019) argue that a research paradigm underpins the researcher's view of the world, research objectives, research questions, research methodologies, how the findings are analysed and interpreted as well as the conclusions and recommendations of the study. A paradigm therefore guides and determines all aspects of the research process from the beginning to the end. The choice of the correct paradigm for a research study is therefore considered as the most important and crucial step in the research process as it determines the success of the research.

According to Brown and Duenas (2019) the four common research paradigms are positivism, interpretivism, emancipatory research and pragmatism. The study was therefore underpinned by both the positivist paradigm as well as the interpretivist paradigm. Heeks and Wall (2018) explain that the key elements of a paradigm are the epistemological, ontological, axiological assumptions and beliefs. Brown and Duenas (2019) concur, and describe epistemology as the nature of knowledge, ontology as the nature of reality, and axiology as the nature of truth. According to Brown and Duenas (2019) epistemology, ontology and axiology can be constructed objectively, subjectively, or even by a combination of both schools of thought. The nature of these three terms therefore varies depending on the research paradigm chosen. Brown and Duenas (2019) suggest that a researcher should thoroughly reflect on the epistemological, ontological and axiological assumptions of the research prior to engaging with the research. To fully achieve the objectives of employing the positivism and interpretivism in the study both quantitative and qualitative data were collected in the study.

4.2.1 Positivism

According to Albusaidi (2019) positivist research usually focuses on the interpretation, analysis and evaluation of mathematical or numerical data and is based on proven facts and theories through hypotheses, experimentation and observation. Therefore, positivism is objective, independent of human influence and associated with quantitative research. Held (2019) further suggests that the assumptions of positivism are therefore that ontology, axiology, and epistemology are all singular and the same for everybody. Albusaidi (2019) affirms that the reality, truth, and knowledge generated by the study is therefore unaffected by the physical, social or cultural context of the study or by the individual perspectives of the respondents. Furthermore, Kumatongo and Muzata (2021) suggest that positivists also consider the epistemology, ontology and axiology of the study as being totally independent and impervious to the researcher's beliefs and values. Therefore, Phothongsunan (2019) argues that the researcher is thus considered as an outside entity and only an observer of the phenomenon which is often investigated through experimentation that can subsequently be duplicated, tested, and verified.

Some of the pros of the positivism paradigm is that vast amounts of quantitative data can be analysed intricately and the objective findings can be generalised to larger populations. Some of the cons of positivism are that it is usually selected for the study of only observable behaviour with a limited number of variables and that it tends to dehumanise people when they are investigated. The positivist paradigm in the study was selected because quantitative data was

required from the respondents in order to investigate the role of the technology adoption on the competitiveness of the companies in the South Durban Basin. The quantitative data was also used to select the sample of the study from the population.

4.2.2 Interpretivism

According to Tilley (2019) interpretative research attempts to gain an in-depth understanding of a particular phenomenon from the perspectives of individuals who have experienced the phenomenon. Interpretivism is therefore subjective and associated with qualitative research. Dean (2018) suggests that interpretivism emphasises the researcher's influence on the research process and findings by contextualising it with the researcher's worldviews. Therefore, interpretivists view the knowledge generated in the study as a product of the researcher's beliefs and values. Albusaidi (2019) concurs that all components of the research methodology are substantially influenced by the ontological, axial, and epistemological views and beliefs of the researcher. Interpretivism therefore describes knowledge as relative and prescribes multiple realities and truths.

Brown and Duenas (2019) further suggest that in interpretivism participants construct their own subjective knowledge, realities, and truths based on their own contextual interpretation of the phenomenon and researchers use these different interwoven interpretations to critically analyse a phenomenon. Kumatongo and Muzata (2021) add that interpretivism is characterised by qualitative data with a human influence, is represented discursively and analysed inductively. This paradigm is also suitable for this study because although the quantitative data was collected the qualitative data was necessary to fully achieve the aim of this study. Phothongsunan (2019) and Tilley (2019) agree that although the positivist paradigm provides a useful approach to research through the rigorous analysis of quantitative data the interpretivist paradigm is especially relevant because it provides deeper insights into the complex issues of individuals.

4.2.3 Pragmatism

According to Kelly and Cordeiro (2020) pragmatism focuses on the practical application of ideas and views truth as what works best in real-world situations. It allowed for the combination of both quantitative and qualitative methods, which is essential for comprehensively exploring the complex topic. The adoption of 4IR technologies and their effect on competitiveness involves not

only measurable, objective data (which aligns with the positivist approach) but also subjective insights from individuals and companies (which aligns with the interpretivist approach).

Tilley (2019) asserts that pragmatism embraces multiple ways of knowing and understanding phenomena. This is useful in the study, as 4IR technology adoption can be understood both through statistical analysis of performance data (positivism) and through the perspectives and experiences of key stakeholders in the South Durban Basin (interpretivism). Pragmatism acknowledges the value of both types of knowledge as it rejects the idea of a single, absolute reality. Instead, it acknowledges that multiple realities exist depending on context. In the study, the "reality" of how 4IR technologies affect competitiveness differs across industries, firms, and stakeholders in the South Durban Basin. In the study, pragmatism allowed for these varied interpretations of reality without forcing the study to commit to a single ontological position. Pragmatism values practical consequences and real-world outcomes over abstract truths. In the study, the focus on the practical impact of 4IR technologies on competitiveness was aligned with pragmatic concerns. The goal was to generate findings that are useful to businesses in the region and can inform decisions, policy, and strategic direction.

Shan (2022) suggests that pragmatism supports the use of mixed methods both quantitative (as in positivism) and qualitative (as in interpretivism). This is critical for the study, as it allows the study to gather and analyse numerical data (e.g., productivity metrics, financial performance) while also interpreting qualitative data (e.g., stakeholder interviews, perceptions of competitiveness). Pragmatism ensured the use of whichever method best addressed the research questions, ensuring a holistic view of the issue. It served as a robust paradigm for the study because it facilitated the integration of both positivist and interpretivist elements. This was vital in addressing the multifaceted nature of how 4IR technologies influence the competitiveness of companies in the South Durban Basin, providing a comprehensive approach that captured both measurable outcomes and subjective experiences.

4.3 Research approach

According to Pardede (2019) the research approach that is used in a study must be guided by the research questions and objectives so that the main aim of the study can be achieved. According to Bloomfield and Fisher (2019) the research design is essential components of any research study. Bell, Bryman, and Harley (2022) define the research design as the overall strategy and plan

that the researcher uses to answer the research questions or to test the research hypothesis and the method, specific techniques, procedures, and tools that the researcher uses to collect, analyse and interpret the data. Similarly, Busetto, Wick, and Gumbinger (2020) state that the research design and method determine the quality and reliability of the research findings and therefore it is crucial to carefully choose and justify the research design and method that best fit the research questions and objectives.

The chapter not only gives the actual research design but also explains the rationale or approach that guided the decisions that were made in order to arrive at the specific design. The aim of the research decisions has been to ensure alignment between the purpose of the study, the research objectives, the research paradigm, and the research design. The research design has driven the structure of the thesis document as well as the sequence in the research process. Blair, Cooper, Coppock and Humphreys (2019) explain that a research design consists of the aims, objectives, paradigms, theoretical frameworks, data collection methods, and data analysis methods used in the study. According to De Block and Vis (2019) the three types of research approaches are quantitative, qualitative and mixed methods. All three research approaches offer their own unique benefits when examining phenomena, associated with their individual beliefs, principles and methodologies.

4.3.1 Quantitative research approaches

According to Tilley (2019) the paradigm of positivism forms the basis of quantitative research approaches. Heeks and Wall (2018) further suggest that a quantitative research approach has an objective view of epistemology, ontology and axiology. Its aim is therefore to prove a hypothesis or theory through scientific inquiry or mathematical analysis with the assumption that there will be one reality, one truth and one type of knowledge produced. Zappa-Hollman and Duff (2018) argue that some of the different quantitative research methods are surveys, questionnaires, tests, and experiments. They suggest that quantitative research approaches are adopted for the investigation of phenomena, which are numerically and statistically orientated, or for scientific phenomena which can be proven through experimental investigation. Quantitative data was collected in this study in order to attain crucial numerical and statistical information from the respondents which was necessary to achieve the research objectives.

4.3.2 Qualitative research approaches

De Block and Vis (2019) argue that qualitative research approaches are aligned with interpretivism because they allow the researcher to investigate a phenomenon in its natural setting by interpreting it from the meanings that participants have assigned to it. According to Zappa-Hollman and Duff (2018) qualitative research approaches assume that knowledge, reality and truth are contextual and can have many meanings. They are usually adopted to describe and investigate phenomena which are not easily measurable in terms of numbers or statistical analysis but are rather utilised to investigate social phenomena and human behaviours. According to Aspers and Corte (2019) some of the different qualitative research methodologies are ethnography, grounded theory, case studies, phenomenology, and narrative research. Zappa-Hollman and Duff (2018) add that since qualitative research is naturalistic, interpretative and uses research methods that are relatively long in duration it allows phenomena to be studied intensively. Qualitative data was collected in this study because it allowed for a more in-depth analysis of the role of the 4IR technologies' adoption in the competitiveness of the companies in the South Durban Basin.

4.3.3 Mixed methods research approaches

De Block and Vis (2019) argue that the mixed methods research approaches combine quantitative and qualitative research approaches. According to Phothongsunan (2019) the mixed methods research approaches adopt both singular and multiple views of reality, knowledge and truth since they incorporate both research approaches. According to Zappa-Hollman and Duff (2018) initially, qualitative research was considered as a competitor or rival to quantitative research but more recently the two research approaches are perceived as complimentary to each other and when used together can result in a more in-depth investigation of a particular phenomenon which produces richer findings. Consequently, Pardede (2019) advocate for a mixed methods research approach because it allows the researcher to critically evaluate quantitative and qualitative data from a positivist and interpretivist perspective respectively and then compare and contrast the data which increases the depth of the findings. This study adopted a mixed methods research approach because both quantitative and qualitative data were required to achieve the research objectives.

The qualitative data from the respondents were necessary to determine in-depth views and opinions which would not have come through the quantitative data alone. The quantitative research and qualitative research components therefore served to triangulate the findings of the

research and provide a more in-depth investigation into the interpretation and enactment of the role the 4IR technologies' adoption in the competitiveness of the companies in the South Durban Basin. Pardede (2019) argue that mixed methods research approaches are usually classified into six main types which are the convergent/parallel mixed methods design, explanatory sequential mixed methods design, exploratory mixed methods design, embedded mixed methods design, transformative mixed methods design, and the multiphase mixed methods design. The mixed method research design for this study was an explanatory sequential mixed methods design. The aim of this mixed method research design is to produce in-depth information about the phenomenon under investigation and it begins with the collection of quantitative data and then continues with the collection of qualitative data to assist in the elucidation of the quantitative data. It allows for an intensive detailed and comprehensive study of a phenomenon, incorporating both quantitative and qualitative research approaches.

4.4 Research philosophy and research method

Research philosophy and research method play crucial roles in shaping the foundation and direction of a research study. According to Saunders, Lewis, and Thornhill (2019) research philosophy refers to the underlying beliefs and assumptions that guide the researcher's approach to understanding the world and conducting investigations. It establishes the ontological, epistemological, and axiological perspectives that shape the researcher's worldview. On the other hand, Goundar (2019) suggest that the research method encompasses the systematic procedures and techniques employed to gather, analyse, and interpret data. The choice of research method depends on the research questions and objectives, influencing data collection, analysis, and the overall validity of findings. Together, research philosophy and research method form the methodological framework, influencing the quality and credibility of research outcomes. A well-aligned and thoughtful combination of research philosophy and method enhances the coherence, reliability, and generalisability of the study, contributing to the advancement of knowledge in a particular field.

4.4.1 Research philosophy

As indicated above, Saunders, Lewis, and Thornhill (2019), contend that the research philosophy refers to the set of fundamental beliefs, principles, and assumptions that guide the overall approach and research method of a research study. It serves as a foundation for how researchers approach their inquiries determine the nature of knowledge and make decisions about method and data analysis. Singh (2019) states that whether the study adopts a positivist, interpretivist, or

pragmatic paradigm. The research philosophy sets the tone for the entire research process and influences the selection of methods and data collection techniques, and it provides a framework for researchers to understand the nature of knowledge, reality, and the relationship between the researcher and the subject of study. Furthermore, Bryman and Bell (2019) state that research philosophy influences the choice of research design, data collection methods, and interpretation of the findings and it encompasses various perspectives, such as positivism, interpretivism, and critical theory, each offering a unique lens through which researchers can examine and understand the world. By explicitly explaining their research philosophy, scholars lay the groundwork for conducting rigorous and valid research that contributes to the advancement of knowledge in their respective fields.

The assessment of the use of the Fourth Industrial Revolution can be approached through various research philosophies, namely positivism, and interpretivism. According to Creswell and Plato-Clark (2018), positivism is a research philosophy that emphasizes the use of scientific methods to obtain objective knowledge about the world. Positivists believe that the social world can be studied like the natural world, using methods such as experiments, surveys, and statistical analysis. In the context of assessing the 4IR as a competitive tool, a positivist approach would involve collecting data using quantitative methods, such as surveys or experiments, to measure the impact of the 4IR on different industries and sectors.

On the other hand, Hennink, Hutter, and Bailey (2020) suggest that interpretivism is a research philosophy that emphasises the importance of understanding subjective experiences and meanings in social phenomena. In the context of assessing the 4IR as a competitive tool, an interpretive approach would involve collecting data using qualitative methods, such as interviews or focus groups, to explore the experiences and perceptions of individuals affected by the 4IR. For example, an interpretive study could examine the attitudes and beliefs of employees who have undergone training for 4IR technologies or the experiences of companies that have implemented 4IR technologies. According to Lamiell (2019) though, the positivist research philosophy can be criticized for overlooking the subjective experiences and perspectives of individuals, interpretivism is also criticised for lacking scientific thoroughness.

According to Saunders et.al (2019), Figure 4.1 below is both popular and helpful in making choices about research philosophy, approach, methods, strategy, time horizon, and subsequent techniques. Introducing the research onion helps in clearly defining the various elements of the research design, such as the research philosophy, approach, strategy, methods, and techniques. This clarity ensures that researchers have a clear understanding of how each component

contributes to the overall study. The research onion allows researchers to align their chosen research methods with their research objectives and philosophical assumptions. This alignment ensures that the methods chosen are appropriate for addressing the research questions and objectives, thereby enhancing the validity and reliability of the study. By presenting a range of options at each layer, the research onion offers researchers flexibility in selecting the most suitable methods for their study. This flexibility is crucial, as it allows researchers to adapt their approach based on the nature of the research problem, available resources, and constraints. The research onion encourages researchers to consider different perspectives and approaches to conducting research. By incorporating multiple layers representing different philosophical stances and methodological choices, the research onion facilitates a more holistic understanding of the research process. By guiding researchers through the various stages of research design, data collection, and analysis, the research onion helps in enhancing the rigor and validity of the study. By ensuring that each layer is carefully considered and justified, researchers can strengthen the overall quality of their research. introducing the research onion in a study provides a structured framework for planning, clarity in research design, alignment with research objectives, flexibility in method selection, integration of different perspectives, and enhancement of rigor and validity. These benefits justify its use as a valuable tool for researchers in designing and conducting their studies.

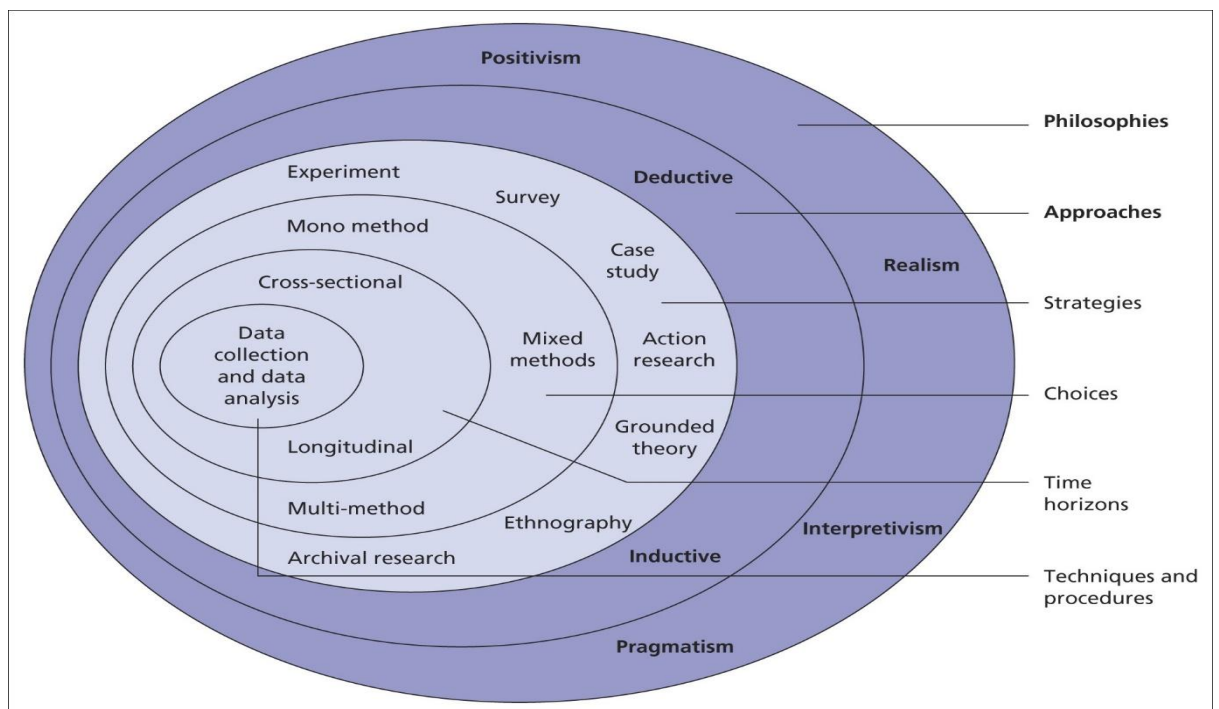


Figure 4.1: Research onion (Adapted from Saunders et.al (2019))

The research onion, according to Saunders et al (2019) is a conceptual framework that helps researchers understand and organise the different layers and stages of conducting research. The research onion consists of multiple layers each being a different stage of the research process. Each layer represents a different aspect of the research process, starting from the outermost layer of philosophical assumptions to the innermost layer of data collection and analysis techniques. The research onion provides a structured approach for planning the research process. By breaking down the research journey into distinct layers, researchers can systematically identify and address each aspect of their study, ensuring a well-organized and coherent research design. These layers include philosophical assumptions, research approaches, research strategies, time horizons, and techniques and procedures. Researchers may organise and carry out their investigations more methodically by conceiving the process as a linked research onion. This ensures coherence and rigor across the whole research process.

Both positivist and interpretivist approaches have their strengths and weaknesses when it comes to assessing the 4IR as a competitive tool. Using both the positivism and interpretivism research approaches the researcher ensured that the study was able to capitalize on the strengths of both approaches while leveraging on the weaknesses of each. The researcher was able to capture both objective and subjective dimensions of the research topic, generating a more comprehensive and nuanced understanding. This mixed method allowed for the triangulation of data, enhancing the validity and reliability of the research findings. The combination of quantitative and qualitative methods provided a more holistic perspective, contributing to a more well-rounded and robust research outcome.

4.4.2 Research method

According to Goundar (2019), research methods are various procedures, and scheme algorithms used in research. Similarly, Andrew, Pederson, and McEvoy (2020) state that the research method serves as a backbone of the study, providing a comprehensive overview of the strategies and procedures employed to address the research objectives. Tracy (2019) further suggests that the research method serves as a comprehensive guide to the systematic and rigorous approach adopted to investigate the research problem. This means that all methods used by a researcher during a research study, including the theoretical procedures, experimental studies, numerical schemes, and statistical approaches are termed the research methods. Furthermore, Goundar (2019), suggests that there are two basic approaches to research i.e. qualitative and quantitative research methods. Saunders et al. (2019) argue that a qualitative research method is a highly subjective

research approach designed to look beyond the percentages and to gain an understanding of feelings, impressions, and viewpoints while quantitative research on the other hand uses numbers and statistics to measure attitudes, and performance and provides results in percentages that are easier to interpret. As a result, Dawadi, Shrestha, and Giri (2021), suggest that researchers can choose to use both the quantitative and qualitative approaches to have a pluralistic stance of gathering all sorts of data to answer the research questions. Additionally, Creswell and Plano Clark (2018) suggest that a mixed-method research design is a research design that has its philosophical assumptions and methods of inquiry rooted in data collection and data analysis from multiple sources in a single study. Dawadi, Shrestha, and Giri (2021) suggest that mixing two methods might be superior to a single method as it is likely to provide rich insights into the research phenomena that cannot be fully understood by using only qualitative or quantitative methods.

The researcher in the study adopted a mixed-methods research approach by incorporating both positivism and interpretivism paradigms. The positivist perspective was employed to investigate the objective aspects of the research topic relying on quantitative data collection methods. This approach aimed to provide empirical evidence and generalizable findings. At the same time, the researcher adopted an interpretivism approach considering the subjective and contextual nature of the research phenomenon. Through qualitative methods like interviews, the researcher aimed to gain a deeper understanding of the participants' perspectives and meanings attached to the research topic. This interpretive approach acknowledged the importance of social construction, cultural factors, and individual subjectivity in shaping the phenomenon under investigation.

A mixed research method was applied in the study because of its ability to provide a more comprehensive understanding of the phenomenon. According to Lamiell (2019), a mixed research method involves the use of both quantitative and qualitative data collection and analysis techniques. Furthermore, Creswell and Plano-Clark (2018) argue that this approach allows researchers to collect and analyse data from multiple sources, providing a more comprehensive understanding of the research problem.

A mixed research method was used to assess the use of the 4IR by companies in the South Durban Basin area. The study combined quantitative data from surveys with qualitative data from semi-structured face-to-face interviews to examine how companies in the South Durban Basin area use the 4IR technologies for competitive advantage and to evaluate if the companies in the South Durban Basin embraced the 4IR opportunities to overcome challenges. A mixed research method proved to be particularly useful in the study of the 4IR as it provided a comprehensive

understanding of the complex relationships between technological advancements, changes in organizational structures, and shifts in societal values and norms.

The study used triangulation to enhance the validity and reliability of the research findings. In support of this, Creswell, and Plano Clark (2018) argue that triangulation is a valuable method in mixed research because it enhances the credibility of research findings by validating them through multiple methods and sources of data. According to Schoonenboom and Johnson (2017) during triangulation, two types of data sets are collected concurrently, and secondly, they are analysed independently using quantitative and qualitative approaches. The study used quantitative data to assess the adoption rate of various technologies and qualitative data to investigate the experiences of workers and managers in organizations undergoing digital transformation. Dawadi, Shrestha, and Giri (2021) suggest that mixed research and triangulation provide a more comprehensive understanding of the research topic by combining both qualitative and quantitative data collection and analysis.

4.5 Location of the study

The South Durban Basin area in KwaZulu-Natal, South Africa has been identified as a potential location for the study of the 4IR due to its unique combination of factors, including a highly industrialised economy, a strong focus on sustainable development, and a diverse population. The study looked at the potential impact of the 4IR on the South Durban Basin and its implications for the South African economy. The study provided an overview of the 4IR and its potential impact on various sectors of the South African economy, including manufacturing, coordination, hospitality, chemical, and healthcare. In addition to academic studies, there have been several initiatives in the South Durban Basin aimed at promoting the adoption of the 4IR technologies. For example, the eThekweni Municipality has established an innovation hub to support the development of modern technologies.

The study examined the potential for the 4IR to contribute to sustainable economic growth and development in the region, as well as the challenges that may arise from the adoption of the modern technologies. Overall, the study of the 4IR in the South Durban Basin offered valuable insights into the potential opportunities and challenges associated with the adoption of new digital technologies in a rapidly evolving economic and social context. By examining the experiences of the South Durban Basin, researchers and policymakers can gain a better understanding of how to promote sustainable economic growth and development in other parts of the world.

4.6 Target Population

The target population of the study of 4IR in the South Durban Basin refers to the group of individuals living or working in the area, which encompasses the southern area of Durban, South Africa. This population consists diverse of stakeholders including workers, residents, businesses, and organisations, all of whom are affected by the ongoing technological advancements and digital transformation associated with the 4IR. As 4IR is characterised by the fusion of technologies that blur the lines between the physical, digital, and biological spheres, studying its effects on the population of the South Durban Basin becomes crucial for understanding the opportunities, challenges, and potential implications for economic, social, and environmental aspects of the region. By examining this population, the researcher was able to gain insights into how the 4IR can be leveraged to drive sustainable development, enhance the livelihood, and address specific needs aspirations, and aspirations of the South Durban Basin community.

The study explored how businesses in the South Basin area were able to adopt the 4IR technologies to create new business opportunities and disrupt traditional business models. The study investigated how companies used the 4IR technologies to identify the benefits of the 4IR while overcoming the challenges of the modern technologies. According to Saunders, Lewis, and Thornhill (2019), when conducting research, the data must be collected from somewhere and the people from whom the data is collected are called the population. The target population in the study included small and medium-sized business owners, entrepreneurs, and senior managers working for companies situated in the South Durban Basin area. The nature of the study and the nature of the questions are such that people from the management of the company are suitable to answer. As a result, the respondents were in the senior management of the companies that were selected because of their authority to comment on the strategic direction of their companies.

By examining the various stakeholders living and working in the South Durban Basin area, the researcher was able to identify the challenges and potential risks associated with 4IR which provides a way for the development of effective policies and strategies that promote inclusivity, sustainability, and fair distribution of benefits. It is through such studies that the South Durban Basin can harness the power of the 4IR to address societal needs, foster innovation, and build a resilient community, prepared for the opportunities and challenges of the digital age. By prioritizing the well-being of its population and leveraging the benefits of technological advancements, the South Durban Basin area can position itself as a leading example of successful integration and utilisation of the 4IR technologies, ensuring a prosperous and sustainable future for all the stakeholders in the area.

4.7 Sampling techniques

The concept of sampling in research is discussed, highlighting its importance in obtaining representative data from a larger group or population. Lohr (2021) defines sampling as the process of selecting a subset of individuals or items to estimate the characteristics of the entire group, emphasising that this method is employed because collecting data from the entire population is often impractical. Saunders et al. (2019) contribute to the discussion by emphasising the crucial role of sampling techniques in research methods. They assert that the chosen sampling method determines the extent to which research findings can be generalized to the target population. This implies that the way samples are selected directly influences the external validity of the study. Bryman, Bell, and Hirschsohn (2021) further support the idea that for research findings to be applicable to the entire population, the selected sample must adequately represent that population. This reinforces the notion that sampling is a critical aspect of research design, impacting the generalisability of study findings. In the context of studying the impact of the 4IR on a specific region, such as the South Durban Basin area, the discussion suggests that employing the right sampling techniques is essential. This is crucial to ensure that the study results are representative and accurate, providing a valid basis for drawing conclusions about the broader population.

Taherdoost (2017) contributes to the discussion by categorising sampling techniques into two main types: probability sampling and non-probability sampling. This classification underscores the importance of understanding the nature of the sampling method chosen, as it influences the statistical validity and generalisability of the research findings. Probability sampling involves random selection, enhancing the likelihood of a representative sample, while non-probability sampling methods may introduce bias, but are often more practical in certain situations. In conclusion, the paper provides a logical discussion on the significance of sampling in research. It emphasizes the need for representative samples to ensure the generalizability of findings and highlights the distinction between probability and non-probability sampling techniques. Overall, the proper application of sampling methods is crucial for the validity and reliability of research results, especially when studying specific regions or populations in the context of broader phenomena such as the 4IR.

Bryman, Bell, and Hirschsohn (2021) suggest that probability sampling is important because it enables the researcher to generalise findings derived from a sample to the population from which it was selected. Furthermore, Maree (2017), believes that the probability sampling technique is an objective sampling method where all elements in the target population have an equal chance of being selected to become part of the sample. Rahi (2017) further suggests that probability

sampling is further divided into four categories such as simple random sampling, systematic random sampling, stratified random sampling, and cluster sampling. Bryman et.al (2021) believe that it is important that a sample design is representative, reliable, and right for the research study. Consequently, the researcher has chosen systematic random sampling which is a type of probability sampling where the first sampling point is selected at random, and the rest of the participants are selected at regular intervals.

Taherdoost (2017) believes that the advantage of this systematic random sampling technique is its simplicity as it involves only the selection of the Kth element from the population list after a random starting point. In this case, the researcher first identified a comprehensive list of organizations or industries operating within the South Durban Basin, which would be relevant to understanding the impact of the 4IR. The researcher determined the sample size using the database provided by the Durban Chamber of Commerce and Business and calculated the sampling interval. Saunders et al. (2019) believe that one advantage of systematic random sampling is its potential to provide a representative sample, eliminate bias, and capture the diversity of organisations within the South Durban Basin area. According to Creswell and Plato-Clark (2018), this method helps ensure that the sample adequately represents the larger population in terms of characteristics, such as the industry sectors, sizes, and locations.

Dawadi et al. (2021), suggest that it is essential to consider the sampling technique carefully and ensure that it accurately represents the population to ensure valid and reliable results. Consequently, Lohr (2021) suggests that systematic random sampling can be more efficient compared to other sampling techniques as it eliminates the need for extensive randomization processes, the starting point is randomly selected, and the subsequent elements are systematically chosen. The researcher considered that systematic random sampling, amongst other benefits discussed above, saves time, and effort compared to simple random sampling, where each element is selected independently hence the selection of the systematic random sampling was chosen as the best sampling technique for the study.

4.7.1 Sample size

Bryman et al. (2021) argue that in research, sampling size plays a crucial role in ensuring the accuracy and generalizability of findings and is a fundamental aspect of both qualitative and quantitative research methodologies, contributing to the validity and reliability of the results. Saunders et al. (2019) state that the choice of an appropriate sampling size depends on a range of

factors such as research objectives, population characteristics, and desired level of precision. According to Sartetd, Mooi, and Wetzels (2019), systematic random sampling is a technique used to select a representative sample from a larger population. Taherdoost (2017) explains that in systematic random sampling, the researcher selects every K th element from the population after randomly selecting a starting point. To determine the sample size using systematic random sampling, the researcher determined the sampling interval (k) based on the total population size (N) and the desired sample size (n). The formula for calculating the sampling interval is as follows:

Sample interval (k) = N / n . Considering that the research is using a mixed method here it will show the two samples for both qualitative and quantitative methods separately. For the quantitative sample, the researcher took a sample size of hundred and sixty (160) from a population of three hundred and twenty (320) companies for quantitative respondents and used the formula to calculate the sampling intervals. Sampling interval (k) = N / n sampling interval. Therefore, in the case of the South Durban Basin the sampling interval (k) = $320 / 160$ and the sampling interval (k) = 2. After having identified the sampling interval the researcher selected every 2nd (k) company from the population of 320 companies to arrive at the desired sample size of 160.

The sample for the qualitative study is a total of forty (40) medium-sized companies based in the South Durban Basin area South of Durban. For calculating the qualitative sample, the researcher took a sample size of forty (40) from a population of three hundred and twenty (320) companies for qualitative respondents and used the same formula to calculate the sampling intervals. Sampling interval (k) = N / n sampling interval. Therefore, in the case of the South Durban Basin the sampling interval (k) = $320 / 40$ and the sampling interval (k) = 8. After having identified the sampling interval the researcher selected every 8th (k) company from the population of 320 companies to arrive at the desired sample size of 40.

According to Hair, Wolfinbarger, Money, Samouel, and Page (2019), systematic random sampling requires randomly selecting a starting point within the sampling interval to ensure that the sample is representative of the population. Saunders et al. (2019) suggest that this can be done using various methods such as random number tables or computer-generated random numbers. The formula provided above is generic and can be based on specific sampling needs and population characteristics.

4.7.2 Process of contacting respondents

Bartels, and Furman (2023) believe that the process of contacting research respondents is a critical phase in the research process, as it sets the foundation for effective communication, trust-building, and ultimately successful data collection. This multifaceted approach involved several key steps, starting with the identification of the research respondents through the selection of a representative sample from a larger population. The first step involved carefully selecting a sample that accurately represents the broader population under study. This selection process ensured the relevance and reliability of the data collected. To reach the identified respondents, the researcher employed various methods to contact the research respondents. The researcher visited respondents at their offices, employing a door-to-door approach. This was based on the belief that face-to-face interactions offer a personal touch, allowing for immediate clarification of any concerns and establishing a rapport with respondents. Electronic communication through emails was a widely used method, providing a written record of the initial contact. The researcher crafted a well-structured and compelling email introducing the study's purpose, ethical considerations, and the importance of the respondents' participation.

Direct communication via telephone also offered an immediate connection with the respondents. It allowed the researcher to address any questions or concerns in real-time and gauge the respondents' initial reactions. The researcher prepared a carefully crafted message to introduce the study. This message clearly articulated the purpose of the research, the importance of the respondents' involvement, and the ethical considerations surrounding their participation. The clarity of communication is crucial in gaining the trust and cooperation of the respondents. Emphasising ethical considerations is essential to building trust. The researcher communicated the ethical principles guiding the study, ensuring that respondents understand the confidentiality, voluntary nature, and potential impacts of their participation. A gatekeeper's letter, such as the one from the Durban Chamber of Commerce and Business, served as an additional layer of assurance. This letter validated the legitimacy of the study and opened doors that would otherwise be challenging to access. It also helped overcome potential scepticism among respondents. Careful planning was vital to the success of the contact process. The researcher needed to consider the timing, frequency, and mode of communication. A respectful and empathetic approach was crucial in fostering a positive relationship with respondents, as it demonstrated the researcher's commitment to valuing their time and contribution.

By employing effective communication strategies and building trust, the researcher increased the likelihood of elevated participation levels. This, in turn, contributed to the overall quality of the

data collected, ensuring the reliability and validity of the research findings. The culmination of these efforts results in the successful completion of the research project. Effective contact strategies not only ensured data collection but also provided the groundwork for potential future collaborations and ongoing engagement with the research community. The process of contacting research respondents was a nuanced and multifaceted endeavour that required careful planning, ethical considerations, effective communication, and a respectful approach to ensure the success of the research project. Each step contributed to building trust, obtaining high-quality data, and fostering positive relationships with the participants in the study.

4.8 Data collection strategies

In a comprehensive research study, employing both qualitative and quantitative data collection strategies is essential to gain a holistic understanding of the subject matter. Quantitative data collection involves structured methods such as surveys, experiments, and statistical analysis, providing measurable and generalizable findings. In contrast, qualitative data collection includes interviews, focus groups, and observations, which capture the depth and complexity of participants' experiences and perspectives. Combining these approaches allowed the researcher to corroborate findings, enrich the data's context, and address the research questions from multiple angles, ultimately leading to more robust and nuanced conclusions.

4.8.1 Qualitative Data Collection Strategy

The qualitative data in this study were collected through interviews, a method that offers a nuanced exploration of participants' experiences, perspectives, and emotions. As Ependi, Rochim, and Wibowo (2023) highlight, interviews serve as a means to orchestrate a symphony of perspectives, capturing the diverse notes that contribute to the richness of qualitative data. Through open-ended questions, the researcher can delve deep into the participants' thoughts and feelings, unraveling the intricate threads of their stories. Yang (2023) aptly compares qualitative methods to the brushstrokes of a masterful painter, emphasizing their ability to capture subtle nuances that lie beneath the surface. In the qualitative data collection process, the researcher likely conducted in-depth, semi-structured, or structured interviews with participants, creating a space for them to share their experiences and insights freely.

Interviews are widely used for collecting qualitative data in research and social sciences. Creswell and Plano Clark (2018) suggest that interviews involve face-to-face or mediated conversations between the interviewer and the interviewee, where the interviewer asks specific questions to

gather information, opinions, experiences, and perspectives from the research participants. Interviews are flexible and allow for in-depth exploration of topics, providing rich, detailed, and context-specific data. The researcher used semi-structured interviews with a pre-determined list of open-ended questions. This ensured a balance between structure and flexibility, allowing for the exploration of innovative ideas while ensuring that key topics were covered consistently across participants. This allowed for planned and unplanned exploration. During the face-to-face interviews, the researcher documented the participants' responses and used the recorder (with the participant's consent) to allow for more accurate transcription and analysis later.

These interviews may have been one-on-one or in a group setting, depending on the research design and objectives. The open-ended nature of qualitative interviews allows for flexibility, enabling the researcher to follow interesting leads and explore unexpected themes that may emerge during the conversation. The goal of qualitative data collection, as described by Yang (2023), is to breathe life into the numbers by providing context and meaning. Through interviews, the researcher was able to uncover the intricacies of human experiences, bringing forth the emotions, stories, and perspectives that quantitative data alone might overlook. This qualitative dimension served as a crucial counterpoint to the precision and rigor of quantitative methods, creating a harmonious blend that contributes to the overall depth and richness of the research ballet.

One of the challenges was to get the sampled companies to confirm their acceptance to participate in the study, confirm who was authorised to respond to the research questions and confirm a suitable time for the interview. The researcher had to make three to four visits before the confirmation of the appointment with the relevant officials. Eventually, all the sampled companies participated in the study and were able to share some valuable insights with the study. Each interview took an average of an hour to complete, depending on the amount of clarity sought both by the researcher and the respondents. The next paragraph discusses the quantitative data collection strategies.

4.8.2 Quantitative data collection strategy

Quantitative data collection is a crucial aspect of research, providing numerical insights into variables and relationships. Sarstedt et al. (2019) suggest that researchers have various strategies at their disposal, such as surveys, experiments, and observational studies. In this discussion, the focus will be on surveys as a quantitative data collection strategy, drawing on the insights from

Saunders et al. (2019). Surveys involve administering a set of structured questions to a sample of respondents. These questions are often predefined and can be closed-ended or open-ended, depending on the research objectives. Surveys aim to gather information on participants' attitudes, opinions, behaviours, or characteristics related to the study. Surveys can be conducted through various means, including online surveys, telephone interviews, or paper-based questionnaires.

The choice of mode depends on factors such as the target population, accessibility, and the nature of the research. The researcher in the study opted for closed-ended questions in the questionnaire. Closed-ended questions provided respondents with a predefined set of response options, making data analysis more straightforward. This approach helped in standardising data collection and ensured consistency across participants. Surveys offered a standardised way of collecting data, ensuring that all participants respond to the same set of questions. This facilitated comparability and enhanced the reliability of results. Surveys can reach a large number of participants, making them a practical choice for studies with diverse samples. The use of technology, such as online surveys, enhances efficiency in data collection. Compared to other data collection methods, surveys are often cost-effective, especially when conducted online or through electronic means. This can be beneficial for researchers with limited resources. The researcher's decision to use questionnaires with closed-ended questions and to distribute them through email was motivated by several factors including the fact that surveys are generally cost-effective, as they minimise the need for extensive resources and personnel.

According to Saunders et al. (2019) email distribution of questionnaires is convenient for both researchers and participants, allowing for flexibility in responding at the participants own pace, but is always criticised for its low rate of responses. However, the use of closed-ended questions simplified data management and analysis, streamlining the research process. On the other hand, Creswell and Plano Clark (2018) believe that surveys may be susceptible to response bias, where participants provide socially desirable answers or respond in a way that they believe aligns with societal norms. Closed-ended questions may limit the depth of responses, potentially overlooking nuanced perspectives that open-ended questions might capture, but surveys are a versatile and widely used quantitative data collection strategy that offers several advantages, including standardization, reach, and cost-effectiveness. The researcher carefully considered the nature of the study, the target population, and the specific research objectives when choosing the survey method for quantitative data collection.

4.9 Research instrument design

Research instrument design is a crucial phase in any empirical investigation, playing a foundational role in shaping the overall research endeavour. As highlighted by Slattery, Saeri, and Bragge (2020), this pivotal stage involves the careful construction and development of tools, surveys, questionnaires, or any other data collection methods tailored to extract information necessary to address the research objectives. The precision and effectiveness of these instruments are directly correlated with the quality and reliability of the resulting data, making their design a paramount consideration in the research process. A well-structured research instrument, as suggested by Javed (2023), goes beyond merely ensuring the collection of accurate and relevant data. It also plays a crucial role in facilitating the subsequent analysis and interpretation of findings, contributing significantly to the credibility and robustness of the research outcomes. Therefore, the design of research instruments should not be viewed in isolation but rather as an integral component of the entire research methodology.

Meticulous attention to detail is essential in the design of research instruments. Robinson, and Leonard (2018) suggest that researchers need to carefully consider each component of the instrument, including the wording of questions, response options, and the overall structure. Ambiguities or biases in the instrument may lead to misinterpretation or skewed results. Moreover, a thorough understanding of the research domain is imperative to ensure that the instruments are contextually relevant and capable of capturing the nuances of the phenomena under investigation. A commitment to methodological rigor is indispensable in the process of crafting research instruments. This involves adhering to established research methodologies, ensuring the reliability and validity of the instruments. Rigorous testing and validation procedures are necessary to identify and rectify potential shortcomings or biases in the instrument design.

Pulling, Braithwaite, Butler, Vogelzang, Moseley, Catley, Murray, and Stanton (2023) suggest that researchers should engage in piloting, pre-testing, and refining the instruments to enhance their effectiveness and reliability. The successful design of research instruments contributes to the advancement of knowledge in various fields. By carefully tailoring instruments to the specific requirements of the research objectives, researchers can uncover valuable insights that contribute to the existing body of knowledge. The reliability and credibility of research findings are contingent on the thoughtful design of instruments, reinforcing the importance of this phase in the research process.

According to Creswell and Creswell (2017) the research instrument design is a critical facet of empirical investigations, acting as the foundation upon which the research endeavour is built. The precision and effectiveness of these instruments directly impact the quality and reliability of the resulting data, making their design a paramount consideration in the research process. A well-structured research instrument not only ensures the collection of accurate and relevant data but also facilitates the analysis and interpretation of findings, contributing to the credibility and robustness of the research outcomes. Meticulous attention to detail, a thorough understanding of the research domain, and a commitment to methodological rigor are essential for crafting instruments that can successfully unearth insights and contribute to the advancement of knowledge in various fields.

4.9.1 Development of the research data instruments

The development of research data instruments is a crucial aspect of any research study, as it directly influences the quality and reliability of the data collected. Creswell and Creswell (2017) emphasise that these instruments encompass a variety of tools, such as surveys, questionnaires, interview protocols, observation checklists, and measurement scales, which are designed to systematically gather, organise, and analyse data. As discussed in section 4.7, the research instruments used were interviews and questionnaires. Before creating any research instrument, it is essential to clearly define the research objectives and formulate research questions. These objectives and questions were able to guide the development of instruments tailored to address specific aspects of the study. Conducting a thorough literature review enabled the researcher to identify existing instruments or methodologies that have been used in similar studies. This helped in understanding best practices, potential challenges, and informed decision-making in developing new instruments for the study. The researcher was able to identify the types of data required for the study. In the research study, both quantitative and qualitative data were collected. Questionnaires were designed for quantitative data, while interviews were chosen for qualitative insights. This decision was typically driven by the nature of the research questions and the depth of understanding needed. In using quantitative instruments like questionnaires, appropriate measurement scales were selected. This included Likert scales, semantic differentials, or other standardised scales based on the variables being measured. This ensured that the scales align with the research objectives and provide reliable data.

The researcher conducted a pilot test of the instruments with a small sample of participants. This helped identify any ambiguities, confusing questions, or potential issues with the instruments. Adjustments were made based on the feedback received during this phase. Based on the feedback from the pilot test, the instrument was refined and improved. This was done to make necessary

adjustments to enhance the reliability and validity of the instruments and to ensure that the development of instruments and the data collection process adhere to ethical standards. The necessary approvals from the ethics committee were requested and utilised to protect participants' rights and privacy. The development of the research data instrument is a systematic process that involves careful planning, refinement, and ethical considerations. By following these steps, the researcher was able to create instruments that effectively addressed the research questions and contribute to the overall validity and reliability of the study.

4.9.1.1 Interview schedule development

Interview schedule development is a crucial aspect of qualitative research, as it plays a significant role in shaping the data collection process. Turner and Hagstrom-Schmidt (2022) highlight several key components and considerations necessary when developing an interview schedule such as flexibility, logical organisation, and producing desired information. The interview schedule included a well-thought-out list of topics, questions, and prompts that the researcher intended to cover during the interviews. This comprehensive approach ensured that the researcher explored all relevant aspects of the research topic, leaving no critical areas unaddressed. This flexibility allowed for spontaneous and meaningful conversations with participants, fostering a more natural and open exchange of information. An adaptable instrument enabled the researcher to explore unexpected insights, follow-up on interesting points, and delved deeper into areas that arose during the interview.

The instrument included open-ended questions, allowing respondents to express themselves freely without being restricted by predetermined answer options. Open-ended questions facilitated a richer understanding of participants' perspectives and experiences, capturing nuanced details that may not be apparent with closed-ended questions. An effective interview schedule allowed for the inclusion of follow-up questions. These questions were crucial for clarifying responses, probing deeper into specific issues, and gaining a more comprehensive understanding of participants' viewpoints. Follow-up questions were asked to demonstrate the researcher's engagement with the participants and a genuine interest in exploring the complexities of the research topic.

The interview schedule was designed to clearly define the objectives of the study. This ensured that the research remains focused and aligned with the overarching goals of the investigation. Well-defined objectives guided the development of interview questions that directly contributed

to addressing the research questions and objectives. The instrument organised research questions into logical themes, creating a coherent structure for the interview. This organisation helped in maintaining a systematic and easy-to-follow flow during the interview process. The interview questions were carefully crafted to elicit the desired information. This involved thoughtful consideration of the research objectives and the specific insights required to answer the research questions effectively. A well-developed interview schedule is a fundamental tool in qualitative research, providing a structured yet flexible approach to data collection. It ensured that the researcher was able to gather in-depth and meaningful insights from participants while maintaining a clear focus on the study's objectives.

The interview schedule in this research project played a crucial role in ensuring methodological rigour, reliability, and validity. Before launching into a larger-scale study, the researcher wisely conducted a pilot study with a small group of five respondents. The researcher piloted the research on a small scale using five (5) respondents to validate the approach and gather preliminary data to inform decision-making about larger-scale studies. The pilot study allowed the researcher to test the research approach, methodology, and interview questions to ensure they were appropriate and effective. By conducting interviews with a small group, the researcher gathered initial data to inform decision-making about the larger-scale study. Piloting on a small scale helped mitigate the risk of scaling up too quickly and mitigate potential issues such as flaws in the instrument before embarking on a larger project. It provided an opportunity to identify and address any flaws in the research instrument or methodology before committing to a larger project. The interview schedule used in the execution of the research project was carefully designed and structured. A well-planned interview schedule was used in the execution of the research project, gathering qualitative data through face-to-face interviews. Through piloting, adjustments, and a well-structured approach, the researcher was able to gather high-quality qualitative data, make meaningful comparisons, and draw reliable conclusions from the data collected.

4.9.1.2 Administration of interviews

In research, interviews are a valuable data collection method used to gather qualitative information from participants. They provide researchers with in-depth insights into individuals' perspectives, experiences, beliefs, and attitudes. Interviews can be conducted in several ways, and the administration process can significantly impact the quality and reliability of the data obtained. Overall, interviews play a significant role in qualitative research, offering unique and valuable insights that other collection methods might not capture. Administering interviews in the research process involved careful planning, execution, and analysis to ensure that the collected data is of high quality and reliability. Before conducting interviews, the researcher needed to develop a

clear understanding of the research objectives, formulate relevant research questions, and design an interview protocol. This included deciding on the type of interview (structured, semi-structured, or unstructured), determining the target participants, and selecting appropriate methods for recruiting participants. The process of recruiting participants for interviews was crucial to ensure diverse perspectives and relevant insights were captured. Building rapport with participants is always essential to creating a comfortable and conducive environment for open communication.

Establishing trust and rapport was achieved through introductions, explaining the purpose of the research, and assuring confidentiality. During the interview, the researcher followed a flexible yet structured approach. The interviewer followed a flexible set of questions in conducting semi-structured interviews, asking questions, and actively listening to the participants, probing further where possible to obtain more detailed responses. This was done in a more relaxed conversational approach to make participants feel comfortable sharing their thoughts. In semi-structured interviews, this typically involved having a set of core questions while allowing for spontaneous follow-up questions and probes based on the participant's responses. Active listening was crucial, as it enabled the interviewer to understand the participant's perspective fully and probe deeper into relevant topics. Interviews were recorded (with the participants' consent) to capture detailed responses accurately. Transcribing the interviews verbatim facilitated analysis and enabled the researcher to extract key themes and patterns from the data.

Once interviews were conducted and transcribed, the researcher analysed the data to identify common themes, patterns, and insights. This involved coding the transcripts, categorising responses, and interpreting the findings in the context of the research objectives. Properly administered interviews were able to yield rich, in-depth qualitative data that enhances understanding of the research topic. By following best practices in interview administration, the researcher was able to ensure the quality and reliability of the data collected, ultimately contributing valuable insights to the research field.

4.9.1.3 Questionnaire development

Questionnaire development is a crucial step in quantitative data collection, particularly in survey-based research. It involves creating a structured set of questions that are designed to gather specific information from respondents. According to Creswell and Creswell (2017), a well-designed questionnaire allows the researcher to effectively collect quantitative data that allows for the analysis and interpretation of results to address the research objectives. A well-designed questionnaire ensured that the data collected was accurate, relevant, and aligned with the research

objectives. Before crafting questions, it was crucial for the researcher to have a clear understanding of the research objectives. These objectives guided the selection of topics and the formulation of questions. In this case, the research aimed to explore the relationship between technology and leadership within organisational contexts. Once the objectives were established, the researcher was able to determine the type of data needed to address those objectives. This involved deciding on the variables to measure and the level of measurement (nominal, ordinal, interval, or ratio). For example, demographic information and organisational classification are likely nominal or ordinal variables, while Likert scale questions assess attitudes or perceptions, typically measured at the ordinal level.

Crafting clear, concise, and unbiased questions was essential. Questions were phrased in a way that minimised ambiguity and ensured that respondents understand what is being asked. For demographic information, questions included age, gender, education level, racial classification, and position of the respondent in the organisation. Organisational classification involved questions about job title, department, and years of experience. Likert scale questions assess respondents' agreement or disagreement with statements related to technology and leadership. It was important to ensure that these questions are aligned with the theoretical frameworks being used in the study, in this case, technology theory and leadership theory. The arrangement of questions can influence respondents' perceptions and responses. Typically, demographic questions are placed at the beginning to establish context, followed by organizational classification, and then Likert scale questions. Within each section, questions are organised logically or grouped by theme.

Additionally, formatting considerations such as font size, spacing, and layout contribute to the questionnaire's readability and ease of completion. Once finalised, the questionnaire was ready for administration to the target population. Questionnaire development involved a systematic process of identifying research objectives, determining data needs, designing clear and unbiased questions, organizing and formatting the questionnaire, conducting pilot testing, and finalising the instrument for data collection. By following these steps, the researcher was able to create a questionnaire that effectively collected quantitative data to address the research objectives, as outlined by Creswell and Creswell (2017).

Questionnaires are essential tools in the research process, particularly in the context of understanding complex phenomena within theoretical frameworks. Theoretical models serve as guiding frameworks, delineating crucial constructs and their interrelations within a particular

domain of study. These models provided a structured approach for comprehending multifaceted phenomena, offering a foundation upon which the researcher was able to build his inquiries. In the discussed scenario, the researcher utilised theoretical models to conceptualize the intricate relationships between various constructs pertinent to the research topic. By identifying and defining these key constructs, the researcher laid the groundwork for developing a questionnaire that operationalized and measured the variables of interest systematically. This systematic approach ensured that the data collected aligns with the theoretical underpinnings, allowing for a coherent investigation of the phenomenon under study. The construction of the questionnaire based on theoretical constructs served multiple purposes. Firstly, it enabled the researcher to translate abstract theoretical concepts into tangible, measurable variables that can be empirically assessed. This process facilitated the quantification of complex phenomena, making them amenable to statistical analysis and interpretation. Moreover, aligning the questionnaire with the theoretical framework allowed for the exploration of relationships and patterns among the variables of interest.

By collecting data through the questionnaire, the researcher was able to empirically evaluate the hypothesized relationships proposed by the theoretical model. This empirical validation served to support and refine the theoretical model, enhancing the understanding of the phenomenon under investigation. Furthermore, the use of questionnaires facilitated the systematic gathering of data from a diverse sample of participants, thereby enhancing the generalizability of the findings. Through careful design and administration, the researcher was able to ensure that the questionnaire adequately captured the relevant aspects of the theoretical constructs, thus enabling robust and reliable data analysis. Ultimately, by aligning the research questionnaire with the theoretical constructs, the researcher was able to assess the relevant variables comprehensively and arrive at informed decisions based on the results. This integration of theory and empirical investigation not only contributed to the advancement of knowledge within the field but also strengthened the theoretical foundations upon which future research can build. In essence, questionnaires served as invaluable instruments for bridging the gap between theory and practice, facilitating the systematic exploration and understanding of complex phenomena.

4.9.1.4 Administration of questionnaires

The administration of questionnaires is a fundamental aspect of any research endeavour, as it significantly influences the quality of the data obtained and the level of participant engagement. Zarouali, Araujo, Ohme, and de Vreese (2023) underscore the importance of this step, emphasizing its direct impact on data quality and respondent participation. Similarly, Gray (2021) highlights the necessity of having a clear comprehension of the research objectives prior to

administering a questionnaire, as this clarity facilitates the identification of the pertinent information needed and its contribution to the study. Regarding the administration formats, Zarouali et al. (2023) propose various options, including paper-based (printed), face-to-face interviews, chatbots, or online surveys. Each format has its own considerations such as accessibility, cost, response rate, and ease of data analysis. In the specific case in hand, the researcher opted for paper-based (printed) questionnaires administered through face-to-face interviews. This choice indicates a preference for a more traditional approach, possibly driven by factors such as the nature of the research context, the characteristics of the target population, or logistical constraints.

All the questionnaires were administered using face-to-face interviews with both the interviewer and the interviewee present in one setting. The decision to conduct face-to-face interviews implies a direct interaction between the interviewer and the interviewee in a single setting. This method offered advantages such as the opportunity for clarification of questions, the establishment of rapport between the interviewer and the participant, and potentially higher response rates due to personal engagement. However, it also presented challenges related to interviewer bias, response bias, and time and resource constraints. The data collected was captured in a spreadsheet that was prepared to digitize the data analysis and interpretation. Furthermore, the researcher's decision to collect and digitise the data personally rather than outsourcing this task to a third party reflects a commitment to maintaining data credibility and quality control. The researcher did not use any services of a third party to collect data but to ensure that the quality of data is credible the researcher collected the data himself. By overseeing the data collection process first-hand, the researcher was able to ensure adherence to the study protocol, address any discrepancies or ambiguities promptly, and maintain confidentiality and ethical standards.

Digitising the collected data into a spreadsheet facilitated data analysis and interpretation, enabling efficient organisation, manipulation, and visualisation of the data. This approach streamlined the research process and enhanced the researcher's ability to derive meaningful insights and draw valid conclusions. The administration of questionnaires is a critical step in the research process, requiring careful consideration of various factors such as research objectives, administration formats, and data management procedures. By employing a paper-based questionnaire administered through face-to-face interviews and personally overseeing the data collection and digitisation process, the researcher demonstrates a commitment to obtaining high-quality data while ensuring methodological rigour and credibility.

4.9.2 Data validation and pre-testing

The validity and reliability of the questionnaire were measured using Cronbach's alpha. Singh (2017) defines Cronbach's alpha as a statistical measure used to assess the internal consistency reliability of a scale or questionnaire. It is commonly used in research and survey studies to determine how well the items in a questionnaire or scale measure the same underlying construct or concept. Cronbach's alpha calculates the extent to which the items within a scale correlate with each other, indicating the reliability and consistency of the measurement. Singh (2017) further explains that the value of Cronbach's alpha ranges from 0 to 1, with higher values indicating greater internal consistency. Typically, a Cronbach's alpha value of 0.7 or higher is considered acceptable for most research purposes, although the specific threshold may vary depending on the field of study and the nature of the construct being measured. Validity was achieved through factor analysis. Factor analysis is a statistical technique used to uncover underlying latent factors or dimensions in a set of observed variables. It is commonly employed in fields such as psychology, sociology, marketing research, and other social sciences.

According to Singh (2017), the goal of factor analysis is to identify the underlying structure or patterns in a dataset by reducing the dimensionality of the variables. It allows researchers to understand the relationships between observed variables and determine whether they can be grouped into meaningful factors. During a factor analysis, the researcher examined the interrelationships among the observed variables to determine which variables were related and contributed to the same underlying factor. The analysis produced a set of factors that account for the shared variance among the variables. There are two main types of factor analysis: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

4.10 Data analysis

Data analysis, as described by Gray (2021), represents a multifaceted process that blends quantitative precision with qualitative depth, offering a transformative lens through which to explore and extract insights from the complex tapestry of information that surrounds us. It is a dynamic fusion of quantitative precision and qualitative depth, wielding the transformative potential to unearth profound insights from the labyrinthine tapestry of information. Quantitative methods provide the scaffolding, offering the rigor of numbers and statistical rigor, enabling us to distil complex datasets into structured, measurable patterns. Quantitative methods serve as the backbone of data analysis, providing a framework of numerical rigor and statistical techniques to dissect and distil intricate datasets into structured and measurable patterns. These methods offer the ability to quantify phenomena, identify trends, and establish correlations with a level of

precision that facilitates objective interpretation and decision-making. Through quantitative analysis, we gain access to the empirical foundations of our inquiries, allowing us to navigate through the labyrinthine complexity of data with clarity and confidence. However, it is the integration of qualitative methods that elevates data analysis into an artful endeavour, transcending the confines of mere numbers to embrace the richness of context and human experience. Qualitative approaches inject nuance into the analysis, delving into the ‘why’ behind the ‘what’ and uncovering the underlying narratives, emotions, and subtleties that numbers alone cannot capture.

By immersing ourselves in qualitative exploration, we gain a deeper understanding of the human stories that underpin the data, allowing us to empathise with the individuals and communities whose lives are reflected in the datasets we analyse. The interplay between quantitative precision and qualitative depth forms a symbiotic relationship, wherein each method complements and enriches the other. Quantitative analysis provides the scaffolding upon which qualitative insights can be anchored, while qualitative exploration imbues the analysis with a sense of context and meaning, enabling us to make sense of the data in a way that resonates with human experiences and perspectives. Together, these methodologies forge a formidable alliance, empowering us to not only understand the empirical realities of our world but also to connect with the human dimensions that give those realities depth and significance. In essence, data analysis represents more than just a technical exercise in number crunching; it is a journey of discovery that invites us to engage with the complexities of our world with both precision and empathy. By embracing the dynamic fusion of quantitative and qualitative methods, we unlock the transformative potential of data analysis to unearth profound insights and foster a more profound and holistic understanding of the intricate tapestry of information that surrounds us.

4.10.1 Qualitative data analysis

Qualitative data analysis involved several key steps and considerations. The researcher used NVivo version 20 to analyse the qualitative data. Busetto, Wick, and Gumbinger (2020) suggest that interviews can be transcribed verbatim with or without annotations for behaviour, followed by coding, labelling, and tagging the transcripts into paragraphs or sentences. The researcher transcribed interviews verbatim capturing every spoken word. After transcription, the data was coded, which involved systematically identifying, labelling, and tagging segments of text (paragraphs or sentences) with meaningful categories or themes. As soon as the data was coded the researcher returned to the research questions to observe if the responses are responding to the research questions. If the answer is negative, this meant that the data collection or analysis is not yet complete, and the researcher gathered additional data to fill out the emerging theoretical

contribution until such time that the codes and emerging analysis are theoretically saturated. The process continued until theoretical saturation is achieved, meaning that no new information or themes are emerging from the data. This indicated that the analysis has reached a point of theoretical completeness. Throughout the analysis process, the researcher continually refers back to the literature review to identify any issues not yet addressed by the data. This ensures that the analysis is grounded in existing theoretical frameworks and contributes to the advancement of knowledge in the field. The researcher tested theoretical propositions against the data to ensure that conclusions drawn are valid and sound. This iterative process helped in refining interpretations and developing robust conclusions.

Similarly, Tracy (2013) states that early in the research process, researchers often do not know why they are taking notes or what they are looking for. Creswell and Plano Clark (2018) further suggest that the researcher might have a primary aim to collect one form of data and have the other form of data provide supportive information. In line with this view, the study will use quantitative data to support qualitative data. The researcher constantly turned back to the literature review section as often as possible to establish issues not yet found in the data. By testing the propositions against the data, the researcher was able to move toward the development of valid and sound conclusions. This process enabled the researcher to interpret the data and be able to draw reliable conclusions from the study. This involves synthesizing findings, identifying patterns, and making connections to broader theoretical concepts or implications.

In summary, Qualitative data analysis involved a systematic process of organising, coding, and interpreting textual data to address research questions and contribute to theoretical understanding. It emphasises reflexivity, constant refinement, and integration with existing literature to ensure rigour and validity. The data from the questionnaires were analysed using a combination of the methods discussed below.

4.10.2 Quantitative data analysis

Appropriate data coding was used to conduct the data analysis, giving each participant's response a number so it could be entered into a database. The researcher used SPSS version 29.0 to analyse quantitative data. The data analysis process involved the use of descriptive and inferential statistics. Descriptive statistics were employed to interpret the biographical data by calculating frequencies and percentages. Measures of central tendency provided insights into the characteristics of the sample, while measures of dispersion assessed the variability of the data.

The results are visually presented using multiple bar charts. Inferential statistics were also utilized to explore relationships and differences. The Spearman correlation coefficient was employed to determine the nature, direction, and significance of the relationship between the Likert scale data. Frequency analysis determined the number of times certain variables occurred where the percentage and accumulative percentage were calculated. A variety of other applicable statistical tests were done in this study. These included:

- **Reliability testing**- Cronbach's coefficient alpha was calculated to assess the reliability of the questionnaire, ensuring consistent and dependable measurements. A Cronbach's alpha score for all the items that constituted the questionnaire was presented which allowed factor analysis to be conducted;

- **Explorative Factor Analysis (EFA)** - this statistical technique was used as a means of data reduction. Factor analysis was used to reduce/combine variables and create a new variable, a factor score variable that contains a score for each respondent on the factor. The principle component analysis was used as the extraction method, and the rotation method was Varma with Kaiser Normalisation. This is an orthogonal rotation method that minimises the number of variables that have high 92 loadings on each factor. It simplifies the interpretation of the factors. Factor analysis/loading shows inter-correlations between variables. Items of questions that loaded similarly imply measurement along a similar factor. An examination of the content of items loading at or above 0.5 (using the higher or highest loading in instances where items cross-loaded at greater than this value) effectively measured along the various components.

Other tests that were done related to the Technology Acceptance Model that was used, including:

- **Maximum Likelihood (MLA)** - a method for extraction for comparative analysis and because of its suitability for a confirmatory factor analysis;

- **Communalities** - which tested significance amongst variable;

- **Factor structure** - presented the relative importance of and how the TAM model fitted in actual data;

- **Cattel's Scree Plot** - done to confirm the number of factors;

- **Rotation Type** - rotation facilitated the interpretation of the results and for easy interpretation of the extracted factors. Promax with Kaiser Normalization was used for the rotation method;

- **Confirmatory Factor Analysis** - the TAM model was assessed using the confirmatory factor analysis (CFA) through Structural Equation Modelling (SEM) technique. It was done with a view to confirming the factor structure that was extracted in the EFA;

- **The model fit** - to assess the overall fitness of the data to the proposed models, the chi-square value, degree of freedom and the corresponding p-value were used;

- **Chi-square** - Chi-square tests of goodness of fit and independence were done to examine relationships between categorical variables. The null hypothesis states that there is no association between the two. The alternate hypothesis indicates that there is an association. Factor analysis was conducted to establish the validity of the questionnaire, aiming to identify underlying factors and dimensions within the data. This analysis provided insights into the structure of the questionnaire and its ability to measure the intended constructs.

- **Correlation** - Pearson' correlation was performed to measure the strength and the significance of the relationship between independent and dependent variables measured at an interval or a ratio level; and

- **Structural Equation Modelling (SEM)** - was used to test independent variables of the 4IR success model as well as the TAM model as well as assessing structural relationships amongst these variables. Where the results were negative, a mediating variable was introduced to produce positive results.

4. 11 Reliability and validity

In the current study, reliability refers to the degree of consistency in the results produced by the quantitative component. As Phothongsunan (2019) explains, reliability can be considered the consistency of the study, meaning it should produce the same data if replicated. Reliability was ensured in the cross-sectional survey, where all respondents received the same questionnaire. Similarly, the interview participants were asked the same open-ended questions in the same sequence, ensuring consistency across the qualitative component. Bergman (2021) highlights the importance of maintaining reliability in mixed methods studies by ensuring that both qualitative and quantitative components produce stable results. In this research, consistency was achieved by employing standardized tools and procedures across all data collection efforts.

Validity, on the other hand, pertains to the accuracy of the findings and whether the study measures what it intended to measure (O' Cathain, 2020). For the quantitative component, internal validity was enhanced through the randomization of respondents, ensuring that the study's design accurately reflected the variables under investigation (Thomas et al., 2023). External validity was also addressed by carefully selecting participants and settings that allowed for the generalization of findings to other similar populations and contexts.

In terms of qualitative data, the credibility of the findings was ensured by choosing an appropriate research design and by using member checking; returning the interview transcripts to participants for verification. Furthermore, triangulation of data from multiple sources helped reinforce the credibility of the results. Taylor et al. (2018) emphasize that convergence between quantitative and qualitative data enhances the overall validity of mixed methods research. This study carefully integrated data from both methods to provide a deeper understanding of the research problem and ensure validity across the different data types.

4.12 Trustworthiness

In qualitative research, trustworthiness is often used as a measure of rigor and encompasses credibility, transferability, dependability, and confirmability. According to Mthimunye and Daniels (2019), these terms provide a comprehensive framework for ensuring the quality of qualitative research. Credibility was ensured in this study by employing strategies such as prolonged engagement with participants and triangulation of data sources and methods. The researcher also returned interview transcripts to participants for review to confirm that their perspectives were accurately captured, thus enhancing credibility.

Transferability, according to Langtree et al. (2019) refers to the extent to which the findings can be generalized or applied to other contexts. In this study, transferability was supported by providing detailed descriptions of the research context, specifically the role of leadership in using 4IR technologies for competitive advantage. These rich descriptions allow other researchers to determine whether the findings may be applicable to their own contexts. Dependability was achieved by ensuring consistency throughout the research process. Langtree et al. (2019) suggest that dependability focuses on the coherence of the research design. The researcher provided a clear explanation of the entire research process, including the design and data collection methods, ensuring that the study could be replicated in other settings.

Confirmability, which addresses the objectivity and accuracy of the data, was reinforced by using triangulation and ensuring that data analysis was conducted objectively, using verbatim quotations from participants. The findings were also returned to participants for review, thus eliminating potential bias and ensuring the accuracy of the conclusions drawn. The strategies employed in this study contributed to the trustworthiness of the research by ensuring that the

findings were credible, transferable, dependable, and confirmable, thereby ensuring the quality and rigour of the qualitative component of the mixed methods approach.

4.13 Ethical considerations

According to Sekaran and Bougie (2016), it is necessary to inform all the employees, particularly those who will be interviewed for preliminary data gathering through structured and unstructured interviews of the proposed study. It is also necessary to assure employees that their responses will be kept confidential and that their responses will not be divulged to anyone in the organization. This makes the employees comfortable with the research undertaken and ensures their cooperation. In line with the above, the researcher observed all guidelines and ensured that all participants were given a choice to participate or not take part in the study. The researcher ensured that participants willingly chose to take part in the study and that they were protected from physical or psychological harm. The researcher ensured that the participant's right to privacy and confidentiality was always protected.

Furthermore, Blanche, Durrheim, and Painter (2014) argue that the purpose of research ethics is to protect the welfare of research participants. Research ethics, however, involves more than a focus on the welfare of research participants but extends into areas such as scientific misconduct and plagiarism. According to Bless, Higson-Smith, and Sithole (2013), social scientists are concerned about research ethics because there have been many cases of abuse of people's rights in the name of social research. Consequently, the researcher observed strictly the ethical standards when conducting the study such as confirming to the participants that their participation is voluntary, guaranteeing the confidentiality of participants by referencing all the sources used in the study, and adhering to the principles of honesty both in the engagement with the respondents and in the reporting of the responses.

The researcher also guaranteed that participants were not harmed by the research project, were not discriminated against during and after the study, maintained the participants' dignity and self-respect, and adhered to the principle of justice. The respondents were guaranteed their right to withdraw from participation at any stage of the study without any adverse consequences on their part. The researcher also ensured that the purpose of the study was explained to the respondents and that they acknowledged that they understood it. All participants read and acknowledged full understanding of the attached informed consent to take part in the study.

4.14 Chapter summary

This chapter delved into various aspects, including research philosophy, research methods, study location, target population, target population, sampling techniques, data collection strategies, research instruments, and data analysis, as well as ensuring reliability, validity, and ethical considerations. The chapter began by elucidating the chosen research philosophy, which serves as the fundamental approach during the study. The research embraced both quantitative and qualitative approaches also known as mixed method where both methods are combined to gain a more comprehensive understanding of the research problem. The detailed geographical location or context in which the research took place explained why the chosen location is relevant to the research objectives and provided insights into how the setting might influence the study's outcomes.

The chapter defines the target population under investigation, describes the characteristics and size of the population, and highlights its significance in the research questions. The chapter also discussed the sampling techniques employed to select a representative subset of the target population for data collection, justified the rationale for the chosen method, and outlined its implications. The chapter outlined the data collection tools and justified their suitability for the research design. The coordination of data collection, and how questionnaires and interviews were distributed and conducted to ensure data quality were also addressed. The chapter then explored the analytical procedures used for quantitative and qualitative data. The chapter further discussed measures taken to ensure the reliability and validity of the research findings to enhance the credibility and trustworthiness of the data and results. The chapter concludes by addressing the ethical aspects of the research, outlining the steps taken to protect the rights and confidentiality of participants, and how ethical dilemmas were handled. The following chapter presents the quantitative analysis.

CHAPTER 5

Quantitative data presentation

5.1 Introduction

This chapter summarises the findings and provides an analysis of the data obtained from the study's surveys. In this chapter, the researcher will systematically organise and display the numerical data using various tools such as tables, graphs, and statistical measures, ensuring clarity and precision. This organised data will be then interpreted and analysed, allowing the researcher to draw meaningful insights and link their results to existing theories or hypotheses. The discussion will also highlight the significance of the findings, exploring potential implications, and acknowledging any limitations, providing a comprehensive understanding of the study's impact and relevance in the broader context. Quantitative data analysis is a crucial component in understanding and interpreting numerical information to draw meaningful insights. The main tool used to gather data was a questionnaire that was administered through face-to-face interviews. In this study, the statistical package of the Social Sciences (SPSS) version 29.0 was used to analyse the data that was gathered from the replies. SPSS, a widely used statistical software was used for its versatility in handling various types of quantitative data and facilitating rigorous statistical analysis. The utilization of SPSS in this research enabled a systematic exploration of patterns, relationships, and trends within the collected data, offering a robust foundation for evidence-based conclusions. The results in this chapter consist of descriptive statistics (graphs, cross-tabulations, and figures) and inferential statistics techniques such as correlations and chi-square tests as well as Structured Equation Modelling (SEM). The Information Systems models were tested using Structural Equation Modelling.

Descriptive statistics are used to display the results, and various figures such as graphs and cross-tabulations are used to show the quantitative data that was gathered. Chi-square tests and correlation studies are two inferential analysis procedures that are used and are interpreted using their p-values. A statement of statistical significance, often represented by a p-value, is required when publishing results according to the conventional protocol, with a significance level of " $p < 0.05$ ". The use of SPSS not only streamlines the analysis process, but also allows for the application of advanced statistical techniques to uncover meaningful associations within the data. Through the application of SPSS, this study aims to contribute valuable insights into the factors under investigation, providing a comprehensive understanding of the phenomena observed among

the study participants. The following sections will elaborate on the methodology employed, the variables considered, and the specific analyses conducted using SPSS as we delve into the quantitative dimensions of our research findings.

5.2 The sample

In total, 160 questionnaires were administered through face-to-face interviews and all the sampled companies volunteered to participate in the study, which gave a 100% response rate.

5.3 The research instrument

The research instrument consisted of 36 items, with a level of measurement at a nominal or an ordinal level. The questionnaire was divided into 4 sections which measured various themes as illustrated below:

- A Biographical data
- B Use of the 4IR technologies
- C Attitudes to using technology
- D Knowledge of technologies

5.4 Reliability statistics

The two most important aspects of precision are reliability and validity. Reliability is computed by taking several measurements on the same subjects. A reliability coefficient of 0.60 or higher is considered “acceptable” for a newly developed construct. Table 5.1 below reflects the Cronbach’s alpha score (reliability testing) for all the items that constituted the questionnaire.

Table 5:1 Cronbach's alpha score

	Section	Number of Items	Cronbach's Alpha
B	Use of the 4IR Technologies	12	0.791
C	Attitudes to using technology	9	0.771
D	Knowledge of technologies	6	0.926
	All items included	27	0.777

Source: Table devised by the researcher

The reliability scores for all sections exceed the recommended Cronbach's alpha value. This indicates a degree of acceptable, consistent scoring for these sections of the research. These scores vary marginally from those obtained from the structural equation model (to be discussed later).

Section B - Use of the 4IR technologies: This section consists of 12 items and has a Cronbach's Alpha of 0.791. An alpha level in this range is generally considered acceptable, indicating that the items have a relatively high level of internal consistency and are likely measuring the same underlying construct.

Section C - Attitudes to using technology: With 9 items, this section has a Cronbach's Alpha of 0.771. Similar to Section B, this is also within the acceptable range, although slightly lower. It suggests that the items are consistent in measuring respondents' attitudes towards technology usage.

Section D - Knowledge of technologies: This section has the highest Cronbach's Alpha of 0.926, which is based on 6 items. An alpha value this high suggests an excellent level of internal consistency among the items, indicating that they are very likely to be measuring the same concept or construct regarding knowledge of technologies.

All items included: When considering all 27 items together, Cronbach's Alpha is 0.777. This is comparable to the alphas for Sections B and C, and while it is slightly lower than those individual sections, it is still within an acceptable range. This suggests that the overall questionnaire has good internal consistency.

Factor analysis

Factor analysis is a statistical method used to describe variability among observed, correlated variables in terms of a potentially lower number of unobserved variables called factors. Essentially, it aims to identify underlying relationships by looking at the systematic interdependencies among a large number of variables and modelling them in terms of a smaller number of factors. The central idea is that multiple observed variables have similar patterns of responses because they are all associated with a latent (not directly measured) variable. The observable variables that are influenced by a common factor tend to coincide with each other. Factor analysis is commonly used in the fields of psychology, social sciences, marketing, product management, operations research, and other applied sciences that deal with large quantities of data.

Key components of factor analysis:

Factors: These are the underlying variables that are supposed to account for the intercorrelations among observed variables. Each factor captures a certain amount of the total variance in the

observed variables, and this is often related to a particular aspect of the construct being investigated.

Factor Loadings: These are the coefficients that represent the relationship between the observed variables and the latent factor. A high absolute value of a factor loading indicates that the factor is a strong contributor to that variable.

Eigenvalues: Each factor has an associated eigenvalue, which represents the amount of variance in all the variables that it accounts for. In general, factors with larger eigenvalues are more significant.

Commonalities: These are estimates of the proportion of each variable's variance that can be explained by the factors. A higher commonality indicates that more of the variable's variance can be explained by the extracted factors.

Rotations: After initial extraction, factors can be rotated to achieve a simpler, more interpretable structure. Rotations can be orthogonal (factors remain uncorrelated) or oblique (factors are allowed to correlate).

The matrix table/s is preceded by a summarised table that reflects the results of KMO and Bartlett's Test. The **KMO and Bartlett's Test** table below shows two tests that indicate the suitability of data for structure detection. The **Kaiser-Meyer-Olkin Measure of Sampling Adequacy** is a statistic that indicates the proportion of variance in the variables that might be caused by underlying factors. High values (close to 1.0) generally indicate that a factor analysis may be useful with the data. If the value is less than 0.50, the results of the factor analysis probably won't be very useful.

Bartlett's test of Sphericity tests the hypothesis that the correlation matrix is an identity matrix, which would indicate that the variables are unrelated and therefore unsuitable for structure detection. Small values (less than 0.05) of the significance level indicate that a factor analysis may be useful with the data.

Factor analysis is done only for the Likert scale items. Certain components are divided into finer components. This is explained below in the rotated component matrix.

Table 5.2: KMO and Bartlett's Test

	Section	Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	Bartlett's Test of Sphericity		
			Approx. Chi-Square	df	Sig.
B	Use of the 4IR Technologies	0.739	287.776	55	< 0.001
C	Attitudes to using technology	0.736	313.145	15	< 0.001
D	Knowledge of technologies	0.830	442.058	15	< 0.001

Source: Table devised by the researcher

All of the conditions are satisfied for factor analysis. That is, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy value should be greater than 0.500, and Bartlett's Test of Sphericity sig. the value should be less than 0.05. The results for each section can be interpreted as follows:

Section B - Use of the 4IR Technologies: The KMO measure is 0.739 indicating that it is a good sampling adequacy for conducting factor analysis. Bartlett's Test returns an approximate chi-square of 287.776 with 55 degrees of freedom and a significance level of less than 0.001. This suggests that the correlations between items are sufficiently large for factor analysis, as the test rejects the null hypothesis that the correlation matrix is an identity matrix.

Section C - Attitudes to using technology: Similarly, the KMO measure of 0.736 suggests good sampling adequacy. The Bartlett's Test has an approximate chi-square of 313.145 with 15 degrees of freedom and a significance level of less than 0.001. Again, this indicates that the variables are correlated and suitable for factor analysis.

Section D - Knowledge of technologies: This section has a KMO measure of 0.830, which is considered excellent for sampling adequacy. The Bartlett's Test yields an approximate chi-square of 442.058 with 15 degrees of freedom, also significant at the level of less than 0.001. This is further evidence against the null hypothesis for Bartlett's test, affirming that factor analysis is appropriate for these items.

These statistics collectively suggest that the data set is suitable for factor analysis, as the measures indicate that the variables are interrelated and not all the variance is attributable to unique factors. The researcher needed to ensure that these conditions are met before proceeding with factor analysis, as it relies on the underlying relationships between variables to extract meaningful

factors. The significance levels being less than 0.001 for Bartlett's Test across all sections also demonstrate a strong correlation structure, which is conducive for the factor analysis.

Table 5.3 Rotated component matrix

B	Component			
	1	2	3	4
Machines connected to the internet	0.057	0.038	-0.011	0.935
Radiofrequency identification (RFI)	0.003	-0.035	0.781	0.172
Additive manufacturing (3D Printing)	0.491	0.330	0.349	0.084
Authentication and Fraud detection software	0.066	0.041	0.707	-0.237
Human machine technology (HMT)	0.753	0.133	0.176	-0.318
Blockchain	0.598	0.402	0.304	0.205
Robotics and Automation	0.432	0.556	0.373	0.015
Augmented Reality	0.849	0.038	-0.041	0.069
Internet of Things (IoT)	0.847	0.031	-0.075	0.091
Artificial Intelligence (AI)	0.089	0.911	-0.032	-0.048
Big Data Analytics	0.063	0.906	-0.028	0.061

Source: Table devised by the researcher

Extraction method: Principal component analysis.

Rotation Method: Varimax with Kaiser Normalisation

a. Rotation converged in 4 iterations

The Rotated Component Matrix provided shows how various the Fourth Industrial Revolution (4IR) technologies are grouped into different components or factors based on their correlations. Below, is the analysis of patterns and suggestions for names for each subtheme:

Component Analysis:

Component 1:

High loadings: Human machine technology (HMT) (0.753), Internet of Things (IoT) (0.847), Augmented reality (0.849)

Moderate loading: Blockchain (0.598)

This component is characterized by technologies that heavily involve direct interaction between human users and digital systems, often enhancing or extending natural human capabilities.

Suggested Name: "**Human-Digital Interaction Technologies**"

Component 2:

High loadings: Artificial Intelligence (AI) (0.911), Big Data Analytics (0.906)

Moderate loading: Robotics and Automation (0.556)

This component represents technologies primarily focused on data processing, analysis, and automation. Artificial Intelligence (AI) and Big Data are closely related in their function of handling and deriving insights from large datasets, while robotics and automation also rely on data and AI for their operations.

Suggested Name: "**Data-Driven and automation technologies**"

Component 3:

High loading: Radiofrequency Identification (RFI) (0.781), Authentication and fraud detection software (0.707)

Moderate loadings: Additive manufacturing (3D Printing) (0.349), robotics and automation (0.373), Blockchain (0.304)

This component includes technologies focused on security, identification, and manufacturing. RFI and authentication software are directly related to security and identification, while additive manufacturing, robotics, and blockchain have applications in secure and efficient production processes.

Suggested Name: "**Security and manufacturing technologies**"

Component 4:

High loading: Machines connected to the internet (0.935)

Moderate loadings: None

This component is distinct in its focus on the basic aspect of the 4IR, which is the connectivity of machines to the internet. It's a fundamental aspect of IoT, but in this analysis, it stands out as its category, possibly emphasizing the foundational role of internet connectivity in modern technologies.

Suggested Name: "**Internet-connected technologies**"

Summary:

These components or subthemes reflect different aspects of the 4IR technologies:

- Human-Digital interaction technologies: Focuses on enhancing human capabilities through technology.
- Data-driven and automation technologies: Centres around technologies that process and analyse data for decision-making and automation.
- Security and manufacturing technologies: Combines technologies for secure identification and innovative manufacturing processes.

- Internet-connected technologies: Emphasizes the fundamental role of Internet connectivity in modern technology applications.
- Each of these themes represents a distinct facet of how 4IR technologies are being deployed and developed.

Table 5.4 Attitudes to using technology

C	Component	
	1	2
The staff feel that technology improves their efficiency	-0.180	0.870
Technology improves customer service	0.311	0.940
Technology has given the company a competitive edge	0.618	0.451
Technology is reliable with few breakages	0.717	-0.022
Using technology saves time	0.911	0.140
Technology causes staff to be more focused on their work	0.905	0.052
Technology will always require human (employee) input	0.852	0.020

Source: Table devised by the researcher

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

For Section C, the Rotated Component Matrix from the SPSS output for Factor Analysis shows how different attitudes toward technology in the workplace are grouped into two components.

Component analysis:

Component 1:

High loadings: Using technology to save time (0.911), Technology causes staff to be more focused on their work (0.905), Technology will always require human (employee) input (0.852), Technology is reliable with few breakages (0.717), Technology has given the company a competitive edge (0.618). This component captures attitudes related to the efficiency and reliability of technology in the workplace. It includes perspectives on how technology aids in time-saving, enhances focus, needs human input, is reliable, and contributes to competitive advantage.

Suggested Name: **"Efficiency and reliability of technology"**

Component 2:

High loadings: Technology improves customer service (0.940), The staff feel that technology improves their efficiency (0.870)

Moderate loading: Technology has given the company a competitive edge (0.451)

This component reflects attitudes toward how technology impacts customer service and staff efficiency. It indicates a belief that technology not only enhances internal processes but also positively affects customer-facing aspects of the business.

Suggested Name: "**Impact of technology on service and efficiency**"

Summary:

These components represent different dimensions of attitudes toward technology in the workplace:

- **Efficiency and reliability of technology:** Focuses on how technology is perceived in terms of improving work efficiency, and reliability and providing a competitive edge while requiring human input.
- **Impact of technology on service and efficiency:** Highlights the perception that technology significantly improves customer service and staff efficiency, contributing to a competitive advantage.

Table 5.5: Knowledge of technologies

D	Component
	1
I am aware of the Internet of Things (IoT)	0.826
The impact of the 4IR on customer interactions is critical for business decisions	0.742
Employees know how to work with advanced technologies and tools relevant to 4IR	0.910
The company utilizes data analytics and artificial intelligence to make informed decisions	0.882
Technological infrastructure and resources are readily available to support the integration of the 4IR technologies	0.926
The company monitors and adapts to technological trends to align with industry best practices	0.877

Source: Table devised by the researcher

Extraction method: Principal component analysis.

a. 1 components extracted.

In Section D, the Rotated Component Matrix from the SPSS output for Factor Analysis shows how different aspects of knowledge and awareness of the 4IR (Fourth Industrial Revolution) technologies are grouped into a single component.

Component analysis:

Single component:

There are high loadings on all items. This component encapsulates a comprehensive understanding and integration of the 4IR technologies within the company. It includes awareness of IoT, the recognition of the impact of the 4IR on customer interactions, employee proficiency in advanced technologies, the application of data analytics and AI in decision-making, the availability of necessary infrastructure, and the company's proactive approach in adapting to technological trends.

Suggested Name: "**Knowledge of technologies**"

Summary:

The single-component represents an overall dimension of knowledge and integration of the 4IR technologies in the business context:

This theme highlights a high level of awareness and integration of the 4IR technologies within the company. It suggests that the company is not only aware of and understands these technologies but also actively integrates and utilizes them in various business processes, from customer interactions to decision-making and staying aligned with industry best practices.

Section A: Biographical data

This section summarises the biographical characteristics of the respondents. The table below describes the overall gender distribution by age.

Table 5.6: Gender distribution by age

Age group (years)		Gender			Total
		Male	Female	Wish not to disclose	
18 - 24	Count	4	2	2	8
	% within Age group (years)	50.0%	25.0%	25.0%	100.0%
	% within Gender	4.0%	3.6%	50.0%	5.0%

	% of Total	2.5%	1.3%	1.3%	5.0%
25 - 34	Count	14	22	0	36
	% within Age group (years)	38.9%	61.1%	0.0%	100.0%
	% within Gender	14.0%	39.3%	0.0%	22.5%
	% of Total	8.8%	13.8%	0.0%	22.5%
35 - 44	Count	18	24	2	54
	% within Age group (years)	51.9%	44.4%	3.7%	100.0%
	% within Gender	28.0%	42.9%	50.0%	33.8%
	% of Total	17.5%	15.0%	1.3%	33.8%
45 - 54	Count	46	8	0	54
	% within Age group (years)	85.2%	14.8%	0.0%	100.0%
	% within Gender	46.0%	14.3%	0.0%	33.8%
	% of Total	28.8%	5.0%	0.0%	33.8%
≥ 55	Count	8	0	0	8
	% within Age group (years)	100.0%	0.0%	0.0%	100.0%
	% within Gender	8.0%	0.0%	0.0%	5.0%
	% of Total	5.0%	0.0%	0.0%	5.0%
Total	Count	100	56	4	160
	% within Age group (years)	62.5%	35.0%	2.5%	100.0%
	% within Gender	100.0%	100.0%	100.0%	100.0%
	% of Total	62.5%	35.0%	2.5%	100.0%

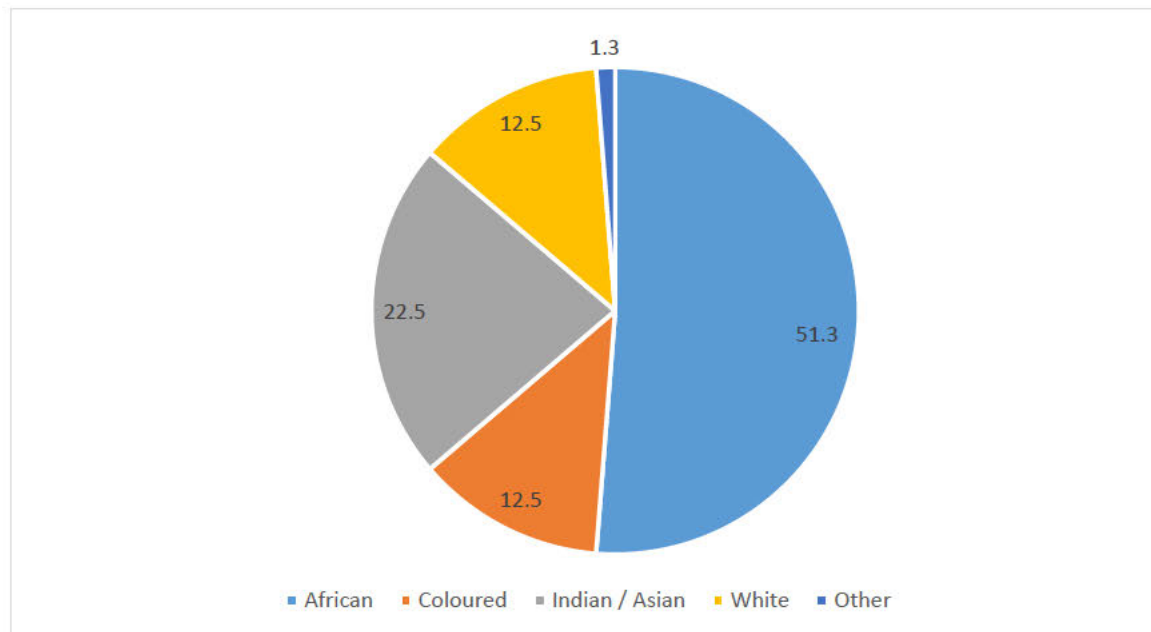
Source: Table devised by the researcher

For the cross-tabulation, the following patterns emerge in the distribution of gender across various age groups within the sample. The gender composition is predominantly male, accounting for 62.5% of the total population ($p < 0.001$), while females represent 35%, and a minimal 2.5% of participants elected not to disclose their gender. This skew towards male representation is particularly pronounced in the older age cohorts. For instance, in the 45 - 54 years and ≥ 55 years' categories, males constitute an overwhelming majority (85.2% and 100%, respectively). This disparity suggests a potential gender imbalance in the population or sector from which the sample is drawn, especially in the higher age brackets.

Conversely, the 25 - 34 years' age group presents a notable deviation from the overall trend, with females being the majority (61.1%). This finding indicates a shift in gender dynamics within this particular age group, contrasting with the male-dominant trend observed in other categories. Additionally, the youngest age group (18 - 24 years) exhibited the highest proportion (50%) of individuals opting not to disclose their gender, reflecting perhaps a generational shift in attitudes

towards gender identity and disclosure. Overall, the 35 - 44 and 45 - 54 age groups form the bulk of the population, suggesting that these age ranges are particularly significant or active within the study context ($p < 0.001$). The figure below indicates the racial composition of the sample.

Figure 5.1: Racial composition

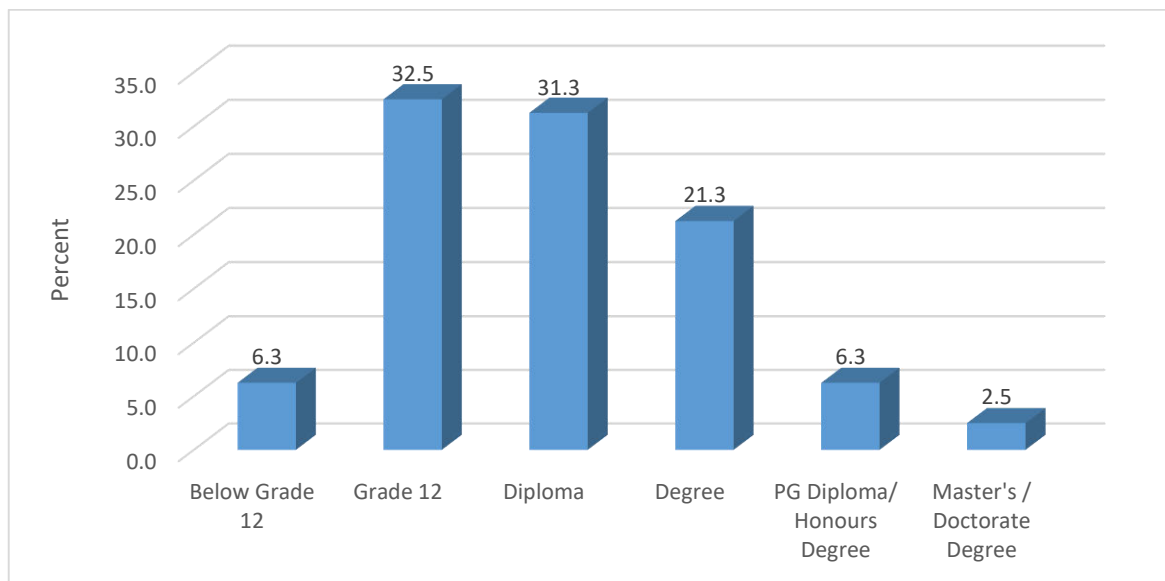


Source: Figure devised by the researcher

From this sample, the majority of individuals identify as African, representing over half of the population at 51.3%. The next largest group is Indian/Asian, constituting 22.5% of the sample. The categories 'Coloured' and 'White' each make up 12.5% of the population, indicating a relatively smaller yet equal representation within the sample ($p < 0.001$). Notably, there is a minimal representation (1.3%) of individuals who identify with racial groups not specified in the provided categories, labelled as 'Other'.

This distribution presents a predominantly African cohort, with Indian/Asian individuals comprising a significant minority. The equal representation of the 'Coloured' and 'White' categories suggests parity between these groups within the context of the sample. The nominal 'Other' category reflects either a diverse but small number of additional racial groups. The figure below indicates the education levels of the respondents.

Figure 5.2: Education levels



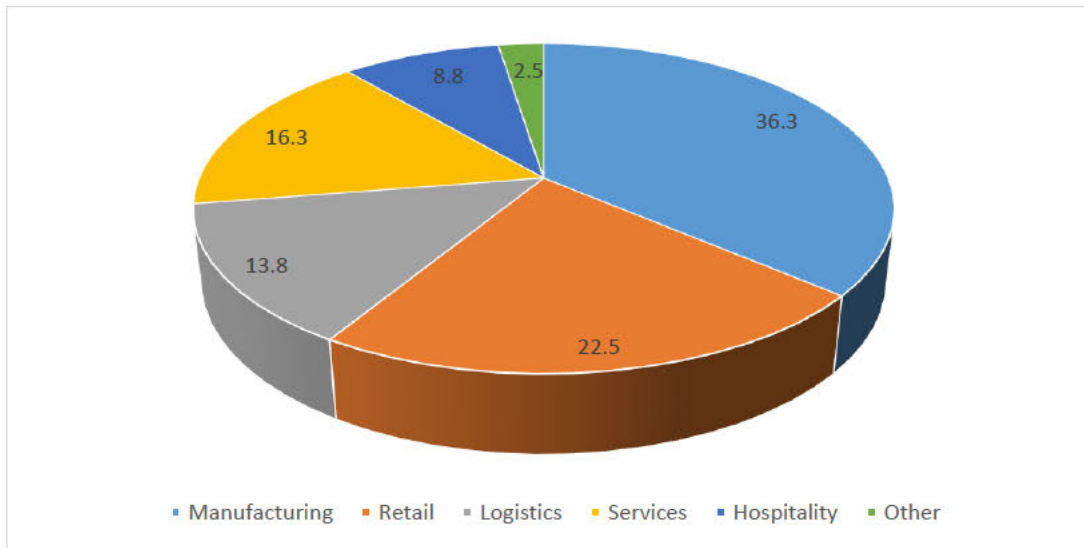
Source: Figure devised by the researcher

The most common level of education is Grade 12, with over a third of the sample (32.5%) having attained this level. Diplomas are also well represented, comprising just over 31% of the group. Individuals with a degree form 21.3% of the sample, suggesting that a significant portion of the population has pursued higher education.

Notably, there are fewer individuals with postgraduate qualifications. Those with a Postgraduate Diploma or Honours Degree make up 6.3%, and a smaller fraction, 2.5%, hold a Master's or Doctorate Degree. This indicates a sharp decline in numbers with advancing educational levels. On the other end of the educational spectrum, 6.3% of the sample have not completed Grade 12, indicating a segment of the population with education levels below high school graduate.

Overall, more than 60% of the respondents hold post-school qualifications ($p < 0.001$), with a smaller yet significant portion holding undergraduate degrees. Postgraduate levels have notably lower representation, highlighting a potential gap in advanced higher education within this particular group. This is a useful statistic as it indicates that a fair proportion of the respondents have a higher qualification. This indicates that the responses gathered would have been from an informed (learned) source. The figure below indicates the industry to which the respondents belong.

Figure 5.3: Grouping by industry



Source: Figure devised by the researcher

Manufacturing emerges as the most represented sector, encompassing 36.3% of the population. Retail also holds a significant proportion, with 22.5% of individuals working within this sector. The services sector is represented by 16.3% of the sample, followed closely by the logistics sector at 13.8% ($p < 0.001$). The hospitality sector has a smaller representation of 8.8%, while a marginal 2.5% of individuals are classified under 'Other', which could include any number of less common industries not specified. This 'Other' category indicates the presence of niche or miscellaneous sectors within the sampled population.

The data suggests a concentration of the workforce in sectors traditionally associated with a high volume of employment, such as manufacturing and retail. The relatively lower percentages in logistics, services, and especially hospitality and other sectors may reflect either a lesser focus of the study or inherent industry sizes within the sampled demographic. The table below lists the positions that respondents hold.

Table 5.7: Positions of respondents

	Frequency	Percent
Owner	24	15.0
Manager	46	28.8
Technician	12	7.5
Supervisor	46	28.8
Other	32	20.0
Total	160	100.0

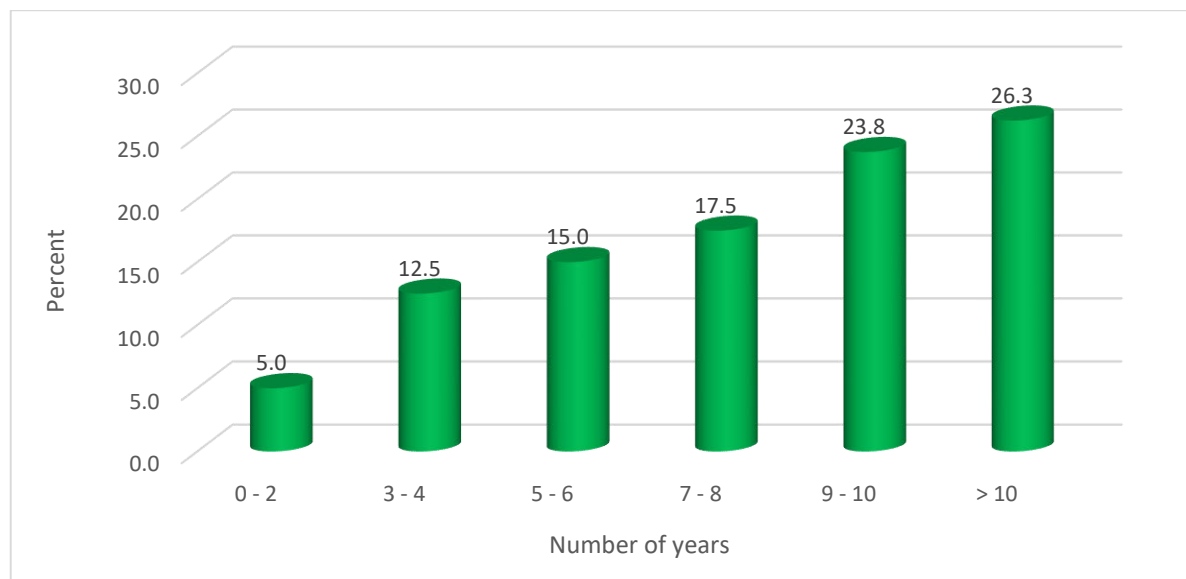
Source: Table devised by the researcher

Managers and supervisors are equally the most common roles, each accounting for 28.8% of the sample. This suggests that a significant proportion of the sampled individuals hold positions with responsibility for overseeing work and managing others. Owners represent 15% of the sample, indicating a smaller but substantial segment of the population who likely have decision-making authority and a vested interest in the success of their business operations. Technicians, who are typically specialists with practical and technical skills, comprise a smaller fraction, at 7.5%. This could imply that the sample has a lesser focus on technical or specialist roles compared to managerial or supervisory positions.

The 'Other' category is quite substantial, making up 20% of the sample. This indicates a diverse array of job roles that do not fall into the conventional categories provided, which could include a wide range of positions across different levels of expertise and responsibility. Overall, the distribution of job roles in this sample points to a workforce with a notable emphasis on management and supervision, a moderate presence of business ownership, and a significant diversity of other employment roles ($p < 0.001$).

The figure below indicates the work experience of the respondents.

Figure 5.4: Work experience of respondents



Source: Figure devised by the researcher

The figure reveals a progression in frequency as experience levels increase. Those with the least experience, ranging from 0 to 2 years, account for a mere 5% of the sample. The 3 - 4 years and 5 - 6 years' brackets show a slight increase, comprising 12.5% and 15.0% respectively ($p < 0.001$). A continued upward trend is observed in the 7 - 8 years' category, representing 17.5% of the individuals, while those with 9 - 10 years of experience make up the second largest group at

23.8%. Notably, the most significant proportion of the sample, 26.3%, possesses over 10 years of experience, suggesting a seasoned workforce with extensive expertise in their respective fields or roles.

This distribution indicates a workforce leaning towards higher levels of experience, with over half of the individuals reporting 7 or more years in their current field or position. It reflects a depth of knowledge and long-term professional engagement among the majority of the sample population. The table below indicates the size of the organization.

Table 5.8: Size of the organization

	Frequency	Percent
Small (less than 50 employees)	106	66.3
Medium (51 to 249 employees)	52	32.5
Large (250 or more employees)	2	1.3
Total	160	100.0

Source: Table devised by the researcher

The majority of individuals, 66.3%, work for small companies with fewer than 50 employees. Medium-sized companies, with a workforce ranging from 51 to 249 employees, employ 32.5% of the sample. There is a minimal representation of individuals working in large companies, with 250 or more employees, making up only 1.3% of the sample ($p < 0.001$).

This data suggests that the sample is skewed towards small businesses, indicating either a focus of the study on smaller enterprises or a reflection of the broader business landscape in which the sample was taken. The substantial difference between the number of individuals in small versus medium-sized companies could also point to differences in job roles, industry types, or economic factors influencing company size. The extremely low percentage of individuals in large companies may indicate barriers to entry or a lesser prevalence of such companies within the context of the study. The table below indicates the current level of familiarity with the Fourth Industrial Revolution.

Table 5.9: Current Level of Familiarity

	Frequency	Percent
Not Familiar at all	2	1.3
Somewhat Familiar	58	36.3

Familiar	70	43.8
Very Familiar	30	18.8
Total	160	100.0

Source: Table devised by the researcher

The data suggests a generally positive level of familiarity with the Fourth Industrial Revolution among the participants. A majority of the sample (98.7%) have some degree of familiarity, ranging from basic to advanced ($p < 0.001$). This distribution may reflect the increasing relevance and discussion of the Fourth Industrial Revolution in various sectors, including education, industry, and media. However, the data also highlights the need for further education and knowledge dissemination, as a significant portion of the sample is only somewhat familiar with the concept.

Section analysis

The section that follows analyses the scoring patterns of the respondents per variable per section. The results are first presented using summarised percentages for the variables that constitute each section. Results are then further analysed according to the importance of the statements.

Section B - Use of the 4IR technologies

This section deals with the use of Fourth Industrial Revolution (4IR) technologies. The table below summarises the scoring patterns.

Table 5.10: Use of the 4IR technologies

		Never		Rarely		Sometimes		Often		All of the time		Chi-Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
Mobile devices (cell phones/ tablets)	B5.1	0	0.0%	0	0.0%	0	0.0%	0	0.0%	160	100.0%	< 0.001
Machines connected to the internet	B5.2	0	0.0%	0	0.0%	0	0.0%	4	2.5%	156	97.5%	< 0.001
Radiofrequency identification (RFI)	B5.3	6	3.8%	4	2.5%	2	1.3%	4	2.5%	144	90.0%	< 0.001

Additive manufacturing (3D Printing)	B5.4	44	27.5%	26	16.3%	22	13.8%	12	7.5%	56	35.0%	< 0.001
Authentication and Fraud detection software	B5.5	12	7.5%	4	2.5%	4	2.5%	12	7.5%	128	80.0%	< 0.001
Human machine technology (HMT)	B5.6	104	65.0%	20	12.5%	14	8.8%	4	2.5%	18	11.3%	< 0.001
Blockchain	B5.7	32	40.0%	12	15.0%	12	15.0%	6	7.5%	18	22.5%	< 0.001
Robotics and Automation	B5.8	38	23.8%	22	13.8%	24	15.0%	24	15.0%	52	32.5%	0.035
Augmented Reality	B5.9	102	63.8%	20	12.5%	14	8.8%	8	5.0%	16	10.0%	< 0.001
Internet of Things (IoT)	B5.10	94	58.8%	24	15.0%	8	10.0%	6	3.8%	20	12.5%	< 0.001
Artificial Intelligence (AI)	B5.11	6	3.8%	0	0.0%	6	3.8%	36	22.5%	112	70.0%	< 0.001
Big Data Analytics	B5.12	4	2.5%	0	0.0%	14	8.8%	22	13.8%	120	75.0%	< 0.001

Source: Table devised by the researcher

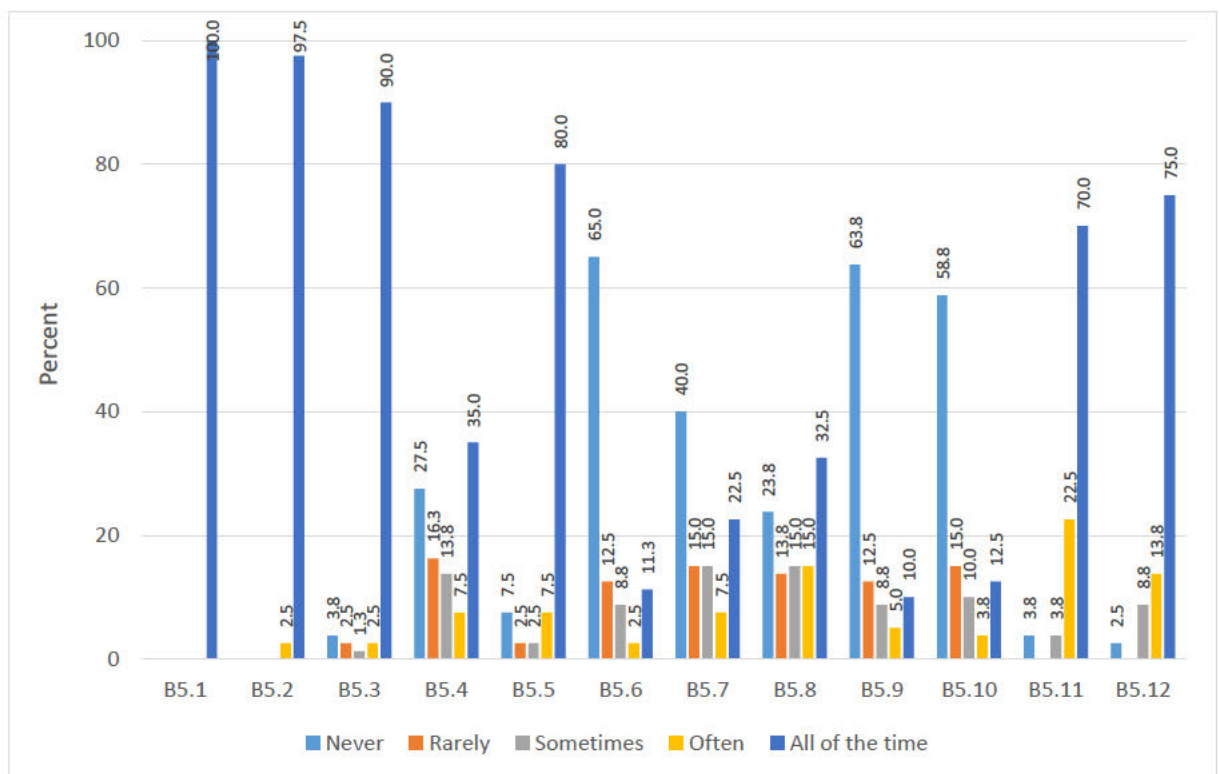
The above table presents information on the utilisation of various 4IR technologies within a given context. The table includes the following technologies:

1. Mobile devices (cell phones/tables – B5.1): The majority of respondents reported using mobile devices (cell phones/tablets) all of the time.
2. Machines connected to the internet (B5.2): A significant percentage (97.5%) reported often or always using machines connected to the internet.
3. Radiofrequency identification (RFI – B5.3): The majority (90%) reported using RFID technology at all the time.
4. Additive manufacturing (3D Printing – B5.4): Responses varied, with 35% using 3D printing all of the time, and 27.5% using it rarely or never.
5. Authentication and fraud detection software (B5.5): The majority (80%) reported using authentication and fraud detection software all of the time.
6. Human Machines Technology (HMT – B5.6): A significant percentage (65%) reported never using HMT, indicating lower utilisation compared to other technologies.
7. Blockchain (B5.7): Of the participating organisations, 40% reported never using blockchain, while 22.5% of the respondents reported using it all of the time.
8. Robotics and automation (B5.8): The usage was distributed, with 32.5% reporting using robotics and automation all of the time.

9. Augmented reality (B5.9): A significant majority (63.8%) reported never using augmented reality, indicating lower adoption in this context.
10. Internet of Things (IoT – B5.10): More than half (58.8%) reported never using IoT, while 12.5% reported using it all of the time
11. Artificial intelligence (AI – B5.11): The majority (70%) reported using AI all of the time.
12. Big data analytics (B5.12): The majority (75%) reported using big data analytics all of the time.

The table also includes a Chi-Square test with p-values for each technology, suggesting the statistical significance of the observed differences in technology usage patterns. Overall, the table provides insights into the frequency of utilization for various 4IR technologies in the surveyed population or context.

Figure 5.5: Adoption levels of the 4IR technologies



Source: Figure devised by the researcher

The following patterns are observed:

- Some statements show (significantly) higher levels of higher frequency whilst other levels of use are lower
- 5 statements indicate higher levels of lower usage

- The significance of the differences is tested and shown in the table. The analysis combined with the usage frequencies of various Fourth Industrial Revolution (4IR) technologies, allows for a detailed assessment of the current integration levels of these technologies. By examining the patterns within the components and their corresponding usage percentages, we gain insights into the adoption trends.

Human-Digital interaction technologies (Component 1):

- This component includes human machine technology (HMT), Internet of Things (IoT), Augmented Reality, and blockchain. The usage pattern reveals that 100% of respondents use mobile devices (integral to IoT) all of the time, indicating complete integration in daily life. However, for technologies like HMT and Augmented Reality, the adoption rates are lower, with 65% and 63.8% of respondents respectively using them rarely or never, suggesting they are still in the early stages of adoption.

Data-Driven and automation technologies (Component 2):

- Involving artificial intelligence (AI), big data analytics, and robotics and automation, this category shows high integration of AI and big data analytics, with 70% and 75% of respondents using them all of the time, respectively. However, robotics and automation display a more varied usage pattern, with only 32.5% using them often or all of the time, indicating a gradual adoption process.

Security and manufacturing technologies (Component 3):

- Technologies such as radiofrequency identification (RFI) and authentication and fraud detection software are highly integrated, with 90% and 80% of respondents using them all of the time, respectively. Additive manufacturing (3D Printing) shows a mixed usage pattern, with 27.5% never using it and only 35% using it often or all of the time, reflecting its nascent stage in the manufacturing sector.

Internet-connected technologies (Component 4):

- Represented predominantly by machines connected to the internet, this technology shows almost universal usage, with 97.5% of respondents using it all of the time. This underscores the foundational role of internet connectivity in modern technologies.

Implications of the Patterns:

- **Widespread adoption of basic IoT and AI:** The near-universal use of mobile devices and high usage rates of AI and big data analytics (70-75%) indicate their deep integration into various sectors.

- **Gradual adoption of advanced interaction and manufacturing technologies:** The lower usage rates for HMT (65% rarely or never) and Augmented reality (63.8% rarely or never), and the diverse usage of Additive Manufacturing (27.5% never, 35% often or all of the time) suggest a slower adoption curve for these advanced technologies.
- **High priority for security technologies:** The dominant usage of security-related technologies (RFI at 90%, authentication software at 80% all of the time) highlights the critical importance of security in digital environments.
- **Balanced integration of robotics and automation:** The spread across usage frequencies for robotics and automation (32.5% often or all of the time, 23.8% never) reflects a sector-specific and cautious approach to adopting these complex technologies.

These patterns reveal a dynamic adoption landscape where foundational technologies like IoT and AI are deeply integrated, while more specialized technologies are being adopted more cautiously and sector-specifically. The emphasis on security technologies aligns with the increasing focus on data protection and integrity in the digital age.

To determine whether the scoring patterns per statement were significantly different per option, a chi-square goodness-of-fit test was done. The null hypothesis claims that similar numbers of respondents scored across each option for each statement (one statement at a time). The alternate states that there is a significant difference between the levels of high and low usage. The results are shown in the table. The highlighted sig. values (p-values) are less than 0.05 (the level of significance), which implies that the distributions were not similar. That is, the differences between the way respondents scored (Never, Rarely, Sometimes, Often, all of the time) were significant.

Section C - Attitudes to using technology

This section deals with the attitudes of various respondents from various industries on the use of Fourth Industrial Revolution (4IR) technologies. The table below summarises the scoring patterns.

Table 5.11: Attitudes to using technology

		Strongly Disagree		Disagree		Not sure		Agree		Strongly Agree		Chi-Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
The staff enjoy using technology	C6.1	0	0.0%	0	0.0%	0	0.0%	0	0.0%	160	100.0%	< 0.001
The staff feel that technology improves their efficiency	C6.2	0	0.0%	0	0.0%	2	1.3%	0	0.0%	158	98.8%	< 0.001
Technology improves customer service	C6.3	0	0.0%	2	1.3%	4	2.5%	0	0.0%	154	96.3%	< 0.001
Technology has given the company a competitive edge	C6.4	0	0.0%	2	1.3%	2	1.3%	0	0.0%	156	97.5%	< 0.001
Technology intimidates and threatens staff	C6.5	56	35.0%	14	8.8%	12	7.5%	24	15.0%	54	33.8%	< 0.001
Technology is reliable with few breakages	C6.6	6	3.8%	6	3.8%	22	13.8%	16	10.0%	110	68.8%	< 0.001
Using technology saves time	C6.7	4	2.5%	0	0.0%	4	2.5%	10	6.3%	142	88.8%	< 0.001
Technology causes staff to be more focused on their work	C6.8	2	1.3%	2	1.3%	6	3.8%	8	5.0%	142	88.8%	< 0.001
Technology will always require human (employee) input	C6.9	2	1.3%	0	0.0%	4	2.5%	4	2.5%	150	93.8%	< 0.001

Source: Table devised by the researcher

The table (Table 5.11) provides a summary of the scoring patterns based on respondents' attitudes toward specific aspects of technology adoption in their respective workplaces. The table is structured to present responses on a Likert scale ranging from "Strongly Disagree" to "Strongly Agree" for various statements related to technology use in the workplace. Additionally, it includes a Chi-Square p-value, which is a statistical measure indicating the significance of the observed patterns in the responses. Below is a summary of the responses:

i. The staff enjoy using technology (C6.1):

All respondents (100%) strongly agree that the staff in their organizations enjoy using technology. This unanimous agreement suggests a positive and favourable perception of technology among the workforce.

ii. The staff feel that technology improves their efficiency (C6.2):

A high percentage (98.8%) agrees that technology enhances efficiency. This indicates a widespread belief among respondents that technology positively impacts work efficiency.

iii. Technology improves customer service (C6.3):

A majority (96.3%) agrees that technology contributes to improving customer service. This positive sentiment suggests that respondents see technology as a valuable tool for enhancing customer interactions.

iv. Technology has given the company a competitive edge (C6.4):

A significant proportion (97.5%) agrees that technology has provided their companies with a competitive edge. This perception highlights the strategic importance of technology in maintaining competitiveness.

v. Technology intimidates and threatens staff (C6.5):

While a substantial percentage (33.8%) feels that technology intimidates and threatens staff, a larger percentage disagrees or strongly disagrees. This indicates a mixed perception, with a notable portion expressing concerns about the impact of technology on the workforce.

vi. Technology is reliable with few breakages (C6.6):

The majority (68.8%) strongly agrees that technology is reliable with few breakages, suggesting a high level of confidence in the reliability of the technology infrastructure.

vii. Using technology saves time (C6.7):

An overwhelming majority (88.8%) agrees that using technology saves time, emphasizing the perceived efficiency gains associated with technology adoption.

viii. Technology causes staff to be more focused on their work (C6.8):

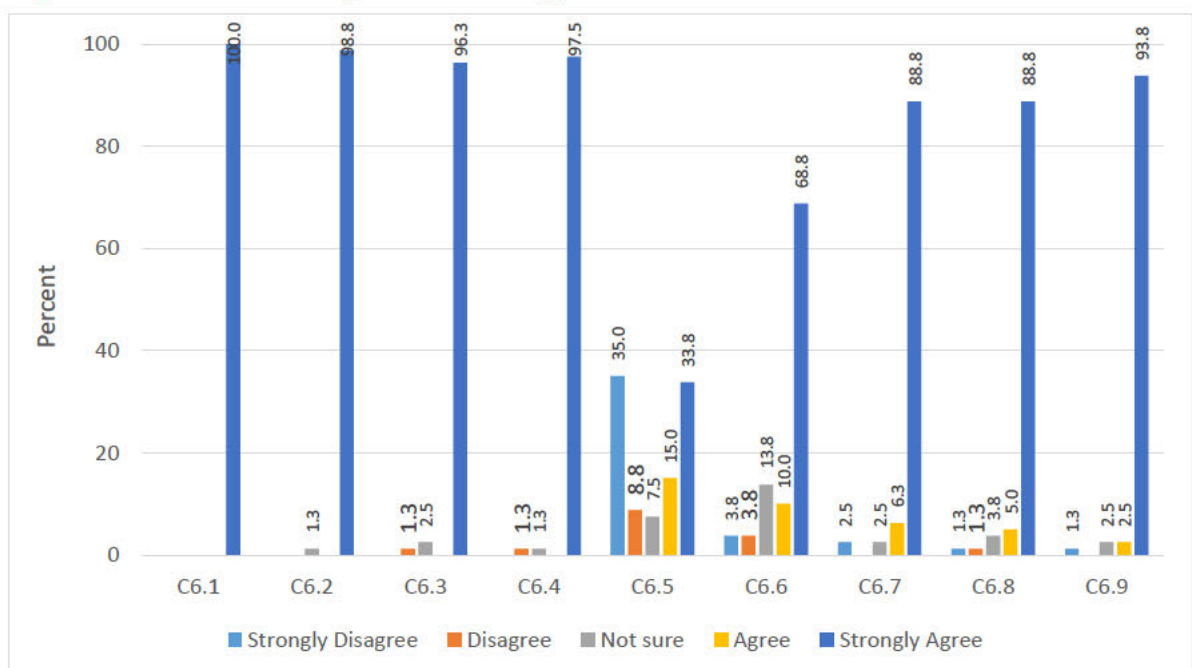
The majority (88.8%) agrees that technology enhances focus on work. This positive perception indicates that respondents believe technology contributes to increased work concentration.

ix. Technology will always require human/employee input (C6.9):

A significant majority (93.8%) agrees that technology will always require human input. This acknowledgment underscores the belief that human employees will continue to play a crucial role alongside technological advancements.

In summary, the table reflects a generally positive attitude towards the use of the 4IR technologies, with respondents acknowledging the benefits of technology in terms of efficiency, competitiveness, and time savings. However, there are also concerns, as indicated by the responses related to the intimidation and threat posed by technology. The statistical significance of these patterns is highlighted by the Chi-Square p-values, emphasizing the reliability of the observed attitudes.

Figure 5.6: The factor analysis of technology use



Source: Figure devised by the researcher

The Rotated Component Matrix combined with the attitudes of staff towards technology usage in the workplace, reveals insightful trends. The factor analysis has identified two main components, and their corresponding attitudes are reinforced by the distribution of responses in terms of agreement or disagreement.

Efficiency and reliability of technology (Component 1):

This component includes attitudes on how technology aids in time-saving, enhances focus, requires human input, is reliable, and contributes to competitive advantage. The response patterns show high levels of agreement with these aspects:

- 88.8% of the respondents strongly agree that using technology saves time,
- 88.8% of the respondents also strongly agree that technology causes staff to be more focused on their work,
- At the same time, 93.8% of the respondents strongly agree that technology will always require human (employee) input,
- Furthermore, 68.8% of the respondents agree or strongly agree that technology is reliable with few breakages,
- A further 97.5% of the respondents either agreed or strongly agreed that technology has given the company a competitive edge.

These responses underscore a strong belief in the efficiency and reliability of technology in enhancing workplace productivity and competitiveness.

Impact of technology on service and efficiency (Component 2):

- This component reflects the belief that technology not only enhances internal processes but also positively affects customer-facing aspects. The response distribution reflects high agreement:
 - 96.3% of the respondents felt that the use of technology improves customer service,
 - The staff feel that technology improves their efficiency (98.8% strongly agree),
 - A further 97.5% of the respondents either agreed or strongly agreed that technology has given their companies a competitive edge.

These numbers indicate a strong consensus among the respondents that technology significantly improves customer service and staff efficiency, contributing to the organization's competitive advantage.

Summary and Implications:

- **High confidence in technology’s role in efficiency and service:** The overwhelmingly positive responses in both components indicate a high level of confidence among staff in the role of technology in improving efficiency, reliability, and customer service.
- **Perception of technology as a competitive advantage:** The high agreement rates (over 90% in most cases) suggest that technology is perceived as a key factor in gaining a competitive edge.
- **Acknowledgment of the need for human input:** Despite the high reliance on technology, there is a strong recognition (93.8% strongly agree) that technology will always require human input, indicating a balanced view of technology as a tool rather than a replacement for human skills.
- **Concerns about technology’s intimidating nature:** Notably, a significant proportion of respondents (35% strongly disagree, 8.8% disagree) feel that technology intimidates and threatens staff, suggesting a need for better integration and training strategies to make technology more accessible and less daunting.

The analysis of Section C reveals a generally positive attitude towards technology in the workplace, with strong agreement on its role in improving efficiency, reliability, and customer service. However, the concern about technology being intimidating indicates a potential area for improvement in its implementation and user training.

Section D - Knowledge of technology

This section deals with the knowledge of various technologies by different respondents and their subsequent impact on various business operations. The table below summarises the scoring patterns.

Table 5.12: The knowledge of technology

		Strongly Disagree		Disagree		Neutral		Agree		Strongly Agree		Chi-Square p-value
		Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	Count	Row N %	
I am aware of the Internet of Things (IoT)	D7.1	2	1.3%	2	2.5%	20	12.5%	22	13.8%	112	70.0%	< 0.001

The impact of the 4IR on customer interactions is critical for business decisions	D7.2	0	0.0%	4	2.5%	0	0.0%	26	16.3%	130	81.3%	< 0.001
Employees know how to work with advanced technologies and tools relevant to 4IR	D7.3	0	0.0%	4	2.5%	10	6.3%	22	13.8%	124	77.5%	< 0.001
The company utilizes data analytics and artificial intelligence to make informed decisions	D7.4	0	0.0%	4	2.5%	16	10.0%	16	10.0%	124	77.5%	< 0.001
Technological infrastructure and resources are readily available to support the integration of the 4IR technologies	D7.5	2	1.3%	4	2.5%	8	5.0%	18	11.3%	128	80.0%	< 0.001
The company monitors and adapts to technological trends to align with industry best practices	D7.6	0	0.0%	2	1.3%	8	5.0%	14	8.8%	136	85.0%	< 0.001

Source: Table devised by the researcher

The table presents survey responses related to the knowledge of technology within a business or organizational context. Respondents were asked to express their level of agreement with statements regarding various aspects of technological awareness and utilization. A summary of the responses is discussed below:

i. Awareness of the Internet of Things (IoT):

The majority of respondents (70.0%) strongly agree that they are aware of the Internet of Things (IoT). Only a small percentage (1.3%) strongly disagree. The high awareness suggests a strong familiarity with IoT, which is crucial in the context of modern technological advancements.

ii. Impact of the 4IR on customer interactions:

A significant percentage (81.3%) strongly agree that the impact of the Fourth Industrial Revolution (4IR) on customer interactions is critical for business decisions. No respondents strongly disagree. Recognizing the importance of the 4IR in customer interactions indicates a forward-looking approach to business strategy.

iii. Employee competence with 4IR technologies

A large proportion (77.5%) strongly agree that employees know how to work with advanced technologies and tools relevant to 4IR. Employee competence in advanced technologies is crucial for the successful integration of the 4IR technologies.

iv. Utilisation of Data Analysis and AI for Decision Making:

The majority (77.5%) strongly agree that the company utilizes data analytics and artificial intelligence to make informed decisions. Leveraging data analytics and AI for decision-making aligns with industry best practices and reflects a data-driven organizational culture.

v. Availability of Technological Infrastructure:

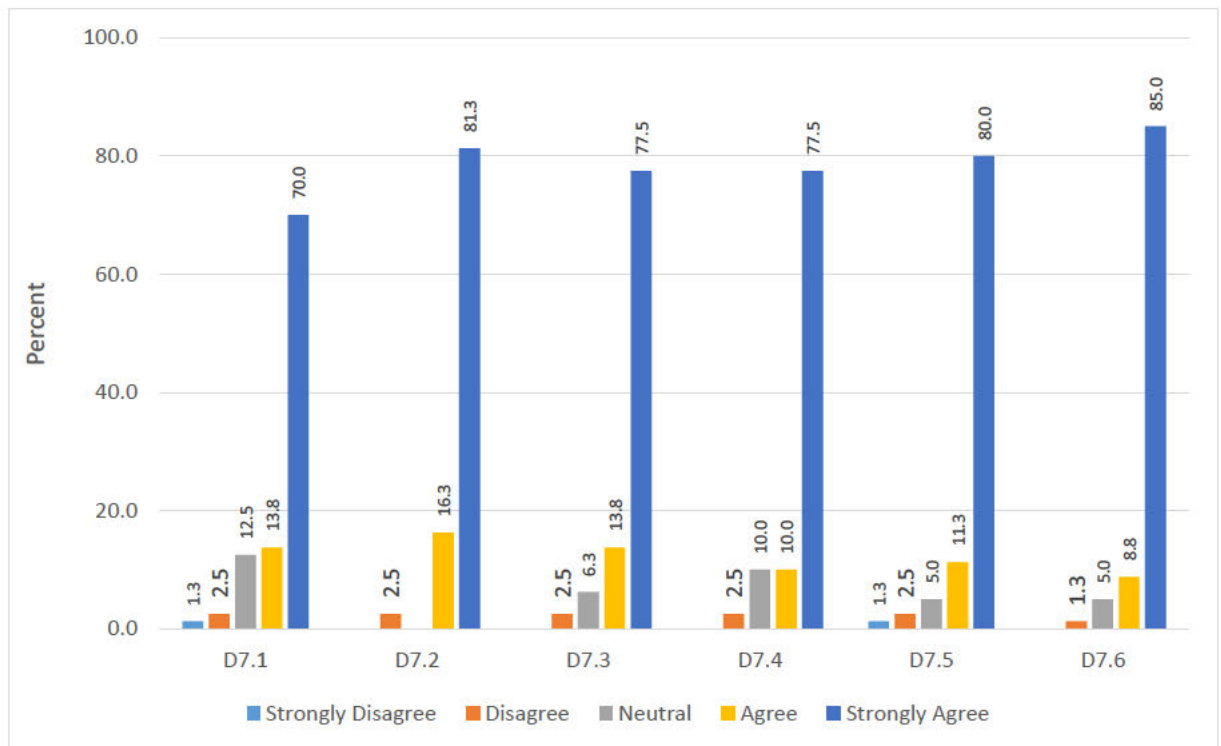
A substantial percentage (80.0%) strongly agree that technological infrastructure and resources are readily available to support the integration of the 4IR technologies. Availability of necessary infrastructure is foundational for the successful implementation of advanced technologies.

vi. Monitoring and Adaptation to Technological Trends:

A significant majority (85.0%) strongly agree that the company monitors and adapts to technological trends to align with industry best practices. Continuous monitoring and adaptation to technological trends indicate a proactive approach to staying abreast of industry advancements.

The overall pattern in the responses suggests a technologically savvy and forward-thinking organizational culture. High levels of agreement across various aspects indicate a strong foundation for embracing and leveraging Fourth Industrial Revolution technologies within the business. The low p-values (all < 0.001) in the Chi-Square tests support the statistical significance of these findings.

Figure 5.7: The scoring patterns



Source: Figure devised by the researcher

In Section D, the rotated component matrix indicates that various aspects of knowledge and awareness of the Fourth Industrial Revolution (4IR) technologies are consolidated into a single component. This suggests a cohesive understanding and application of these technologies within the companies.

Component analysis:

Single component:

- This component has high loadings across all items, indicating a strong and unified dimension of the 4IR technology awareness and integration within the respondents' companies.
- The aspects include awareness of the Internet of Things (IoT), recognition of the 4IR's impact on customer interactions, employee proficiency in advanced technologies, utilization of data analytics and AI for decision-making, availability of necessary technological infrastructure, and the company's proactive approach in adapting to technological trends.

Analysis of Response Patterns:

- **Awareness of IoT:** A significant majority (83.8%) of respondents agree or strongly agree that they are aware of IoT, showing a high level of basic understanding of the 4IR technologies.
- **Impact of the 4IR on customer interactions:** An overwhelming 97.6% of the respondents recognize the critical impact of the 4IR on customer interactions, highlighting the importance placed on adapting business strategies in response to technological advancements.
- **Employee proficiency with advanced technologies:** A combined 91.3% of respondents agree or strongly agree that employees are proficient with advanced technologies relevant to 4IR, indicating effective training or hiring practices.
- **Data analytics and AI in decision making:** A combined 87.5% of respondents agree or strongly agree that the company utilizes data analytics and AI to make informed decisions, reflecting a data-driven approach in business operations.
- **Availability of technological infrastructure:** A strong majority (91.3%) of respondents agree or strongly agree that the necessary technological infrastructure and resources are readily available, suggesting good support for 4IR technology integration.
- **Monitoring and adapting to technological trends:** A total of 93.8% of respondents agree or strongly agree that the company monitors and adapts to technological trends to align with industry best practices, indicating a proactive and adaptive business strategy.

Implications:

- **Unified approach to 4IR technologies:** The consolidation of various aspects into a single component suggests a holistic and integrated approach to 4IR technologies within the companies.

- **High awareness and adaptability:** The high percentages of agreement across all aspects indicate not only awareness but also adaptability and responsiveness to 4IR technologies and trends.
- **Focus on employee proficiency and infrastructure:** The strong emphasis on employee proficiency and infrastructure availability highlights the companies' commitment to equipping their workforce with the necessary tools and skills to navigate the 4IR landscape.
- **Data-driven decision-making:** The reliance on data analytics and AI for decision-making underscores a modern, forward-thinking approach to business strategy and operations.

The analysis of Section D indicates a comprehensive and cohesive integration of the 4IR technologies in the company, reflected in the high levels of agreement across all aspects of the single component. This suggests a strong alignment with 4IR trends and a proactive approach to leveraging these technologies for competitive advantage.

Cross tabulations

A Chi-square test of independence was performed to determine whether there was a statistically significant relationship between the variables. The null hypothesis states that there is no association between the two. The alternate hypothesis indicates that there is an association. The table summarises the results of the chi-square tests. The p-value between “Machines connected to the Internet” and “Industry Type” is 0.018. This means that there is a significant relationship between the variables. That is, the industry type did play a significant role in terms of how respondents viewed machines connected to the internet.

Table 5.13: Chi-square rest

		Industry Type							Total
		Manufacturing	Retail	Logistics	Services	Hospitality	Other		
Machines connected to the internet	Often	Count	0	0	2	0	0	2	4
		% within Industry Type	0.0%	0.0%	9.1%	0.0%	0.0%	50.0%	2.5%
	All of the time	Count	58	36	20	26	14	2	156
		% within Industry Type	100.0%	100.0%	90.9%	100.0%	100.0%	50.0%	97.5%
Total		Count	58	36	22	26	14	4	160

	% within Industry Type	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
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Source: Table devised by the researcher

Manufacturing, retail, services, and hospitality industries: These sectors show a unanimous pattern where 100% of machines are connected to the internet "All of the time." This indicates a pervasive and consistent use of internet-connected machinery in these industries.

Logistics industry: A notable deviation is observed in this sector. While the majority (90.9%) of machines are connected "All of the time," a small portion (9.1%) is connected "Often." This suggests a slightly less consistent usage of internet-connected machinery compared to the aforementioned industries.

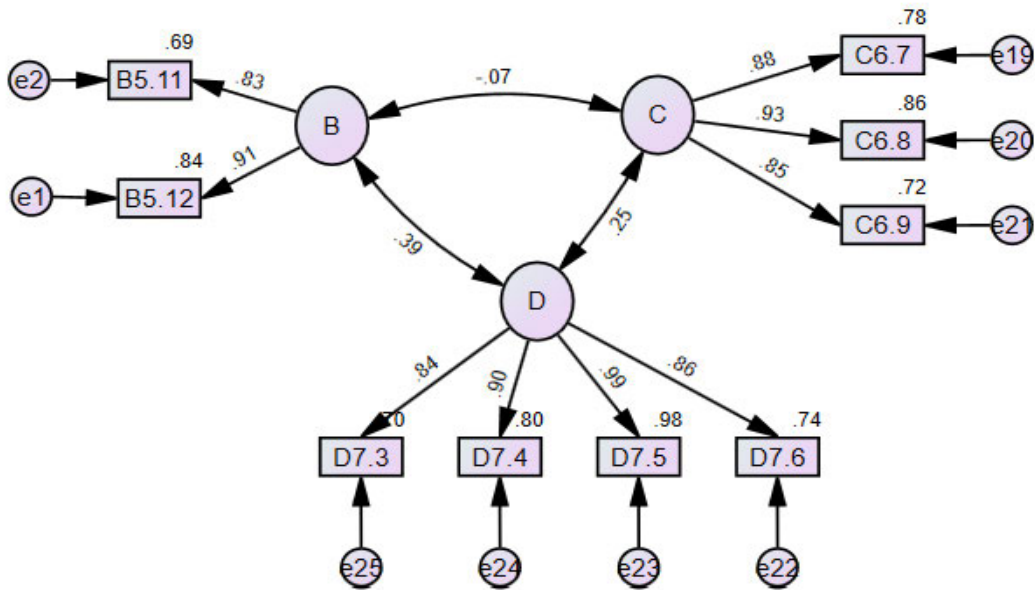
Other industry: This category exhibits the most significant divergence. Half of the machines are connected "Often," and the other half "All of the time." This stark 50-50 split is markedly different from the patterns observed in other industries and is likely a key contributor to the statistical significance denoted by the p-value.

The pattern across most industries leans heavily towards consistent, full-time internet connectivity of machines, with Logistics showing a slight deviation and the Other category displaying a significantly different pattern of connectivity. The heterogeneity in the "Other" category, combined with the slight variation in Logistics, likely drives the statistical significance observed. All p-values more than 0.05 do not have a significant relationship.

Structural equation model

Structural equation modelling (SEM) is a statistical technique used to analyse complex relationships between observed and latent variables. It provides a framework for testing and validating theoretical models by combining measurement models and structural models. In SEM, observed variables are measured directly, while latent variables represent constructs that are not directly observable but are inferred from the observed variables. The technique allows estimation of the strength and direction of relationships between variables, assessment of the overall fit of the model to the data, and the evaluation of the significance of individual paths and coefficients.

Figure 5.8: Structural equation model



Source: Figure devised by the researcher

The path diagram for the modified SEM is shown above. The model is a multivariate statistical result that was obtained using structural relationships, applying a combination of factor analysis and multiple regression analysis techniques. It is used to analyse the structural relationship between measured variables and latent constructs. The dimensions are coded as under reliability. The AMOS Structural Equation Model (SEM) output provides a variety of information that assesses the fit of the model, the relationships between the constructs, and the reliability of the measurement scales. The detailed analysis is as follows:

Model Fit

Minimum was achieved

Chi-square = 33.519

Degrees of freedom = 24

Probability level = .094

The Chi-square tests the null hypothesis that the over-identified (reduced) model fits the data as well as does a just-identified (full, saturated) model. In a just-identified model, there is a direct path (not through an intervening variable) from each variable to each other variable. In such a model the Chi-square will always have a value of zero since the fit will always be perfect. The probability should **not** be significant. In this model, the chi-square p-value is > 0.050 (p = 0.094).

The Chi-square value is 33.519 with 24 degrees of freedom, resulting in a probability level of .094. This indicates a decent fit as a non-significant Chi-square suggests that the model does not significantly deviate from the observed data.

Maximum likelihood estimates

Regression weights: (Group number 1 - Default model) Maximum likelihood estimates in AMOS SEM are used to find parameter values that best fit the observed data. Regression weights represent the strength and direction of relationships between variables in the model. The “Group number 1 - Default model” indicates these weights for the primary group in the analysis.

Table 5.14: Regression weights

	Estimate	S.E.	C.R.	P	Label
B5.12 <--- B	1.000				
B5.11 <--- B	.941	.201	4.678	***	par_1
C6.7 <--- C	1.000				
C6.8 <--- C	.999	.088	11.391	***	par_2
C6.9 <--- C	.744	.074	10.089	***	par_3
D7.6 <--- D	1.000				
D7.5 <--- D	1.541	.111	13.939	***	par_4
D7.4 <--- D	1.347	.118	11.404	***	par_5
D7.3 <--- D	1.160	.117	9.959	***	par_6

Source: Table devised by the researcher

The variables loaded strongly along their various factors (significant p-values indicated by *** p < 0.001). These verify the EFA obtained under factor analysis.

Table 5.15: Standardized regression weights: (Group number 1 - Default model)

	Estimate
B5.12 <--- B	.914
B5.11 <--- B	.829
C6.7 <--- C	.883
C6.8 <--- C	.928
C6.9 <--- C	.849
D7.6 <--- D	.860
D7.5 <--- D	.992
D7.4 <--- D	.896
D7.3 <--- D	.835

Source: Table devised by the researcher

The parameters are estimated by maximum likelihood (ML) methods, which (is an iterative procedure that) attempts to maximize the likelihood that obtained values of the criterion variable will be correctly predicted. All the coefficients were above the suggested value of 0.600. Statements that loaded poorly or that were redundant were omitted from the model. Also, statements that had little or zero variance were omitted.

- The weights range from .829 to .992, suggesting that all the paths in the model are substantial and the constructs are well explained by their indicators.
- The significant Critical Ratios (C.R.), all above 1.96 (here they are shown with *** for $p < .001$), indicate that the regression weights are significantly different from zero at the .001 level.

Model fit summary

The suggested acceptable value for relative chi-square, CMIN/DF should not be greater than 5 which is used to reduce dependency on sample size. However, the cut-off point for TLI, CFI, NFI, and IFI is between zero to one. A good model is indicated by an RMSEA value of less than or equal to 0.05.

Table 5.16: Model fit

Model	NPAR	CMIN	DF	P	CMIN/DF
Default model	30	33.519	24	.094	1.397
Saturated model	54	.000	0		
Independence model	18	609.332	36	.000	16.926

Source: Table devised by the researcher

CMIN is a Chi-square statistic comparing the tested model and the independence model to the saturated model. The ratio, CMIN/DF, the relative chi-square, is an index of how much the fit of data to the model has been reduced by dropping one or more paths. The CMIN/DF is less than the acceptable value of 5 (1.397). This meets the CMIN condition.

Table 5.17: Baseline comparisons

Model	NFI Delta1	RFI rho1	IF Delta2	TLI rho2	CFI
Default model	.945	.917	.984	.975	.983
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000

Source: Table devised by the researcher

This goodness of fit indices compares the model to the independence model rather than to the saturated model. The Normed Fit Index (NFI) is simply the difference between the two models' chi-squares divided by the chi-square for the independence model. For this data, the NFI is 0.945, which is more than the recommended value of 0.90 for a good fit. The Comparative Fit Index (CFI) uses a similar approach (with a noncentral chi-square) and is said to be a good index for use even with small samples. It ranges from 0 to 1, like the NFI, and 0.90 indicates a good fit. The CFI value is 0.983, implying a good fit.

Table 5.18: RMSEA

Model	RMSEA	LO 90	HI 90	CLOSE
Default model	.071	.000	.123	.259
Independence model	.449	.418	.481	.000

Source: Table devised by the researcher

The Root Mean Square Error of Approximation (RMSEA) estimates the lack of fit compared to the saturated model. The p-of-close fit (PCLOSE) is a statistical measure used to assess the fit of a model. An RMSEA value of 0.05 or less indicates a "close fit" for the model, and between .05 and .10, an adequate fit. In line with this definition, if the p-value of PCLOSE is greater than 0.05, it suggests that the RMSEA value is less than 0.05, indicating a close fit for the model. Conversely, if the p-value is less than 0.05, it indicates that the model's fit is not as good as a close fit.

The obtained PCLOSE value for the initial model was 0.259, which is greater than the recommended threshold of 0.05. This suggests that the model's fit was good, with the RMSEA also showing an adequate fit (0.071).

Regression Analysis

The level of significance relates to the strength of the relationships. The correlations are tested below. Covariances: (Group number 1 - Default model)

Table 5.19: Covariances: (Group number 1 - Default model)

	Estimate	S.E.	C.R.	P	Label
B <--> C	-.036	.062	-.590	.555	par_7
D <--> B	.154	.053	2.929	.003	par_8
D <--> C	.081	.040	2.046	.041	par_9

Table 5.20: Correlations: (Group number 1 - Default model)

	Estimate
B <--> C	-.074
D <--> B	.392
D <--> C	.252

Source: Table devised by the researcher

Null hypothesis: There is no correlation between each of the dimensions.

Alternate hypothesis: There is a significant correlation.

In general, if the co-variance between two constructs is significant, then correlations between them should also be significant as correlation is a standardized form of co-variance, and both show the strength and direction of the relationship.

From the output, the covariance estimates between selected pairs of variables were examined. Notably, the covariance between variables B and C was found to be -0.036 (standard error = 0.062, p-value = 0.555). This negative value suggests a slight inverse relationship, indicating that as one variable increases, the other tends to decrease, albeit the relationship is not statistically significant given the p-value. This lack of significance might be due to a limited sample size, measurement error, or the true absence of a substantial relationship in the population. The other two covariances were however significant.

Correlation coefficients provide a standardized measure of the relationship between two variables, scaled from -1 to 1. Unlike covariances, correlations are unaffected by the scale of the variables, making them more interpretable, especially when comparing relationships across different pairs of variables. The correlation analysis revealed several interesting relationships. For instance, the correlation between variables B and C was -0.074, suggesting a weak negative relationship. In contrast, variables D and B showed a moderate positive correlation of 0.392, and variables D and C correlated 0.252. These positive correlations indicate that as one variable increases, so does the other.

Interpretation

The SEM analysis using AMOS software provided valuable insights into the relationships among the variables in the model. The covariance and correlation analyses are particularly useful in

understanding the nature and strength of these relationships. The weak to moderate correlations observed suggest that while there are relationships among the variables, they may not be strong or may be influenced by other factors not included in the model.

Future research should consider expanding the model to include additional variables or interactions that might better explain the observed relationships. Additionally, the findings should be interpreted with caution due to potential limitations such as sample size, measurement error, or model misspecification.

5.5 Chapter Summary

In this chapter, a meticulously crafted questionnaire comprising 36 items, strategically calibrated to nominal or ordinal measurement levels, enabled a nuanced analysis of participants' responses. Through its systematic segmentation into thematic sections, the questionnaire emerged as a robust mechanism poised to unearth critical insights into respondents' biographical contexts, technological proclivities, attitudinal dispositions, and knowledge reservoirs regarding contemporary technologies. SPSS software was used to analyse quantitative data 5.5 using a variety of relevant statistical approaches. The first section of the chapter included the reliability analysis (Cronbach's Alpha score) for each of the questionnaire components. Descriptive data in the form of tables, graphs, and charts were then presented.

The answers to several queries about the use of the 4IR technologies, attitudes to using technology, and knowledge of technologies were represented in the tables, graphs, and charts. All of the questionnaire's parts had reliability scores higher than the recommended Cronbach's Alpha level. In structural equation modelling, the chi-square test was used to assess the goodness of fit between the observed data and the estimated model. The acceptability of a chi-square value depends on several factors, including the degrees of freedom, the significance level, and the fit indices associated with the model. For this research, the chi-square value is 33.52 with 24 degrees of freedom, resulting in a probability level of 0.094. This indicates that the observed data does not deviate significantly from the estimated model. Typically, a non-significant chi-square value ($p > 0.05$) suggests a good fit and this condition has been met. In this case, the CFI value (0.983) indicates a good fit, as values above 0.90 are considered acceptable. The TLI value (0.975) also suggests a good fit, with values above 0.90 indicating a satisfactory fit. The RMSEA value (0.071) falls within the acceptable range, where values between 0.05 and 0.10 are considered acceptable. Considering the combination of these fit indices, it appears that the fit indices suggest a reasonably acceptable fit for the model.

Some of the low-loading factors (statements) or those with little or zero variance, were omitted from the model. An inspection of the coefficients for each latent variable indicated high factor loadings. In addition, the path coefficients are reflected on the diagram. All of the coefficients are positive (proportional relationship) between the latent variables. As this was a newly developed construct, it is also expected that the structural relationships may not have fitted accurately. However, the indices are met and the model is a good fit. It is recommended that the model be revised in terms of the measured variables constituting the latent variables to improve factor loadings. In the results and discussion portion of this study, the quantitative and qualitative data are given independently and discussed together in the findings and discussion chapter. To gain a better understanding of how businesses in the South Durban Basin are utilizing the Fourth Industrial Revolution to gain a competitive advantage, the following chapter presents qualitative data to complement the quantitative data.

CHAPTER 6

Qualitative analysis

6.1 Introduction

Qualitative analysis is a crucial methodology in research, allowing for a deeper exploration and understanding of complex phenomena. In this chapter, the focus shifts from quantitative exploration to delving into the rich tapestry of insights gathered through a questionnaire-based interview process involving forty (40) respondents or companies situated within the South Durban Basin. Using NVivo version 20 as the analytical tool, this phase of the research journey embarks on a thematic analysis, unravelling the nuanced perspectives, and narrative. As a complementary thread to the preceding quantitative analysis, this qualitative exploration looks to unveil the deeper layers of understanding, shedding light on the intricate and diverse viewpoints prevalent within this dynamic setting. This qualitative exploration serves as a complementary thread to the preceding quantitative analysis, aiming to unveil the deeper layers of understanding and shed light on the diverse viewpoints prevalent within this dynamic setting. The transition to qualitative analysis marks a significant shift in our research approach, enabling a deeper exploration of the multifaceted aspects inherent in the South Durban Basin context.

Through the questionnaire-based interview process, we engaged with forty respondents or companies, capturing a rich array of perspectives and experiences. The utilization of NVivo facilitated a systematic analysis, allowing us to identify recurring themes and patterns within the dataset. This thematic analysis revealed a tapestry of insights, highlighting the complexities and nuances of the issues under investigation. Moreover, the qualitative exploration served to complement the quantitative findings, providing a deeper understanding of the underlying dynamics at play. By unravelling the diverse viewpoints prevalent within the basin, we were able to gain a more comprehensive understanding of the socio-economic and environmental landscape. Overall, the qualitative analysis adds depth and richness to our research findings, contributing to a more holistic perspective on the subject matter.

6.2 Analysis and interpretation of interview results

The process of analysing and interpreting interview results gathered through a set of structured questions on the Fourth Industrial Revolution (4IR) and its impact on the South Durban Basin

involved several key aspects. Firstly, understanding the participants' grasp of the 4IR and its potential implications sets the foundational knowledge base. Assessing familiarity with current applications and the implementation of the 4IR technologies in the area provided insight into the existing landscape. Organisations implementing 4IR tools and their perceived competitive advantages shed light on strategic perspectives. Evaluating the effectiveness of digital technology within company operations elucidates practical implications.

Understanding challenges faced, their resolution, necessary skill sets, and areas digitised within the business framework delineate the practical hurdles and adaptations. Addressing the impact on the local job market and employment, along with the company's approach to upskilling, projects the human dimension. Crafting a theoretical framework for 4IR's effective use as a competitive advantage for the region involved synthesizing these insights. Recommendations to optimize digital technology usage and the role of various stakeholders, such as the government, private sector, and local communities, highlight collaborative efforts in 4IR promotion. Finally, gathering additional comments or insights on 4IR as a competitive advantage encapsulates diverse viewpoints, enriching the overall analysis and interpretation of the interview findings. The research instruments enabled the researcher to develop themes that are relevant to the research study.

6.3 Themes

NVivo was used in the systematic analysis of qualitative data, aiding in the organisation, coding, and categorization of information derived from research interviews. The responses from the research participants were coded into six themes and nine sub-themes, forming a coherent structure for analysis. The questions naturally aligned with thematic areas such as understanding of the 4IR, application of the 4IR technologies, challenges and overcoming them, impact on company and community, skills and training, role of government and leadership. Each of these broader themes were then subdivided into specific sub-themes, corresponding to the questions asked. For instance, under impact on company and community, sub-themes included competitive position, job market impact, and role of different stakeholders. These themes and sub-themes are grouped to show their interconnectedness and relevance within the context of the South Durban Basin's 4IR impact. Themes and sub-themes are further discussed in detail below.

Theme 1: Understanding of the 4IR

- Sub-theme 1.1: Potential Impact on the South Durban Basin

Theme 2: Application of the 4IR technologies

- Sub-theme 2.1: Familiarity with the 4IR technologies
- Sub-theme 2.2: Company implementation and competitive advantage
- Sub-theme 2.3: Effectiveness in company operations
- Sub-theme 2.4: Digitized business operations

Theme 3: Challenges and overcoming them

Theme 4: Impact on company and community

- Sub-theme 4.1: Competitive position
- Sub-theme 4.2: Job market impact
- Sub-theme 4.3: Recommendations for effective use
- Sub-theme 4.4: Roles of government, private sector, and communities

Theme 5: Skills and training for implementation

Theme 6: Role of leadership

6.3.1 Theme 1: Understanding of the 4IR

The responses gathered reflect a diverse understanding of the Fourth Industrial Revolution (4IR) and its potential impact on the South Durban Basin. Many respondents foresee improvements in industrial processes, supply chain management, and manufacturing competitiveness through the adoption of smart technologies, automation, and data-driven decision-making. Some respondents highlighted the potential for 4IR to improve environmental monitoring, waste management, and energy efficiency, leading to a cleaner and more sustainable South Durban Basin. There is a perception that 4IR could create new job opportunities, foster economic growth, and enhance the competitiveness of industries within the area, as reflected in multiple responses. Expectations also exist for the transformation of South Durban into a smart city, with efficient public services, infrastructure, and resource management using advanced technologies.

Respondent 20 stated that *“The 4IR is a transformative period, and in the South Durban Basin, it can improve the quality of healthcare and access to medical services through telehealth and AI-driven diagnosis”*.

This view was shared by few other respondents that these developments are expected to lead to an improvement in healthcare services, including telemedicine, AI-driven diagnostics, and enhanced access to medical services. Some respondents foresee advancements in educational and training programs, empowering the local workforce with digital skills, and potentially increasing employment prospects.

Ideas about creating smart and connected communities, enhancing quality of life, and ensuring public safety through technology integration, transportation efficiency, and environmental friendliness are prevalent in the responses.

Respondent 1: *“The Fourth Industrial Revolution (4IR) refers to the fusion of digital technologies, artificial intelligence, and the physical world, and it has the potential to revolutionize industries in the South Durban Basin by enhancing productivity and innovation.”*

Respondent 2 said *“The 4IR is a new era of advanced technology, characterized by automation, IoT, and big data. In South Durban, it could improve environmental monitoring and management”*.

Respondent 8 further said *“The 4IR can enable South Durban to transition to cleaner and more sustainable energy sources through advanced energy management systems”*.

These responses collectively suggest a holistic potential for the 4IR to positively affect various sides of life within the South Durban Basin, including its industries, environment, economy, healthcare, education, infrastructure, and community well-being. The convergence of technology and innovation appears poised to bring about transformative changes across multiple sectors, potentially positioning South Durban as a hub for advanced technologies, sustainability, and economic development. The sub-theme of the potential impact of the 4IR on the South Durban Basin emerged from the theme.

6.3.1.1 Sub-Theme 1.1: Potential impact on the South Durban Basin

The potential impact of the Fourth Industrial Revolution (4IR) on the South Durban Basin is poised to be transformative across various sectors. With its focus on technological advancements such as automation, artificial intelligence, and the Internet of Things (IoT), 4IR has the capacity to revolutionize the industrial landscape of the South Durban Basin.

Respondent 3: *“The implementation of the 4IR tools like robotics and automation has streamlined production processes, allowing us to be more cost-effective and responsive to market demands.”*

Respondent 2 suggested that *“the 4IR is a new era of advanced technology, characterized by automation, IoT, and big data. In South Durban, it could improve environmental monitoring and management”*.

Respondent 7 said that *“he understands the 4IR to foster innovation, particularly in the South Durban Basin's chemical and manufacturing sectors”*.

In manufacturing, the integration of smart technologies could optimize production processes, enhancing efficiency while reducing environmental impact. Moreover, advancements in

renewable energy and digital infrastructure could bolster the area's sustainability efforts, potentially mitigating the challenges of the load shedding in South Africa.

However, there are also concerns about job displacement due to automation, needing proactive measures for upskilling the local workforce to adapt to the changing technological landscape. According to respondent 13 *“the 4IR means adopting smart manufacturing techniques in South Durban, which can lead to increased competitiveness in the job market”*.

Overall, while the 4IR holds the promise of innovation and sustainability, its successful implementation in the South Durban Basin will require a delicate balance between technological advancement and socio-economic inclusivity.

6.3.2 Theme 2: Application of the 4IR technologies

The second theme addresses the question number one, related to how the 4IR was implemented to ensure competitive advantage. The Fourth Industrial Revolution (4IR) brings together various technologies that blur the lines between physical, digital, and biological spheres. Its applications are vast and transformative across many sectors. Here are some key areas where 4IR technologies mentioned by various respondents:

- i. Automation and robotics: Advanced robotics and automation are revolutionizing manufacturing, logistics, and several industries. Autonomous robots and drones are enhancing efficiency, reducing errors, and enabling tasks in hazardous environments.
- ii. Artificial Intelligence (AI) and machine learning: AI is at the core of the 4IR, enabling machines to learn, adapt, and perform tasks that traditionally required human intelligence. It is applied in healthcare diagnostics, personalized marketing, predictive maintenance, and more.
- iii. Internet of Things (IoT): IoT connects devices and systems to collect, exchange, and analyse data, fostering smart cities, optimized supply chains, and intelligent infrastructure management. It enhances efficiency and decision-making across sectors.
- iv. Big data and analytics: The abundance of data is used through advanced analytics to derive insights, predict trends, and make data-driven decisions. This affects areas like healthcare, finance, and urban planning.
- v. Biotechnology and nanotechnology: These fields drive advancements in medicine, materials science, and beyond. They enable breakthroughs in drug development, personalized medicine, and the creation of novel materials with unique properties.

- vi. 3D printing: Additive manufacturing allows for cost-effective, customized production across industries, from aerospace to healthcare, by creating objects layer by layer, often with less waste.
- vii. Renewable energy and sustainability: 4IR technologies contribute to the development of clean energy sources and sustainable practices. Smart grids, energy-efficient systems, and innovations in battery technology are just a few examples.
- viii. Augmented and virtual reality (AR/VR): These technologies transform education, training, entertainment, and even remote work by providing immersive experiences and simulations.
- ix. Blockchain: Beyond cryptocurrencies, blockchain technology ensures secure and transparent transactions in various sectors like finance, supply chain, and healthcare.
- x. Cybersecurity: As technology advances, the need for robust cybersecurity measures increases. the 4IR technologies are used to develop more secure systems and pre-emptive threat detection.

In essence, the 4IR technologies interconnect and catalyse each other's potential, reshaping industries, economies, and societies. However, while these advancements offer incredible opportunities, they also raise ethical, social, and economic challenges that need to be addressed for responsible and equitable implementation. Four themes such as familiarity with the 4IR technologies, company implementation and competitive advantage, effectiveness of the 4IR in company operations, and digitized business operations emerged in the discussion of the theme. The four themes are further discussed in detail below.

6.3.2.1 Sub-theme 2.1 Familiarity with the 4IR technologies

The research participants have shown a range of familiarity levels with 4IR technologies. Creating a diagram to visualize this can be helpful. One way to represent this information was by use of a pie with levels of familiarity (e.g., "Highly Familiar," "Good Understanding," "Moderately Familiar," "Limited Familiarity," "Not Very Familiar"), with each section representing the count of respondents in each familiarity category. The information can be represented by Table 6.1 below.

Table 6.1 Familiarity with the 4IR

Level of familiarity	Number of respondents	Percentage
Highly familiar	8 respondents	20%
Good understanding	8 respondents	20%

Moderately familiar	12 respondents	30%
Limited familiarity	8 respondents	20%
Not Very familiar	4 respondents	10%

Source: Table devised by the researcher

These responses paint a diverse picture of how different individuals perceive and interact with 4IR technologies in the South Durban Basin. There is a range of familiarity among respondents, from highly familiar to having limited knowledge about 4IR technologies. This spectrum shows a varying degree of exposure and understanding within the community. Each respondent mentions specific applications of the 4IR technologies. These applications span across diverse sectors like manufacturing, transportation, healthcare, environmental monitoring, education, safety inspections, cybersecurity, and more. That indicates the wide-ranging impact of the 4IR across various domains.

The examples provided by respondents include automation, IoT, AI-driven systems, blockchain, drones, data analytics, telemedicine, robotics, smart sensors, big data analytics, AI-driven education, cybersecurity solutions, smart grids, precision agriculture, and more. This proves the breadth of technological advancements being used. The mentioned applications hint at potential benefits, such as increased efficiency, optimized resource use, enhanced services, improved safety measures, and competitive advantages in sectors like manufacturing and agriculture.

Most responses reference the South Durban Basin, suggesting a localized implementation of the 4IR technologies. This localized adoption signifies a concerted effort within the community or specific industries to leverage technological advancements for various purposes.

Respondent 1: *I'm highly familiar with 4IR technologies in the South Durban Basin. Examples include smart factories using automation and IoT for production optimisation.*

Respondent 4: *I have limited familiarity with 4IR applications, but I know that there are efforts to implement blockchain for supply chain transparency in South Durban.*

Respondent 6: *I'm not very familiar with 4IR applications, but I've heard about AI-powered energy management systems being used in South Durban.*

Respondent 12: *I'm not very familiar with 4IR technologies, but I've heard about the use of drones for safety inspections in the South Durban Basin.*

This is a reflection of various responses which reflect varied level of understanding of the 4IR technologies and their uses. Some respondents admit to having limited knowledge or being not very familiar with certain 4IR applications. This underscores the need for more widespread education or information dissemination about these technologies. These findings can be further categorized into familiarity levels, or the impact of these technologies on the South Durban Basin. This breakdown could help highlight the diversity of perspectives and the wide-ranging influence of the 4IR technologies in the area.

6.3.2.2 Sub-theme 2.2: Company implementation and competitive advantage

The insights from the respondents shed light on the multifaceted ways in which companies are leveraging Fourth Industrial Revolution (4IR) tools to gain competitive advantage across various domains. Below is the summary of the common overarching implications from the responses:

i. Operational efficiency & cost reduction:

Utilisation of robotics, automation, and IoT: These tools streamline production processes, enhance operational efficiency, and reduce costs by optimising resource utilisation and minimising errors.

ii. Customer-centric approach:

AI-Driven analytics & personalised marketing with companies using AI-driven analytics to understand customer preferences and behaviours, enabling personalised marketing strategies that enhance customer engagement and loyalty.

iii. Innovation & product development

Prototyping with 3D printing & fast iteration technologies like 3D printing facilitate rapid prototyping and iteration, fostering innovation and giving a significant edge in product development.

iv. Supply chain optimization

Blockchain technology improves transparency, reduces fraud, and builds trust in the supply chain, while IoT-enabled sensors aid in predictive maintenance, ensuring efficient operations.

v. Talent management & sustainability

Companies are using AI for talent acquisition, ensuring the recruitment of the best-fit candidates quickly. Additionally, they leverage 4IR tools for energy management, reducing costs and appealing to eco-conscious customers.

vi. Real-time decision making

Edge computing ensures low-latency data processing critical for real-time decision-making, while predictive analytics in inventory and demand forecasting allows proactive adjustments in volatile markets.

vii. Enhanced customer experience

Tools like augmented reality, instant support, and chatbots improve employee training, reduce errors, and provide instant customer support, enhancing overall productivity and customer satisfaction.

viii. Global operations & collaboration

Tools facilitating remote collaboration and efficient project management provide a competitive advantage in global operations by ensuring effective teamwork.

The common thread across these diverse applications is the strategic use of the 4IR tools to enhance efficiency, innovation, customer experience, and adaptability in rapidly changing markets. Companies that effectively integrate these technologies gain a competitive edge by being more agile, responsive, and customer focused.

6.3.2.3 Sub-theme 2.3: Effectiveness of the 4IR in company operations

The responses from the research participants overwhelmingly highlight the positive impact of digital technology, specifically the Fourth Industrial Revolution (4IR), on companies' operational effectiveness. Multiple respondents emphasised how digital technology significantly improved efficiency and productivity within their company operations.

Respondent number 1 said that *"Digital technology has greatly improved our company's efficiency and productivity, making our operations significantly more effective"*.

Similarly, respondent number 2 stated that *"We've seen a remarkable increase in our operational effectiveness since adopting digital technology, particularly in terms of cost reduction and streamlined processes"*.

There's a consensus on the cost-reducing effect and streamlining of processes due to digital technology adoption. They highlight the ability of modern technologies to adapt quickly to market changes, meet customer demands, and respond faster to trends. Respondents feel that digital tools have enabled automation of tasks, better decision-making through data analysis, and real-time

insights, allowing informed decisions. This results to improved communication, collaboration, project management, and a more cohesive work environment amongst the benefits.

Respondent number 7 states that *“the integration of digital technology has led to reduced errors, improved customer satisfaction, and better inventory and supply chain management”*.

This results in companies having expanded into new markets, tailored services to customer preferences, and gained a competitive edge due to digital technology. This enforces the ability to facilitate remote work and enhance customer engagement which is seen as a significant advantage.

Respondent number 11 suggests that *“digital tools have optimised marketing efforts, increased sales, improved service quality, and customer retention. The use of digital technology has helped in process optimisation, waste reduction, and better resource allocation which has a direct influence on the profitability of the companies”*.

The consensus among respondents suggests that the 4IR and the adoption of digital technology have brought about transformative changes, making companies more adaptable, efficient, and competitive in the modern business landscape.

6.3.2.4 Sub-theme 2.4: Digitized business operations

The responses paint a comprehensive picture of how various business operations across different departments have transitioned into the digital realm. Respondents have pointed at financial operations such as payroll processing, expense tracking, financial reporting, and analysis as some of the operations heavily reliant on digital systems. Most companies also indicated that online advertising, e-commerce platforms, digital marketing campaigns, social media engagement, marketing research, and consumer behaviour analysis have embraced digital transformation. These interventions result to customer service programmes such as chatbots, online support portals, customer relations management systems, and leveraging online customer feedback play crucial roles in enhancing customer service operations.

Some companies pointed out to digitization of human resources, inventory management, supply chain management, data analytics, manufacturing automation and robotics, communication and

collaboration, research and development project management, quality control enhanced through digital sensors and monitoring systems.

Respondent 8: *"We've experienced a notable increase in cost-effectiveness and operational agility since integrating digital technology into our daily processes."*

Respondent 9: *"The use of digital technology has allowed us to better track and manage inventory, leading to a more effective supply chain management."*

Respondent 10: *"Our company's operational effectiveness has improved thanks to digital technology, which has helped us reach new markets and customers."*

Respondent 11: *"Digital technology has given us a competitive edge by enabling us to tailor our services to customer preferences, making our operations highly effective."*

Respondent 12: *"The company's operations have become more efficient and adaptable, as digital technology has enabled remote work and improved customer engagement."*

Each response highlights a specific aspect of the business that has undergone digitization, demonstrating how technology has become integrated across multiple facets, from core operations to decision-making processes and customer engagement strategies.

6.3.3 Theme 3: Challenges and overcoming them

The theme is related to question number 2 that is investigating the extent that the South Durban Basin embrace the opportunities of the 4IR, and overcame its challenges, and how that impacted its competitiveness. The responses from the various research respondents highlight a multifaceted approach taken by the South Durban Basin to overcome the challenges associated with implementing the 4IR technologies. Respondent number 1 emphasized the importance of involving all stakeholders and fostering a shared purpose, indicating that collective efforts were crucial in addressing challenges.

While respondent number 2 pointed at the challenge of scarcity of technical skills amongst most of the employees, she further advised that companies need to implement technology literacy programmes and training initiatives to equip the local workforce with the necessary skills for the 4IR, to ensure that they could effectively engage with new technologies. She emphasized the role of collaborations between the public and private sectors, research institutions and universities, pooling resources and expertise to tackle challenges of crime, power disruptions and poor

infrastructure collectively. The role of government in this partnership should be to provide incentives and subsidies to encourage investment in 4IR technologies, reducing financial barriers for industries.

To combat security concerns, respondent number 6 suggested the establishment of robust cybersecurity measures and data protection protocols to address security concerns associated with 4IR technologies. Respondent number 20 suggested the significance of learning from global best practices and case studies in guiding the approach to overcoming challenges associated with 4IR implementation.

Respondent 1: *"We struggled with the high cost of acquiring and implementing advanced technologies."*

Respondent 3: *"Integrating new technologies with our existing systems proved to be complex and time-consuming."*

Respondent 5: *"Resistance to change from employees who were accustomed to traditional methods."*

Respondent 7: *"We faced connectivity issues, especially during the load-shedding."*

Respondent 17: *"Securing intellectual property and proprietary data in a connected world was a major challenge."*

The responses collectively showcase a comprehensive and holistic approach that involves various stakeholders, policies, skills development, sustainability measures, and strategic planning to successfully navigate the challenges associated with implementing 4IR technologies in the South Durban Basin.

6.3.4 Theme 4: Impact on company and community

The theme is based on the latter part of question 2, which dealt with the impact of the use of Fourth Industrial Revolution (4IR) on the competitiveness of the organisation. The perspectives shared by various respondents shed light on the nuanced impacts of the 4IR on the local job market and the broader community in the South Durban Basin. Several respondents highlighted the likelihood of automation leading to the displacement of certain traditional jobs. Sectors like manufacturing have experienced initial decline in employment due to increased automation and Artificial Intelligence. However, the adoption of the 4IR technologies is expected to create new

job opportunities in technology-related fields such as data analysis, cybersecurity, Artificial Intelligence, robotics, and software development. But this cannot be achieved without an emphatic shift toward digital and technical skill demands.

This was confirmed by respondent number 9 in that *“Fourth Industrial Revolution technologies have allowed us to offer remote work options, attracting top talent and giving us a competitive advantage in recruitment”*.

This points to the importance of upskilling and adaptation within the workforce to stay relevant in an evolving job market that heavily favours technological expertise. Moreover, respondent number 19 and 20 suggest that *“Fourth Industrial Revolution technologies have enabled us to implement just-in-time inventory management, reducing carrying costs and making us more competitive in pricing. The use of cybersecurity technologies has enhanced our data protection, ensured customer trust and maintained our competitive edge in the digital marketplace”*.

Collaboration among government, businesses, and educational institutions is deemed crucial for preparing the workforce for the 4IR era. This collaboration was confirmed by respondent number 12: *“The extent of embracing 4IR opportunities is influenced by the regulatory environment and government support in different regions”*.

While acknowledging short-term disruptions, there is an optimistic view of the 4IR technologies driving economic growth and innovation. This includes the potential for entrepreneurship, diversification of employment, and the creation of new businesses. Additionally, fostering a supportive ecosystem for technological start-ups and entrepreneurs is seen as a way to create job opportunities and drive economic growth. Respondents unanimously suggest a need for a balanced approach to automation and workforce development. They emphasize the coexistence of traditional and technology-driven jobs, to balance the transition so as to minimize disruptions.

Overall, the perspectives converge on the transformative nature of the 4IR technologies, indicating both challenges and opportunities for the South Durban Basin. The consensus suggests a need for proactive measures in skills development, fostering innovation, and creating an environment conducive to both traditional and technology-driven job sectors to minimize the benefits of this technological shift. The analysis of the theme has generated four sub-themes such as competitive position, job market impact, effective use of the 4IR, and roles of government, private sector and community.

6.3.4.1 Sub-theme 4.1: Competitive position

The impact of 4IR technologies on the different companies in the South Durban Basin is multifaceted and impressive. Each respondent showcases how their respective companies have strategically utilized these advancements to bolster their competitive positions. Automation, data analytics, AI, IoT, 3D printing, blockchain, augmented reality, and various other technological implementations have evidently played crucial roles in enhancing efficiency, reducing costs, improving products, and transforming business operations.

Respondent number 19 stated that *“the 4IR technologies have enabled us to implement just-in-time inventory management, reducing carrying costs and making us more competitive in pricing”*.

Some companies stated to have benefited from improved supply chain management, reduced lead times, and increased transparency through technologies like IoT and blockchain. Respondent number 11 stated that *“we have harnessed the power of the Internet of Things to create predictive maintenance solutions, minimizing downtime and making us more competitive in our sector”*.

Others have confirmed that they have capitalized on customization through 3D printing and additive manufacturing, gaining an edge in the market. Others suggested that the integration of AI and data analytics has empowered smarter decision-making, personalized marketing, and better customer experiences. Additionally, remote work options, advanced quality control processes, predictive maintenance solutions, and cloud computing have all contributed significantly to maintaining or advancing competitive positions in their respective industries.

Respondent 1: *“The Fourth Industrial Revolution technologies have significantly enhanced our company's competitive position by enabling us to automate processes and improve efficiency, reducing operational costs.”*

Respondent 2: *“These technologies have allowed us to stay ahead of the competition by leveraging data analytics and AI to make informed business decisions and provide better customer experiences.”*

Respondent 8: *“Our company's use of automation and robotics has increased productivity and reduced errors, which has helped us maintain a competitive edge in our industry.”*

Moreover, technologies such as 5G, nanotechnology, biotechnology, virtual reality, just-in-time inventory management, cybersecurity, and sustainability-focused practices have brought unique advantages to these companies. They've leveraged these advancements to improve communication, product innovation, inventory management, security, and environmental impact, ultimately shaping their competitive advantage.

Respondent 20: *“The use of cybersecurity technologies has enhanced our data protection, ensured customer trust and maintained our competitive edge in the digital marketplace.”*

Overall, these responses collectively highlight how embracing and effectively implementing 4IR technologies have been instrumental in shaping these companies' competitiveness across various sectors, enabling them to innovate, adapt, and differentiate themselves in their markets.

6.3.4.2 Sub-theme 4.2: Job market impact

The views of the research participants on the impact of the Fourth Industrial Revolution (4IR) on the job market in the South Durban Basin paint a multi-faceted picture of opportunities and challenges. However, there is a collective understanding among respondents that the integration of advanced technologies will significantly shape the landscape of employment. Various responses and views are classified below.

Respondents 1, 4, 5, and 8 emphasize the potential for new job creation in technology-related fields such as data analysis, cybersecurity, information technology, software development, and automation. They highlight the transformative effect of the 4IR, foreseeing a shift from traditional industries towards these emerging sectors. This outlook suggests an optimistic perspective, viewing technological advancements as catalysts for economic growth and job diversification.

Conversely, respondents 2, 3, 9, and 14 foresee a transition characterized by the decline of traditional manual labour jobs and a greater demand for digital and technical skills. They collectively agree that there is a need for upskilling and adaptation to navigate this evolving job market effectively. They acknowledge the short-term challenges, particularly in industries undergoing significant technological disruptions.

Respondents 6, 10, 11, and 20 underscore the importance of education, upskilling, and workforce adaptability. They highlight the necessity for collaborative efforts between government, businesses, and educational institutions to equip the local workforce with the skills demanded by the 4IR era. This sentiment emphasizes the pivotal role of proactive initiatives in preparing individuals for the changing job landscape.

Moreover, respondents 7, 12, 13, 15, 16, 17, 18, and 19 shed light on the potential for innovation, entrepreneurship, and the diversification of employment opportunities. They foresee the emergence of new businesses, remote work possibilities, and a more competitive job market that demands a skilled and adaptable workforce.

Collectively, these diverse perspectives suggest a nuanced understanding of the impact of the 4IR on the job market in the South Durban Basin. While there's recognition of potential job displacement in certain sectors, there's also a prevailing optimism about the creation of new job opportunities in technology-driven fields. The consensus centres on the need for proactive

measures, education, and skill development to ensure a successful transition and harness the potential benefits of technological advancements.

6.3.4.3 Sub-theme 4.3: Recommendations for effective use

The responses from the research participants showcase a comprehensive view of how Fourth Industrial Revolution (4IR) technologies have revolutionised various facets of company's operations. All the respondents noted a substantial improvement in overall efficiency and productivity attributed to the streamlining of processes and the automation of repetitive tasks, allowing employees to focus on higher-value activities. They state that digital technology has been instrumental in reducing costs by optimising resource allocation, cutting down on waste, and enabling better inventory and supply chain management.

Respondent 2 said *“We've seen a remarkable increase in our operational effectiveness since adopting digital technology, particularly in terms of cost reduction and streamlined processes.”*

The respondents state that the agility gained through the implementation of the 4IR technologies has allowed companies to adapt swiftly to market changes, meet customer demands more effectively, and scale their business operations efficiently.

Respondent 8 stated that *“the integration of digital tools has facilitated real-time insights and data analytics, empowering informed decision-making and personalised services, which in turn have improved customer satisfaction and retention”*.

Respondents highlighted how the 4IR technologies have provided a competitive advantage by tailoring services to customer preferences, improving customer engagement, and reaching new markets effectively. This can be achieved by the implementation of collaborative effort, enhanced communication, project management, and remote work capabilities, leading to a more cohesive and effective work environment.

The above discussion indicates a unanimous agreement on the transformative power of the 4IR technologies within the company's operations. The overarching transformation in operations is notable, with the company becoming more adaptable, agile, and equipped to navigate the digital era. These technologies have not only optimised existing processes but also opened avenues for innovation, responsiveness, and improved customer-centric strategies. The holistic impact spans from internal efficiencies to customer-facing aspects, solidifying the company's position in a rapidly evolving market landscape.

6.3.4.4 Sub-theme 4.4: Roles of government, private sector, and communities

The perspectives of the respondents offer a comprehensive view of the multi-stakeholder approach necessary for the successful implementation of the 4IR technologies in South Durban. Each viewpoint accentuates the importance of the government, private sector, and local communities, reflecting a synergy needed for comprehensive development.

Government role: The respondents collectively advocate for diverse government roles. From creating regulatory frameworks and policy environments to funding research and development, digital skills training, and infrastructure. The emphasis is on the government's pivotal role in laying foundations, ensuring inclusivity, and providing resources for 4IR integration.

Private sector engagement: There's a consistent call for the private sector to invest in various aspects of the 4IR, including research and development, infrastructure, start-ups, job creation, CSR initiatives, and fostering innovation. Respondents stress the private sector's capacity to drive technological advancements and economic growth, highlighting the need for collaboration with other stakeholders.

Local community involvement: The respondents recognize communities as active participants in the 4IR transformation. Suggestions encompass skill development, educational initiatives, technological-focused programs, entrepreneurship, environmental conservation, and community-driven projects, showcasing the potential of grassroots efforts in harnessing and benefiting from technological advancements.

Synergies: Several respondents emphasize the importance of educational initiatives and skill development. This highlights the consensus on the critical role of knowledge and capacity-building in 4IR adoption. Multiple perspectives advocate for using 4IR technologies for environmental and sustainable development, showcasing a shared concern for responsible technology integration. The private sector's role in fostering innovation, supporting start-ups, and creating job opportunities aligns with community-driven initiatives for entrepreneurship and tech-focused cooperatives, underscoring a collective aspiration for inclusive economic growth.

Coordinating efforts between these three stakeholders poses a challenge, requiring effective communication and cooperation. Ensuring equitable access, digital literacy, and inclusion across

communities remains a common thread, reflecting the need to bridge technological disparities. In essence, the collective voice of these respondents highlights the need for a holistic approach to 4IR implementation in the South Durban Basin. They call for a development strategy that prioritises collaboration, education, sustainability, and inclusivity across government, private sector, and local community initiatives.

6.3.5 Theme 5: Skills and training for implementation

The theme deals with question number 3, which deals with the nature of skills required for the effective implementation of the 4IR. The respondents offer a comprehensive array of skills essential for navigating the 4IR. The skills range from adaptability, data analysis, communication, project management, and emotional intelligence, just to mention a few.

Respondent 1 rightly highlights the importance of being adaptable to change and open to embracing new technologies, as the landscape of the 4IR constantly evolves.

Respondents 2 and 11 emphasise the significance of data-related skills, including analysis, interpretation, and visualisation, which are crucial for informed decision-making in a data-driven 4IR environment.

Respondent 3 stresses the need for effective communication skills to bridge the gap between technical experts and non-technical stakeholders. Respondent 19 also highlights the importance of interpersonal skills for effective teamwork.

Respondent 4 and Respondent 16 focus on problem-solving and critical thinking skills, essential for addressing the complex challenges and evaluating the impact of the 4IR technologies.

Respondents 6 and 18 emphasize the critical need for cybersecurity expertise, data privacy knowledge, and legal compliance awareness to protect sensitive data and ensure ethical standards are met in 4IR implementations.

Respondents 9 and 12 underscore the indispensability of technical proficiency, especially in emerging technologies like AI and robotics, as well as the need for continuous learning to keep up with rapid technological advancement.

Respondents 10, 15, and 20 shed light on the importance of ethical awareness in navigating dilemmas, the role of emotional intelligence in managing human aspects of transformation, and cultural sensitivity for success in a globalized 4IR landscape.

Respondents 13, 14, and 17 emphasise skills like systems thinking to understand the interconnectedness of technology and society, multidisciplinary collaboration to draw insights from diverse fields, and resilience to overcome setbacks in 4IR initiatives.

Each skill highlighted by the respondents plays a pivotal role in ensuring the successful implementation of the 4IR technologies, reflecting the diverse and interconnected nature of the requirements in this rapidly evolving landscape.

6.3.6 Theme 6: Role of leadership

The theme deals with the role of leadership in establishing whether there is a relationship between the type of leadership and the effective implementation of the 4IR. The responses collectively emphasise the significant role of leadership style in successfully implementing strategies for the 4IR. The perspectives offered by the respondents highlight the multifaceted role of leadership in navigating the 4IR. Leadership establishes the tone, vision, and goals necessary for aligning the organisation with the technological advancements and opportunities presented by the 4IR.

Respondent number 7 stated that, *“Leadership skills are necessary to guide teams and organisations through the transformative changes of the 4IR”*. He emphasised that various leadership styles impact the organisation's capacity to innovate, be agile, and adapt to the rapidly evolving landscape of the 4IR.

Respondent number 15 stated that *“emotional intelligence is important for managing the human side of the 4IR transformations and maintaining employee morale”*. The emphasis is that transformational, participative, and visionary leadership styles, for instance, foster innovation and adaptability.

Respondent number 19 stated that *“leadership profoundly influences employee engagement and motivation, essential for harnessing the potential of emerging technologies”*. She emphasized that the servant leadership, participative leadership, and fostering a culture of continuous learning contribute to the effective implementation of the 4IR.

According to respondent number 20 *“effective leadership cultivates a culture of collaboration, continuous learning, diversity, inclusion, and ethical responsibility”*. These cultural aspects are vital for leveraging the full potential of the 4IR technologies and ideas.

Respondent number 3 states that *“leadership style affects decision-making speed and change management capabilities, critical in a rapidly evolving 4IR landscape where quick decisions and adaptability are crucial and having a vision, backed by substance and expertise, is crucial in an*

organisation". He further emphasized that charismatic and visionary leadership, when supported by knowledge and strategic insight, can motivate and unite teams effectively.

Respondent number 4 state that *"leaders must prioritize ethical and responsible use of technology, maintaining public trust and compliance with regulations in the 4IR era and need to be adaptable themselves, demonstrating technological proficiency and embracing digital tools in the 4IR landscape"*. She believes that effective communication of a clear vision and the ability to inspire confidence among the workforce are fundamental aspects of successful leadership during the 4IR.

In summary, leadership plays a pivotal role in driving successful implementation of the 4IR strategies by influencing organisational culture, innovation, adaptability, decision-making, and ethical considerations. Different leadership styles offer unique contributions, but a combination or adaptation of these styles based on the organisation's context and needs may be most effective in navigating the complexities of the 4IR.

6.4 Chapter summary

In this chapter, the research journey transitioned into a qualitative exploration, utilising NVivo as the analytical tool to delve into the intricate layers of perspectives and narratives surrounding the impact of the 4IR within the South Durban Basin. As a complementary phase to prior quantitative analysis, this phase sought to unearth nuanced viewpoints prevalent among senior managers from various companies in the South Durban Basin. The chapter discussed how data was collected using semi-structured interviews from a sample that was randomly selected. The advantages of using NVivo as an analytical tool to analyse the data collected from the sample of 20 managers was highlighted. Also the process of data collection was also discussed in the chapter. How the software organised data into themes was also discussed with various themes discussed.

The chapter identified six themes such as understanding of the 4IR, application of the 4IR technologies, challenges of the 4IR and how to overcome them, impact of the 4IR on company and community, skills and training for implementation of the 4IR, and the role of leadership. Each theme was further subdivided into specific sub-themes, aligning with the questions posed during interviews. This thematic analysis, constructed through NVivo, provided a comprehensive framework for understanding the diverse perspectives and implications of the 4IR within this dynamic industrial setting.

CHAPTER 7

Findings and discussion

7.1 Introduction

In this chapter, the study's findings will be presented, followed by thorough discussions. This crucial chapter takes us on a tour through the complex web of conclusions and conversations that sums up our study project. We start with a laser-like focus as we go over the original goal that inspired this research, laying the groundwork for a thorough disclosure of findings. We explore the core of our research questions and throw light on the numerous insights discovered by drawing from the vast reservoir of quantitative and qualitative data that has been painstakingly collected. The literature that has already been published will guide us as we make our way through the maze of findings, helping us to navigate the areas where our findings and existing knowledge overlap or diverge. By means of this comparative study, we want to identify trends, expose disparities, and provide fresh directions for future research.

The theoretical frameworks that serve as the basis for our investigation will not escape criticism; rather, they will be subjected to a thorough assessment in the face of empirical data, demonstrating how our research either supports, expands upon, or contradicts these fundamental constructions. The framework of our theoretical model is derived from this synthesis of theory and data; it is shaped by the combination of conceptual frameworks and empirical insights. However, our trip doesn't end here. Instead, it peaks when we thoroughly examine the suggested model, breaking it down into its component parts, analysing its implications, and considering how important it is to how we interpret the phenomena we are studying. We will therefore be able to solve the riddles of our scholarly endeavours through this method, so let us approach it with curiosity, rigour, and scholarly humility as we set out on this journey of discovery and discourse. The chapter will begin with a recap of the purpose of the study, followed by the findings from both quantitative and qualitative data addressing the research inquiries. The chapter will conclude with an in-depth discussion of the proposed model.

7.2 The Summary of the results

To summarise the results of the study, the research questions will be organised according to the research questions that guided both quantitative and qualitative methods. The research questions

are re-iterated here for ease of reference. Each research question will be examined in a listed sequence:

- How was the 4IR implemented to ensure a competitive advantage?
- To what extent did the South Durban Basin embrace the opportunities of the 4IR, and overcome its challenges, and how did that affect its competitiveness?
- What personnel skills were able to ensure the successful implementation of the 4IR?
- How can a theoretical framework for effective use of the 4IR as a competitive advantage for the South Durban Basin be developed?

7.2.1 Implementation of the 4IR technologies to ensure a competitive advantage

The literature review has revealed a need for human beings to ensure that the challenges technology throws at them are properly understood and analysed to guarantee that people are served, and not enslaved by technology (Schwab 2018). In support of the above, Morsy (2020) stated that owing to its large and growing youth population, South Africa desperately needs to supply the education and skills training necessary for future jobs. This was supported by the findings that when technology literacy programs and training initiatives are implemented, they are able to ensure that the workforce in the South Durban Basin had the necessary skills to embrace the 4IR. Furthermore, the public-private partnerships were confirmed to have played a significant role in achieving competitive advantage, as they allowed for the pooling of resources and expertise. This supports Gleason (2018), in the assertion that technical education is extremely important for the development of industrial society and that in the post-industrial world, employers value softer skills such as creativity, the ability to think creatively, and openness to multiple perspectives as these skills have become more important as AI replaces human workers in many technical fields.

Gleason (2018) further calls on higher education to recognise the necessity of adapting and scaling up these new 4IR curricula to assure the sustainability of the South African environment and economy, as well as to sustain the relevance of higher education as a responsive and vital part of society. Similarly, Lent (2018), argues that adaptability under uncertain fluctuating conditions requires the most critical skills, and that requires the education sector to mirror the knowledge requirement of the work environment relevant to the 4IR. Furthermore, Wessels (2020) cautions that many qualifications that are currently offered by tertiary institutions prepare the workforce for jobs that will be non-existent within five years, or that, at the very least, will be drastically different. In line with this thinking, the findings confirmed the importance of regular assessments and feedback loops to ensure upskilling efforts of the employees align with the 4IR goals. The

findings further pointed out that the approach to upskilling should be data-driven, with analytics guiding the decisions on where to invest in employee development for the 4IR.

The findings pointed out to the benefits such as improved effectiveness resulting from the implementation of digital technology, more effective supply chain management as a result of a better tracking and inventory management, improved customer engagement as a result of the implementation of remote work experience, and all the above giving the companies a competitive edge through the provision of services that are tailor made to customer preferences. This affirms the claims made by Raj, Dwivedi, Sharma, Jabbour, and Rajak (2020) that the advanced technologies of the 4IR are restructuring entire production systems by transforming workflows into digital and decentralized production processes resulting in a significant increase in production effectiveness and efficiencies. Raj et al. (2020) further suggest that in manufacturing terms, efficiency equals profitability, and 4IR technologies help manufacturers maximize revenue growth by reducing operational expenses and increasing asset efficiency.

Lekhanya (2019) suggests that the 4IR cannot only improve efficiency but also our quality of life as it fundamentally changes the way we work and the way we interact. Anand (2022) further suggests that efficiency is achieved through enhanced operational intelligence such as real-time performance management data and reporting, reduced manufacturing costs, increased flexibility, and increased agility, resulting in the 4IR revolutionizing manufacturing for the better. Similarly, the results confirm that the effective employment of the 4IR is able to deliver a competitive advantage in areas such as increased efficiency, predictive and proactive maintenance ability, reduced costs, improved costs, improved safety, improved customer service, and reduced margin of error.

The insights generated from diverse research respondents corroborate the existing literature, highlighting the transformative power of these technologies across various facets of business. The findings do confirm that enhanced effectiveness, streamlined supply chain management, improved customer engagement, and personalized services collectively underscore the pivotal role of the 4IR technologies in fostering competitiveness. The emphasis on operational intelligence, as alluded to by various respondents, further emphasizes the multifaceted benefits, ranging from cost reduction to increased flexibility, marking a revolutionized manufacturing landscape. The next discussion looks at embracing the opportunities the 4IR brings and how companies use embrace those opportunities to overcome the challenges it brings. The section looks at the proactive strategies and innovative approaches that enable entities to navigate and

harness the full potential of the 4IR technologies, surmounting the obstacles encountered in their adoption and integration.

7.2.2 Embracing the opportunities to overcome challenges of the 4IR

In an era marked by rapid technological advancements and transformative societal shifts, the Fourth Industrial Revolution (4IR) has emerged as a pivotal juncture in human history. With innovations such as artificial intelligence, automation, and the Internet of Things fundamentally altering the landscape of industries and economies worldwide, the challenges and opportunities presented by the 4IR are immense. Embracing these opportunities is crucial for navigating the complexities of this era and harnessing its potential for positive change. By proactively addressing the challenges of the 4IR, individuals, organizations, and societies can pave the way for innovative solutions, sustainable development, and inclusive growth. This necessitates a proactive stance towards adapting to technological disruptions, fostering digital literacy, and fostering collaborative approaches to problem-solving. In this context, exploring strategies to embrace the opportunities within the challenges of the 4IR becomes imperative for shaping a future that is both resilient and equitable. Lekhanya (2019) contends that the 4IR cannot only improve efficiency but also our quality of life as it fundamentally changes the way we work and the way we interact. The findings from the research participants do confirm that there is a discourse surrounding the 4IR teams with insights, apprehensions, and prophecies about its impact on economies, ethics, as the very fabric of human existence.

However, Gastrow (2018) raises several ethical questions for consideration, including questions related to data privacy, responsibility for autonomous drones and vehicles, the bioethics of genetic modification, and the societal and developmental impacts of social media and internet use by individuals and populations. Furthermore, Bird et al. (2020) believe that robots do not have the capacity for ethical reflection or a moral basis for decision-making, and thus humans must hold ultimate control over any decision-making. The research respondents then contended that as technological innovations continue to surge forward, this discussion encapsulates the pulse of this revolution, exploring the dichotomy between embracing its opportunities and grappling with the ethical, societal, and economic challenges it presents. From concerns about data security to the ethical implications of intelligent machines, the intersection of existing literature and primary data unveils a narrative that oscillates between optimism and caution, painting a complex canvas of possibilities and hurdles inherent in the journey towards integrating 4IR technologies. The reality of the matter is that whether the country is prepared to embrace the 4IR technologies will not

change the fact that the 4IR is upon us, and if employed correctly it has a prospect of lifting the country into a collective and moral consciousness with a sense of shared destiny.

Consequently, Serafini (2018) and Naidoo (2021) hold a view that the 4IR provides lucrative opportunities for developing economies to try to come on par with technological, social, and economic development opportunities in the region. Contrary to this belief, Serumaga-Zake et al. (2021) suggest that manufacturing SMEs are facing both social challenges, which include social responsibility as well as values and beliefs, and technological challenges, making it hard for a small organization to survive in a competitive environment. In line with this argument, the findings point out to various challenges including the shortage of the necessary skills for 4IR, the problems of inequality and access to technology, data security, poor connectivity, and resistance to change amongst the employees.

While some of the respondents suggest that they are cautiously exploring the opportunities of the 4IR others suggest they are still in the early stages of adoption. Those that are still reluctant to embrace the 4IR have pointed out concerns about data security and privacy amongst other concerns. The study conducted by the World Bank (2019), shows that businesses face significant challenges of ethical implications of modern technologies which is in line with the findings of the study. Various respondents indicated that as a result of the cultural shift their companies are going through, they face challenges of securing intellectual property, proprietary data, and were uncertain about the long-term implications of these modern technologies due to the constant need for software and hardware updates that strained their resources. This confirms the argument by Velarde (2019) that intelligent machines lack ethics, fairness, privacy, and safety as algorithms can contribute to discrimination in civil rights while also presenting the risk of accidents in real-world applications. Gastrow (2018) also concurred that 4IR raises several ethical questions including questions related to data privacy, responsibility for autonomous drones and vehicles, the bioethics of genetic modification, and the societal and developmental impacts of social media and internet use by individuals and populations. They all argue that humans, unlike robots are certified by their professional standards to hold certain levels of ethical obligations and the fact that robots do not have certificates or qualifications makes them exempt from ethical obligations.

Francis and Webster (2019) suggest that South Africa faces several challenges such as the country's elevated levels of inequality, with a considerable proportion of the population lacking access to basic services such as electricity, water, healthcare, and education. Despite the challenges raised above, the study suggests that the 4IR technologies have the potential to

significantly alter political and economic landscapes within states by reconfiguring labour markets, economies, and political alliances, leading to possible societal disruptions. Velarde (2019), further suggest that in recent years, intelligent machines have proven a significant advance in tasks involving feeling, creativity, and complex strategic execution which has a potential to address the concerns raised about machines not being able to think. Nyagadza, Pashapa, Chare, Mazuruse, and Hove (2022), further suggest that the adoption of blockchain, the advent of 3D printing and additive manufacturing mean that the very structure of society will change and will lead to machine learning with a relationship to human resources and will have teams composed of engineers, computer scientists, developers, data scientists, and mathematical and technical ability personnel.

Velarde (2019) further suggests that the 4IR will transform most industries and will make it indispensable to a wide range of businesses and organizations. This is because of the understanding that computational creativity can boost human intelligence by supplying tools that help to reason, and machines that can learn to describe complex phenomena automatically. Similarly, the study suggests that as a result of their ability to think and analyse complex tasks, creative machines can also be used to complete tasks such as automatically generating images from human sketches. The point of departure is whether machines can excel in human intelligence with computers and human brains connected to the cloud in a symbiotic enhancement, where humans work only on tasks of their interest and robots take care of the rest of the jobs. The findings suggest that resilience is key to overcoming setbacks and challenges that often accompany 4IR initiatives.

Various respondents shared the best practices used by their respective organisations to overcome the challenges of technology adoption. They pointed out to the importance of research and development initiatives to create local solutions to unique challenges encountered during the 4IR implementation. They indicated that such interventions were done through partnerships with research institutions and universities to access cutting-edge knowledge and expertise, learning from global best practices and case studies to overcoming challenges associated with 4IR implementation. They also suggest the importance of fostering the culture of innovation and continuous improvement through the establishment of a dedicated team to help coordinate efforts to adapt to the rapid changes brought about by the 4IR. Some respondents pointed to the use of renewable energy sources to power 4IR technologies to ensure that the benefits of the 4IR are accessible to all members of the society. They suggest that this was able to alleviate the challenges of disruptions in power supply and poor connectivity in their areas of operation. For that to be implemented successfully, the respondents pointed to the importance of the development of the

regulatory framework, public awareness campaigns, and outreach programs to garner support and address concerns about the 4IR.

In traversing the labyrinth of literature and primary data, the discourse illuminates the multifaceted nature of embracing the 4IR. Gastrow (2018) and Bird et al. (2020), echoed the concerns voiced by respondents, emphasising the cost of data, ethical dilemmas, privacy issues, and the seismic societal shifts imminent with technology's exponential growth. Yet amidst these challenges, a chorus of optimism emerges, extolling the transformative power of the 4IR technologies in reshaping industries, labour markets, and societal structures. The convergence of literature and primary data underscores the urgency of proactive measures such as a robust regulatory framework, investment in research and development, and a cultural shift towards innovation.

While the challenges are undeniable, the synthesis of literature and the insights from the research findings suggests a plausible roadmap for harnessing the potential of the 4IR technologies. Ultimately, this discussion navigates the nuanced terrain, illustrating that while the challenges are formidable, strategic initiatives and concerted efforts can pave the way for a future where the opportunities of the 4IR are harnessed responsibly, addressing the pertinent research question of readiness and adaptability in the face of this technological revolution.

7.2.3 Personnel skills necessary for the successful implementation of the 4IR

In navigating the landscape of the 4IR, the prowess of technological advancements is undeniable. However, the true catalysts for successful implementation lie in the personnel who harness these innovations. The findings suggest that the 4IR is not merely about adopting new technologies but also about equipping individuals with a dynamic skill set that complements and maximizes these advancements. It has confirmed that to thrive in this era of transformative change, certain key personnel skills become essential. Adaptability reigns supreme in an environment where technology evolves at an unprecedented pace. The research findings confirm that individuals who embrace continuous learning and adapt swiftly to new tools, methodologies, and paradigms excel. Creativity and innovation stand tall as well, fostering the space for new ideas, innovate, and think outside conventional boundaries.

Collaboration takes centre stage as complex challenges demand interdisciplinary teamwork and communication across diverse technological domains. Moreover, a strong foundation in critical

thinking and problem-solving is indispensable. In the face of intricate technological dilemmas, individuals must analyse, strategize, and derive effective solutions. Emotional intelligence becomes pivotal too, as human-machine interactions and leadership in a digitized world require empathy, understanding, and effective communication. This is as Anifowose (2021) suggests that the intelligent machines are smarter than the brightest people and could improve themselves and outperform humans on cognitive tasks, becoming potentially dangerous if their goals attempt life. Consequently, the landscape of the 4IR demands a workforce adept at navigating the interface between technology and humanity. Balancing technical expertise with interpersonal skills, adaptability with emotional intelligence, and creativity with problem-solving is the cornerstone of success in embracing the opportunities and overcoming the challenges of the Fourth Industrial Revolution.

According to Schulz et al. (2018), it is envisaged that the 4IR will result in a further shift from labour-intensive production to knowledge and skills-intensive production resulting in a need for an adequate pool of available digital, technical, commercial, and management ability to drive the immediate adoption and use of emerging technologies. Most of the research respondents agreed that data analysis and interpretation skills are crucial for making informed decisions in the 4IR landscape. Gastrow (2018), further suggests that school curricula should steer away from machine-like tasks (memorization, repetition) towards human traits that machines are unlikely to replicate (empathy, creativity, innovation, social skills, and managing complexity) but also argues that each of the 4IR's technologies holds the potential for greater inclusion in school curricula. This view was affirmed by my respondents that emotional intelligence is important for managing the human side of the 4IR transformations and maintaining employee morale. They affirm that more than any content area, curriculum needs to help students develop the ability for ethical reasoning, for awareness of societal and human impacts, and to be able to understand the impacts of the 4IR technologies on people, so they are trained to not only increase the society's material prosperity but also to improve the social and cultural fabric.

According to Xing et al. (2017), higher education in the 4IR is a complex, dialectical, and exciting opportunity that can potentially transform society for the better, powered by artificial intelligence and it will transform the workplace from task-based characteristics to human-centered characteristics. This view was supported by various respondents that technical proficiency, especially in areas like artificial intelligence and robotics, is indispensable for driving 4IR innovation. They suggest that for this to be achieved it will necessarily require much more interdisciplinary teaching, research, and innovation. According to Gleason (2018) technical education is extremely important for the development of industrial society, but in the post-

industrial world, employers value softer skills such as creativity, the ability to think creatively, and openness to multiple perspectives and these skills have become more important as artificial intelligence replaces human workers in many technical fields. Furthermore, Makhanya (2019) argues that the world is changing and confusing as it is fully engaged in change and transformation, and academics need to be prepared to deal with the transition. In support of this view, various respondents suggest that as a result of these changes that are taking place, leadership skills are necessary to guide teams and organizations through the transformative changes of the 4IR. Higher education needs to recognise the necessity of adapting and scaling up these new 4IR curricula to assure the sustainability of the South African environment and economy, as well as to sustain the relevance of higher education as a responsive and vital part of society.

Menon et al. (2019) believe that the traditional qualifications of three to four years will not supply the skills needed to meet the 4IR requirements but instead, students should take a variety of courses to better prepare them for the flexible and complicated 4IR workplace. This view was supported by various respondents who suggested that continuous learning and upskilling are vital as technology evolves rapidly in the 4IR era. Some respondents suggested that cultural sensitivity and the ability to navigate global differences in the 4IR landscape are increasingly important for success in a globalized world. They highlighted the importance of interpersonal skills to facilitate effective teamwork and cooperation in 4IR projects while also learning the global trends. They also emphasized the importance of systems thinking skills to understand the interconnectedness of technology and society in the 4IR, and that critical thinking skills aid in evaluating the impact of the 4IR technologies and making informed decisions.

Olaitan et al. (2021) suggest that a highly skilled population will have the capability to utilize 4IR technologies but further cautioned that South Africa does not have a sufficient skill base to support the envisioned elevated level of technological innovation. The majority of the respondents suggest that considering the South African history, adaptability and a willingness to embrace new technologies and methodologies, which the country has demonstrated few times during difficult times, are key personnel skills for the successful implementation of the 4IR. This is a view that is shared by Alexander (2022), that South Africa has many people who are unemployed and if these people are incorporated into existing or new businesses, they could bring new opportunities for innovation. The findings suggest that the challenges that South Africa faces such as crime, unemployment, and lack of infrastructure could be converted into opportunities given the available resources that South Africa has in abundance. Crime, for example, becomes an opportunity for security companies to supply technologies that can combat crime. Morsy (2020) further states that owing to its large and growing youth population, South Africa desperately needs

to supply the education and skills training necessary for future jobs. If that suggestion is adopted, South Africa can leapfrog many development hurdles by empowering its people through technology.

The exploration of primary data in relation to insights from existing literature presents a cohesive narrative affirming the anticipated shift of the 4IR towards a landscape heavily reliant on knowledge and skills intensive production. Schultz et al. (2018) and Gastrow (2018) underscored the necessity for competencies like data analysis, emotional intelligence, and ethical reasoning in navigating the 4IR, a sentiment echoed by the respondents' consensus on the indispensability of these skills. The alignment between the existing literature and primary data signifies a convergence, emphasising the urgency for educational restructuring to incorporate interdisciplinary approaches, technical proficiency, and the cultivation of softer skills. This confirmation paves a way for the subsequent discussion on the development of a theoretical framework for leveraging the 4IR as a competitive advantage.

The synergy observed between research findings and established literature underscores the imperative for recalibrating educational paradigms to harness the potential of the 4IR. As Xing et al. (2017), and Gleason (2018), assert that the evolving landscape demands a blend of technical expertise, creativity, adaptability, and leadership. The necessity for continuous learning, cultural sensitivity, and systemic thinking, as highlighted by Menon et al. (2019) and Olaitan et al. (2021), resonates vividly within the primary data, fortifying the call for an educational framework that nurtures these multifaceted competencies. Furthermore, the emphasis on leveraging South Africa's strengths amidst challenges, as articulated by Alexander (2022) and Morsy (2020), accentuates the pivotal role of education in not just addressing employment needs but also in transforming obstacles into opportunities. Thus, this confirmation becomes the cornerstone for devising a theoretical framework aimed at leveraging these insights for effectively harnessing the 4IR's potential as a competitive advantage.

In conclusion, the successful implementation of the 4IR relies heavily on a diverse set of personnel skills, as evidenced by an array of literature and research findings. From technical competencies such as data analytics and artificial intelligence to softer skills like adaptability, creativity, and effective communication, the workforce of the 4IR must possess a multifaceted skill set. Moreover, the ability to continuously learn and adapt to rapid technological advancements emerges as a central theme across various sources. As organisations navigate the complexities of the 4IR landscape, investing in the development and cultivation of these essential

skills among their personnel will be crucial for not only surviving but thriving in the era of unprecedented digital transformation.

7.2.4 A Discussion of the results in relation to theoretical frameworks

The effective implementation of the 4IR has become a focal point for organizations seeking a competitive edge in the rapidly evolving global landscape. Although this subject was covered in chapters two and three, it is crucial to go over the main concepts once more before discussing the research findings. In this study, the convergence of technology theory and leadership theory serves as a guiding framework to assess the efficacy of integrating 4IR technologies as a strategic advantage. Leveraging KMO and Bartlett's tests for factor analysis, along with the application of structural equation modelling, this research endeavours to scrutinize the intricate relationship between technological advancements, leadership strategies, and the realisation of competitive superiority in the era of the 4IR.

This discussion aims to illuminate the results gleaned from these methodological approaches, providing a comprehensive exploration of their implications within established theoretical paradigms. To understand how technology theory affects the effective use of the 4IR as a competitive tool, the researcher explores the Technology theory and Leadership theory and their relevance in the context of effective utilisation of the 4IR. The research findings from both the primary data and the literature review confirm that 4IR technologies can be used to achieve competitiveness which is in line with the main objective of the study.

7.2.4.1 Integration with technology theory

Technology theory is widely used to explain how the use of technology results to competitiveness. Technology theory provides a lens through which we can understand the factors influencing the adoption and effective use of the 4IR technologies. It comprises of two primary factors: Perceived Usefulness and Perceived Ease of Use.

- i. **Perceived Usefulness:** The philosophy underpinning the study is the belief that the use of the 4IR technologies will enhance the organisational performance or productivity. In confirming the philosophy, the findings of the study have established that technologies such as AI, IoT, and blockchain and others offer tangible benefits to businesses in terms of efficiency, cost reduction, and innovation.

- ii. **Perceived Ease of Use:** This measures the user's perception of the simplicity and user-friendliness of the technology. According to the theory being tested, for 4IR technologies to be adopted effectively, they need to be intuitive, accessible, and not overly complex. The findings of the study suggest that user interfaces, training, and implementation strategies play a crucial role in the perceived ease of use.

Application to the 4IR as a competitive tool

The results of the investigation being conducted suggest that for businesses to leverage the 4IR effectively and gain a competitive edge, they need to consider the following factors:

- i. **Awareness and education:** Technology theory suggests that users must have the positive perception of the usefulness of technology. Therefore, the investment by the education stakeholders on the understanding of the benefits of the 4IR technologies is critical. The findings suggest that demonstrating real-world applications, case studies, and success stories can increase awareness and encourage adoption.
- ii. **User-centric design:** Making 4IR technologies user-friendly and intuitive is essential. Simplifying interfaces, providing training, and offering ongoing support can reduce barriers to adoption.
- iii. **Integration and compatibility:** 4IR technologies often interact with existing systems. Therefore, ensuring seamless integration and compatibility with current infrastructure is crucial to minimising disruptions and encouraging adoption.
- iv. **Continuous improvements:** Technology theory acknowledges that perceptions about usefulness and ease of use can change over time. Therefore, businesses should continuously gather feedback and improve the technology's features and usability based on user experiences.
- v. **Change management and culture shift:** The research findings confirm what Alade and Windapo (2021) suggested that adopting 4IR technologies requires a cultural shift within organisations. Therefore, effective change management strategies, leadership support, and fostering a culture of innovation are vital to successful technology adoption.

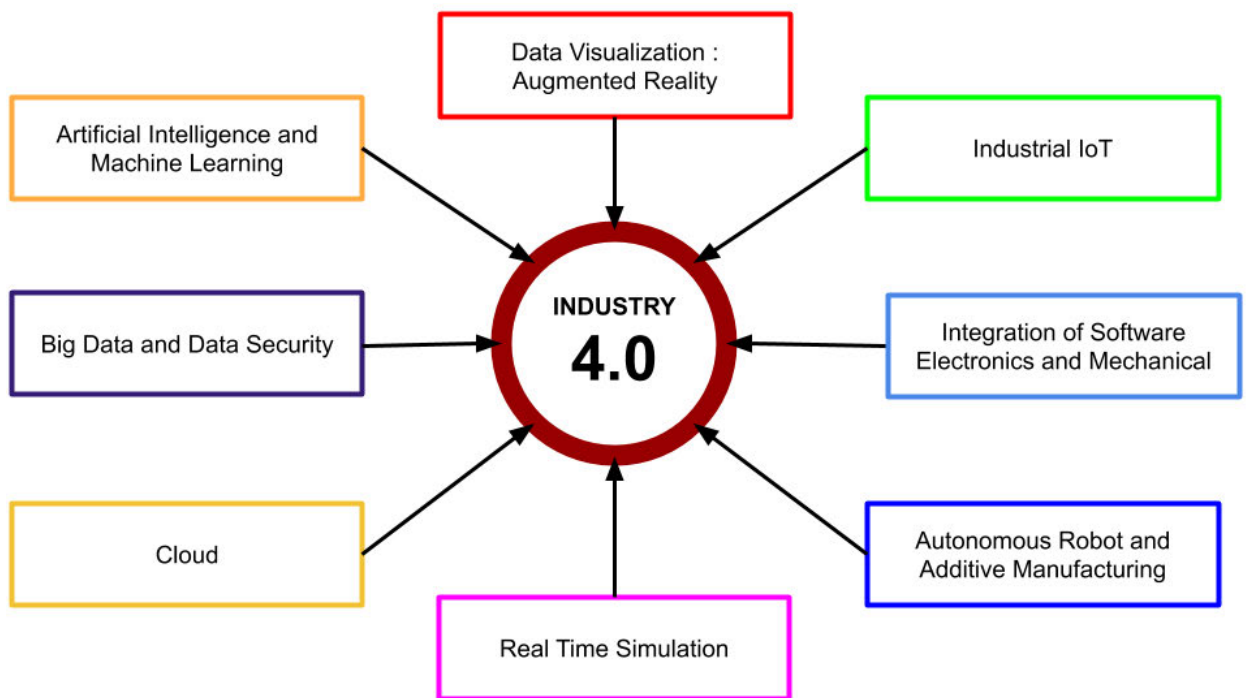
- vi. **Data privacy and security:** The findings suggest that addressing concerns about data privacy and security is paramount. Therefore, it was found that establishing robust security measures and ensuring compliance with regulations build trust among users and stakeholders.

In the dynamic landscape of the 4IR, companies in the South Durban Basin are navigating a complex and interconnected web of transformative technologies. The findings confirm the assertion by Nawaser (2021) that to harness the full potential of the 4IR technologies as competitive tools, businesses need to focus on demonstrating their usefulness, ensuring ease of use, fostering a supportive culture, and continuously improving their implementation strategies. Augmented reality (AR) enhances human-machine interactions, while artificial intelligence (AI) and machine learning (ML) algorithms process vast amounts of data, extracted from the intricate network, to derive actionable insights. Big data and data security play pivotal roles in ensuring the confidentiality and integrity of the colossal datasets involved. Cloud computing provides the scalable infrastructure required for efficient processing, storage, and retrieval of information. This convergence model (Figure 7.1) encompasses a multitude of transformative technologies, each playing a crucial role in reshaping the industrial landscape. Real-time simulation enables companies to model and optimize their operations swiftly.

Autonomous robots and additive manufacturing redefine traditional production methods, fostering efficiency and customization. This convergence is further augmented by the integration of software, electronics, and mechanical systems, creating a holistic technological ecosystem. In exploring the dynamic landscape of the 4IR, the integration with technology theory serves as a pivotal framework, seamlessly connecting with the integrated model to provide a comprehensive approach for the effective utilisation of cutting-edge technologies in this transformative era. These assertions, grounded in both empirical data and extensive literature reviews, underscore the multifaceted nature of the South Durban Basin's technological evolution.

The convergence model driving this integration is informed by the imperative to enhance operational efficiency, reduce costs, and foster innovation in a globally competitive landscape. Companies leverage these technologies to not only adapt to the evolving industrial paradigm but also to thrive in an era defined by interconnected smart systems and agile manufacturing processes.

Figure 7:1 Integrated model for effective 4IR technology utilization



Source: Figure devised by the researcher

Figure 7.1 explores the interconnected web of the Industrial Internet of Things (IIoT), augmented reality (AR), artificial intelligence and machine learning (AI/ML), big data and data security, cloud computing, real-time simulation, autonomous robots, additive manufacturing, and the integration of software, electronics, and mechanical systems to support the effective implementation of the 4IR.

i. Industrial Internet of Things (IIoT):

- Foundation of connectivity and data exchange between industrial devices.
- Enables real-time monitoring, control, and optimization of processes.
- Enhances efficiency, reduces downtime, and facilitates predictive maintenance.

ii. Augmented reality (AR):

- Overlays digital information onto the physical world, enhancing human-machine interactions.
- Improves worker efficiency through immersive training, maintenance support, and remote assistance.
- Augments decision-making by providing real-time data visualization.

- iii. Artificial intelligence and machine learning (AI/ML):**
 - Empowers systems to learn, adapt, and make intelligent decisions autonomously.
 - Enhances predictive analytics, quality control, and optimization of production processes.
 - Enables the development of smart, self-optimizing industrial ecosystems.
- iv. Big data and data security:**
 - Harnesses vast amounts of data generated by interconnected devices and processes.
 - Facilitates data-driven decision-making for process optimization and innovation.
 - Prioritizes robust data security measures to protect sensitive industrial information.
- v. Cloud computing:**
 - Provides scalable and flexible computing resources for storage, processing, and analysis.
 - Enables remote access to data and applications, fostering collaboration and agility.
 - Supports seamless integration with other technologies for enhanced functionality.
- vi. Real-time simulation:**
 - Facilitates virtual testing and optimisation of systems and processes in real-time
 - Enhances prototyping, reduces development time, and mitigates risks.
 - Enables continuous improvement through simulation-based learning.
- vii. Autonomous robots:**
 - Enhance automation in manufacturing and logistics.
 - Improve efficiency, reduce labour costs, and perform tasks in hazardous environments.
 - Work collaboratively with human operators for increased productivity.
- viii. Additive manufacturing:**
 - Revolutionizes traditional manufacturing processes through layer-by-layer construction.
 - Enables rapid prototyping, customization, and reduced material waste.
 - Drives innovation in design and manufacturing capabilities.
- ix. Integration of software, electronics, and mechanical systems:**
 - Harmonizes the synergy between software, electronics, and mechanical components.
 - Creates smart, interconnected systems that communicate seamlessly.
 - Enables the development of intelligent products and processes.

Figure 7.1 illustrates the intricate interplay of technologies driving the 4IR, showcasing how their convergence leads to more adaptive, efficient, and intelligent industrial ecosystems. As industries embrace this amalgamation, they are poised to unlock unprecedented levels of innovation,

productivity, and sustainability. However, careful consideration must be given to challenges such as data security, ethical AI use, and workforce upskilling to ensure a smooth transition into this new era of industrial transformation. To be able to execute the technology theory, the research findings have established that a strong leadership is required.

7.2.4.2 Integration with leadership theory

According to the theory being tested, an effective leadership plays a crucial role in leveraging 4IR technologies as competitive tools. In the study of leadership theory within the context of the 4IR, understanding the dynamic relationship between leadership styles and the effective utilization of technological advancements is paramount. Illustrated in the accompanying diagram are various leadership styles, each representing distinct approaches to guiding and influencing teams amidst the transformative landscape of the 4IR. This diagram serves as a comprehensive visual aid, offering insight into how different leadership styles can impact organizational outcomes within the framework of technological innovation.

By examining these leadership paradigms in conjunction with the principles of the 4IR, scholars and practitioners can gain a deeper understanding of the nuanced interplay between leadership strategies and the successful adaptation to emerging technologies, thereby informing more effective leadership practices in the modern digital age. Several leadership theories can be applied to illustrate their impact on utilizing these technologies effectively. Figure 7.2 illustrates the different leadership theories and how they can assist in the effective utilisation of the 4IR technologies.

Figure 7:2 Different leadership theories



Source: Figure devised by the researcher

- i. **Transformational leadership:** This theory emphasises inspiring and motivating followers to exceed their self-interests for the greater good of the organisation. In the context of the 4IR, transformational leaders can drive innovation and adaptation to technological changes by creating a shared vision, fostering creativity, and encouraging a culture of continuous learning. They empower employees to embrace and implement new technologies, thereby enhancing the organisation's competitive edge.
- ii. **Transactional leadership:** This theory focuses on the exchange between leaders and followers. Transactional leaders set clear goals, provide rewards for accomplishments, and establish structures for task completion. In the 4IR landscape, transactional leaders can ensure efficient utilisation of technology by setting specific targets related to technology adoption, monitoring progress, and providing incentives for achieving technological milestones.
- iii. **Situational leadership:** This theory suggests that effective leaders adapt their style based on the readiness and maturity of their followers. In the context of the 4IR, leaders need to be flexible and adaptable to different situations regarding technology adoption. They need to employ a more directive approach when introducing new technologies to a team

unfamiliar with them, and switch to a more delegative approach as the team becomes proficient.

- iv. **Charismatic leadership:** This theory revolves around a leader's ability to inspire and influence others through their charisma and personality. Charismatic leaders in the 4IR era can create enthusiasm and excitement around technological advancements, persuading stakeholders to embrace change and harness the potential of emerging technologies for competitive advantage.

- v. **Adaptive leadership:** This theory emphasises the importance of leaders navigating through complex and uncertain environments. In the 4IR, adaptive leaders are crucial as they facilitate organisational agility and resilience in the face of rapid technological advancements. They encourage experimentation, tolerate calculated risks, and promote a culture that embraces change.

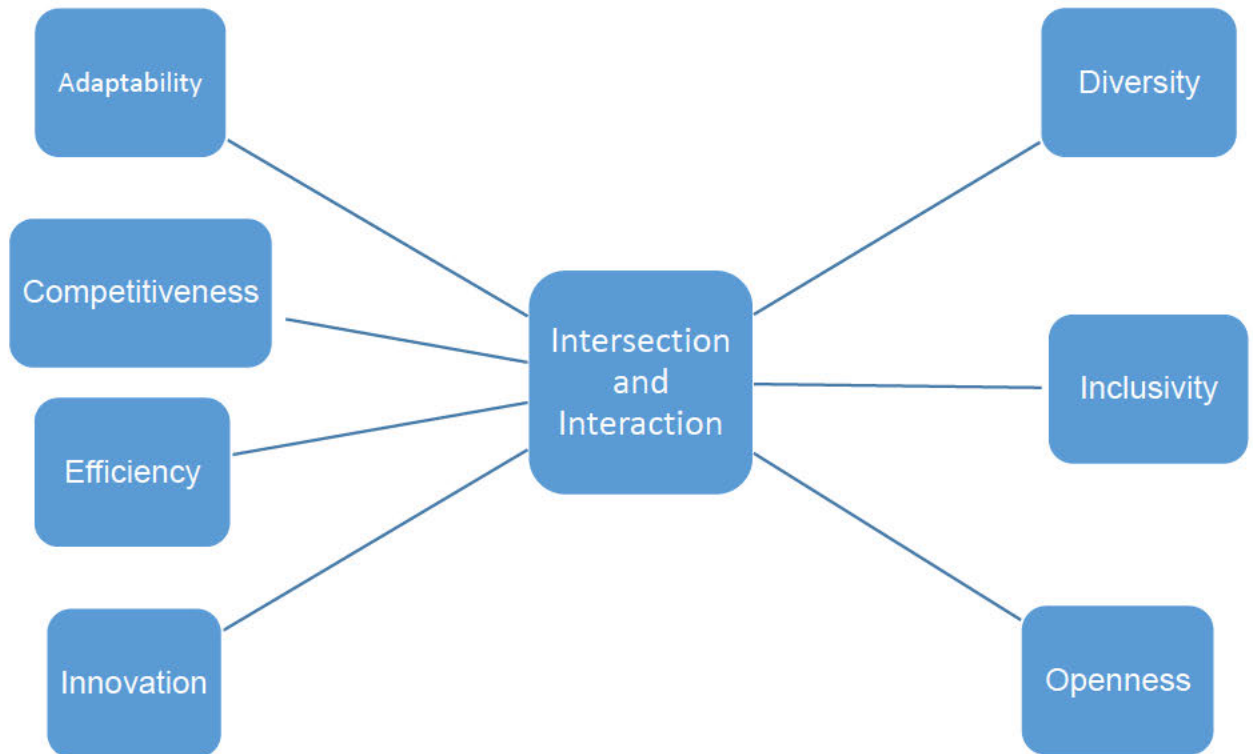
The results from both quantitative and qualitative study confirm that the effective utilisation of the 4IR as a competitive tool requires leaders who can blend these theories and adapt their leadership styles to the dynamic technological landscape. Leaders who can inspire, facilitate learning, set clear goals, and adapt to changing circumstances are better equipped to harness the potential of the 4IR technologies, enabling their organisations to gain a competitive edge in the market.

7.2.4.3 Intersections and interactions

Integrating technology theory and leadership theory to effectively leverage 4IR technologies involves understanding the synergies between these two domains. Collaboration between technology experts and leaders is essential for effective decision-making. While formulating a comprehensive technology strategy aligned with organisational goals organisations need to identify key 4IR technologies that can drive innovation, efficiency, and competitiveness. They also have to align leadership strategies with the technology roadmap so as to cultivate leaders who can envision and articulate a compelling vision for the organisation's technological future. The convergent model represents a dynamic organizational approach where adaptability, competitiveness, efficiency, innovation, diversity, inclusivity, and openness intersect and interact synergistically. The intersection of these elements creates a holistic and resilient organizational framework, where each component reinforces the others, leading to enhanced overall

performance and sustained success in a rapidly evolving business landscape. Figure 7.3 below, illustrates how the effective integration of technology theory and leadership theories to drive the effective implementation of the 4IR.

Figure 7:3 Convergence model



Source: Figure devised by the researcher

In this model, adaptability allows the organisation to respond swiftly to changing environments, fostering competitiveness. Efficiency is optimised through streamlined processes, creating a foundation for innovation to flourish. Diversity and inclusivity contribute to a rich pool of perspectives, fuelling creativity and adaptability. Openness encourages transparency and information flow, facilitating the exchange of ideas. The findings further confirmed that organisations need to foster a culture of experimentation and technological curiosity in order to promote cross functional collaboration to break down silos and encourage knowledge sharing. This can only be achieved if organisations instil a leadership culture that values diversity, inclusivity, and openness to new ideas and also encourage leaders to model adaptive behaviour and embrace change.

The study found that the majority of companies are investing in training programmes to develop technical skills required by the 4IR technologies. But it was further confirmed that technological developments needed to be combined with adaptive leadership, emotional intelligence, and strategic

thinking to foster a culture of mentorship to facilitate knowledge transfer from experienced leaders to emerging talent. The implementation of the 4IR requires agile governance structures to adapt quickly to the evolving technological landscape able to implement robust cybersecurity measures to safeguard against emerging threats. To integrate leadership governance practices that promote ethical decision-making and responsible use of technology leaders themselves need to be familiar with the legal and ethical implications of the 4IR technologies. Companies need to develop key performance indicators that measure the effectiveness and impact of the 4IR technologies on business objectives to regularly assess and update technology metrics to reflect advancements in the field. Technology metrics also requires leadership performance metrics tied to innovation, employee satisfaction, and adaptability in order to encourage leaders to engage in regular self-assessments and seek feedback for continuous improvement.

By converging technology and leadership theories, organisations can create a holistic framework that not only embraces 4IR technologies but also ensures effective leadership in navigating the complexities and uncertainties associated with technological advancements. This integrated model fosters a culture of innovation, adaptability, and continuous improvement, positioning the organization to thrive in the rapidly changing landscape of the 4IR.

7.3 Chapter summary

The chapter aimed to discuss key findings that emerged through both quantitative and qualitative data and to merge them into the comprehensive exploration of the 4IR and its strategic implications for gaining a competitive advantage through the implementation of cutting-edge technologies. The initial section presented a thorough analysis of the research outcomes. Following this, a consolidation of key findings, provides readers with a condensed overview of the empirical data gathered. A focus was placed on the practical implications of these results, setting the stage for the subsequent section. The chapter looked at the central theme of implementation of the 4IR technologies to ensure a competitive advantage. It examined how organizations can leverage advanced technologies inherent in the 4IR to position themselves ahead in the market. The discussion emphasized the importance of strategic deployment and integration of these technologies to achieve sustainable success. In parallel, the narrative emphasizes the necessity of embracing the opportunities to overcome challenges of the 4IR. Acknowledging the transformative nature of the 4IR, the chapter discussed how organizations can proactively turn challenges into opportunities, fostering adaptability and resilience. A critical aspect addressed was the personnel skills necessary for the successful implementation of the 4IR. The chapter underlined the significance of upskilling and reskilling the workforce to navigate the

complexities introduced by 4IR technologies, ensuring a workforce equipped for the demands of the future.

Further enriching the discussion, the chapter incorporated a discussion of the results in relation to theoretical frameworks. It connected the empirical findings with established theoretical frameworks, providing a theoretical lens to interpret and contextualize the research outcomes. The technology theory model emerged as a key aspect of the chapter, serving as a conceptual framework to guide the understanding of the interplay between technology and organizational dynamics. It offers a structured approach to analyse and implement 4IR technologies within the organizational context. The chapter concluded with the exploration of the model design, a critical aspect that outlines a blueprint for organizations seeking to navigate the 4IR landscape. This section provides a practical roadmap derived from the synthesis of findings, theoretical frameworks, and the technology theory model, offering a holistic perspective on achieving a competitive advantage in the era of the Fourth Industrial Revolution. The pertinent conclusions and recommendations for further research are outlined in the next chapter. The next chapter will also comment on the contribution of the study to both theory and practice.

CHAPTER 8

Conclusions and recommendations

8.1 Introduction

This chapter provides a comprehensive conclusion to the study on the assessment of the 4IR technologies used by companies in the South Durban Basin. The examination aimed to gain a deeper understanding of how these technologies were implemented, the challenges faced and their impact on the competitiveness of the region. The findings and insights derived from the research contribute to a deeper understanding of the implementation, challenges, and impacts of the 4IR technologies in this specific industrial region. The research questions and problem statement will be reviewed, and a summary of the major discoveries will be provided, utilising the research questions as a way to indicate whether or not the questions have been addressed. Results will be presented in respect to the models and frameworks that were employed as well. The chapter also discusses the study's theoretical and practical contributions. Finally, the study's conclusions will be discussed along with suggestions, restrictions, and directions for future researchers.

8.2 Problem statement and research questions

The problem statement and research questions are reviewed in this section. This helps to provide closure to the readers and reminds them of the main issue or question the research aimed to address. It further provides an opportunity to highlight the alignment between the research findings and the original research questions, demonstrating the study's success in addressing the problem. By revisiting the problem statement and research questions, the author was able to link the findings to the initial purpose of the research and discuss how the results contribute to theoretical understanding or practical applications. Additionally, it set the stage for suggesting areas for future research, emphasising the ongoing relevance of the initial problem and the need for further exploration. By revisiting the problem statement and research questions, the author was able to connect the recommendations to the original goals and objectives, reinforcing their relevance and importance. This provided a comprehensive view of how the study has addressed the initial problem, what has been learned, and what implications and recommendations arise from the research findings.

8.2.1 Problem statement overview

The study aimed to address the challenges and opportunities related to the implementation of the 4IR technologies in the South Durban Basin. The South Durban Basin, known for its industrial significance, faced the imperative to integrate 4IR technologies to maintain a competitive edge in the global landscape. By exploring this context, the research sought to identify key factors influencing competitiveness in the era of the 4IR. The challenge was to navigate the complexities of implementation and harness the opportunities presented by the 4IR technologies while mitigating potential drawbacks.

8.2.2 Research questions

The research questions provided a structured framework for the investigation. They served as the guiding framework for the study, focusing on critical aspects of the 4IR implementation in the South Durban Basin. The research questions for the study were:

- How was the Fourth Industrial Revolution (4IR) implemented to ensure a competitive advantage?
- To what extent did the South Durban Basin embrace the opportunities of the 4IR, and how did that impact its competitiveness?
- What personnel skills were able to ensure the successful implementation of the 4IR?
- How can a theoretical framework for effective utilisation of the 4IR as a competitive advantage for the South Durban Basin be developed?

8.3 Key findings for the study research questions

The main conclusions of the research questions are outlined in this section, which also offers an analysis of how the questions were approached and whether or not they were resolved. This serves as a crucial juncture where the culmination of the research journey is synthesized and presented. Here, the spotlight shines on the pivotal discoveries unearthed through meticulous investigation and analysis. These findings are the cornerstone upon which the entire study is built, reflecting the depth of understanding achieved in addressing the research questions. Each key finding represents a significant stride forward in unravelling the complexities of the subject matter, shedding light on previously obscured aspects and offering valuable insights. As the narrative unfolds, these findings pave the way for insightful conclusions to be drawn and actionable recommendations to be formulated, ultimately contributing to the advancement of knowledge within the field.

8.3.1 Question number 1: How was the 4IR implemented to ensure a competitive advantage?

In exploring the implementation of the 4IR technologies within the companies of the South Durban Basin, it becomes evident that these advancements have significantly influenced their competitive landscape. Through a comprehensive study, diverse approaches to leveraging technologies such as IoT, AI, blockchain, data analytics, and automation have been uncovered, showcasing how these innovations have propelled companies towards gaining a competitive edge.

It was revealed that the 4IR technologies have played a crucial role in enhancing the competitive positions of their respective companies. The findings indicated diverse approaches to 4IR implementation. Overall, the study revealed that companies in the South Durban Basin strategically implemented 4IR technologies to gain a competitive advantage. Companies leveraged advanced technologies such as IoT, AI, blockchain, data analytics, and automation to enhance operational efficiency, reduce costs, and create innovative products and services. Strategic partnerships and investments also played a pivotal role in securing a competitive advantage. The findings collectively illustrate the diverse ways in which 4IR technologies have positively impacted various aspects of business operations, contributing to enhanced competitiveness across different industries in the South Durban Basin.

In conclusion, the findings of this study underscore the pivotal role played by 4IR technologies in enhancing the competitive positions of companies within the South Durban Basin. Through strategic implementation, leveraging advanced technologies, fostering partnerships, and making targeted investments, these companies have effectively optimized their operations, reduced costs, and fostered innovation, thus solidifying their competitive advantage in the regional and global marketplaces.

8.3.2 Question number 2: To what extent did the South Durban Basin embrace the opportunities of the 4IR, and how did that impact its competitiveness?

In examining the extent to which the South Durban Basin has embraced the opportunities presented by the 4IR, it becomes evident that the region's response is marked by a diverse spectrum of engagement among its role players. From advanced adoption to cautious exploration, the landscape reflects varied degrees of integration of Fourth Industrial Revolution (4IR)

technologies. This study delves into the impacts of these disparate approaches on the competitiveness of the region, shedding light on the factors shaping this intricate dynamic.

The study revealed a diverse landscape of engagement and varied degree of adoption of the 4IR by role players in the South Durban Basin. While some companies have fully embraced 4IR technologies and improved their competitiveness, others are still in the early stages or are cautious in their approach. Those that have adopted the 4IR technologies testified that it has positively impacted their competitiveness by improving productivity, reducing costs, and fostering adaptability to market changes. Collaboration emerged as a critical factor in overcoming challenges and fostering a collective competitive environment.

The findings revealed that the level of the 4IR adoption depend on the industry, with tech-focused sectors leading the way. This indicate that different sectors might have distinct needs, challenges, and levels of readiness. Factors such as funding, infrastructure, and expertise influence the willingness of role players to embrace 4IR opportunities. This implies that external elements play a crucial role in the adoption process. The regulatory environment and government support impact the extent of the 4IR adoption. This indicates that external policies and support structures can shape the landscape for role players. The findings highlight a complex landscape where role players are at various stages of adopting 4IR technologies, influenced by industry specifics, external factors, internal challenges, and strategic considerations. The willingness to embrace change, along with effective adaptation strategies, emerges as a key determinant of success in the evolving business landscape.

In conclusion, the investigation into the South Durban Basin's embrace of the Fourth Industrial Revolution has unveiled a multifaceted scenario. While certain entities have fully embraced 4IR technologies and reaped the benefits in terms of enhanced competitiveness, others are still navigating the early stages or proceeding with caution. The pivotal role of collaboration in overcoming challenges and fostering a collective competitive environment cannot be overstated. Moreover, the influence of industry-specific needs, external factors, regulatory environments, and government support underscores the complexity of the adoption process. Ultimately, success in this evolving landscape hinges on both the willingness to embrace change and the efficacy of adaptation strategies employed by role players across various sectors.

8.3.3 Question number 3: What personnel skills were able to ensure the successful implementation of the 4IR?

The successful implementation of the 4IR hinges upon a multifaceted approach to personnel skills, as underscored by recent research. This approach encompasses technical prowess in data analytics and machine learning, alongside a diverse array of interpersonal and adaptive capabilities. Moreover, the findings emphasize the pivotal role of continuous training and upskilling initiatives in enabling employees to adeptly navigate the evolving technological landscape of the 4IR.

The research highlighted the importance of a skilled workforce with expertise in data analytics, machine learning, and a diverse set of personnel skills essential for the successful implementation of the 4IR. Some of the skills encompass a broad spectrum of technical, interpersonal, and adaptive capabilities. The research found that continuous training and upskilling programmes were crucial in ensuring that employees could effectively navigate the evolving technological landscape. Companies that invested in upskilling their employees indicated that they experienced smoother 4IR implementation. The emphasis was on the importance of adaptability and openness to embracing new technologies and methodologies, reflecting the dynamic nature of the 4IR landscape. Data analysis and interpretation skills are also crucial for making informed decisions in the data-driven environment of the 4IR. The findings further reflect the significance of effective communication skills in bridging the gap between technical experts and non-technical stakeholders during 4IR projects, highlighting the need for clear and transparent communication.

The security concerns around the implementation of the 4IR technologies raise the essential nature of cybersecurity expertise to protect sensitive data and systems in the digital age of the 4IR, highlighting the growing concern for security in technological advancements. Leadership skills are necessary to guide teams and organizations through the transformative changes of the 4IR, emphasizing the role of visionary leaders in driving successful implementations. Ethical and legal awareness is also crucial for navigating the ethical dilemmas and legal implications that may arise in the 4IR, emphasising the importance of ethical considerations in technological advancements. The increasing importance of cultural sensitivity and the ability to navigate global differences in the 4IR landscape, reflecting the globalized nature of technology and business. In essence, the successful implementation of the 4IR requires a combination of technical expertise, adaptability, communication, leadership, and ethical considerations. A well-rounded skill set that spans both

technical and soft skills is essential for navigating the complexities and opportunities presented by the 4IR.

In conclusion, the research underscores that the realisation of a seamless transition into the 4IR era necessitates a holistic amalgamation of technical acumen, adaptability, effective communication, leadership prowess, ethical awareness, and cultural sensitivity. Companies that invest in cultivating such a well-rounded skill set among their workforce are poised to not only mitigate the security concerns associated with technological advancements, but also harness the transformative potential of the 4IR to drive innovation and sustainable growth.

8.3.4 Question number 4: How can a theoretical framework for effective utilisation of the 4IR as a competitive advantage for the South Durban Basin be developed?

In exploring the development of a theoretical framework for harnessing the 4IR as a competitive advantage for the South Durban Basin, it is imperative to consider various factors and integrate relevant concepts. This endeavour involves understanding the key technologies associated with the 4IR, evaluating the readiness of the region for their adoption, and addressing pertinent issues such as data governance and privacy. The aim is to create a robust framework that enables the effective utilization of the 4IR technologies to enhance efficiency, productivity, and innovation across industries within the South Durban Basin.

The study proposed a comprehensive theoretical framework encompassing technology integration, and a supportive leadership assisted by an organisational culture seeking to maximise the benefits of the 4IR for sustained competitive advantage. Developing a theoretical framework for the effective utilisation of the 4IR as a competitive advantage for the South Durban Basin involved considering various factors and integrating relevant concepts. Below are the key findings and considerations that could contribute to the development of such a framework.

Understanding the 4IR technologies: Identify and comprehend the key technologies associated with the 4IR, such as artificial intelligence, robotics, Internet of Things, and advanced data analytics. Assess the readiness of the South Durban Basin in adopting these technologies and address any existing gaps. Analyse the specific industries present in the South Durban Basin and identify how 4IR technologies can be applied to enhance efficiency, productivity, and innovation within the sectors such as manufacturing, logistics, hospitality, retail or services industries.

Data governance and privacy: Consider the implications of increased data generation and utilisation, emphasising the importance of robust data governance and privacy measures. Propose

strategies for managing and protecting sensitive data while fostering data-driven decision-making. Involve local communities in the development and implementation of the 4IR strategies to ensure inclusivity and address any socio-economic disparities.

The study has proposed a comprehensive theoretical framework encompassing technology integration, robust data governance, and inclusive community involvement, supported by leadership and an organizational culture geared towards maximizing the benefits of the 4IR for sustained competitive advantage. By considering these key factors, a roadmap emerges for the South Durban Basin to strategically navigate the complexities of the 4IR, fostering economic growth, and ensuring social inclusivity in the process. By considering these key factors, a comprehensive theoretical framework can be developed to guide the effective utilisation of the 4IR as a competitive advantage for the South Durban Basin.

8.4 The 4IR model conceptualisation

The conceptualization of the 4IR model serves as a beacon amidst this transformative era, synthesizing profound insights derived from rigorous studies into a cohesive framework. Through a comprehensive analysis, a conceptual model tailored specifically for the South Durban Basin emerges, delineating crucial components and their intricate interdependencies. This model not only elucidates the essence of the 4IR implementation but also serves as a guiding compass for companies seeking to navigate the intricate tapestry of technological advancements. In essence, it heralds a new era of strategic integration, empowering businesses within the South Durban Basin to harness the full potential of the 4IR technologies and maintain a competitive edge in an ever-evolving industrial landscape.

The conceptualisation of the 4IR model synthesised insights from the study into a cohesive framework. Based on the findings, a conceptual model for 4IR implementation in the South Durban Basin is presented. This model outlines key components and their interrelationships, providing a guide for companies aiming to navigate the complexities of the 4IR. It also provides a roadmap for businesses in the South Durban Basin to strategically integrate 4IR technologies and stay competitive in the dynamic industrial landscape.

In conclusion, the conceptualization of the 4IR model stands as a testament to the inexorable march of technological progress and its profound implications for industrial ecosystems. Through meticulous research and analysis, a bespoke framework tailored to the unique context of the South Durban Basin emerges, offering a roadmap for enterprises to embrace the transformative power

of the 4IR. By delineating key components and their synergistic relationships, this model not only illuminates the path towards technological integration but also underscores the imperative for strategic foresight and adaptability. As businesses in the South Durban Basin embark on this journey of innovation and reinvention, the 4IR model serves as an indispensable tool, catalysing sustainable growth and resilience in the face of dynamic market forces.

8.5 Contribution of the study

The investigation conducted in the South Durban Basin, South Africa's industrial hub, has yielded significant contributions to both theoretical understanding and practical application within the realm of the 4IR. This study has served as a practical demonstration of the integration of technology and leadership approaches necessary for successful 4IR implementation. While numerous studies have explored the theoretical underpinnings of the 4IR and its implementation strategies, this investigation stands out for its direct application of existing theories and concepts without modification to the specific context. The decision not to alter variables underscores the confidence in the validity and relevance of established theories, leading to findings that align closely with theoretical expectations. This approach not only bolsters the robustness and durability of the theoretical framework employed, but also provides a valuable benchmark for assessing the consistency of such frameworks across diverse settings. Consequently, the findings hold significant implications for both researchers and practitioners, offering insights into the transferability of theoretical interventions and strategies to similar contexts.

As highlighted above, both theory and practice benefited from this investigation. The South Durban Basin, South Africa's industrial hub, is the site of the practical contribution to 4IR practice. Several studies that use technology and leadership approaches to the successful implementation of the 4IR have been conducted in examination of the theory of the 4IR. Consequently, both theory and practice benefited from this study. The variables were applied in the study as they were without any changes, meaning that the researcher utilised existing theories, concepts, or measures without modifying them to suit the specific context of the study. The decision not to modify variables was as a result of the confidence in the validity and relevance of existing theories and consequently the findings align with the expectations based on these theories, which supports the robustness and durability of the theoretical framework used. This provides the basis for researchers and practitioners to assess the consistency of theoretical frameworks across diverse settings. This suggests that interventions or strategies based on these theories may be directly transferable to similar situations. The findings can contribute to the

academic community by validating the applicability of these theories in the investigated context or by uncovering nuances that prompt further refinement and exploration.

Overall, the contribution of this study extends beyond its immediate practical implications in the South Durban Basin to enrich the broader academic community's understanding of the 4IR implementation. By validating the applicability of existing theories in a specific industrial context and uncovering potential nuances for further exploration, this research serves as a catalyst for advancing theoretical discourse and refining practical strategies. The findings not only validate the efficacy of established theories but also pave the way for future investigations aimed at enhancing their adaptability and effectiveness across varied settings. Ultimately, this study bridges the gap between theory and practice, offering a solid foundation for future research endeavours and empowering practitioners with actionable insights for navigating the complexities of the Fourth Industrial Revolution.

8.5.1 Practical contribution

In exploring the intersection of business strategy and technological advancement, this study delves into the practical implications of embracing 4IR technologies within the South Durban Basin. By scrutinising factors crucial to the successful integration of such innovations, including productivity enhancements, innovation stimulation, job creation, environmental sustainability, supply chain optimisation, and cybersecurity protocols, this research offers actionable insights for local businesses. Through rigorous data collection and in-depth analysis, the study not only elucidates these critical components but also provides a comprehensive conceptual framework. This framework equips developers and stakeholders with a practical blueprint to navigate the complexities of the 4IR implementation, fostering informed decision-making and driving sustainable industrial development in the region.

The practical contribution of the study lies in offering actionable insights and recommendations for businesses in the South Durban Basin to effectively implement and leverage 4IR technologies for competitive advantage. The study has made practical recommendations through understanding the factors that contribute to the effective implementation of the 4IR. These factors included enhanced productivity and efficiency, innovation and competitiveness, job impact and skills development, environmental sustainability, supply chain optimization, and cybersecurity and data privacy. The findings provided valuable insights for stakeholders to make informed decisions and shape the future of industrial development in the region. The study's findings, which were based on data collection and comprehensive, in-depth analysis approaches, were taken into

consideration while designing the conceptual model, which developers may now use to test development from a practical and applied standpoint.

In conclusion, the practical contribution of this study is manifold. By distilling key insights and recommendations, it empowers businesses in the South Durban Basin to harness the transformative potential of the 4IR technologies effectively. From bolstering productivity and fostering innovation to addressing concerns regarding job displacement and environmental impact, the study's findings serve as a compass for navigating the evolving landscape of industrial development. Moreover, the meticulously crafted conceptual model not only serves as a roadmap for implementation but also invites further exploration and refinement. As stakeholders embrace these insights and engage in collaborative efforts, they are poised to shape a future where technological advancement aligns seamlessly with sustainable economic growth, ensuring the region's continued competitiveness on the global stage.

8.5.2 Theoretical contribution

The study presented herein makes a significant theoretical contribution to the field by advancing our understanding of effective utilization of Fourth Industrial Revolution (4IR) technologies within industrial contexts. At its core, this research proposes a novel theoretical framework that extends current knowledge in this domain, offering a comprehensive blueprint for integrating 4IR technologies into industrial settings. Through a meticulous examination of institutional theory, industrial theory, and adoption theory, this study transcends disciplinary boundaries, paving the way for a more nuanced understanding of the complexities surrounding the adoption and impact of the 4IR technologies. By grounding the investigation within these established theoretical frameworks, scholars, policymakers, and practitioners alike can glean valuable insights to inform future research endeavours, strategic planning initiatives, and policy interventions aimed at maximizing the potential benefits of the 4IR technologies within industrial ecosystems.

The study contributes to the academic field by proposing a theoretical framework that extends existing knowledge on effective 4IR utilisation in an industrial context. It also involves the development of a comprehensive framework that can guide future research and strategic planning in the integration of the 4IR technologies in industrial settings. The study's contribution is multifaceted, encompassing various academic disciplines and theoretical frameworks including institutional theory, industrial theory, and adoption theory. By grounding the study in one or more of these theoretical frameworks, researchers can contribute to the academic discourse on the adoption and impact of the 4IR technologies, providing valuable insights for practitioners,

policymakers, and scholars interested in the intersection of technology and industrial development. Accordingly, the study has theoretically added fresh information that will help the 4IR to be implemented effectively not only in the South Durban Basin but in other parts of the country as well.

Overall, the theoretical contribution of this study holds immense promise in guiding the effective implementation of the 4IR technologies not only within the South Durban Basin, but also across broader industrial landscapes. By synthesizing insights from institutional theory, industrial theory, and adoption theory, this research provides a robust foundation upon which future investigations can build, fostering a more holistic understanding of the dynamics shaping the adoption and impact of the 4IR technologies. As such, this study not only enriches academic discourse but also offers actionable insights for practitioners and policymakers seeking to harness the transformative potential of the 4IR technologies in driving industrial development and innovation. Ultimately, the theoretical frameworks proposed herein serve as invaluable tools in navigating the complexities inherent in the integration of the 4IR technologies, thereby facilitating informed decision-making and fostering sustainable industrial growth in the digital age.

8.6 Recommendations

The recommendations stemming from this study are integral for businesses in the South Durban Basin to effectively navigate the challenges and capitalize on the opportunities presented by the 4IR. The rapid advancements in 4IR technologies necessitate proactive measures to build a skilled workforce, foster a culture of innovation and collaboration, facilitate knowledge sharing, establish strategic partnerships, and develop tailored strategic roadmaps. These recommendations are not only essential for individual organizational success but also contribute to the overall resilience and competitiveness of the region amidst the transformative impacts of the 4IR. Based on the study's findings, the following recommendations are made to companies in the South Durban Basin.

- i. Invest in continuous employee training to build a skilled workforce capable of navigating 4IR technologies**

This recommendation stems from the recognition that the rapid advancements in 4IR technologies require a highly skilled workforce capable of navigating and leveraging these technologies to ensure sustained competitiveness and innovation. Based on the identified technologies and workforce skill gaps training programs should focus on both technical skills related to the

operation and maintenance of the 4IR technologies and soft skills such as adaptability, critical thinking, and problem-solving. Training programmes that focus on enhancing communication, teamwork, adaptability, and creativity are crucial for successfully navigating the evolving technological landscape. Investing in continuous employee training is not only a strategic move to align with the 4IR but also a proactive measure to empower the workforce and enhance overall organizational resilience and competitiveness in the South Durban Basin.

ii. Foster a culture of innovation and collaboration within the organisation

This recommendation is crucial for businesses to effectively leverage the benefits of the 4IR technologies and stay competitive in the rapidly evolving industrial landscape. Companies should foster a collaborative environment by breaking down silos between different departments. They should encourage cross-functional teams to work together on projects that involve 4IR technologies. This approach promotes a holistic understanding of the technology's applications and encourages diverse perspectives, ultimately leading to more comprehensive and innovative solutions. This can be facilitated through regular team meetings, brainstorming sessions, and communication platforms. Employees should feel comfortable expressing their ideas and providing constructive feedback, fostering an environment where innovation thrives. Fostering a culture of innovation and collaboration is essential for companies in the South Durban Basin to successfully navigate and capitalize on the opportunities presented by 4IR technologies. This can contribute to a dynamic and adaptive organizational culture that is better positioned to thrive in the 4IR.

iii. Foster collaboration among companies to share knowledge, resources, and best practices in 4IR implementation.

Fostering collaboration among companies is a crucial recommendation to enhance the use of 4IR technologies in the South Durban Basin. The study recognizes the potential benefits of collective efforts, shared knowledge, and resource pooling. This could involve setting up industry forums, regular meetings, or online platforms where companies can share success stories, challenges faced, and lessons learned. A collaborative approach allows each company to benefit from the collective knowledge of the community.

By pooling research capabilities and financial resources, companies can collectively explore innovative solutions, identify common challenges, and work towards shared goals. Governments can play a crucial role in providing incentives, regulatory frameworks, and funding to encourage companies to work together towards the common goal of embracing 4IR technologies. By fostering collaboration among companies in the South Durban Basin, the region can create a synergistic environment where collective efforts enhance the overall 4IR implementation, leading to shared benefits and sustainable growth.

iv. Establish partnerships with technology providers and industry experts to stay abreast of the 4IR advancements.

One key recommendation from the study is to encourage companies in the South Durban Basin to establish partnerships with technology providers and industry experts to stay abreast of the 4IR advancements. Collaborating with technology providers and industry experts can offer companies in the South Durban Basin a strategic advantage. By forming partnerships, businesses can gain access to cutting-edge technologies, expertise, and insights that might not be readily available within their own organization.

By establishing partnerships with technology providers, companies can ensure they have access to the latest innovations, allowing them to stay ahead of the curve and remain competitive in their respective industries. Partnering with industry experts facilitates knowledge transfer where companies can tap into the expertise of these professionals to better understand the implications and applications of the 4IR technologies. This knowledge transfer can enhance internal capabilities and help organizations make informed decisions about technology adoption. The recommendation to establish partnerships with technology providers and industry experts is a strategic move for companies in the South Durban Basin aiming to harness the benefits of the 4IR. This collaborative approach not only ensures access to the latest technologies but also promotes innovation, risk mitigation, and resource optimization.

v. Develop and implement a strategic roadmap based on the proposed 4IR model to ensure effective and sustainable integration of advanced technologies.

One of the primary recommendations is to develop and implement a strategic roadmap based on the proposed 4IR model. This strategic roadmap is crucial for ensuring the effective and

sustainable integration of advanced technologies within the business landscape of the South Durban Basin. This may include technologies such as artificial intelligence, Internet of Things (IoT), blockchain, robotics, and data analytics. Assessing the specific needs and challenges faced by companies in the South Durban Basin to tailor the roadmap accordingly must be done. Companies need to develop a customised 4IR model that aligns with the unique characteristics and requirements of companies in the South Durban Basin. This model should take into account the industry-specific challenges, regulatory environment, and existing technological infrastructure of the region. This involves breaking down the strategic roadmap into manageable phases, allowing companies to gradually adopt and adapt to advanced technologies without disrupting their existing operations. Each phase should have clear objectives, timelines, and performance indicators. Through this recommendation, companies in the South Durban Basin can navigate the 4IR effectively, fostering innovation, and competitiveness.

In conclusion, the recommendations outlined in this study underscore the critical importance of strategic actions to harness the full potential of the 4IR technologies in the South Durban Basin. By investing in continuous employee training, fostering a culture of innovation and collaboration, fostering collaboration among companies, establishing partnerships with technology providers and industry experts, and developing and implementing strategic roadmaps, businesses can effectively navigate the complexities of the 4IR landscape. Embracing these recommendations will not only position companies for sustainable growth and competitiveness but also contribute to the broader socio-economic development of the region. As businesses embark on this transformative journey, embracing these recommendations will be paramount in shaping a future where innovation, resilience, and prosperity thrive in the South Durban Basin.

8.7 Limitations

The study on 4IR technology adoption in the South Durban Basin offers valuable insights into the dynamics of industrial transformation. However, it is imperative to recognize the inherent limitations that accompany such research endeavours. Firstly, the specific context of the South Durban Basin poses a challenge to the generalizability of findings to other regions with differing socio-economic, cultural, and industrial landscapes. Unique challenges and opportunities within the basin may not be representative of broader industrial ecosystems. Additionally, the rapid evolution of the 4IR technologies introduces another limitation. As the technological landscape continues to evolve, the study's conclusions may become outdated, failing to capture the latest advancements in the field. Furthermore, potential biases in data collection present a significant concern. Biases stemming from researchers' perspectives, respondent attitudes, or other

contextual factors could undermine the study's objectivity and comprehensiveness. Lastly, while the study provides valuable insights into the South Durban Basin, caution must be exercised when extrapolating these findings to other regions. Varying economic structures, regulatory environments, and technological infrastructures across regions can significantly impact the applicability of the study's conclusions. Acknowledging these limitations is paramount for responsibly interpreting and applying the study's results. These limitations are further discussed below.

- i. **Specific context of the South Durban Basin:** The study focuses on a particular geographical area, the South Durban Basin. This specificity may limit the generalizability of the findings to other regions with different socio-economic, cultural, and industrial contexts. Companies in the South Durban Basin may have unique challenges, opportunities, and adoption patterns for 4IR technologies that may not be representative of other areas.
- ii. **Dynamic nature of the 4IR Technologies:** The 4IR is characterized by rapidly evolving and dynamic technologies. The study's findings might be subject to change as new technologies emerge or existing ones undergo advancements. The fast-paced nature of technological innovation could mean that the study's conclusions might have a limited shelf life, and it might not capture the most recent developments in 4IR technologies.
- iii. **Potential for biases in data collection:** The accuracy and reliability of the study's results are contingent on the quality of data collected. There is a possibility of biases in the data collection process, whether due to the researchers' perspectives, the respondents' attitudes, or other contextual factors. Biases could impact the comprehensiveness and objectivity of the study, potentially leading to an incomplete or skewed understanding of the utilization of the 4IR technologies by companies in the South Durban Basin.
- iv. **Generalisability of findings to other regions:** While the study provides valuable insights into the specific region it focuses on, caution should be exercised when attempting to generalise the findings to other areas. The unique characteristics of the South Durban Basin may not be representative of broader industrial landscapes. Factors such as varying economic structures, regulatory environments, and technological infrastructures in different regions could significantly impact the applicability of the study's conclusions beyond the South Durban Basin.

Acknowledging these limitations is crucial for interpreting and applying the study's results responsibly. Researchers and practitioners should consider these factors when drawing conclusions or making decisions based on the findings, and future studies may need to address

these limitations for a more comprehensive understanding of the broader implications of the 4IR technology adoption in diverse contexts.

Overall, while the study contributes to our understanding of the 4IR technology adoption in the South Durban Basin, it is crucial to approach its findings with caution due to several limitations. The specific context of the basin, the dynamic nature of the 4IR technologies, potential biases in data collection, and challenges in generalising findings to other regions all warrant careful consideration. By acknowledging these limitations, researchers and practitioners can better contextualize the study's results and make informed decisions. Moving forward, addressing these limitations in future research endeavours will be essential for gaining a more comprehensive understanding of the 4IR technology adoption across diverse industrial contexts.

8.8 Directions for future research

As we move forward, there are several avenues for future research that could enhance our understanding and contribute to the advancement of industrial practices. To further advance our comprehension, future research endeavours should delve into exploring emerging technologies and their potential applications within specific industry sectors in the region. Moreover, there is a pressing need to investigate the long-term impacts of the 4IR implementation on the South Durban Basin. This research sets the stage for an exploration of the directions for future research, highlighting the significance of enhancing our understanding of the 4IR's implications within this specific industrial landscape. Firstly, an in-depth analysis of the socio-economic impacts of the 4IR technologies on local communities could shed light on the broader implications of technological integration. Additionally, a further investigation of the challenges faced by companies in implementing these technologies and identifying potential solutions would be crucial for facilitating a smoother transition. Moreover, exploring the role of government policies and initiatives in supporting and regulating the adoption of the 4IR in the South Durban Basin could provide a comprehensive perspective. Furthermore, a comparative study with other industrial regions could help benchmark the region's progress and identify best practices. Overall, future research should aim to address the gaps identified in the current study, providing a holistic understanding of the dynamics surrounding the integration of the 4IR technologies in the South Durban Basin.

Overall, by delving into the socio-economic impacts of these technologies on local communities, researchers can illuminate the broader implications of technological integration. Additionally, addressing the challenges faced by companies in adopting 4IR technologies and identifying

potential solutions is pivotal for facilitating a seamless transition. Moreover, analysing the role of government policies and initiatives in supporting and regulating the adoption of the 4IR can provide a comprehensive perspective. Furthermore, conducting comparative studies with other industrial regions can offer valuable insights for benchmarking progress and identifying best practices. Overall, future research endeavours should strive to fill the identified gaps, thereby contributing to a holistic understanding of the dynamics surrounding 4IR integration in the South Durban Basin and paving the way for informed decision-making and sustainable industrial practices.

8.9 Conclusion

In conclusion, this study delved into the intricacies of the 4IR within the South Durban Basin, employing a robust methodological framework that justified the use of both quantitative and qualitative methods. The comprehensive exploration of the study area, target population, sampling techniques, and research instruments, coupled with a meticulous consideration of validity, reliability, and ethical considerations, laid a solid foundation for the research. The literature review underscored the economic potential of the 4IR in South Africa while emphasizing the need for a balanced approach to avoid unemployment growth. The study further highlighted the pivotal role of educational and institutional alignment for successful industrialization.

The empirical findings, meticulously analysed through structural equation modelling and thematic analysis, elucidated key insights into the understanding, application, challenges, and impacts of the 4IR. Through conducting interviews, obtaining data, and applying structural equation modelling, all of the study's objectives were fully achieved. The results of the study have been reported, and the researcher has made recommendations. This study has shed light on the effective use of the 4IR technologies in the South Durban Basin, providing valuable insights for companies seeking to navigate the challenges and leverage the opportunities presented by the 4IR. The findings underscore the need for strategic planning, collaboration, and continuous adaptation required in the era of the 4IR.

The research was organized to cover both quantitative and qualitative aspects. The key findings highlight the importance of a holistic approach that combines technological advancements with adaptive leadership to ensure a competitive advantage. The study emphasised the need for organisations in the South Durban Basin to embrace 4IR opportunities, overcome challenges, and

foster a culture of innovation, adaptability, and continuous improvement. Additionally, the study revealed that companies are investing in training programs for technical skills related to 4IR technologies. However, it underscored the importance of combining technological advancements with adaptive leadership and governance structures. The findings emphasised the need for agile governance, robust cybersecurity measures, ethical decision-making, and responsible technology use.

Furthermore, the study recommended the development of key performance indicators measuring the effectiveness of the 4IR technologies on business objectives. It stressed the importance of leadership performance metrics tied to innovation, employee satisfaction, and adaptability for continuous improvement. The integrated model proposed by the study converges technology and leadership theories, providing organizations in the South Durban Basin with a comprehensive framework for thriving in the evolving landscape of the 4IR. The research outcomes contribute valuable knowledge to the ongoing discourse on navigating the complexities of the 4IR in the South Durban Basin, providing a basis for informed decision-making and strategic alignment in the pursuit of sustainable industrialization.

8.10 Chapter Summary

This chapter summarised the key findings, contributions, and recommendations derived from the study. It begins by presenting the problem statement and research questions, outlining the context and motivation for the study. The researcher introduces the concept of the 4IR model and its significance in the research domain. A detailed exploration of the research questions follows, providing clarity on the objectives and scope of the study. Each research question is carefully examined and justified, setting the stage for subsequent discussions. By addressing the research questions and proposing a theoretical framework, the study provides a guideline for practical applications in the South Durban Basin and beyond.

The core of the chapter delves into the conceptualization of the 4IR model. The researcher provides a comprehensive overview, defining key elements and illustrating the model's relevance to the study. This section establishes a solid foundation for the subsequent analysis. It offered a comprehensive understanding of the implementation of the 4IR technologies in the South Durban Basin and provided a foundation for future research and strategic decision-making in the region's industrial landscape. The chapter proceeds to present the key findings derived from the investigation of the research questions. Each research question is addressed systematically, and the corresponding results are discussed, providing insights into the study's outcomes.

The researcher synthesises the findings, drawing conclusions based on the results. This section not only highlights the significance of the study but also emphasizes its contribution to existing knowledge. Practical and theoretical implications are discussed, laying the groundwork for subsequent recommendations. The chapter articulates the contribution of the study, emphasizing how the research adds value to the field. The researcher discusses the novel insights gained, potential applications of the findings, and any advancements in understanding brought about by the study. Acknowledging the inherent constraints and challenges of the research, the chapter addresses limitations. This section provides transparency about the study's constraints and offers a realistic perspective on the generalisability and scope of the findings.

The chapter concludes by outlining directions for future research, identifying areas that merit further exploration. The researcher suggests potential avenues for extending the study, addressing unresolved questions, and contributing to the ongoing discourse within the field. This well-structured chapter provides a cohesive overview of the essential components within the chapter, guiding the reader through the problem statement, research questions, key findings, conceptual framework, contribution, limitations, and future research directions

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UNIVERSITY OF
KWAZULU-NATAL

APPENDIX 1: ETHICS CLEARANCE

30 March 2023

Livingstone P Smith (942406474)

Grad School of Bus & Leadership

Westville Campus

Dear LP Smith,

Protocol reference number: HSSREC/00005221/2023

Project title: Assessing the use of the fourth industrial revolution technologies by companies in the South Durban Basin

Degree: PhD

Approval Notification — Expedited Application

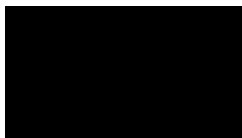
This letter serves to notify you that your application received on 20 January 2023 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted FULL APPROVAL.

Any alteration/s to the approved research protocol i.e. Questionnaire/interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid until 30 March 2024.

To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished. HSSREC is registered with the South African National Health Research Ethics Council (REC-040414-040).

Yours sincerely,



Professor Dipane Hlalele (Chair)



EST 1856

APPENDIX 2: GATEKEEPER PERMISSION

DURBAN CHAMBER
OF COMMERCE AND
INDUSTRY NPC

101 Isaiah Ntshangase Road, 4000
PO Box 1506. Durban 4001. KwaZulu-Natal, South Africa
T: +27 31 3351000 | F: +2731 303 114
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22 February 2021

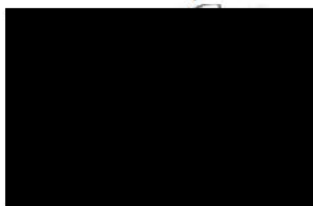
Mr. Livingstone Smith
University of KwaZulu-Natal: Graduate School of Business and Leadership
Westville Campus, J Block, 2nd Floor, Room 039
Private Bag X 54001
Durban
4000
Dear Mr. Smith

RE: PERMISSION TO CONDUCT RESEARCH

This letter serves to confirm that the Durban Chamber of Commerce and Industry hereby acknowledges and approves the research to be conducted through the Durban Chamber of Commerce and Industry for the completion of Doctor of Business Administration (DBA), research to be performed on: **The Role of the Fourth Industrial Revolution Technologies' Adoption on the Competitiveness of Companies in the South African Basin**

Please note that the data collected must be treated with due confidentiality and anonymity. This information is also provided by the Durban Chamber of Commerce and Industry on the condition that a copy of the final research output will be given to the Durban Chamber of Commerce and Industry for information purposes.

Yours Sincerely



Yolan Nazoc

Manager: Policy and Advocacy
Durban Chamber of Commerce and Industry NPC

T: 031 335 1000

Executive: President: NG Ward | Deputy President: TG Mahshe | Past President: MJ Mamunga
Directors: GM Langa JD Bhana, LR Nocobo, RD Qjrtis, FS Mkhize and PSS Maharaj InBusinessForABetterWorld



APPENDIX 3: INFORMED CONSENT LETTER
INFORMED CONSENT TO PARTICIPATE IN A RESEARCH STUDY

University of KwaZulu-Natal: Graduate School of Business and Leadership

Title: The Role of the Fourth Industrial Revolution Technologies' Adoption on the Competitiveness of Companies in the South African Basin

Researcher: Livingstone Smith

PURPOSE AND BACKGROUND

Livingstone Smith, a student at the University of KwaZulu-Natal, is conducting an academic study for a Doctor of Business Administration (DBA) assessing the impact of the Fourth Industrial Revolution on the South Durban Basin companies. Your organisation was selected to participate in the study because of its geographical location and you in particular to participate on behalf of your company.

PROCEDURES

If you agree to participate in the study, you will provide information on the interview questions, provide any personal information when required, and consent that all your responses can be recorded either through audio or in a written form or both.

CONFIDENTIALITY

The records from this interview will be kept as confidential as possible. No individual identities will be used in any reports or publications resulting from the study. All transcripts and summaries will be given codes and stored separately from the names or identification of participants. After the study is completed the collected data will be kept in a locked cabinet where it can only be accessed by the research team on request for a period of three years after which period it will be destroyed.

VOLUNTARY PARTICIPATION

Your decision to participate in the study is voluntary and you can decide to withdraw your participation in the study at any stage of the study without prejudice on your part. There will be no benefits directly to you, monetary or otherwise derived by participating in the study.

QUESTIONS

If you have any questions about the study, please contact the faculty office at +27 31 2602 784. You can also contact the research office at +27 31 2607 291 with any questions about the rights of research participants or research related concerns.

CONSENT

YOUR SIGNATURE BELOW INDICATES THAT YOU HAVE DECIDED TO PARTICIPATE IN THE STUDY AFTER READING ALL OF THE INFORMATION ABOVE AND YOU UNDERSTAND THE INFORMATION IN THIS DOCUMENT, HAVE HAD ANY QUESTIONS ANSWERED AND HAVE RECEIVED A COPY OF THIS FORM FOR YOU TO KEEP.

Signature: _____ Date: _____

Research Participant

Signature: _____ Date: _____

Interviewer

APPENDIX 4: QUESTIONNAIRE

Project Title: The Role of the Fourth Industrial Revolution Technologies' Adoption on the Competitiveness of Companies in the South African Basin

Dear Participant

You are being invited to consider participating in a study that involves gaining knowledge on how companies in the South Durban Basin area implemented the 4IR strategies to gain a competitive advantage, and how the challenges of the 4IR were overcome by companies in the South Durban Basin to gain a competitive advantage. The aim is to bring a new body of knowledge on the impact of the 4IR on human lives and economic activity and how such strategic advantage can be sustained. Your participation in the study is completely voluntary and any information you provide will be used for the research project only. You can withdraw from participating at any stage of the research process should you feel uncomfortable with the questions. Your identity will be kept confidential and there are no risks associated with your participation in the study. There are no risks or discomforts anticipated as a result of participating in the study, and there are no direct benefits to the participants resulting from participation. There will be no compensation for participants. This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (approval number: HSSREC/00005221/2023). In the event of any problems or concerns/questions, you may contact the researcher at [942406474@stu.ukzn.ac.za/](mailto:942406474@stu.ukzn.ac.za) [REDACTED] or supervisor Dr. Xoliswa Majola at Majolax@ukzn.ac.za. Please answer the following questions to the best of your knowledge.

Thank you for your time

1. Demographic information

Choose one option by marking it with an X

Please indicate your gender				
Male	Female		Wish not to disclose	
<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>	
Please indicate your age group				
18 -24	25 - 34	35 - 44	45 - 54	55 and older

Please indicate the racial group you closely identify with				
African	Coloured	Indian/Asian	White	Other

2. Educational Qualification

Below Grade 12	Grade 12	Diploma	Degree	PG Diploma/ Honours Degree	Masters/Doctorate Degree

3. Organisational Classification

Choose one option by marking it with an X

Industry Type					
Manufacturing	Retail	Logistics	Services	Hospitality	Other
Position					
Owner	CEO	Manager	Technician	Supervisor	Other
Work experience in years					
0 -2 years	3 -4 years	5 -6 years	7 - 8 years	9 - 10 years	> 10 years
Size of Organisation					
Small (less than 50 employees)		Medium (51 to 249 employees)		Large (250 or more employees)	

4. Familiarity with the Fourth Industrial Revolution technologies

What is your current level of familiarity with the Fourth Industrial Revolution?			
Very Familiar	Familiar	Somewhat Familiar	Not Familiar at all

--	--	--	--

5. Use of the 4IR Technologies

Indicate the use of the 4IR technologies (on a scale of 1 – 5) (1= never, 2 = rarely, 3 = sometimes, 4 = often, 5 = all of the time)

	1	2	3	4	5
Mobile devices (cell phones/ tablets)					
Machines connected to the internet					
Radiofrequency identification (RFI)					
Additive manufacturing (3D Printing)					
Authentication and Fraud detection software					
Human machine technology (HMT)					
Blockchain					
Robotics and Automation					
Augmented Reality					
Internet of Things (IoT)					
Artificial Intelligence (AI)					
Big Data Analytics					

6. Attitudes to using technology (on a scale of 1 – 5)

(1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, and 5 = strongly agree)

	1	2	3	4	5
The staff enjoy using technology					
The staff feel that technology improves their efficiency					
Technology improves customer service					
Technology has given the company a competitive edge					
Technology intimidates and threatens staff					
Technology is reliable with few breakages					
Using technology saves time					
Technology causes staff to be more focused on their work					
Technology will always require human (employee) input					

7. Knowledge of technology (on a scale of 1 – 5)

(1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree)

	1	2	3	4	5
I am aware of the Internet of Things (IoT)					
The impact of the 4IR on customer interactions is critical for business decisions					
Employees know how to work with advanced technologies and tools relevant to 4IR					
The company utilizes data analytics and artificial intelligence to make informed decisions					
Technological infrastructure and resources are readily available to support the integration of the 4IR technologies					
The company monitors and adapts to technological trends to align with industry best practices					

APPENDIX 5: RESEARCH INTERVIEW QUESTIONS

Demographic information

Choose one option by marking it with an X

Please indicate your gender					
Male	Female	Wish not to disclose			
Please indicate your age group					
18 -24	25 - 34	35 - 44	45 - 54	55 and older	
What is your highest qualification?					
No matric	Matric	Certificate	Diploma	Degree	other
Please indicate the racial group you closely identify with					
White	African	Coloured	Indian/Asian	Other	

Organisational Classification: Choose one option by marking it with an X

Industry Type					
Manufacturing	Retail	Logistics	Services	Hospitality	Other
Position					
Owner	CEO	Manager	Technician	Supervisor	Other
Work experience in years					
Over 10 years	8 – 10 years	6 – 8 years	4 – 6 years	2 – 4 years	0 - 2 years
Size of Organisation					
Small (less than 50 employees)		Medium (50 to 249 employees)		Large (250 or more employees)	

What is your current level of familiarity with the Fourth Industrial Revolution?		
Very Familiar	Somewhat Familiar	Not Familiar at all

Technological Efficiencies (on a scale of 1 – 5) 1= never used, 2 = rarely used, 3 = often used, 4 = very often used, and 5 = Always used

	1	2	3	4	5
Mobile devices (cell phones/ tablets)					
Machines connected to the internet					
Radiofrequency identification (RFI)					
3D Printers					
Authentication and Fraud detection software					
Human machine technology (HMT)					

Attitudes to technology: How do you feel about using technology?

1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, and 5 = strongly agree

	1	2	3	4	5
The staff enjoy using technology					
The staff feel that technology improves their efficiency					
Technology improves customer service					
Technology intimidates and threatens staff					
Technology often breaks down to be of very much use					
Using technology takes too much time					
Technology often distracts staff from their work					
Technology will eventually replace employees					

How was the Fourth Industrial Revolution implemented to ensure a competitive advantage?

How effective is the use of digital technology in the company's operations?

How have the Fourth Industrial Revolution technologies impacted your company's competitive position?

To what extent that the role players embraced the opportunities of the 4IR?

What challenges have you faced in implementing Fourth Industrial Revolution technologies or strategies?

How were these challenges of the 4IR overcome?

What personnel skills were able to ensure the successful implementation of the 4IR?

What operations of the business have been digitized?

What is the company's philosophy on upskilling and reskilling existing employees?

How can a theoretical framework for the effective utilization of the Fourth Industrial Revolution as a competitive advantage for the South Durban Basin be developed?

What would be your recommendation to the company with regard to the effective use of digital technologies?

What strategies can be recommended to both businesses and the government to assist companies in capitalizing on the use of the 4IR technologies?

Do you have any additional comments or insights on the Fourth Industrial Revolution and its potential as a competitive advantage?

APPENDIX 6: CERTIFICATE OF EDITING



Kinnoull Road 53
Pietermaritzburg, 3209,
KwaZulu-Natal
South Africa



18 August 2024

TO WHOM IT MAY CONCERN

Certification of editing of CLMA thesis:

The role of the Fourth Industrial Revolution technologies' adoption on the competitiveness of companies in the South Durban Basin.

This is to state that I have edited the above thesis of Livingstone Smith (Student number 942406474). I can confirm that it conforms to the CLMA Dissertation Style Guideline and satisfies the linguistic and editing requirements for such a thesis.

Sincerely



D.Z. van der Berg

Prof. D.Z. van der Berg

Kinnoullweg 53 Kinnoull Road, Pietermaritzburg, 3209, South Africa/Suid-Afrika

translationxchange@gmail.com dzvdberg@gmail.com

Cell +



Sworn translator / Beëdigde vertaler

APPENDIX 8: ETHICS CLEARANCE



12 August 2024

Livingstone P Smith (942406474)
Grad School of Bus & Leadership
Westville Campus

Dear LP Smith,

Protocol reference number: HSSREC/00005221/2023

Project title: Assessing the use of the Fourth Industrial Revolution technologies by companies in the South Durban Basin

Amended title: The role of the fourth industrial revolution technologies adoption on the competitiveness of companies in the South Durban Basin

Degree: PhD

Approval Notification – Amendment Application

This letter serves to notify you that your application and request for an amendment received on 08 August 2024 has now been approved as follows:

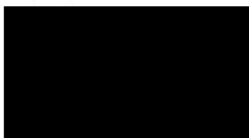
- Change in title

Any alterations to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form; Title of the Project, Location of the Study must be reviewed and approved through an amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

HSSREC is registered with the South African National Health Research Ethics Council (REC-040414-040). Best wishes for the successful completion of your research protocol.

Yours faithfully



.....
Professor Dipane Hlalele (Chair)
/nng

Humanities & Social Sciences Research Ethics Committee
UKZN Research Ethics Office
Westville