THE INCORPORATION OF SMART PRODUCTION IN FUTURE FACTORIES WITHIN THE FOURTH INDUSTRIAL REVOLUTION TOWARDS 2030

By

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ABSTRACT

Industry 4.0 is impressively creating a lasting impact on the manufacturing industry and on the industry outlook on the benefits of the implementation of new technology. The concept currently trending entails merging cyber systems, the Internet of Things and the Internet of Systems all together to construct the revolutionary 'Smart Factories'.

The use of advanced technologies brings about new methodology to improve the results of manufacturing. Complex activities will be performed by machines equipped in using intelligent information systems and new technology to improve productivity, enhance quality and reduce costs of manufacturing products. South Africa is at the height of the 'Fourth Industrial Revolution' (4IR) which will essentially change the way we work. This innovative rubric of high-tech modernisation is characterised by a merging of technologies from the physical, digital, biological and neuro-technological spheres. The hesitation over jobs being substituted with co-bots, a robot envisioned to actually cooperate with humans in a communal workplace, is profound. Skills volatility is estimated to effect all industries. There are uncertainties that the underprivileged and non-skilled would be thrust into an even profounder deficiency with the upsurge of the digital age. Organisations regard robotics and modern technology as strategic corporate tools which are utilised to enhance short- and long-term profitability and achieve operating goals. In dissimilarity, the application of robotics and modern technology in the place of work increases labour stability concerns, anxiety of downsizings and terminations within the workforce.

The purpose of this research was to heighten the comprehension of smart factories in the manufacturing industry by conclusively embracing a methodical examination of the factors which influence the outlook of those involved concerning smart factory implementation and also of assessing the readiness of the South African manufacturing industry for 4IR towards 2030. The 'golden thread' running through the study is the significance of the impact of the 4IR on the workforce and the creation of new jobs for the future, the reskilling of the workforce and the enhancement of capabilities of future factories in embracing the implementation and the incorporation of advanced manufacturing principles in production processes.

This must form a substantial consideration in the preparation of the vison of the "Incorporation of smart production in future factories within the fourth industrial revolution towards 2030".

The results of the in-depth analysis of future studies practice and theory in this research study give credibility to the argument that the way in which planning for the future of the 4IR in the South African context is taking place requires insightful adaptation by all stakeholders. The development of new insights through the application of futures studies is vital to this planning process, as is progressively demonstrated in the propensity for present day business to enable collaborative decisions and strategies that are established on, and informed by, futures studies. This research has attempted to gain insight into the possible future of the implementation of 4IR elements within the future manufacturing factories in South Africa through the creation of four scenarios towards 2030. These are defined as follows: The Fifth Element, which is the 'best case' scenario, and to which the country aspires; the 'worst case' scenario, in which everything goes badly; the outlier future founded on a surprising, disruptive, emerging matter; and 'business as usual' in which no change takes place.

The research additionally made efforts to determine the preferred future for the 4IR from a South African perspective, as a base for the Future Vision of the 4IR in the South African manufacturing industry towards 2030. Throughout this study, Inayatullah's (2008) pillars of futures studies were implemented as a guide in mapping the present and future, further deepening and widening the future through the development of scenarios and, lastly, by transforming the future by narrowing it down to the preferred future. The South African manufacturing sector must select which path to follow in the decisions surrounding the acceptance of the 4IR as the country progresses towards aligning itself with the global players in technology acceptance. Through a unique and innovative approach, the establishment of an atmosphere of trust and the sharing of purpose, values and benefits, a collective Future Vision of the implementing of 4IR elements such as smart production in future factories within South Africa towards 2030, is achievable.

All stakeholders must be committed to operating in collaborative partnerships, with government, society, local communities and the workforce all treading boldly together into a sphere of technological, commercial, environmental and social innovation.

Keywords:

Smart factories, Futures studies, scenarios, Fourth Industrial Revolution, workforce, manufacturing industry, advance technology, co-bots, cyber systems, the Internet of Things, the Internet of System.

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LIST OF ACRONYMS AND ABBREVIATIONS

AI	Artificial Intelligence
AR	Augmented Reality
BD	Big Data
CLA	Causal Layered Analysis
Co-bots	Collaborative Robots
CPS	Cyber-Physical Systems
DAPPs	Decentralised Applications
DMDU	Decision-Making under Deep Uncertainty
EDE	Electronic Data Exchange
ES	Environmental Scan
EV	Electronic Vehicle
FDI	Foreign Direct Investment
FTA	Future-Orientated Technology Analysis
GDP	Gross Domestic Product
ICT	Information and Communication Technology
ICPS	Industrial Cyber-Physical Systems
IoT	Internet of Things
IP	Intellectual Property
IT	Information Technology
ML	Machine Learning
P2P	Peer-to-Peer
RFID	Radio-Frequency Identification
SDGs	Sustainable Development Goals
STEM	Science Technology Engineering Mathematics
VR	Virtual Reality
WEF	World Economic Forum
4IR	Fourth Industrial Revolution

CHAPTER 1

THE RESEARCH PROPOSAL

1.1 INTRODUCTION

The manufacturing industry is on the edge of revolution, with smart factories and the prominence of digitisation in the lead (Govindan, 2014). In order to remain sustainable, manufacturing companies are required to be flexible, adaptable, proactive, responsive to change and able to produce a variety of products in minimum time at a lower cost (Kumar, Karunamoorthy, Roth, & Mirnalinee, 2005).

The manufacturing sector is vital to the economy and continues to be a central driver of growth for economies worldwide (Gehrke, et al., 2015). It contributes towards the gross domestic product (GDP) and influences infrastructure development and job creation (Deloitte, 2016). In South Africa (SA), vehicle and component production is the largest sector within the manufacturing environment. In 2016, the broader automotive industry contributed 7.4% towards GDP (AIEC, 2017).

As a result of technological advances, the current increase in manufacturing productivity has been the greatest since the dawn of the industrial revolution. Today's economy is at the cusp of the Fourth Industrial Revolution (4IR), which is also known as 'Industry 4.0'. Industry 4.0 is a new rubric referring to technological forces and innovations that will disrupt and transform lives in extraordinary ways. It is characterised by a fusion of technologies that are blurring the lines between the physical, digital and biological spheres (Schwab, 2016).

Industry 4.0 is a new manufacturing paradigm, which focusses on creating smart products, procedures and processes (Kagermann, Wahlster, & Helbig, 2013). A smart factory is a component of Industry 4.0 and is a self-organised, modular, highly flexible and reconfigurable factory that enables the production of customised products at low cost, thereby maximising profitability (Wang, Wan, Li, & Zhang, 2016a).

Through smart factories, products and services, the expected industrial production systems are transformed into a connected and intelligent manufacturing system (Thoben, Wiesner, & Wuest, 2017). The ultimate goal is that machinery and equipment should improve processes through self-optimisation and autonomous decision-making, without any involvement from human workers (Kagermann, et al., 2013).

Kagermann, et al (2013) state that the terms ‘smart production’, ‘smart manufacturing’ or ‘smart factory’ were created by China, United States of America (USA) and Europe, respectively, and these refer explicitly to the digital networking of production to create smart manufacturing systems.

Smart factories originated in developed economies. Smit, Kreutzer, Moeller and Carlberg (2016), recognise six prerequisites for their successful implementation in Industry 4.0. These include following; the standardisation of systems, platforms and protocols, fluctuations in work organisation reflecting new business models, digital security and protection of know-how, availablity of skilled workers, research and investment and a common EU legal framework. Technology forms the foundation of a smart factory. Through the introduction of automation and technology, organisations experience vagaries in work conditions and the environment (Lasi, Kemper, Fettke, Feld, & Hoffmann, 2014). Fundamental to the successful execution of technological systems in the workplace, is the individual employee’s attitude towards technology (Elias, Smith, & Barney, 2012). Consequently, the individual employee’s attitude towards the fluctuations can either be positive or negative.

Technology acceptance theories are broadly used to understand the factors which impact upon technology acceptance. Bingi, Mir and Khamalah (2000) compared the differences in IT adoption between developed and developing countries and determined that the substitution of labour, quality of infrastructure and ability to buy IT equipment were the main priorities in developing countries. Another study, by Kuan and Chau (2001), used technology acceptance theories to understand the perception of Electronic Data Exchange (EDE) adoption within small businesses.

Organisations consider automation and technology as strategic business tools used to increase short- and long-term profits and to realise operating objectives. In contrast, the implementation of automation and technology in the workplace raises labour concerns, fear of layoffs and redundancies among the workforce (Fourie, 2016; Ngin & Wong, 1997; Solis, 2011). This in turn influences the employees' attitudes towards the use of technology which could lead to either its acceptance or rejection. In order to gain an understanding of the factors influencing the readiness of South Africa's manufacturing industry in embracing 4IR principles in future factories, this treatise will make use of 'causal layered analysis' (CLA), incorporate a universal foresight process structure and the six pillars approach, which will be discussed at length in Chapter 2.

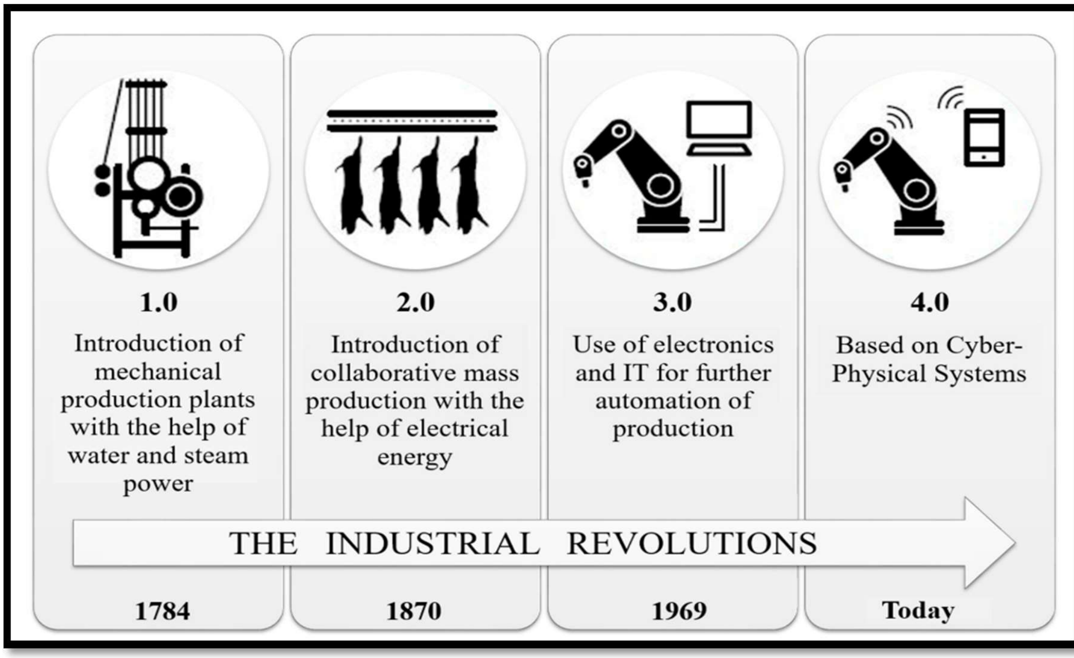
1.2 PROBLEM STATEMENT

The study aimed to explore and determine the possible future of the incorporation of smart production in future factories within the fourth industrial revolution towards 2030 with a view to providing valuable information for decision-making to the management, directors and key shareholders. This decision-making information will assist the stakeholders in developing and testing both possible and desirable future visions for future factories. The fourth industrial revolution, globalisation, socio-economic, technological, political and economic turbulence and regulatory environment dynamics are identified as the key drivers that will change the structure and shape of the manufacturing industry in South Africa. These drivers of change consistently affect all countries worldwide. This information will assist economic stakeholders in setting achievable goals for their organisations and in being equipped for confronting challenges brought about by the drivers identified above within the medium to long term frameworks.

The evolution of smart production has been driven by the Industry 4.0 movement in manufacturing transformation. In the previous dispensation manufacturing processes were driven by steam engines. Thus the introduction of the assembly line and the computer-executed fundamental economic changes, as depicted in Figure 1.1. (Herrmann, 2018).

FIGURE 1.1

SUMMARY OF THE INDUSTRIAL REVOLUTION.



(Source: Herrmann, 2018)

The general aim of the 4IR is to assimilate production with the most up-to-date information and communication technologies. This enables manufacturing of products to comply with customer needs and to produce it in consignment proportions of single quantity at the price of bulk-produced stock. The mechanical foundation is designed by intelligent, digitally-networked systems and manufacturing processes.

Industry 4.0 controls the complete life-cycle of a product. It facilitates the concept of, "the development, the production, the use and the maintenance up to the recycling of the product" (Inayatullah, 2008). Schaeffer (2017) suggests that the 4IR will have profound implications for businesses' cost structure, work process design, the involvement of human labour and, crucially, the composition of products and services. Technological improvement is an enabler for enhancing competitiveness, through increased manufacturing flexibility and competence with reduced dependence on labour.

Collaborative robots or co-bots are a class of robots that are intended to work alongside human-beings. Through the combination of the abilities of the robot such as meticulousness and strength with the skill and problem-solving capabilities of the human, it would be possible to accomplish everyday jobs that cannot be completely automated and advance the production quality and working conditions of labourers (El Makrini et al., 2018). Owen-Hill (2016) suggests that the implementation of collaborative robots in manufacturing factories to support labourers could aid in reducing the amount of work and injuries in the work environment such as musculoskeletal disorders. In the last few years, the technological field was developed for a better human-robot collaboration for example, sensors and control algorithms.

The demand for collaborative robots is anticipated to grow from $100 million to $1 to $3 billion by 2020. The proposed collaborative robot is designed to work interchangeably and closely with workers on the production line. Research has shown that the factors influencing collaboration between human and robot are mainly trust, movement and safety. There exists insufficient research which focus on studying final users of collaborative robots, such as workers on the production line. Thus, the need to gather information between the collaboration of a human and robot was of keen interest in the study to encourage forward thinking in industry (Elprama, Jewell, Jacobs, El Makrini, & Vanderborght, 2017).

1.2.1 Primary Research Question

The primary research objective (RO_M) of the research study was to investigate the extent and impact of the readiness of the South African manufacturing industry for the fourth industrial revolution and for the incorporation of smart production into future factories towards 2030.

1.2.2 Secondary Research Questions

The main research question is further supported by the secondary research questions presented in Table 1.1.

TABLE 1.1
SECONDARY RESEARCH QUESTIONS

RQ_1	What are the factors to be considered in determining readiness of South African manufacturing industry for the incorporation of smart production within the fourth industrial revolution (4IR)?
RQ_2	What are the potential implications and impact on the South African manufacturing industry as a result of the 4IR movement?
RQ_3	What are the key success factors related to the introduction of smart production in future factories and the impact on the economy?
RQ_4	What is the composition of future factories in South African manufacturing industry?
RQ_5	What are the key success factors of introducing co-bots in smart factories and the resultant impact on the labour force in South African Automotive Industry and economy?

1.3 RESEARCH OBJECTIVES

1.3.1 Primary Research Objective

The primary research objective (RO_M) of the research study was be to investigate the extent and impact of the readiness of the South African manufacturing industry for the fourth industrial revolution and incorporation of smart production in future factories towards 2030.

1.3.2 Secondary Research Objectives

To support the primary research objective, the secondary research objectives were identified and are listed in Table 1.2

TABLE 1.2
SECONDARY RESEARCH OBJECTIVES

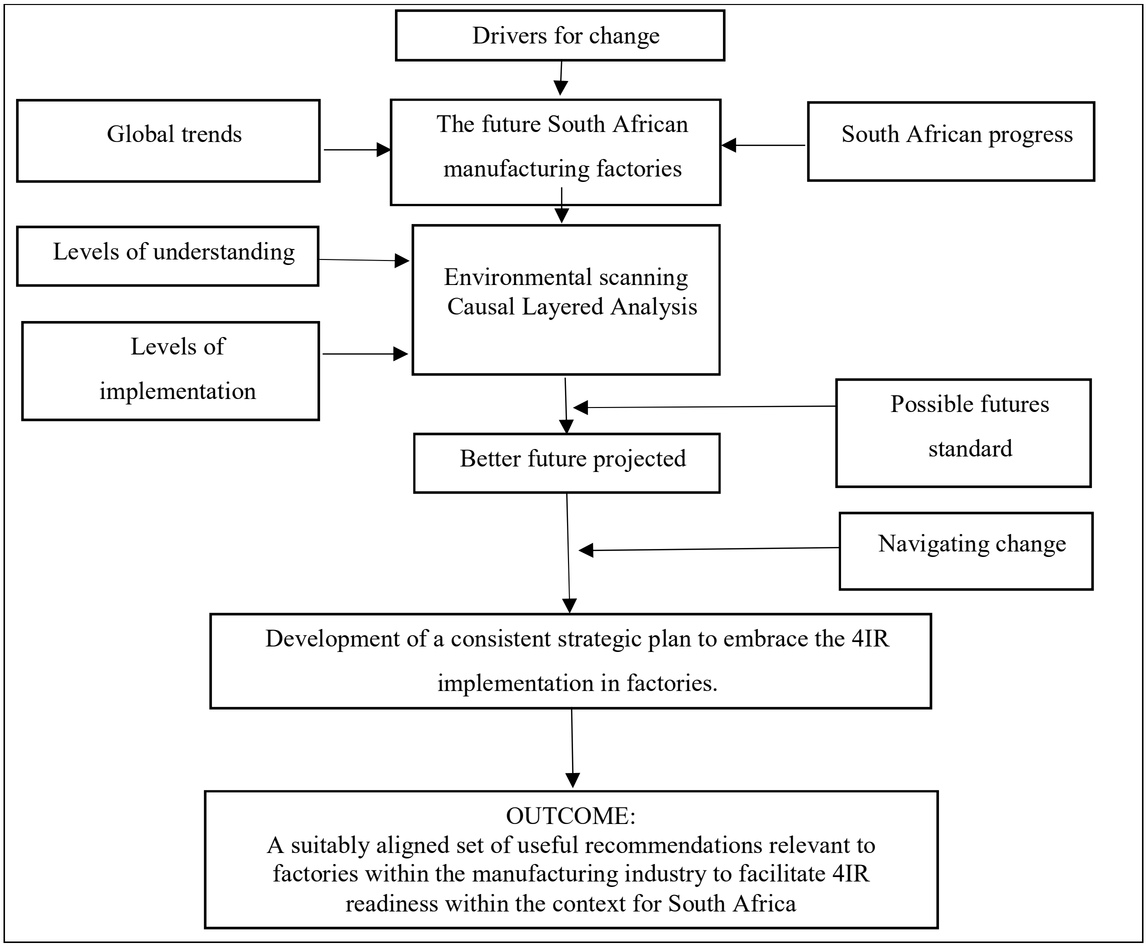
RO_1	Conduct an in-depth analysis of 4IR in South Africa and establish whether or not the manufacturing sector is aligned with the requirements of Industry 4.0 readiness.
RO_2	Evaluate the developing threats and opportunities that will influence the future of 4IR in South Africa by determining various alternative futures in accordance with specific drivers.
RO_3	Encourage information flow throughout the manufacturing industries, at all levels of stakeholders, to develop an inclusive, consistent strategic plan to embrace the 4IR implementation in factories.
RO_4	Gain a better understanding of the best possible future for South African manufacturing factories.
RO_5	Analyse the manufacturing industry's progress and failure in terms of the 4IR implementation in factories.
RO_6	Develop a simple yet practical set of recommendations to address the main factors that hinder the possible implementation of the 4IR in manufacturing factories, with the purpose of improving the level of technology management and implementation in the manufacturing industry in South Africa.

1.4 CONCEPTUAL RESEARCH FRAMEWORK

To enable a more enhanced comprehension of the purpose of the research, a conceptual framework was established and aids as a foundation for the research (Baxter & Jack, 2008). A conceptual framework serves a number of purposes.

- Recognise active and non-active participants in the study.
- Define relationships that may be existent based on theory, logic and/or experience.
- Provide the researcher with the opportunity to collect general constructs into logical 'bins' (Miles & Huberman, 1994).

FIGURE 1.2
CONCEPTUAL FRAMEWORK



Source: Researcher's own construction

Figure 1.2 above, outlines the extent to which the variables that influence the 4IR are understood. It also aims to identify the drivers for change, global trends and standards, the nature and impact of technological advancement and progress in manufacturing factories in a South African context and the development of ideas for a better future, by identifying factors which determine the route of change for South Africa (Osmond, 2015).

1.5 RESEARCH DESIGN AND METHODOLOGY

The methodological paradigm is a framework that guides how research should be conducted, based on people's philosophies and their assumptions about the world and the nature of knowledge such as positivism, interpretivism, critical theory, modernist and post-modernist. Qualitative research according to Collis and Hussey (2014), is more subjective and humanistic as the researcher interacts with what is being researched. This study is located within the interpretivism research paradigm which follows a qualitative research methodology. The Interpretivistic paradigm assumes the world is socially constructed and subjective and research is part of what is observed in the form of case studies and follows the induction for theory-building by means of qualitative data using the inductive approach.

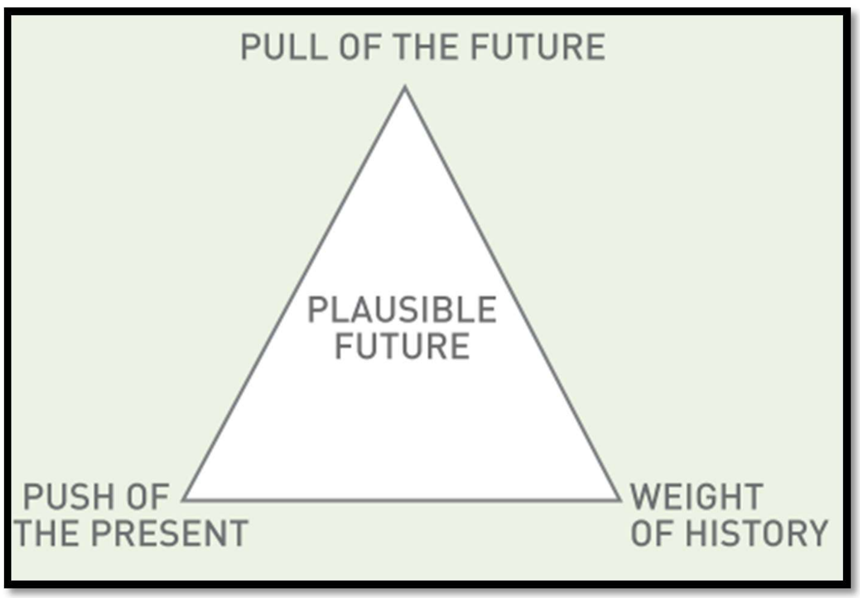
The preferred method of futures research in this paper, to analyse the past, present and future theoretical viewpoints of futures studies and the social sciences, will be 'causal layered analysis' (CLA). Composed from theories of poststructuralist discussion, and developed by Inayatullah (1998), CLA affords a basis for evaluating the social hypothesis of the 'real' and recommends a layered approach with which to analyse the results from the key focus areas of the research (Inayatullah, 1998). To conduct these analyses, the hermeneutics approach (science of interpretation) was used. The CLA method adopts four levels of analysis.

- The 'litany' level, which is the official public description of the topics.
- The 'social causes or systems' level, at which some fundamental systemic causes are revealed.
- The 'world-view or paradigm' level, in which the analysis is concerned with challenging the deeper assumptions behind the topic.
- The 'myth/metaphor' level, where the viewpoint is rational and the method endeavours to discern the irrational (Inayatullah, 1998).

These four levels are used to find the full array of stories, including the conscious, unconscious and controversial views of the topics. CLA's capability to create new techniques of knowing by interpreting and re-interpreting topics and their solutions delivers a rich method for the analysis of scenarios and case studies (Gould, 2008). The research undertaken was a futures study.

According to Inayatullah (2005), CLA is used in the deepening process. Issues are identified then explored from multiple perspectives. A map of the current reality, charted along four levels, is then developed. A map of the preferred or transformed future is also drafted. At this point, CLA may be applied to the narrative of the stakeholders so that they better understand their inner metaphors and strategies. This application to narrative helps ensure that they are aligned in their thinking. After the deepening process, CLA is used in the 'in-casting' scenario phase so that each scenario includes not just drivers and weights of the past but the four layers/levels of analysis. Similarly, CLA serves in the transforming phase in 'back casting'. It is important to keep in mind that not just events are 'remembered' from the past, but also the shift in metaphors that helped create the desired future.

FIGURE 1.3
THE FUTURES TRIANGLE



(Source: Inayatullah, 2019)

The above-mentioned futures triangle describes how the plausible future is derived by the push of the present quantitatively by a shift in the demographic environment, while examples of the weight of history are qualitative, related as they are to barriers to change and a visual representation of the desired future depicted by the pull of the future (Inayatullah, 2019). CLA may possibly be used in executing new strategies which resolve issues.

The layered analysis approach encourages questions such as:

- Does the new strategy guarantee universal changes?
- Will it result in worldview and cultural change?
- Is the resultant a new strategy, a new metaphor or a new narrative?
- Will the new vision result in a new litany and ensure that the strategies are designed to reinforce the new desired future and not linked to the past?

CLA, therefore, enhances understanding of strategy whilst plotting the reality from the vantage point of several stakeholders and allows users to implement more robust scenarios. (Inayatullah, 2019). In addition, this study follows Inayatullah's six pillars of futures studies approach, which provides a theory of futures thinking that is linked with methods and tools that are matured through practice (Inayatullah, 2008).

1.5.1 Quantitative research

The positivist paradigm is linked with quantitative methods of analysis, as it is based on the statistical analysis of quantitative data (Collis & Hussey, 2014). The positivist paradigm of observing social reality is grounded on the philosophical thinking of the French philosopher Auguste Comte, according to whom reason and observation are the best ways of understanding human actions. True facts are built on an awareness of the senses and can be gained by observation and experimentation. At the ontological level, positivists assume that certainty and, therefore, knowledge, is both objective and measurable using properties that are independent of the researcher's instruments.

Positivistic scholars embrace scientific methods and organise the knowledge-gathering process with the assistance of quantification to advance precision in the narrative of parameters and the connections between them. Positivism is focused on finding the truth and executing it by means of empirical methods (Thomas, 2010), while quantitative research allows separation from the subjective viewpoint of the researcher (Wahyuni, 2012).

Prescribed in the methods of quantitative research, measurement is a vital element and it is thus important to guarantee the accuracy of that measurement (Collis & Hussey, 2014).

1.5.2 Qualitative Research

Qualitative research follows the paradigm of interpretivist which is entrenched in the principles of idealism (Collis & Hussey, 2014). The entreaty of qualitative study is that it enables the researcher to conduct in-depth studies about an all-encompassing array of themes, expressed in a plain and everyday manner. According to Yin (2015), qualitative research permits greater flexibility in selecting topics of interest, whereas other research approaches are likely to be limited by:

- The inability to form the required research environments (an experiment);
- The lack of a satisfactory data series or insufficiency of coverage of appropriate variables (an economic study);
- The challenge of locating an acceptable sample of respondents and accomplishing an appropriately high response rate (as in a survey); or
- Other restrictions, such as being eager to study the past but not ongoing events (Yin, 2015).

The assumption of interpretivism is that social reality is subjective and socially designed or constructed, thus indicating that numerous realities exist (Yin, 2015). The epistemological assumption is based on the interaction of the researcher with the occurrence under study and, therefore, knowledge is resultant from the contributors' subjective evidence. Therefore, qualitative research emphasises quality through the depth and richness of primary data collected (Collis & Hussey, 2014).

1.6 STUDY OUTLINE

CHAPTER 1: Introduction and Background

Chapter 1 embraces the introduction to the research, the problem statement, and the integration of the study. It introduces and encapsulates the 4IR, considers the challenges and concerns faced by the manufacturing industry, and further directs the research objectives and questions. Furthermore, it provides abbreviated research methodologies that will be employed so that they can meet the primary objective and secondary objectives of the research.

CHAPTER 2: Research design and methodology

Chapter 2 sets the scene and deliberates on the research design and logic for the research process being followed, along with an assessment of the design criteria to ensure an adequate, research outcome with specific emphasis on the futures research methodology as depicted by Professor Inayatullah and which outlines, Causal Layered Analysis (CLA), 6 pillars constructs and environmental scanning. Although these methodologies were briefly touched on in Chapter 1, Chapter 2 will provide a comprehensive deliberation of these methodologies.

CHAPTER 3: Literature review

Chapter 3 comprises of a literature review, exploring and expanding on the global trends and challenges faced by the manufacturing industry aligning the readiness of factories in a South African context and also examines the disruptive technologies currently, and in the future, which will be shaping the industry.

CHAPTER 4: Six pillars of future studies

Chapter 4 focuses on the application of the Six Pillars of Futures Studies being reviewed along with causal layered analysis (CLA) as a methodology. CLA and scenario planning are studied in this paper to present alternative, plausible futures and to deepen insight into the future of the South African manufacturing factories and their readiness for the 4IR. These methodologies have been identified as preferred foresight techniques relevant to this study.

CHAPTER 5: Transforming the future

Chapter 5 presents an ideal, realistic future for all manufacturing stakeholders within a South African context of the 4IR, through a “Future Vision of South African manufacturing factories within the Fourth Industrial Revolution towards 2030”. This ideology will be offered along with a set of contextually aligned, practical recommendations and, finally, an overview of the research and a summary of its findings and conclusions.

CHAPTER 2

RESEARCH METHODOLOGY AND DESIGN

2.1 INTRODUCTION

In Chapter 1, the various ideas and factors that relate to the research study, including the definition of the primary research objective and research questions, from the viewpoint of the Fourth Industrial Revolution (4IR) in South Africa, were introduced. In addition, the proposed research methodology as well as an assessment of the design standards to ensure a satisfactory and successful research outcome were presented. Chapter 2 applies the research methodology approach to address those issues that relate to the research questions. The global views of the 4IR will be examined, with a specific focus on the growth, drivers for change, principles and global trends that have been the substance for the remarkable explosion and growing significance of the 4IR in the manufacturing industry.

The discussion follows on in the direction of the impact of the 4IR on Africa, and which will be analysed to ascertain the continent's evolution and its acceptance and implementation of the 4IR. From a South African perspective, a comprehensive assessment will be embarked upon to establish the impact that the 4IR has had on the country's economic growth. Lastly, this chapter also reviews the various 'strategies' embarked upon through the use of CLA and their applicability in the real world for South Africa. "CLA is based on Sohail Inayatullah's future-orientated methodology, which pursues to emphasize the issue of the current future-orientated thinking, exploring the assumptions, worldviews, ideologies, statements or even policy-orientated futures" (Osmond, 2015).

2.2 ORIENTATION AND SCOPING

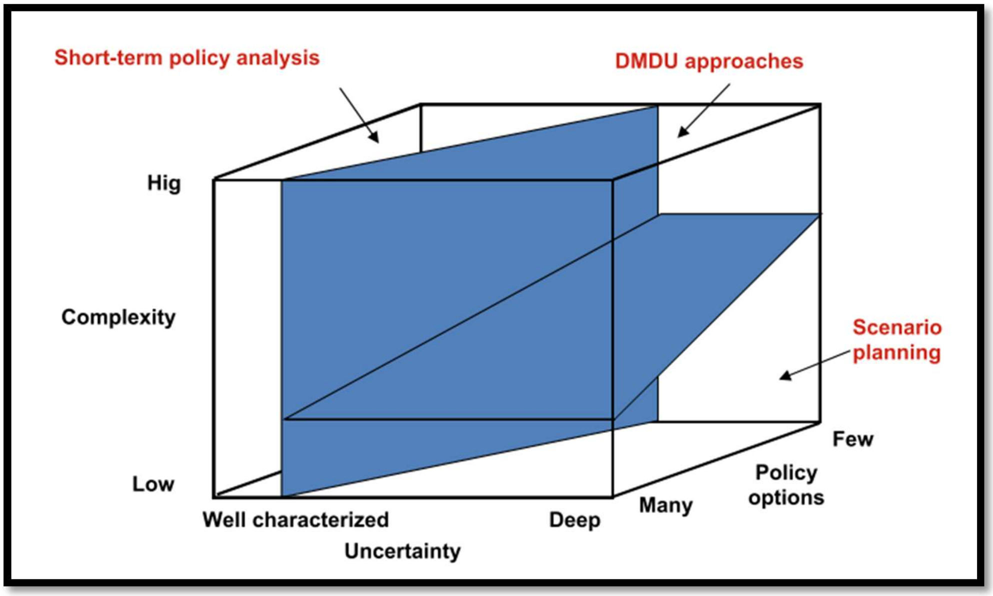
Conducting research, in part, is an act of foresight as the research formed is often still applicable in future years. Mankoff, Rode and Faste (2013) propose that research will frequently provide some degree of foresight.

However, it is generally prejudiced towards the short term and immediate future. In executing a systematic approach when considering the future, one is capable of critically examining several potential futures, multiplying the set of externalities under analysis and addressing the positive and negative predictions of the future (Mankoff, et al., 2013). Geldenhuys (2006) suggests that numerous leaders still use past trends as a basis for decisions, providing minimal support when encountering uncertainty, turbulence and an unstable environment. It is foreseeable that the future will be immensely different to the current environment. As the future is rapidly changing and remains unpredictable, business and government leaders need to ensure that adaptiveness, flexibility and responsiveness are key strategic goals (Adendorff, 2013).

Creating strategies for the future implicates expecting changes, particularly when devising long-term strategies or planning for unusual scenarios. Deep uncertainty arises when these scenarios are accompanied by a high degree of uncertainty which depicts a situation in which stakeholders are in disagreement with, relating to the applicable models to define the collaborations among a system's variables, as well as the probability distributions to signify uncertainty about significant variables and parameters in the models, and to determine the valuation of the desired outcomes (Marchau, Walker, Bloemen, & Popper, 2019). Decision-making for the future is determined by anticipating change and this anticipation is proving to be progressively difficult, thus creating apprehension when seeking to adapt short-term decisions to long-term objectives or to prepare for rare scenarios (Marchau et al., 2019). Scenarios are determinants of numerous unique futures which, when analysed, can offer a wide-ranging, clear and accessible comprehension into how policies might play out in various futures. The goal for researchers and stakeholders is to envisage various scenarios simultaneously in order to understand their options or possibilities. A true test of a good variation of scenarios is found in the reader considering which option is most likely to occur or has the highest probability, thus allowing the reader to reason more and which equates to fulfilling the purpose of conducting scenario planning. The development of scenarios by researchers should be for the core purpose to educate stakeholders and not to hypothesise the preferred future (Adendorff, 2013). According to Marchau et al., (2019) decision-making under deep uncertainty approaches provides many benefits, but also inflicts costs.

FIGURE 2.1

DECISION-MAKING UNDER DEEP UNCERTAINTY



(Source: Marchau et al.,2019)

As displayed in Figure 2.1, the benefits are most likely outweighed by the costs, provided that three conditions are satisfied. The deeper the contextual uncertainties (X), the more likely that such approaches would result in being more useful. Additionally, decision-making under deep uncertainty (DMDU) approaches is more useful when the set of policies (P) has more than fewer less degrees of freedom. When uncertainties are well-characterised and lower degrees of decision freedom occur, decision-making under deep uncertainty approaches produces fewer benefits over the customary ‘predict-then-act’ approaches. The third requirement, system complexity (R), is an exploratory view to determine how well professionals do know, and disagree, on the appropriate models, probabilities and system outcomes. The scenario planning is successful when expert clairvoyance is sufficient in marrying the policies to the appropriate outcomes (Marchau et al., 2019).

2.3 FUTURES STUDIES

Futures Studies or otherwise known as ‘transformative strategic foresight’ is the comprehension of alternative meanings of possible, probable, and preferred futures, worldviews and beliefs that inspire it (Milojević & Inayatullah, 2018).

In modern futures studies, contradictory opinions are not only cohesive, they are vital to the flexibility and robustness of the hypotheses (Inayatullah, 2010a). Futures studies is a thorough discipline that has progressed over a period of time from futures thinking (Adendorff, 2013). With futures thinking being deeply rooted in the history and growth of mankind, the explicit field of futures studies forms part of the sphere of modern humanism and is both metaphysical and scientific in nature (Adendorff, 2013). This section pursues to research into the discipline of futures studies and lays emphases on the purposes, characteristics, values and ethics of futures studies.

2.3.1 Purpose of Futures Studies

The purposes of futures studies are to determine or create, examine, evaluate and, recommend possible, plausible and preferable futures as futurists attempt to distinguish; what can or could be (the possible), what is expected to be (the plausible), and what should be (the preferable). Thus, with its theoretical background and previously-defined objectives, futures studies does not attempt to forecast a single future but endeavours to make people aware of the fact that there are numerous futures that may be shaped by our viewpoints (Irmak, 2003).

Futures studies has progressed from concentrating on the external objective world to a layered approach in which how one sees the world essentially shapes the future one sees. While many consider futures studies so, in order to minimise risk and to evade negative futures (predominantly the worst case), others enthusiastically move to constructing desired futures and positive apparitions of the future.

The realisation of alternative futures is thus a solid co-ordination of structure (the weights of history) and agency (the capacity to impact on the world and create desired futures). As the world has come to be progressively risky, at least in perception if not in fact, futures studies has been enthusiastically embraced by executive leadership groups and planning divisions in organisations, institutions and nations throughout the world. While futures studies sits securely as an executive role by providing the big picture view, there remain concrete pressures between planning and futures structures.

Planning intends to control and close the future, while futures studies seeks to open up the future by moving from the future to alternative futures (Inayatullah, 2010a).

2.3.2 Futures Studies Time Frames

Future studies has been identified by Slaughter (1998) as progressing to possess the most appropriate tools to negotiate the unsettled circumstances facing mankind. Derbyshire (2016) proposes that human attempts to construct the future are moderately restricted by determinism, but on the other hand have intervention to build a preferable future rather than being inactive responders. The great benefit of future studies, as Vásquez (1999) states, is in its inclination to modify the present for a more improved future.

Future studies has been implemented by organisations and establishments world-wide to assist with strategic thinking, organisational expansion and policy design. Canada, Finland, Japan, Singapore, South Korea, United Kingdom and United States, amongst others, have deployed regulated tactics that integrate futures studies methods targeted to produce, implement and fulfil strategies towards economic growth, technological advancement and a more robust future (Dawson, 2019). However, future studies should not be considered the same task as planning. Futures studies generally contests the conventional future and approaches longer horizons, from 10 to 15, and even to a 100 years (Inayatullah, 2008). Actually, the most frequently cited future markers nowadays have been 2050 and 2100 (Scolozzi & Geneletti, 2017) which corresponds to the same timeframes that the circular economy often makes predictions about.

The distinct difference between futures studies and planning is that futures studies experts are dedicated to constructing scenarios that compare to each other and take less popular views, rather than having slight deviations from the norm. Futures studies possesses various interpretations of reality. In conclusion, futures studies is extremely action-oriented, which is, focused on building the most preferable futures and then implementing to prevent less preferred or dystopic futures. Bishop and Strong (2010) contend that transformation follows in three timeframes or time horizons; namely short, medium and long-term.

These are defined in more detail as follows:

- Short-term transformation is what is dealt with every day. This time horizon is denoted in hours, days and perhaps a few weeks.
- Medium-term transformation is lengthier as it contains transformation in the processes that are used. The time horizon is measured in a few months to a few years.
- Long-term transformation takes the longest. This time horizon involves a number of years. Paralleling the global environment, long-term strategic transformation seldom enters day-to-day thought (Bishop & Strong, 2010).

The futures approach is devoted to the formation of reliable alternative futures in which each scenario is in essence different from the other. When economic analysts and planners use scenarios, they habitually include mere deviations from each other (Inayatullah, 2010a). A scenario is a story with possible cause and effect that links a future condition with the present, while demonstrating events, key decisions and effects throughout the storyline (Glenn, 2006), and can furthermore be seen as a means of exercising our foresight competencies (Bell,1997). Futurists correspondingly advance the idea of scenarios as a remarkably appropriate way to consider the future, and not as a forecast claiming to state categorically what will happen in the future. As an alternative, a scenario is a fictional, though plausible and realistic explanation of events that could possibly happen in the future (World Future Society, 2004). Possibly a dynamic characteristic of scenarios is that they are hypothetical, as the future is distinctively unknown and hence none of the scenarios will necessarily develop as imagined (Puglisi, 2001). Scenarios have been shaped and utilised for a variety of reasons.

- Determine what is unknown that should be known, before making decisions.
- Demonstrate what is likely and what is not likely.
- Appreciate the importance of uncertainties.
- Recognise what strategies may possibly work in a range of possible scenarios.

- Create a realistic future for decision makers to engage in original thinking and new decisions.
- Establish what has to be avoided and determine new prospects (Glenn, 2006).

The stance of Kreibich, Oertel and Wőlk (2012) is that societies need to deal with strategic planners, conceptual intellectuals and policy-makers in politics and business who claim to understand that the world is moulded by globalisation and long-term trends, yet the policies and programmes that are applied tend to be hypothetical and do not provide the answers required by government because of their prejudiced, short-term approach (Kreibich et al., 2012).

2.3.3 Future Technologies Consideration

Adendorff (2015) suggests that technology is undeniably one of the most important drivers of revolution due to its potentially transformative role, with both positive and negative impacts. Major developments in science, technology and society have been perceived in recent years (European Commission, 2014), and are usually associated with societal, exemplary changes which alter the fundamental logic, structures and values upon which the systems are founded (Wilenius & Kurki, 2010). Bishop and Strong (2010) suggest that currently the most substantial driver of change is the swiftness with which data is able to travel around the globe. The digital revolution has placed the capacity to generate and diffuse data into the hands of far more people and with at greater expanse than ever before. Ease of access to the expanding world of information is fueling the speed of technological revolution (Bishop & Strong, 2010). At present, the stimulating sectors that are utilising future technologies include nanotechnology, biotechnology, micro and nanoelectronics, new materials, photonics and innumerable innovative manufacturing technologies (Briseno, 2016). This dialogue will be discussed in Chapter 3, when the detailed literature review is conducted.

Future-oriented Technology Analysis (FTA) can be viewed as an umbrella concept for foresight, forecasting and assessment of technology. The related topics signify various phases of FTA, such as exploration, analysis and anticipation and monitoring.
FTA may be segregated into three focus areas; assessment, forecasting and foresight. The assessment is meticulously associated with the advancement of government policies concerning technologies. Forecasting is linked to short-term estimates of specific technological futures, frequently founded in the extrapolations of the current trends. Foresight is associated with long-term forecasts, generally open to technological breakthroughs. These actions rarely aim to foretell 'the' future. As an alternative they explore possible futures or fluctuating degrees of likelihood. Future-oriented Technology Analysis incorporates numerous approaches that may be utilised to analyse trends in order to forecast the future impact of technologies (European Commission, 2014).

The outcomes of FTA become robust as more FTA methods are implemented. FTA has a potentially valuable role since it can achieve a number of objectives. Enhance the quality and robustness of preventive intelligence and readiness for disruptive events through the use of organised approaches and the improvement of shared insights and perceptions. Provide platforms for exchange of ideas between key stakeholders from different domains, with diverging opinions and experiences. Construct vision and agreement for considering and encouraging directed processes of transformation. Contour and define interchanges of transformations and policy discussions on undertaking these major changes, as well as research and innovation schedules to maintain these dialogues and policy discussions (European Commission, 2014).

FTA provides support to an organisation's ability to comprehend the environment and to effectively utilise the research and development budget. It assists the organisations to be more agile in anticipating and addressing continuous as well as disruptive changes, thus, more adaptive to change. FTA affords an organisation some capability to set new trends and developed new methods of operation and it can play an significant role in organising an exchange of ideas among role players who might otherwise not be collaborating with each other (Ferreira, Barbosa, Oliveira, & De Souza, 2016).

2.3.4 Future of Sustainability Development

Sustainable development goals (SDGs) are established to alleviate poverty, advance health and education, and support prosperity and well-being through environmental sustainability. The 2030 sustainability agenda viewpoint of 'no one left behind' involves global conglomerates and participation in the amalgamation of environmental, social, economic and governance activities in the practice of development. The notion of sustainable development is perceived as an equilibrium between sustainable economic growth and ecological regeneration. Sustainable development involves the execution of suitable environmentally friendly technologies that are mutually efficient and adaptable to local environments. Eco-technology can enable the preservation and reinstatement of the environment through the incorporation of engineering and ecological ideologies.

The expansion of science and technology plays a substantial role in attaining SDG targets by refining the efficiency and effectiveness of new and sustainable development techniques. The implementation of green technology, efficient and effective methodologies, safer materials and enhanced performances are some of the outcomes of sustainable development. The afore-mentioned proves how technological applications and expansions have been implemented to conform to the ideologies of social, economic, and ecologic welfare. Enhancing technology, implementing innovation and creating revolutionary results are critical for providing SDG targets, from poverty eradication to refining food security to reversing climate control.

Strong alliance formation in private and public conglomerates will fast-track suitable and sustainable technological development, up-scale and transfer these in order to produce more social welfare and economic returns while minimising environmental effects. Industries have to implement lean principles to minimise waste and operate more effectively. Technological advances for utilising renewable energy resources, building urban water structures and sustainable public infrastructure, growing food and manufacturing environmentally friendly resources and products are amongst the methods by which technology will considerably contribute to the accomplishment of SDG targets. Technology currently plays a vital role in sustainable social, environmental and economic development.

Information and communication technology (ICT) is motivating innovation, efficiency and effectiveness across all segments and resources by giving everyone the potential to access and share of information and then utilise it to generate new opportunities. Technology is changing the manner in which businesses are operated. ICT can be utilised to support governments in providing better public services as well as in generating smart and resilient cities. ICT has enhanced the way society works and lives as well as the views on the expansion of urban areas. The 4IR enabled the broader society to enhance manufacturing processes, management and governance for more effective and efficient systems in related societies.

The welfare of the future is reliant on the application of technology to manage climate, health, social parity and stability. The 4IR can be utilised to alleviate difficulties and provide resolutions for improving societies' living conditions by means of sustainable products and services. The resourcefulness and innovation of technological development assists in cultivating the global environment by generating green, resource secure and all-encompassing economies for all. In addition, technologies such as the Internet of Things, artificial intelligence, data analytics, machine learning and 3D printing, can be utilised to generate, magnify and monitor the efficiency of sustainable development and environmental compliance. Technology is a contributor to improved living standards of society and continuously has a significant effect on the manner in which society re-engineers and protects the environment through the implementation of sustainable practices (Berawi, 2019).

2.4 FEATURES OF FUTURES STUDIES

Futures Studies otherwise known as 'transformative strategic foresight', is the conceptualisation of alternate (possible, probable, and preferred) futures and the world-views and mythologies that motivate it (Milojević & Inayatullah, 2018). Futures studies is not an effort to 'predict' the future, in the logic of dictating exactly what will transpire in a country, organisation or individual, prior to an event happening. Rather, futurists forecast a wide array of 'alternative futures' rather than trying to predict 'the future' (Dator, 1998). Robinson (1990) detected that even if the future could be foreseen accurately, the incorrect question would in all likelihood have been addressed.

Futures studies is fundamentally a vessel through which the future can be decolonised and in which prominent images can be challenged and alternative images created (Inayatullah, 2013). The most likely future is, more often than not, the most suitable or desirable result and it therefore becomes vital not simply to deliver good predictions but rather to hint at the alternative futures that are available and their likely features (Robinson, 1990). Characteristics of futures studies contain a wide range of factors, some of which are vital to the understanding of futures studies (Osmond, 2015). One such common characteristic is the prediction of the most likely future state of the system under study. Undeniably, predictive objectives inspire much of the long-term socioeconomic forecasting and are entrenched in the economic placement of several of the models utilised for such purposes (Robinson, 1990). An added factor to acknowledge is that there does not exist one single future, but always a number of alternative futures (Inayatullah, 2013).

Embodied in the profound study of social, economic and technological evolution and their relationships which impact on each other, futures studies further intends to explore "alternative futures, specifically the possible, the probable and the preferable". The following fundamental principle is that of disruption, planned through emerging issues exploration and in which these emerging issues may be found to be predictive, but still do help individuals to reconsider their conception of a 'normal' world (Inayatullah, 2013). Futures studies has evolved from concentrating on the external neutral world into a layered approach whereby how an individual perceives the world essentially forms the future one envisages. Although many perceive futures studies as a mitigation of risk, to elude negative futures, i.e. predominantly the worst case, others enthusiastically progress towards producing desired futures with positive visions of the future. The realisation of alternative futures is, therefore, a unsolidified dance of structure and activity (Inayatullah, 2010b). Inayatullah's (2013) opinion of the purpose of a futurist, or a futures-orientated 'thinker', is understood to be the capability to challenge the real future and through that produce a space for alternative futures to be recognised. Glenn (2004) has earlier maintained that futures research should be adjudicated by its ability to assist key stakeholders in policy-making decisions, instead of determining if a forecast is accurate, because futurists can definitely make a forecast that is predicted and it can be proven wrong.

2.5 FUTURES STUDIES METHODOLOGIES AND TECHNIQUES

There are a number of methodological methods and techniques that have been established in order to explore and foresee possible, probable, preferable and plausible futures (Adendorff, 2013). Hideg (2015) states that as a result of the fast changes and transformation of research fields, it is implausible that a certain researcher would do lasting research with a single paradigm. It is generally accepted currently that a researcher or a research team would be required to be familiar with numerous methodological approaches and be able to alternate between, and develop, paradigms in order to present authenticated research (Hideg, 2015). The approaches and methodologies in the futures sphere are continually changing and becoming progressively complex in nature, making it more challenging for those involved in the study of the future (Krawczyk, 2008). Futures studies is a focus on the understanding of the arena of futures in its entirety; developing countless hypotheses and constructs of the future, while sharing these with several groups of interest.

Futures research deals with the forecasting, planning, and exploration of futures using quantitative, qualitative, and analytical techniques. Futures movements refer to groups of individuals that have an effect on the objectives of the futures sphere and society as a whole (Adendorff, 2013; Krawczyk, 2008; Slaughter, 2000). Futures Studies is inclined to epitomise the hypothetical aspect of the futures field, while futures research often progresses towards the policy and decision-making aspect of the discipline (Adendorff, 2013; Geldenhuys, 2006; Krawczyk, 2008). Puglisi (2001) states that a wide range of methods has been developed for use in futures studies and the most commonly understood purpose of futures methods is to provide support in identifying what one doesn't know, but must know, in order to make more intellectual choices (Glenn, 2004).

The use of technology is a significant driver of change and there is frequently a robust focus on the possible use and progress of technology in a scenario analysis (Iversen, 2006). Lang (2000) had earlier expresses similar sentiments in that science and technology, predominantly the new developments in microbiology, biotechnology, physics, computer science, ecology and engineering, are the key significant drivers of future events and, accordingly, are principal areas to be observed.

Technology embodies innovative techniques of doing things and, once grasped, creates lasting change, which corporations and cultures do not easily 'unlearn' (Giyose, 2014). While the diverse scientific methods of constructing strategies for the future have not been restricted to particular issues, a strong weighting has traditionally been placed on the questions surrounding science and technology (Kreibich et al., 2012). Since the beginning of digital computing in the mid-1940s, the world has observed a historic revolution in the acquisition, communication and processing of data, one which has altered every single aspect of society through its universal access to information, automation and global human networking (Alkhatib et al., 2014). Kreibich et al. (2012) note that it is significant that present-day futures studies have become progressively cognisant of the risks and consequences of the dynamic forces of technology and industry. An indispensable objective of futures research is the systematic generation of a concept that can contribute in addressing future assessments and predicaments. Foundationally, foresight is an interdisciplinary undertaking, necessitating a methodology dependent on distinctive disciplines and integrating it, into a mutual reference structure (Kreibich et al., 2012). Iversen (2006) expands on research done earlier to test and measure intelligence, in which he recognises two apparently different forms of thinking (or skills); convergent and divergent thinking. Both these skills can be drawn upon when applying futures studies, especially in scenario setting:

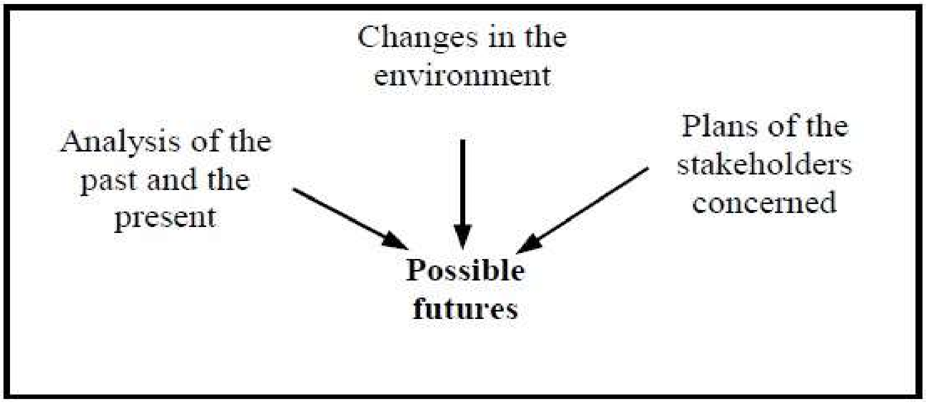
- Convergent thinking is essentially about old-fashioned problem-solving. It generally incorporates material from a number of sources in a method that produces the 'correct' response to a problem. This kind of thinking is particularly suitable in the fields of mathematics, science and technology, since it includes reasoning, observation, description and prioritisation in comparison to a given problem.
- Divergent thinking is an ability commonly associated with the innovative expansion of ideas and fortified by a motivation. Such thinking is conservatively a better fit for artistic pursuits and studies within the humanities (Iversen, 2006).

Kreibich et al. (2012) reason that the use of most methods of futures research has not been sufficiently systemised and they outline four elementary procedures of futures research:

- Explorative empirical-analytical method: This approach is achieved by accumulating a wealth of knowledge, including new data, facts, trends, possible and probable developments, all of which will be organised according to specific determinable circumstances and assumptions and analysed according to specific rules. This approach can be prevalent in both quantitative and qualitative form.
- Normative-prospective method: Accompanied by the use of creativity and imagination in futures projects, studies and data that is empirically analytically obtained; a collective vision of the future or wherein future-preferable projections can be created.
- Communicative-project method: A combination of knowledge and experience are used for practical application in this method when defining futures strategies and objectives in support of decision-making, communications and implementation processes.
- Participative-creative approach: This comprises of the use of actors from social areas, which proliferates the content for future knowledge and introduces aspects of the desired futures. In this way, a possibility for design and implementation and, more precisely, the research and design process, is proven (Kreibich et al., 2012).

There are three features of exploration common to all futures studies that should be measured when reviewing the characteristics of futures study methods.
These include the exploration of the past and the present, the changes in the environment, as well as the plans of the stakeholders concerned (African Futures and Phylos IPE, 2002), as demonstrated in Figure 2.2 below.

FIGURE 2.2
A MULTIDISCIPLINARY APPROACH



(Source: African Futures and Phylos IPE, 2002)

Hugon and Sudrie (1999) suggest that the classification of futures study methods should be categorised into four groups:

- Scenario methods: outlines the possible futures which are determined by long-term variations in significant factors.
- Predictive methods: are founded on constructing formal models to define the actions of the different stakeholders involved.
- Methods based on a linear view of history: the application of robust historical trends which are not necessarily continuous.
- Methods based on locating the common thread of a 'driving force': utilised to determine the probable futures (African Futures and Phylos IPE, 2002).

The first three aforementioned categories examine the encumbrances of the past in different ways and reflect the vision of the future by permitting long-term modifications in key features or incoherence in strong historical trends. The fourth category lays emphasis on the driving force, or motivation and the vision of the future that usually underlies it (African Futures and Phylos IPE, 2002). Hugon and Sudrie (1999) had earlier, similarly maintained that this classification is slightly theoretical, but emphasised that in practice it had been proven to provide solid reactions to the questions they had asked and, therefore, they suggested that researchers apply a mixture of these methods (African Futures and Phylos IPE, 2002).

Puglisi (2001) considers that all futures methods consist of different meanings during application, a characteristic that owes more to the objectives of their application than to their methodological characteristics.

2.6 THE SIX PILLARS OF FUTURES STUDIES

Futures studies has frequently been judged, for its requirement of a conceptual framework, a foresight process. During the last century numerous frameworks which included concrete theory and practice had been established and which incorporated a universal foresight process structure and the six pillars approach. The six pillars afford a theory of futures philosophy that is associated with approaches and tools, and established through praxis. The pillars are; mapping, anticipation, timing, deepening, creating alternatives and transforming (Inayatullah, 2010a). The conceptual framework for this study, was based on the six pillars of futures studies, as presented in Figure 2.3 below. The framework demonstrates a systematic input-output process describing the methods applied as well as the expected outcomes. Subsequently, it offers a useful framework in which to explore, interpret and construct alternative futures.

FIGURE 2.3
THE CONCEPTUAL FRAMEWORK OF THE SIX PILLARS OF FUTURE STUDIES

INPUT	PILLAR	OUTPUT
CREATION OF KNOWLEDGE Environmental scan Futures triangle	1 Mapping the future	The past, present and future are mapped
Emerging issues analysis	2 Anticipating the future	Trends or emerging challenges are identified
FORESIGHT Future is linear, cyclical, spiral and driven by creative minority`s action	3 Timing the future	Patterns, stages and mechanisms of long-term change identified
Causal layered analysis	4 Deepening the future	The futures are unpacked or deepened
CREATION OF VALUE Scenario planning	5 Creating alternative futures	The futures are broaden by way of alternatives
Visioning Backcasting Transcend	6 Transforming the future	The futures are narrowed to the preferred

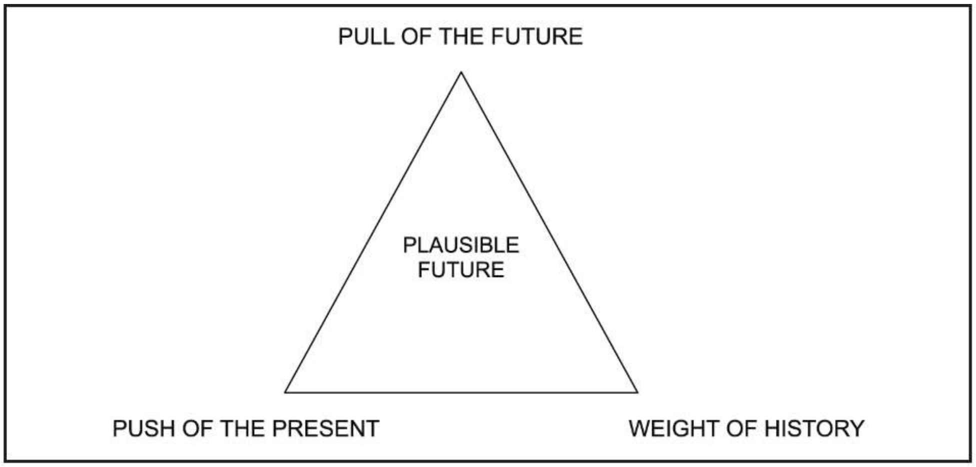
(Source: Adapted from Inayatullah, 2008, 2013)

The purpose is to generate an understanding of current manufacturing situations through exploring what has changed and, more importantly, what has not changed (Inayatullah, 2005). Past, present and future are mapped in the first pillar to disclose where the manufacturing industry is currently in the incorporation of smart production in future factories within the sphere of embracing the 4IR, in essence, where it is headed (Inayatullah, 2008). An environmental scan (ES) of the manufacturing industry was executed to reveal the existing trends and driving forces influencing the future of the industry. Environmental scans deliver strategic intelligence through the identification of situations, emerging issues and possible consequences that could impact upon the future of an organisation or industry. Slaughter (as cited in Puglisi, 2001) highlights how environmental scanning introduces organisationally-relevant criteria to allow equipped human minds to distinguish information, knowledge and insight from the multitude of 'signals' that occur daily. The information can be gathered from very different media sources, including conferences, reports and fiction.

The second stage of mapping the future is to distinguish those forces that create a particular future. This can be accomplished through the application of a futures triangle (see Figure 2.4). The process has three key measurements; push, pull and the weight of the future. The push (key drivers of change) for the manufacturing industry can include; the 4IR, smart technology and economic climate. The pull specifies the official, and sometimes feared, image of the future, as viewed by different stakeholders within the manufacturing industry. The weight of the past (barriers to the foreseen change) resists the forces of change and can include; organisational and societal structures, past histories and patterns of behaviour (Gould, 2008; Inayatullah, 2008).

Thirdly, mapping seeks to position the focus for the future on one of four levels in the 'futures landscape' (Inayatullah 2007). Through mapping, this study was able to determine the level of readiness on current assumptions about the future of the incorporation of smart production in future factories.

FIGURE 2.4
FUTURES TRIANGLE



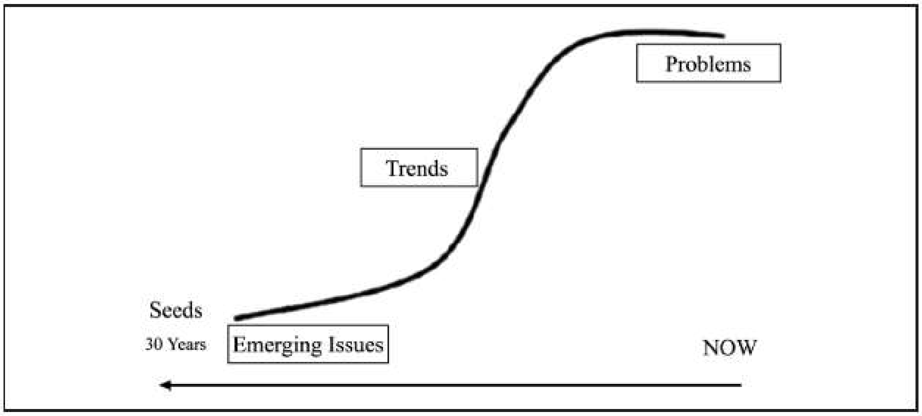
(Source: Inayatullah, 2008)

2.6.1 Anticipation

Data assembled during the environmental scan in the initial mapping phase may be understood through this pillar of futures thinking when an analysis of the emerging issues (see Figure 2.4 below) and drivers is executed to identify areas in which social innovation can be instigated (Inayatullah, 2008). In this study, critical questions about the manufacturing industry in South Africa were considered. This is in accordance with the guiding principles recommended by Horton (1999), who considers the response to the following important questions crucial to the process of foresight creation.

- What does the introduction of smart production mean to the manufacturing industry in South Africa?
- What are the consequences for the stakeholders?
- What are the concerns that challenge the realisation of the incorporation of smart production in future factories?
- What can be done about it today?

FIGURE 2.5
EMERGING ISSUES ANALYSIS

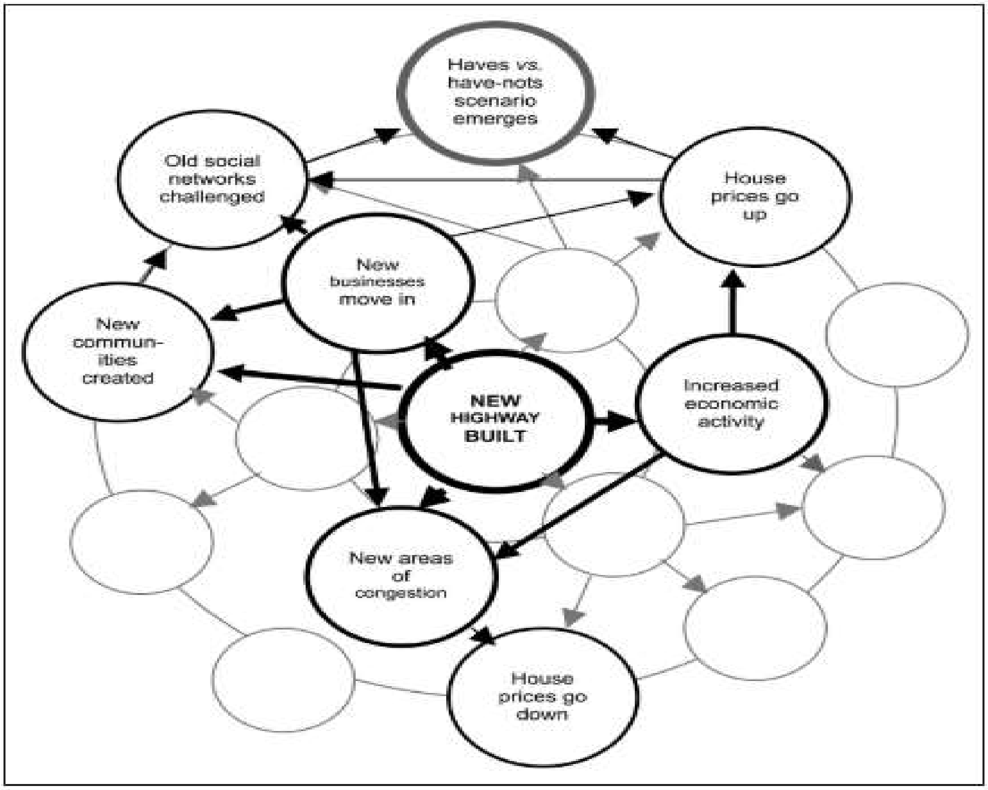


(Source: Inayatullah, 2005)

Emerging issues analysis tries to plot the possible sphere of current difficulties or issues (Gould, 2008), and intends to isolate problems before they become uncontrollable and costly, while examining novel opportunities (Molitor, 2003). Accompanied by emerging issues analysis is the futures wheel, as depicted in Figure 2.6 below. The futures wheel seeks to improve the impact of current issues on the longer-term future. This enables stakeholders to evaluate the impact that a particular new technology will have on various role players 20 years from the current position.
The futures wheel rolls to the second order and beyond that and does not simply stop at the first order impacts, by exploring and deducting unintended consequences. Fig 2.6 illustrates an example that maps logical implications of constructing a new highway to a formerly emergent city.

The resultant impacts, through the use of the futures wheel, is a possible increase in economic activity, there may be an increase of congestion on the roads, resulting in an increase in pollution, and which gives rise to increased health challenges for the populace. The highway may alter the location of social networks to a more secluded area of a ‘have and have-not’ scenario which may arise if the enthusiasm for fast growth endures at the cost of equity.

FIGURE 2.6
THE FUTURES WHEEL



(Source: Inayatullah, 2008)

The futures wheel aids in anticipating future challenges and generates the possibility of new products and progresses from viewing the world as an unassuming, unconnected level to a multifaceted connected level (Inayatullah, 2008).

2.6.2 Timing

Timing contains macro history and the analysis of grand configurations of social change. Galtung and Inayatullah (1997) propose that macro history is "the study of a trajectory of a unit through time and the study of non-contiguous points, neighbourhoods, and contexts, while searching for patterns, regularities and change." Applying macro history as a technique affords the opportunity to step back and distinguish between systematic disturbances and real transformations from a longer-term view about the past, present and future (Inayatullah, 2005). Is deep change in the manufacturing industry impossible? Is technology the most important force that it governs how work is done?

These questions, in turn, prompt wider speculation, including how the future is timed. Is the future a planned, comprehensible action created by selection and risk analysis, or is the future entirely open and anything probable? Macro historians and grand thinkers have been wrestling with these questions for millennia. Galtung and Inayatullah (1997) identify certain essential but divergent ideas that have arisen:

- The future is linear, good, advanced and attainable through commitment and hard work.
- The future is cyclical: Top structures struggle with adaptation and will in the future be demoted to the bottom.
- The future is spiral-shaped: Courageous leadership with foresight can construct a positive spiral by taking possession of the past and integrating it into the roadmap of an ideal future.
- New futures are often determined by a creative few, thus challenging the notion of a used future through political, spiritual, cultural, social or technological innovation.
- There are pivotal stages in human history when the actions of a few can result in a remarkable transformation.
- Conventional means of behavioural management are no longer effective during these eras (Inayatullah, 2008).

2.6.3 Deepening the Future

The comprehension of the future is deepened in the fifth pillar, through perceiving the same issue from many viewpoints or ways of knowing. Causal layered analysis (CLA) and Four-quadrant Mapping are two approaches that can be used for a deepening of the future. CLA is implemented by choosing an issue and conceptually unpacking comprehension of the issue from four levels of interpretation, namely; litany, social systems, worldviews and viewing an issue in terms of myth or metaphor (Inayatullah, 2008). CLA was the selected primary research methodology for this research endeavour and will be discussed in detail in Chapter 4. The four-quadrant mapping advances the inner measurement of CLA (Slaughter, 2005) by examining the following four features:

- The inner-individual which is the meaning given to the world that must be altered.
- The outer-individual – the demeanour.
- The outer-collective – the approved strategies untaken by organisations.
- The inner-collective – the internal map of organisations (Inayatullah, 2008).

The litany or the day-to-day future, is the frequently acknowledged headline of the way things are or are required to be. Solutions to problems are at this level typically short-term. The second dimension is deeper, concentrated on the social, economic, political foundations of the matter. The third dimension is the worldview which focuses on the big picture, the pattern that advises what is perceived as real and unreal, the perceptive lense that is used to comprehend and form the world-view.

The fourth dimension is 'the myth' or 'the metaphor'. This is the profound, unconscious storyline. Levels 1 and 2 are easily noticeable while levels 3 and 4 are comprehensive and deeper and more complexed to recognise. CLA seeks to assimilate these four levels of comprehension. Every individual level is true, and resolutions must be established at each level. Therefore, policy resolutions are possibly deeper. Litany interventions result in short-term solutions, easy to comprehend and filled with data. Systemic responses entail interventions by productivity experts. Worldview transformation is more complex and long-term and involves pursuing solutions from outside the framework from wherein the solution is defined. Myth resolution entails the deepest interventions, because this involves narrating a new story, reconditioning the brain and constructing new remembrances and the personal and combined body. Therefore, CLA and the four-quadrant method must be pursued simultaneously. Consequently, the four-quadrant method is an inner CLA. When the future is deepened, it can then be broadened by means of the fifth pillar (Inayatullah, 2008).

2.6.4 Creating Alternatives

Alternative futures creation occurs in the fifth pillar and is based on scenario development. Multiple scenario techniques exist; single variable, double variable, organisational, anticipatory, archetypes and integrated (Inayatullah, 2008).

Utilising four scenarios, one can preempt how an organisation may perform in each alternative future (Inayatullah, 2008). There are four variables used in creating alternatives. These are based on the following:

- Best case (towards which the organisation desires to progress).
- Worst case (most severe possible outcome).
- Outlier (an unforeseen future grounded on a disruptive emerging problem).
- Business as usual (no alteration) (Inayatullah, 2008).

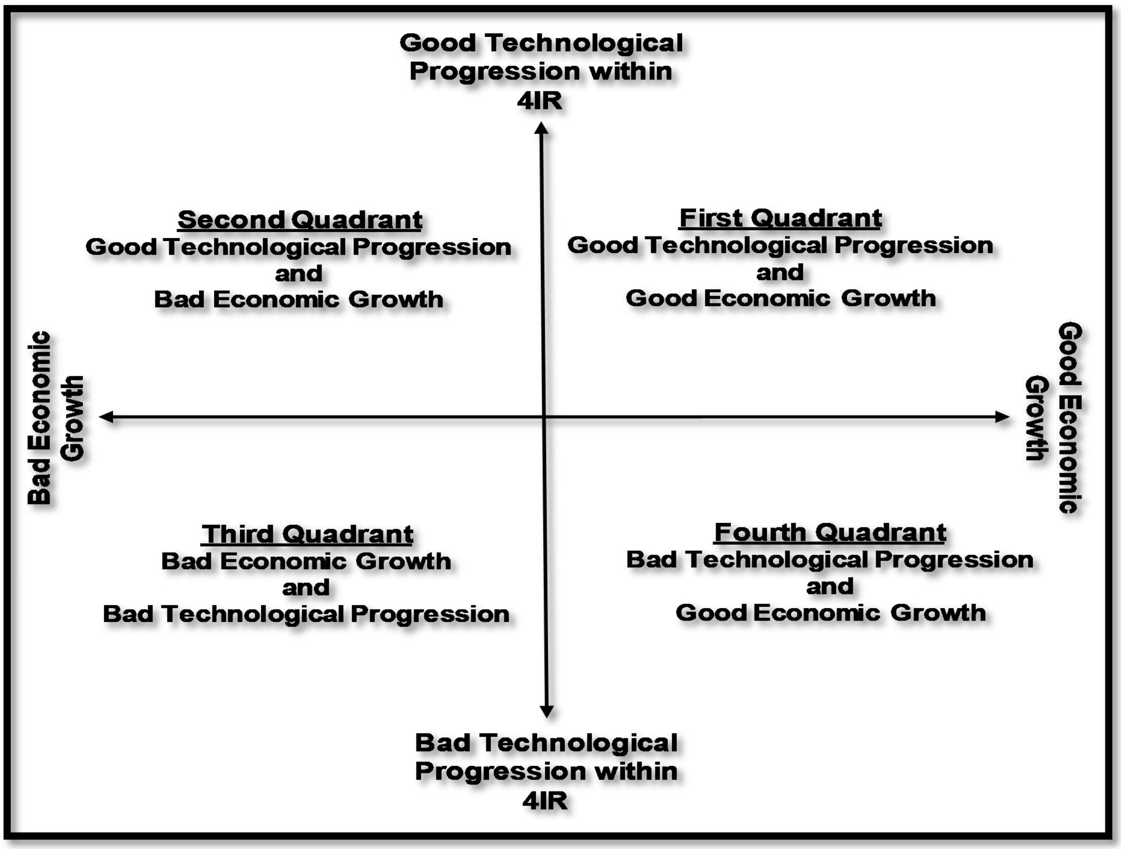
Scenarios conjure up a sense of empowerment and encourage action to create alternative images, thus proposing choice and capacity for change (Inayatullah, 2005). Scenarios are unmatched as a tool of Futures Studies. They unlock the present, direct the spectrum of uncertainty, act as an early warning sign, offer alternatives and, even better, predict the future (Inayatullah, 2008). Scenarios have a tendency to be constructed from the macro environmental viewpoints about what the future is likely to contain.

Scenarios are the instruments of transcendence of futures studies and reveal the present, outline the array of uncertainty, suggest alternatives and enhance prediction. Multiple scenario methods exist, namely; single and double variable, archetypes, organisational and integrated scenarios. The first, or single variable emanates from the futures triangle. Centered on the metaphors or the drivers, a variety of scenarios of the future are formed. The second scenario, the double variable method, identifies the two major uncertainties and cultivates scenarios based on these two major uncertainties, as developed by Galtung (1998).

The key variables of the scenarios are scrutinised by means of a Cartesian coordinate plane, an example of which is illustrated in Figure 2.7 below, and which outlines the possible South African manufacturing industry scenarios impacted upon by the 4IR. The x-axis signifies economic growth and the y-axis signifies technological progression within the 4IR. Consequently, the negative x-axis signifies bad economic growth whereas the positive x-axis signifies good economic growth.

The negative y-axis embodies bad technological progression within the 4IR. However, the positive y-axis embodies good technological progression within the 4IR.

FIGURE 2.7
POSSIBLE SCENARIOS FOR THE MANUFACTURING INDUSTRY



(Source: Researcher's own construction)

Consequently, this research paper constructed the following scenarios:

- The first scenario in the first quadrant highlights that equally the technological progression within 4IR' and 'economic growth' must be good for the scenario to be a success. This is the best-case scenario for South Africa's manufacturing industry.
- The second scenario within the second quadrant, portrays that technological progression within 4IR is good but 'economic growth' is bad. This is an unfavourable and unsuitable scenario for South Africa's manufacturing industry if an investment in technology within the industry does not lead to economic growth for the country as a whole. Good technological progression

within 4IR and bad economic growth are not the ultimate desired or outlier scenario for South Africa's manufacturing industry.

- The third scenario jointly, 'technological progression within 4IR' and 'economic growth' are bad in the third quadrant. This is the worst-case scenario for South Africa's manufacturing industry. Corruption and political superiority triumph in this scenario.
- In the fourth scenario located in the fourth quadrant, 'technological progression within 4IR' is bad, but the 'economic growth' is good. South Africa's manufacturing industry is not in the best state, or it is depicted as 'business as usual' for companies within the manufacturing industry. However, the impact of new technology in future factories is marginal due to a lack of technological progression within the industry.

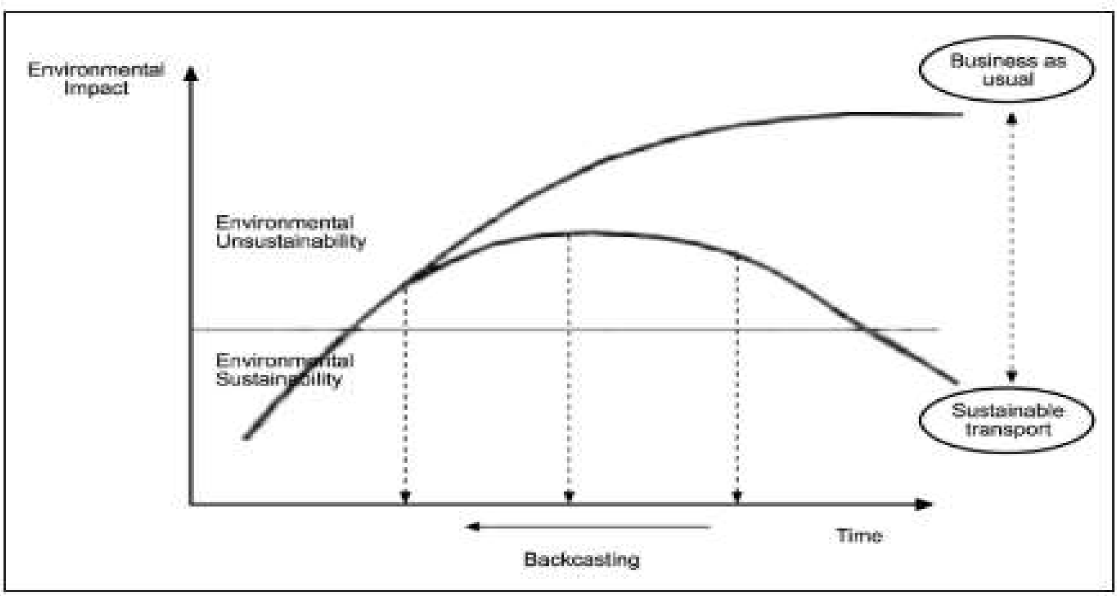
All the scenarios are driven by the present state of affairs of South Africa's manufacturing industry as internationally observed by scholars, academics, and researchers (Adendorff, 2013). Developed by Dator (2002) the third method elucidates these views as archetypes:

- Sustained growth along current lines - where present conditions are improved and technology is considered the answer to every problem.
- Collapse - this future prevails as constant growth fails. The ambiguities are too great.
- Steady state – this future tends to halt growth and finds a balance in the economy and with nature. Community is influential in this future. Steady state is equally 'back to nature' and 'back to the past'. Human values are the first priority. Technology is frequently viewed as the problem.
- Transformation or outlier - these future attempts to change the basic norms between the three. Transformation is a result of either intense technological change with artificial intelligence replacing the workforce, as an example, or as a result of bureaucracy and many practices of governance. Genetics altering nature is another example and is concluded through spiritual change (i.e. humans modifying their consciousness and affecting not only values, but the understanding of deep divine existence).

2.6.5 Transforming the future

The final pillar is transformation. The desired future can progress from scenarios. The future can be narrowed toward the preferred through a process of questioning. For example, what will future smart factories look like? How will machine learning affect the human element? Through which technological platform will machine learning be implemented? The preferred future can also be shaped through a process of creative visualisation (Inayatullah, 2008). Backcasting is an added future-transforming process which unites the vision to the present day in terms of time and space. Backcasting is valuable for pointing out key milestones and indicators that assist in outlining manageable amounts of time and events that collectively contribute to the achievement of the vision (Gould, 2008; Inayatullah, 2008). The vision can be backcasted as depicted in Figure 2.8 below. Backcasting completes the gap between the future and the past, thus enabling the future to be more attainable. The required steps to attain the preferred future can then be endorsed, either through the implementation of a plan or action learning steps where a development of experimentation commences to create the desired future. Backcasting, furthermore, can be utilised to evade the worst-case scenario. As soon as the steps which resulted in the worst case scenario are established, then strategies to evade that scenario can be adopted (Inayatullah, 2008).

FIGURE 2.8
THE FUTURES WHEEL



(Source: Inayatullah, 2008)

2.7 CONCLUSION

This chapter has outlined the research design and methodology to be followed in this research to generate a successful outcome. This includes narrowing down the impact of the 4IR on the manufacturing industry within South Africa and the country's preferred future, grounded in alternative plausible scenarios that will be obtained. The research process has five stages; a review of suitable literature, knowledge creation, foresight, value creation and reflection. The chapter to follow presents a summary of the accessible literature and reviews the trends and disruptive technologies that comprise the 4IR. It outlines smart production in future factories and the readiness of the South African manufacturing factories for the 4IR.

CHAPTER 3

LITERATURE REVIEW

3.1 INTRODUCTION

The previous chapter on the research methodology, expanded in detail on the methodology that this research study followed. The previous chapter also discussed Inayatullah's 6 pillars for future studies research process, which will be adopted in this research study. This chapter presents a comprehensive literature review on the South African's manufacturing industry's readiness to incorporate smart production into future factories and factors that are likely to affect its possible futures.

The methodological paradigm of this academic research treatise is based on a framework that guides how research should be conducted, based on people's philosophies and their assumptions about the world and the nature of knowledge such as positivism, interpretivism, critical theory, modernist and post-modernist. Qualitative research according to Collis and Hussey (2014) is more subjective and humanistic as the researcher interacts with what is being researched. This research study is located in the interpretivist research paradigm which follows a qualitative research methodology. The Interpretivistic paradigm assumes that the world is socially constructed, subjective and research is part of what is observed in the form of case studies and follows the inductive approach for theory building by means of qualitative data.

3.2 THE FOURTH INDUSTRIAL REVOLUTION

The term 'industrial revolution' is used to refer to the transformation of the social and technological economic systems in industry, focusing in particular on changes in living conditions, circumstances of work and economic wealth (Dombrowski & Wagner, 2014). The first industrial revolution mechanised production, the second industrial revolution utilised electric power for mass manufacturing and the third industrial revolution used information technology to automate production while the fourth industrial revolution will distort the lines between the digital, the physical and the biological realms (Falcioni, 2016). While the earlier industry revolutions were influenced by swift developments in connectivity and automation, beginning with the technologies that launched the first Industrial Revolution in eighteenth century England, through to the exponential increases in the computing power of modern times, the 4IR is similarly driven by the same two forces of automation and connectivity (Baweja, Donovan, Haefele, Siddiqi & Smiles, 2016).

Manufacturing is the operation of converting raw materials into finished products by using manual or mechanised transformational methods (Wuest, 2015). The manufacturing industry has undergone vast technological leaps since the commencement of industrialisation. This has led to fundamental changes in manufacturing and is today known as the industrial revolution (Lasi, Kemper, Fettke, Feld & Hoffman, 2014; Qin, Liu, & Grosvenor, 2016). The 4IR embraces a paradigm shift from mechanical manufacturing toward an intelligent manufacturing concept. The physical and virtual world's expansion, includes machines that are equipped with sensors and actuators. Intelligent manufacturing execution will utilise concepts such as the Internet of Things (IoT) to simplify this change (Thoben, Wiesner, & Wuest, 2017). The first industrial revolution in the 18th century, altered the manufacturing environment by consuming water and steam-power to mechanise manufacturing. In the 20th century, the second industrial revolution, presented electrical power to permit mass production (Bartodziej, 2015). Factory mechanisation enabled mass production, to warrant that consumers' demands for improved products were met (Kumar, et al, 2005). In order to overcome the disadvantages of cost and quality problems, the third revolution, in the 1970s, used electronics and information technology (IT) to systematise production (Möller, 2016). Each revolution greatly enhanced productivity and promoted economic development. The conservative manufacturing approach concentrates on increasing outputs and productivity by producing standardised products, economically and plentifully with indifference to the variation in customer needs (Brettel, Friederichsen, Keller, & Rosenberg, 2014). This approach emphasises the role of the product above the role of the customer. However, over time, this strategy advanced to include market demand, therefore permitting organisations to build their strategies on either customised product to serve particular customers or production efficiency and standardisation (Bartodziej, 2015).

To enable advancement in operational capabilities in factories, organisations continuously implement technological advances, fluctuating from radio-frequency identification (RFID) to lean and agile manufacturing practices (Hallgren & Olhager, 2009; Schumacher, Erol & Sihn, 2016). These advances have led to extraordinary but secluded gains in product quality and process efficiency (Schumacher, et al., 2016). Additionally, businesses are undergoing new challenges such as globalisation, cost pressure, product evolution, consumer demands and scarce resources (Weyer, Schmitt, Ohmer & Gorecky, 2015).

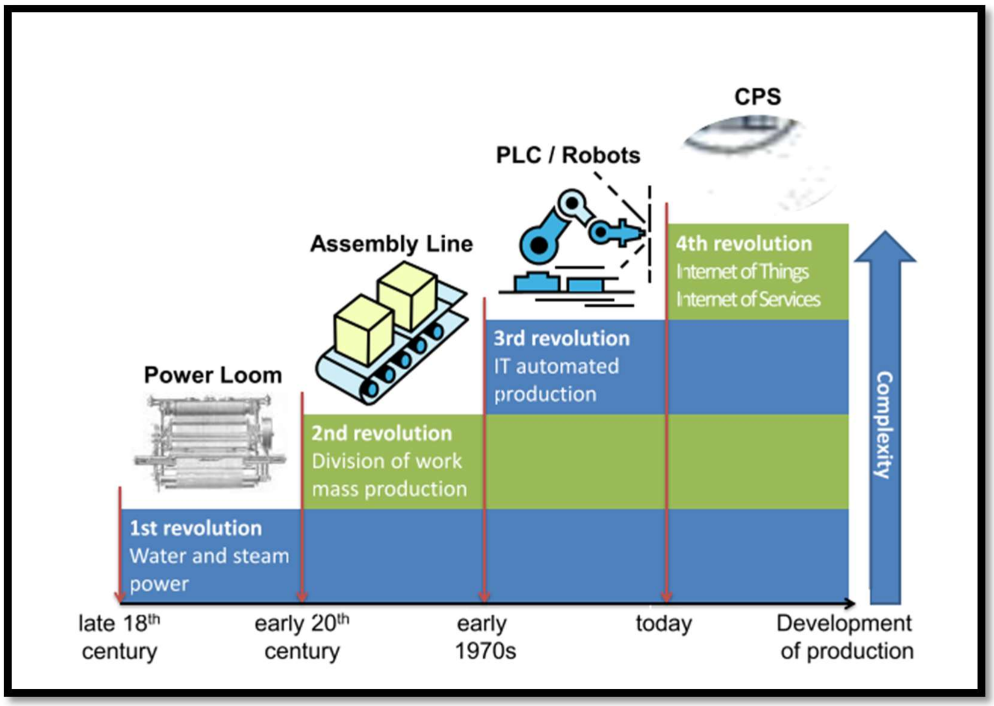
In an effort to overcome these new challenges and reinforce the competitiveness of the manufacturing industry, the 4IR (Bartodziej, 2015). The 4IR, also known as 'Industry 4.0' (named 'Industrie 4.0' in German), is a high-tech strategic initiative introduced by the German government. This initiative was developed in an effort to advance and sustain the global competitiveness of the German industrial sector (Smit, et al, 2016). The basis of the 4IR is focused on the introduction of the Internet of things (IoT) and servitisation models into manufacturing businesses, resulting in vertically and horizontally assimilated systems of production with the resultant effect being smart factories which are able to meet diverse customer demands with high variability in lot sizes which are small, while assimilating human resourcefulness and automation.

To assist the manufacturing industry in this transformation process and encourage global competitiveness, policy makers in quite a few countries have reputable research and technology transfer structures. Germany has endorsed its Industrie 4.0 initiative, which is progressively impacting upon European policy, whereas the United States concentrates on smart manufacturing. Many industrial countries have developed their own smart production programmes, such as Japan and Korea. This is evidence that intelligence in manufacturing processes is turning out to be a vital topic for researchers and industries globally. The main purpose of these undertakings is the introduction of cyber-physical systems (CPS) i.e. physical objects (e.g., machines, vehicles, and work processes) which are enabled with technologies such as RFIDs, sensors, microprocessors, telematics or comprehensive embedded systems.

These systems are regarded as by being able to accumulate data, process and assess the data, associate and communicate with other systems and launch desired actions. Additionally, CPS has permitted new services that can substitute conservative business models centered exclusively on product sales (Thoben et al., 2017).

FIGURE 3.1

FOUR INDUSTRIAL REVOLUTIONS



(Source: Thoben et al., 2017)

As demonstrated in Figure 3.1, the intricacy in production has amplified with each progressive industrial revolution. Vigorous socio-technical structures have transpired, and have impacted on an increasing number of tangible, intangible, as well as human factors. This intricacy has to be facilitated by applicable systems and tools. In addition, the collaboration between mankind and machines requires the right interfaces and theories to be effective and secure. Industry 4.0 and smart production's purpose is to improve and deliver suitable models, methods, and tools for manufacturing organisations and to create a prototype which can be used as an exemplary model for other manufacturing organisations wishing to advance in this direction of a becoming a smart factory (Thoben et al., 2017).

Industry 4.0 emphasise the concept of smart products, procedures and processes, which result in the smart factory paradigm (Kagermann, et al, 2013; Möller, 2016). A smart factory is the vertical amalgamation of processes, physical hardware (e.g. sensors and actuators) and IT systems at different graded levels of the organisation (Kagermann, et al., 2013; Möller, 2016). Thoben, et al. (2017, p. 6) define it as, "a data-intensive application of information technology at the shop floor level and above to enable intelligent, efficient and responsive operations". Industry 4.0 is a synonym for the conversion of traditional factories into smart factories (Weyer, et al., 2015).

3.2.1 The Fourth Industrial Revolution and Africa

The African continent has for many years been behind in the adoption of new technology thus resulting in the continent taking on the role of spectator instead of leader in this field, due to its history of oppression that has caused this predicament. China is one of the prominent nations concerning technology globally and they have been financing several African countries. This is viewed by analysts as a strategy that China is utilising to recolonise Africa. This implores the question relating to what the African continent would be viewed as with its own technological innovations (Viëtor, 2014).

3.2.2 Shaping Africa for the Fourth Industrial Revolution

African leaders today have to be careful when it comes to working with other nations in the wake of this new industrial revolution, so that it may work to Africa's advantage, since Africans are now exposed to technological information and education which they were deprived of during the past industrial revolutions. To achieve this, African leaders must give more attention and invest more in technologies and innovations in Africa. An example of such technology is the introduction of a robot called 'Libby' which was installed at the library of the Pretoria University in South Africa and used to assist students in locating textbooks or retrieving content. The robot might be viewed as replacing humans in performing this particular function. The benefit is that with such a robot and with the possibility of manufacturing it locally, this might give rise to creating new jobs in the manufacturing industry.

The process of depending on primarily, locally manufactured innovations will be the start of Africa's self-reliance, which is one of the Pan-Africanist philosophy's significant objectives. The downfall of having a dependency on foreign manufacturers of robotics lies in the possibility that something might influence the relationship between countries and this would have a negative impact on the supply. An example of this is the relationship challenges between America and China regarding the Huawei debacle which resulted in a trade war between the two countries and which might impact upon everyday activities of consumers as the trade war grows (Viëtor, 2014).

3.2.3 Decolonising technology

African leaders must pay more to monitor the situation and they should invest more funds in local innovators who developed new technologies significant for the 4IR. The focus on Universities gaining momentum is seen in the example of the University of Johannesburg which began introducing new technology into its curriculum and has thus positioned 4IR technology at the centre of education. This innovative methodology forms part of an extensive history of requests for the decolonisation of knowledge from the African continent. Self-reliant economies are a solution to many of Africa's challenges and can also be attained through a different approach of using the 4IR to drive African economies into an improved state.

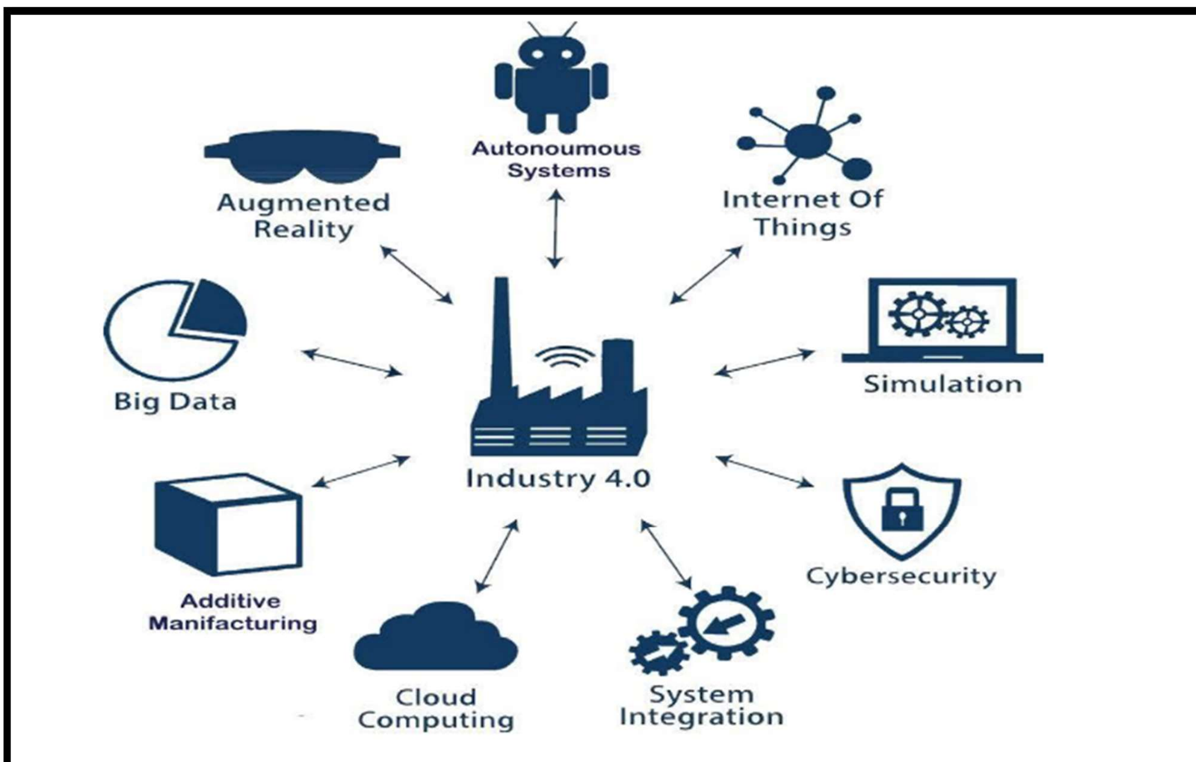
Centres such as the Innovation Hub in South Africa are intended to support innovation amongst the youth, however, such developments have unfortunately been at a very slow pace and with limited funding. These centres primarily cover the funding required to trial an idea, but there are no initiatives to support the innovators' personal expenditures. In reality, personal expenses are of great significance in poorer states where the majority of the youth is not able to support themselves financially. Technology has the potential to enhance the living conditions of the populace of certain poverty-stricken countries in the long run. Thus, the afore-mentioned approach to the introduction of technology is short-sighted. In technology prominent countries such as China, it takes less time to move an invention from idea stage to commercialisation stage, whereas in Africa this process is much longer and might result in innovators giving up on their initial idea.

African governments must provide more assistance to innovators to propel the continent forward towards being a player in the 4IR sphere. The 4IR is rapidly expanding in comparison with previous industrial revolutions and thus Africa will be left behind the global players if it does not act swiftly (Viëtor, 2014).

3.3 GLOBAL TRENDS IN TECHNOLOGY IMPACTING UPON THE MANUFACTURING INDUSTRY

The future shape of the 4IR signifies a globally interrelated world defined by the complete digitisation of economic and manufacturing processes. It necessitates horizontal amalgamation at each phase of the manufacturing process, cooperating with the machines which communicate in sync. The Boston Consulting Group has recognised the vital base of the 4IR by identifying nine technological pillars as depicted in Figure 3.2 below.

FIGURE 3.2
PILLARS OF INDUSTRY 4.0



(Source : Benotsmane, Dudás, & Kovács, 2018)

3.3.1 Autonomous Systems

A robotic system, comprises sensors, actuators and a regulator and is equipped for carrying out tasks repetitively and is designed to be functional in the industrial sphere. Autonomous systems contribute to a broad array of services and result in flexible and cooperative systems. Autonomous systems takes two forms, namely:

- A multi-agent system is characterised as a system encompassing numerous agents that cooperate together. “An agent is a computer method situated in a progressive setting such as in robots or in intelligent machines and skilled to execute independent or intelligent actions, using tools and systems of artificial intelligence”.
- An intelligent industrial robot is a valuable amalgamation of a “manipulator arm, sensors and intelligent controllers”, which substitutes a labourer and can finish proceedings and equipped for resolution of problems. Machine learning can enhance productivity, quality of products, generating smart manufacturing (Benotsmane, Dudás, & Kovács, 2018).

3.3.2 Industrial Internet of Things (IoT)

The industrial internet of things is the capability of machines to exert control and work together with other systems. This system accumulates and distributes a vast amount of data which facilitates the exchange of information between systems in a network. The collated information is directed to a cloud- centered service where it is integrated with other data and then shared with users in a valuable manner (Benotsmane, et al, 2018).

3.3.3 3D Simulation Tool

This process is a method for implementing real-time information to examine the physical world in a virtual environment that will take account of machines, products and human beings.

The aim of this process is to effectively increase productivity through enabling scenario systems and utilise resources optimally, thus resulting in waste reduction and quality improvement (Benotsmane et al., 2018).

3.3.4 Cybersecurity

The sharing of information and big data through the implementation of the IoT platform and the resultant impact on Industry 4.0, thus requires the data to be protected and secure. Therefore, cyber security emerges. It comprises of “technologies, processes and controls that are designed to safeguard systems, networks and data from cyber-attacks” (Benotsmane et al., 2018).

3.3.5 Horizontal and Vertical Systems Integration

When proceeding to construct a smart factory which adapts to the requirements of Industry 4.0, it is vital to implement particular technology which administers the integration of horizontal and vertical system constructs as outlined as follows (Benotsmane et al., 2018) :

- Vertical integration of system elements aims to optimise the reconfiguration of production processes by connecting all Cyber-Physical Systems (sensors, actuators, etc.) with the various production management tools (planning, inventory, etc.) which allows as easy reconfiguring of the production process according to customer demand.
- Horizontal integration of system elements aims to optimise the product in the supply chain by connecting all the elements of the production chain (suppliers, customers, service providers, etc.), beyond the scope of the company. It also concerns the organisational problem.

3.3.6 Cloud Computing

Cloud computing is an analogy for the Internet which roughly translates to storing and retrieving data over the Internet as an alternative to a computer's memory.

Industry can gain access to insurmountable computer power as offered by the cloud. Information is safeguarded whilst being transferred and storage takes place through the use of encryption and collaboration to enable the analysis and storage of big data in the 4IR. The cloud permits all machines, wherever they are stationed, to synchronise the activities and work on joint information and applications concurrently in real time (Benotsmane et al., 2018).

3.3.7 Additive manufacturing / 3D Printing

Additive manufacturing is generally utilised in the industrial sector, founded on the production of a piece of work used in manufacturing and identified as 3D printing. It progresses past the boundaries of customary manufacturing and comprises of the probability of manufacturing of quantities of more multifaceted components, unattainable by alternative techniques, thus broadening the possibilities for it to be innovative. During the implementation of 4IR, 3D printing technology is selected for its extraordinary ability for manufacturing small consignments of tailored products (Benotsmane et al., 2018).

3.3.8 Augmented / Virtual Reality

Augmented reality (AR) operates by converting the real setting to a virtual model. Virtual reality results scrutinise imageries or sense motion and compare everything with data from numerous sensors. As a result of this technology, the worker can control the whole process and can sense the irregularity in crisis situations. Virtual reality can be utilised in the smart factories for a multitude of applications. The applications that are most prominent and which are regularly cited in the literature are in the arena of job learning, training and skills development (Gavish et al., 2013; Janssen, Tummal, Richert & Isenhardt, 2016; Kovar et al., 2016; Peniche, Diaz, trefftz & Paramo 2012; Turner, Hutabarat, Oyekan & Tiwari, 2016). Virtual reality will generate a safe, simulated and fully-immersive learning atmosphere where the risk of injuring man or machine is reduced, thus leading to more efficient training. Furthermore, it could also be utilised with, or in unification or as a replacement for, some of the applications highlighted under the AI section.

This technology also takes the need for physical existence away as operators can accomplish their tasks away from where the physical operation happens. This technology can thus aid as a vital link between the physical and virtual world in the cyber-physical system (Thoben et al., 2017).

3.3.9 Artificial Intelligence

Artificial Intelligence (AI) is a division of engineering and science that deals with the construction machine intelligence. It assists in to discovering solutions to difficult problems more humanely, and normally comprises of assimilating features from human intellect, and implementing algorithms to configure them so as to simulate the human intelligence processes by each machine (Benotsmane et al., 2018).

AI and machine learning (ML) have now extended to the point where they can advance or augment virtually every technologically-enabled service, object, or application and they embrace technologies such as deep learning, neural networks and natural language processing (Panetta, 2016). AI technologies could be rooted in various products and machines (Wan et al, 2016), sensors (Deloitte, 2015) and robots (Rosenberg, Haeusler, Araullo, & Gardner, 2015) in the smart factory, thus not only allowing them to calculate, communicate and control but also to provide them with independence and sociality (Wan et al., 2016). This suggests that machines or robots could program themselves and learn independently, thus empowering them to determine or find the best solution to problems centered on first principles (Schwab, 2016). This evolution in autonomy will speed up the individualisation and flexibility that are required by the 4IR (Deloitte, 2015).

AI embraces remarkable benefits for humankind, but it is not universally accepted by humanity with various renowned public figures such as Steven Hawking, Elon Musk, Bill Gates and Steve Wozniak cautioning of the possible adverse repercussions that this technology might hold and proposing that humans will be redundant (Cellan-Jones, 2016). Within the framework of the 4IR people are irreplaceable (Leitao, Maly & Sedlacek, 2016) and AI would not entirely be a substitute for humans, but rather that this technology would be utilised to improve the competences of humans on the shop floor (Thoben et al., 2017).

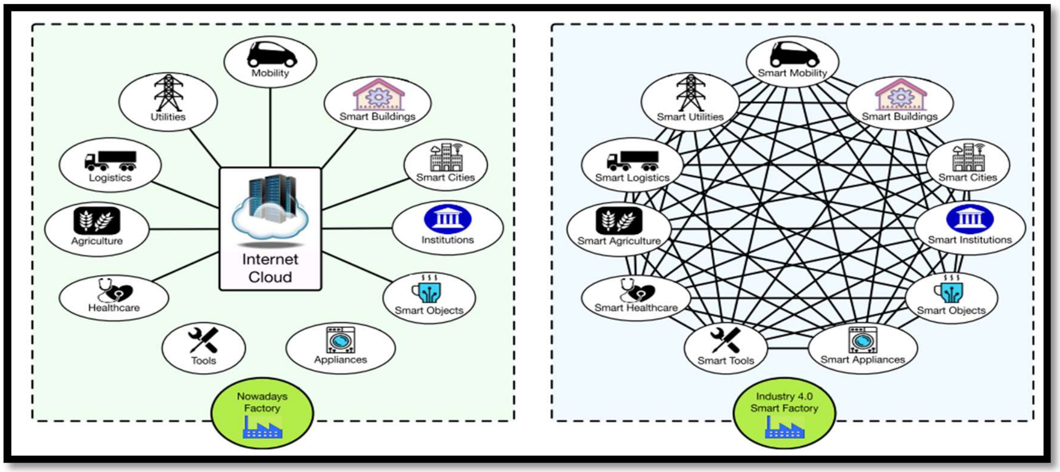
3.3.10 Collaborating Robots (Co-bots)

Recently collaborative robots or 'co-bots' has been the vocal point in many manufacturing industries due their ability to work alongside humans as opposed to replacing them entirely. The collaborative nature of these robots assists operators on the line to do their work efficiently, therefore decreasing potential health problems caused by the manual labour, for example, lifting heavy equipment on an assembly line. This technology is sought after by many manufacturing organisations due to the cost saving of capital expenditure on the traditional caged robots which work in isolation and are pre-programmed to perform only limited functions. Furthermore the transportability and capability to operate in a reconfigurable layout renders co-bots, the best choice for progressive organisations who requires flexibility in assembly lines in order to fit in with their customer preferences (Djuric, Urbanic, & Rickli, 2016). Progressively, developments in AI, machine learning and regular user interfaces are permitting the automation of many workers' duties which for have long been regarded as too challenging or unrealistic for machines to perform (Manyika, Chui, Bughin, Dobbs, Bisson & Marrs, 2013). Additionally, as the competences of machines continues to progress, enabling them to detect faces, convert speech in real time, learn and process language, AI's capability to impersonate human actions and roles will magnify (Stuart, Currie, Goodman, Ives & Scott, 2015). Extreme automation via AI will increasingly automate some of the capabilities previously only possessed by humans (Baweja et al., 2016).

3.4 BLOCKCHAIN

The digital revolution is shaping profound, new methodologies that alter the way in which organisations and people engage and collaborate (Institute for the future, 2017). One such profound new technology to be implemented in industrial locations is 'blockchain', which was invented from the Bitcoin cryptocurrency and allows for the producing of decentralised applications (DApps) capable to tracking and collating transactions executed by a vast number of concurrent users and devices (Fernandez-Carames & Fraga-Lamas, 2019).

FIGURE 3.3
EVOLUTION OF THE COMMUNICATIONS ARCHITECTURE: FROM MODERN FACTORY TO AN INDUSTRY 4.0 SMART FACTORY.



(Source : Fernandez-Carames & Fraga-Lamas, 2019)

The purpose of blockchain is to provide a high-degree of connectivity. The 4IR model recommends the utilisation of relevant disruptive technologies that allow autonomous infrastructures among multiple industrial platforms distributed through a factory and on the web. Such enabling technologies include: 3D printing, Augmented Reality (AR) or Virtual Reality (VR), Industrial Cyber-Physical Systems (ICPS) and the Internet of Things (IoT). The 4IR model adopts the implementation of such technologies to facilitate the evolution of the factory communications design from current cloud or internet service-aligned architectures, to architectures which incorporate all the segments involved in the industrial developments in the interchange of information such as in a Peer-to-Peer (P2P) network as outlined in Figure. 3.3.

3.4.1 Smart Contracts for Industry 4.0 Factories

Blockchain can assist in the automation of industrial procedures that involve multiple corporations, thus it is imperative to describe the concept of ‘smart contract’ which is a computer program that executes agreements established between at least two parties, causing certain actions to happen when a series of specific conditions are met. Therefore, when such formerly encoded situations occur, the smart contract spontaneously executes the parallel clause.

Thus, the encryption may decode into legal terms, outlining the switch over to physical or digital entities through an executable platform. Smart contract circumstances are founded on information that relies on external services that take information from the real world and store it in the blockchain (Fernandez-Carames & Fraga-Lamas, 2019).

These services are referred to as ‘oracles’. An oracle could examine registers to recognise whether an asset has reached its destination and it might write the arrival data on the blockchain. Thereafter, the smart contract might activate a provisional statement centered on the delivered value and perform a block of code. The type of information collated determines the type of oracles required, for example, software, hardware, inbound and outbound and consensus-based oracles (Fernandez-Carames & Fraga-Lamas, 2019) :

- Software oracles manage the accessible online data, for example, the temperature of a warehoused product, the purchased price of parts or the tracking of the location of trucks associated with logistical procedures. Information originates predominantly from internet sources and is collated by the software oracle, which extrapolates the necessary information and drives it into the smart contract.
- Hardware oracles are designed to extract information directly from the real world, for example, RFID sensors are a likely source.
- Inbound oracles include data from the external world into the block chain. Subsequently, the outbound oracles permit smart contracts to transmit data to the external world (for example, when parts are established to have been received acceptably, payment can be released automatically).
- Consensus-based oracles link diverse oracles to conclude the conclusion of an event.

The 4IR technologies can profit from the utilisation of blockchain to address the four leading obstacles currently encountered throughout the deployment of networks.
A 4IR factory must deploy networks to enable connectivity to vertically smart production systems. A vertical connection within a smart factory, connects two entities that are actively involved in a product’s lifecycle.

Thus, once such connectivity becomes automatic, data can be collated and transmitted automatically from the numerous systems deployed in a production facility to any of the appropriate segments of the value chain (for example, to the design group or to manufacturing line workers).

A blockchain can support vertical integration by supplying a collective and reliable data or money interchange point through which the several smart factory units may work together. Horizontal integration is also required for 4IR technologies, which suggests that manufacturers, suppliers and customers must work in sync and this requires the distribution of low-latency and adaptable communication networks, to enable smart contracts and the blockchain to develop the horizontal integration mechanisms for the units involved in 4IR processes to execute economic or simple information relations. Additionally, integration amongst customers and organisations can be attained primarily through the utilisation of IoT devices (for example, smart cars and smart machinery) and social systems, with secure connectivity, to enable interaction through a blockchain.

Smart factories, furthermore, need to incorporate the design and engineering phases all the way through the value chain. The purpose of this amalgamation is to permit rapid responses to the feedback retained by the various stakeholders partaking in the value chain. 4IR adopts the application of an array of new technologies that alters the manner in which operators work together and with the surrounding environment. Blockchain can be an information exchange center where users only have to execute the applicable blockchain customer capabilities (Fernandez-Carames & Fraga-Lamas, 2019).

3.5 THE AFRICAN ECONOMY

Africa, a rich continent boasting 54 countries and in excess of 2 000 languages, provides an elaborate framework and the analysis presented in this chapter, describes this rich diversity. Although it is definitely not the aim of the researcher to disregard this nuance, the stance in this treatise embarks on a long-term macro view. This approach has weaknesses and strengths.

A crucial strength is its observation of collaboration across key global systems, and countries, and aids in seeing the 'big picture' of change. A fundamental weakness of this kind of illustration is that it is not as considerate of trends at the micro-level (including 'weak-signals') that can eventually have an extensive impact. In the same manner, researchers cannot forecast secluded events, though researchers and decision-makers similarly can consider their consequences (Cilliers, Hughes & Moyer, 2011).

Key shifts are rapidly revolutionising Africa (Cilliers et al., 2011, Gbla & Rugumamu, 2003; Hartmann, 2009). Populations are growing significantly and urbanisation is the trend and economic growth has speedily increased over the past decade. New technologies, for instance solar cells and mobile phones, are broadly distributed throughout the continent (Unwin, 2008). On the broader spectrum, but with vital regional consequences, the rise of India, China and other key evolving countries, is changing Africa's investment and trading patterns (Balakrishna, 2004; Global Economic Outlook, 2011).

There are still important uncertainties facing Africa, namely:

- How fast will Africa bring contagious diseases under control and improve the education of its population?
- Is Africa able to expand its economies and afford employment for its emergent population in industries such as services and manufacturing, and additionally, efficiently manage the wealth created by its raw materials?
- Will climate change contribute to the pressures on agriculture or will Africa have its own green revolution?
- How will Africa build the extensive infrastructures that it desperately requires?
- What will be the value of Africa's governance?
- How will stakeholders, both organisations and governments, approach and influence Africa? (Cilliers et al., 2011; Desker, Herbst, Mills & Spicer, 2008; Forje, 2005).

It is claimed that Africans share related goals and search for viable and extensive human development (Gbla & Rugumamu, 2003). Africans attempt to reduce conflict and have an all-encompassing acceptance of, and even support for, diversity (Cilliers et al., 2011). Africans yearn to see human rights valued everywhere (Sripati, 2005). As Africans pursue their goals within the framework of great uncertainty and fast change, Africans require insight into the pathway that Africa is on and where that path will lead Africans and additionally, they need insight into the liberty that African choices afford its people (Gbla & Rugumamu, 2003; Gopal & Tyler, 2010; Hartmann, 2009).

South Africa, has been recognised as one of the most stable economies on the African continent (HSBC, 2011). South Africa has proved to be the economic giant of Africa and in addition is a prominent producer of minerals and the country boasts the highest industrial output on the African continent. Most importantly, it has been accountable for the generation of a very large amount of the continent's electricity (Essel, 2012). South Africa is located on the African continent; however, this has some very unfortunate consequences for the country. The continent has been viewed as very precarious due to uncertainty over potential policy difficulties, persistent reorganisation and political and civil unrest (Essel, 2012; Pekeur, 2003). Political risk issues in African countries predominantly have been exaggerated (Control Risks, 2007). Conversely, foreign investors also usually associate business in Africa with corruption (Zaayman, 2003), but this is not a matter related to African countries only (Essel, 2012).

The South African economy presents two contradictory sides:

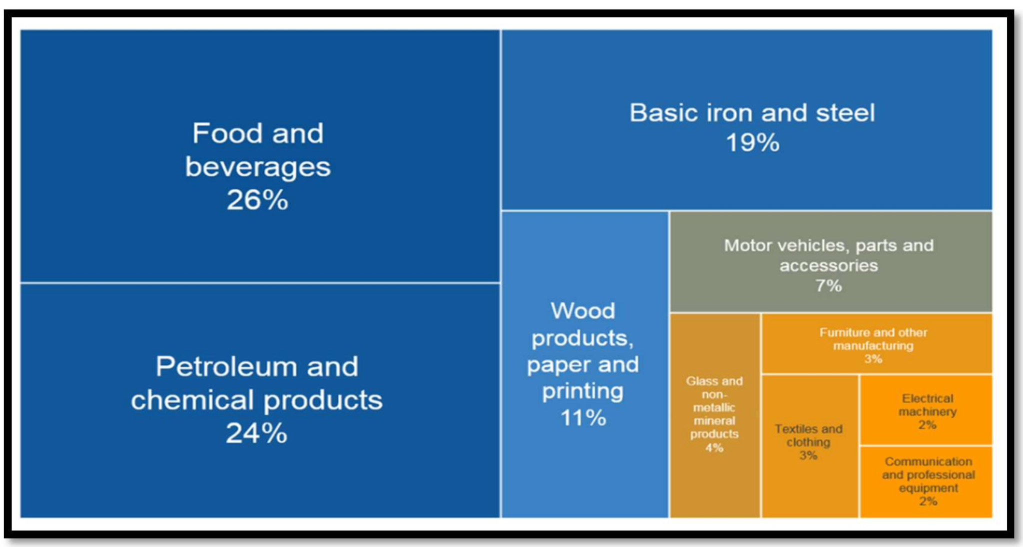
- It competes with developed countries through its established mining, agricultural, manufacturing, and services industries.
- It has challenges with its infrastructure and has presented features of a developing country. Legacy infrastructure has significantly inhibited the country's economic growth (Bureau of African Affairs, 2010; Essel, 2012; Central Intelligence Agency, 2010).

South Africa is consequently a middle-income country experiencing a number of complex economic difficulties (Economy Watch, 2012). Inequality has been a huge concern for the country as the gap between the rich and poor is the largest compared to the rest of the world (British Broadcasting Corporation, 2011). The country is plagued by high unemployment which is the primary cause of poverty and could impact upon social stability and cause violent conflict against the government (Essel, 2012). Economic inequality and unemployment, coupled with dissatisfaction concerning low wages and poor government performance, possibly account for the majority of the strikes and uprisings in the country. Added socio-economic difficulties include a high crime rate and HIV infection rate (Bureau of African Affairs, 2010; Haldenwang, 2011; Venter, 2005; Zaayman, 2003). While the aforesaid factors are not under control, South Africa's economic growth will remain unstable (Essel, 2012).

3.6 THE SOUTH AFRICAN MANUFACTURING INDUSTRY

The manufacturing industry is South Africa's fourth major industry, contributing 14% to the gross domestic product (GDP). Figure. 3.4 below, offers a summary of the leading sectors within the South African manufacturing industry.

FIGURE 3.4
PERCENTAGE CONTRIBUTION TO TOTAL MANUFACTURING VALUE ADDED

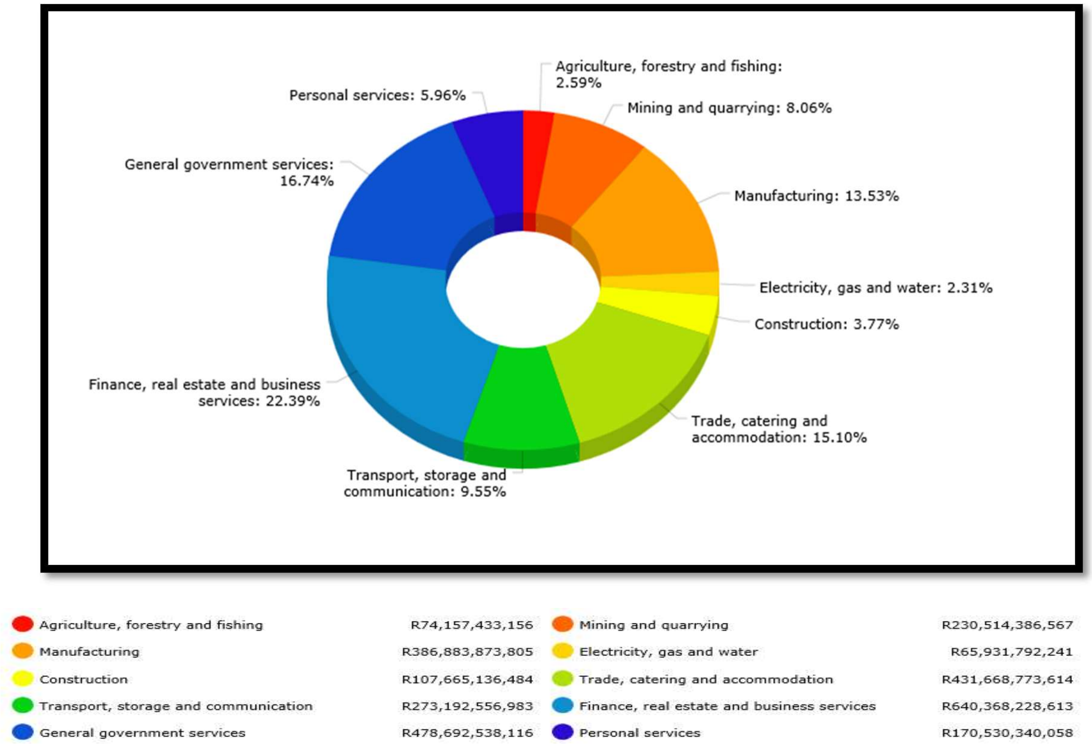


(Source:www.southafricanmi.com, 2019)

Food and beverages are the most significant contributor to South Africa's manufacturing industry, diligently tracked by the petroleum and chemical products sector while third place is occupied by the basic iron and steel sector. In total these three sectors contribute close to 70% of total manufacturing output in South Africa (Southafricanmi.com, 2019). Figure 3.5 below demonstrates the total value of each industry and its inclusive input in the total economic value of South Africa in the year 2018 and depicts that the manufacturing industry is the fourth leading industry in South Africa. Sectors are categorised from largest to smallest contribution:

- Finance, real estate and business services: R 640 368 228 613 (22.39%).
- General government services: R 478 692 538 116 (16.74%).
- Trade, catering and accommodation: R 431 668 773 614 (15.10%).
- **Manufacturing: R 386 883 873 805 (13.53%)**.
- Transport, storage and communication: R 273 192 556 983 (9.55%).
- Mining and quarrying: R 230 514 386 567 (8.06%).
- Personal services: R 170 530 340 058 (5.96%).
- Construction: R 107 665 136 484 (3.77%).
- Agriculture, forestry and fishing: R 74 157 433 156 (2.59%).
- Electricity, gas and water: R 65 931 792 241 (2.31%)
  (www.southafricanmi.com, 2019)

FIGURE 3.5
RELATIVE CONTRIBUTION OF THE VARIOUS INDUSTRIES TO SOUTH AFRICA'S GDP



(Source: www.southafricanmi.com, 2019)

The manufacturing industry during the month of June 2019, had sales amounting to R203.7 billion in comparison to South Africa's total imports of R103.7 billion, therefore, the manufacturing to total imports ratio is at present (1.97) equating to R1 in goods manufactured locally to 50.7c in imported products (Southafricanmi.com, 2019).

Table 3.1 below presents the manufacturing sales for South African industry for the period June of 2019 through to June of 2019.

TABLE 3.1
SOUTH AFRICAN MANUFACTURING SALES OVER THE LAST YEAR

Month	Sales values	Year on year growth
Jun-18:	R 191 557 184 000	6.11%
Jul-18:	R 196 460 817 000	9.18%
Aug-18:	R 196 356 816 000	7.64%
Sep-18:	R 201 095 627 000	10.74%
Oct-18:	R 202 552 057 000	11.27%
Nov-18:	R 201 153 730 000	4.89%
Dec-18:	R 197 406 269 000	5.31%
Jan-19:	R 201 519 371 000	9.17%
Feb-19:	R 199 006 001 000	5.99%
Mar-19:	R 201 339 607 000	7.30%
Apr-19:	R 206 869 442 000	15.21%
May-19:	R 200 463 705 000	3.92%
Jun-19:	R 203 734 151 000	6.36%

(Source: www.southafricanmi.com, 2019)

3.6.1 The South African automotive industry

The automotive industry is an active player in the manufacturing sector in South Africa, and thus is part of the backbone of the national manufacturing hub and contributes 6.8% of GDP (4.3% manufacturing and 2.5% retail). South Africa upgraded its international ranking to 22nd (24th in 2014) in the world with a manufacturing market share of 0.68%. The automotive industry consequently provided a progressively significant strategic and catalytic part in the general South African economy by directly influencing many important economic policy objectives, such as the impact on GDP, employment, skills growth, economic interrelationships, technology advancements and innovation, and it contributes substantially to the fiscal policy through statutory taxes and extensive foreign direct investment. The value of exports to the North American Free Trade Agreement (NAFTA) has experienced a deterioration from $1.66 billion in 2017 to $836 million.

The cause for the decline in exports is predominantly ascribed to the decline in automobile exports to the U.S. in 2018. Automobile exports to the U.S. in 2018, at 11 440 vehicles, decreased by 28 974 from the 40 414 vehicles exported in 2017.

The overall automotive revenue of the automotive industry in South Africa resulted to $38.1 billion in 2018 compared to $37.57 in 2017. Exports of automotive products in 2018 represented $13.52 billion, amounting to 14.3% of total South African exports. As the leading manufacturing segment in the nation’s economy, vehicle and component production contributed 29, 9% of South Africa’s manufacturing output in 2018 (Brand South Africa, 2019). Additionally, investments by the key seven original equipment manufacturers (OEMs) in the state resulted to a further $545 million in 2018, including the investment of $265 million by the automotive component suppliers (Brand South Africa, 2019).

The South African automotive sector is geographically divided into two segments. The first, located in Gauteng, incorporates three OEMs namely BMW, SA Nissan SA, Ford Motor Company of Southern Africa as well as a further 200 automotive component suppliers. The second, located in the Eastern Cape, includes Volkswagen Group SA, Mercedes-Benz SA, Isuzu as well as the engine plant of the Ford Motor Company of Southern Africa. Additionally, there are 150 automotive component manufacturers situated in the Eastern Cape. Apart from these two segments, Toyota, as well as 80 automotive components manufacturers, are located in KwaZulu-Natal (Automotive Industry Export Council, 2017).

The international automotive sector dedicates in excess of $100 billion globally to research and development per year (Auto Alliance, 2012) and, therefore, it is considered an industry leader in the arena of innovation (Ringel, Taylor & Zablit, 2017) and in the utilisation and development of sophisticated technologies. In addition, within the framework of the Industry 4.0, automotive manufacturers and suppliers are seen as the traditional digitisation leaders (Buhr, 2015). The general assumption is thus that the international automotive industry will be at the forefront of developing, adopting and implementing the technological developments made as a result of Industry 4.0.

As a result of foreign direct investment; mergers and acquisitions or joint venture agreements, international multinational companies now own the majority of the local South African vehicle and component manufacturers. The South African companies will be dependent on, and impacted upon by, the technological progression, and the state-of-the-art plant and equipment provided by international parent companies and will benefit through large investments in gearing local factories towards aligning with the global progression in smart factories, following on the principles of 4IR.

It is predicted that 41% of work activities in South Africa are at risk of being substituted by automation (World Economic Forum, 2017). In comparison to the rest of Sub-Sahara Africa, South Africa has proven to be slightly better equipped to adjust to the disruption resulting from the 4IR, but this disruption is likely to be more abrupt, leaving little time for corrective interventions. A critical concern identified by employers is whether the inadequately skilled workforce will be able to adapt to this radical change. For instance, 39% of essential work-related skills required in South Africa currently will be entirely different in 2020 (World Economic Forum, 2017). It will be imperative to ensure that operators are aligned and equipped to comprehend changes that will be required in the production process, thus the upskilling of workers should take place as a matter of urgency (Deloitte, 2016). Therefore, to produce a future supply of suitably skilled workers, initiatives should be embarked upon which focus on skills such as critical thinking, innovation, cognitive flexibility and emotional intelligence.

Adaptation in the fields of study of science, technology, engineering and mathematics (STEM) and information and communication technology (ICT) will become more critical as the 4IR will accelerate the use of technology and will intensify the collaboration between humankind and machines such as artificial intelligence and robotics (World Economic Forum, 2016).

3.7 CONCLUSION

This chapter delivered a review of literature on the key factors and global trends in technology that are influencing the design and structure of future factories in a South African context as a direct result of the 4IR towards 2030.

The key focus areas involved looking at what changes globally in technology will impact upon local manufacturing organisations such as disruptive technologies with specific reference to artificial intelligence, blockchain, internet of things and adaptive/virtual reality, to name a few that will impact on how future factors will be required to change production processes to incorporate technology in the factories of the future.

The performance of the manufacturing industry was investigated within a South African context with a focus on the automotive industry to measure its contribution to the GDP of South Africa. Based on the above review of literature, it can be noted that although technological advancements are not the only driver of future factories, they have the most detectable and material influence when compared to other factors. For example, robust globalisation is reliant mostly on communication and distribution technology. The job-profiles of operators will have to be aligned to incorporate the use of robotics, for example, the introduction of co-bots to enhance the operators' work processes and skills on the production line and to enable a collaborative work environment with humans and machines. It has been identified through literature that the upskilling of workers would be critical for the incorporation of 4IR principles in smart factories. Thus stakeholders have to ensure that there are appropriate skills transfers to make this transition effective.

Chapter 4 is dedicated to the in-depth application of the 6 Pillars of Futures Studies as the preferred futures methodology adopted in this study.

CHAPTER 4

THE SIX PILLARS OF FUTURES STUDIES

4.1 INTRODUCTION

The previous chapter (Chapter 3) discussed comprehensive literature reviewed on South Africa's manufacturing industry with a focus on the disruptive technology shaping South Africa's future factories. Chapter 3 depicted the current status of South Africa's manufacturing industry and the global trends towards the 4IR. In concluding Chapter 3, it was specified that Chapter 4, would journey on 6 pillars of futures as a methodology to establish possible futures for South Africa's manufacturing industry towards 2030.

This research study follows Inayatullah's six pillars of futures studies approach, which is based on a theory of futures philosophy that is associated with methods and tools that were developed through practice (Inayatullah, 2008). The six pillars are mapping, anticipation, timing, deepening, creating alternatives and transforming (Inayatullah, 2008). An environmental scan (mapping) of the drivers of change and the effect on the manufacturing industry will be executed to reveal the prevailing trends and driving forces influencing the future of the manufacturing industry.

Futures studies have been judged as lacking a conceptual framework or a foresight methodology, but current frameworks have been established with a dynamic theory and practice in the groundwork, embracing Voros' common foresight method framework and the six pillars approach, an offshoot of Dator's Manoa Research Centre for Futures Studies (Inayatullah, 2010a). Foresight can be viewed as the crucial element of success, since in its absence humankind is incapable of preparing and planning for the future. However, despite its vital importance having been proven, foresight is now much more difficult to be achieved as everything in the world is changing and evolving more rapidly than ever before (World Future Society, 2004).

Acquiring an understanding of the uncertainty inherent in the external and future environments and then challenging the strength of any strategic plan compared to a set of possible futures, are critical components of long-term and strategic planning. Any level of uncertainty must be assessed prudently before any organisational, conclusions, (whether private or public sector) can be derived (Du Plessis, 2016). The future is unspoilt, hopeful and full of potential, while simultaneously uncertain and multi-layered. No facts or evidence of the future exist, although near immediate futures appear probable while others, even if possible, may never occur and yet the future matters and not all futures are favoured (European Commission, 2014).

Futures questions are encapsulated in response to uncertainty, will, hidden assumptions, preferred futures, alternative futures and next stages (Inayatullah, 2008). The six pillars of futures studies are identified as: mapping, anticipation, timing, deepening, creating alternatives and transforming. The purpose is to provide a theory of futures philosophy that is linked to methods and tools and refined through practice and which can be utilised as theory in a futures workshop environment (Inayatullah, 2008).

4.2 FUTURE MAPPED

Pillar one in the six pillars of futures studies is used to map the past, present and future, because it is through mapping time that it becomes clearer where humanity has come from and where mankind is going (Inayatullah, 2008). The first undertaking in this research paper will be to reflect and discuss, from an international perspective, the key trends characterising the 4IR today, without attempting to predict the future, by anticipating the 'Where?', the 'Who?', the 'What?' and the 'How?' of the 4IR, today, and as it evolves into the future. Thereafter, a detailed environmental scan (ES) of the 4IR from a South African viewpoint will be performed to identify the forces of the present, and to reveal the drivers and developments that exist in the manufacturing industry and that will likely have an effect on future factories. Choo (2005) defines environmental scanning as "the acquisition and use of information about events, trends and relationships in an organisation's external environment, the knowledge of which would assist with planning the organisation's future course of action".

Du Plessis (2016) states that, when “selecting our future, it is essential to have a handle on the possibilities of the future”. Oner and Oner (2003) suggest that in this stage the collation and summarising of information results in strategic knowledge and, in addition, that creativity assists in converting that knowledge into understanding. Knowledge may be divided into two sections; knowledge observing the past is ‘analysis’, while knowledge relating to the future is ‘foresight’ (Oner & Oner, 2003). The concept ‘tracking’ in this phase was used by Lindgren and Bandhold (2003) because it involves locating changes in the environment that could possibly influence the important questions, and determines trends, drivers and unknowns that need to be considered since they could have an effect on the central question. A distinctive importance of trends is that they offer a link between the past and the future, allowing for the conversion of information about what has transpired in the past into knowledge about what might happen in the future (Du Plessis, 2016). This research attempts to recognise the key trends and events leading up to the present and builds a historical timeline to the present to determine the links and discontinuations in the history of the industrial revolutions.

4.2.1 The features of the 4IR

The World Economic Forum (WEF) attempts to highlight key elements contributing towards anticipated changes in society brought about by the expansion of the 4IR. Klaus Scwab, the initiator and chairman of the WEF (2018a), states that the 4IR is unique compared to the previous revolutions due to its speed and its exponential growth rate, the extent and complexity of merging and its systems effect on industries, organisations, governments and general society (Schwab, 2018). Manufacturing is a major contributor towards economic growth, wealth and innovation and many organisations has reaped the rewards through the exponential growth and development which accompanies industrialisation. Nonetheless, the customary industrial development structures that have sustained growth historically, might not be feasible structures for the future (WEF, 2018a). For this reason, developed countries do not wish to be left behind or be at a disadvantage when it comes to implementing the 4IR principles, as falling behind might have detrimental effects on their societies and the economies.

The 4IR is understood to have a tremendous impact on various segments such as employment and in changing the scope of jobs. New industries are generating less employment and require innovative skills to perform jobs that has been created (WEF, 2017). Additionally, disruptive technologies such as artificial intelligence and robotics may extinguish or discontinue numerous roles in the services industry and in organisations relying on manual labour. Improved digitisation will require further emphasis on risks such as cybersecurity, privacy and data security. The WEF (2017) view is that the 4IR will result in the advancement towards new methods and business models which will essentially change manufacturing processes, government decision-making, the business sphere and societies. The focus will move from physical technologies to adaptive social technologies, a segment where trust, policy linkages, action learning, and collaboration between diverse social players are serious success features (WEF, 2017). The afore-mentioned factors represent the most challenges for developing countries such as:

- Trust issues between social players.
- Centralised decision-making by government.
- Concentrated industries.
- High research and development costs (WEF, 2017).

Amidst these challenges, it is reported by the WEF (2017), that the key focus is on physical and data technologies and the impact they will have on industries, productivity, overheads and society, with an emphasis on the promotion of new social technologies and governance activities. This 'new' stage of technological progression is forecasting the extensive application of robotics and automation, artificial intelligence, nanotechnology and material sciences to customary and new industries. This is anticipated to revolutionise future manufacturing processes considerably and, consequently, impact upon the expansion and execution of future industrial approaches. The below table emphasises a segment of the collective or high-level technologies which are frequently defined as 4IR important technologies.

TABLE 4.1
TECHNOLOGIES SUPPORTED UNDER THE FOURTH INDUSTRIAL REVOLUTION.

Technology	Description
Artificial intelligence and robotics	Development of machines that can substitute for humans, increasingly in tasks
Ubiquitous linked sensors	Also known as the "Internet of Things". The use of networked sensors to remotely connect, track and manage products, systems and grids.
Virtual and augmented realities	Next-step interfaces between humans and computers involving immersive environments, holographic readouts, and digitally produced overlays for mixed-reality experiences.
Additive manufacturing	Advances in additive manufacturing, using a widening range of materials and methods. Innovations include 3D bioprinting of organic tissues.
Blockchain and distributed ledger technology	Distributed ledger technology based on cryptographic systems that manage, verify and publicly record transaction data; the basis of "cryptocurrencies" such as bitcoin.
Advanced materials and nanomaterials	Creation of new materials and nanostructures for the development of beneficial material properties, such as thermoelectric efficiency, shape retention and new functionality.
Energy capture, storage and transmission	Breakthroughs in battery and fuel cell efficiency; renewable energy through solar, wind, and tidal technologies; energy distribution through smart grid systems; wireless energy transfer; and more.
New computing technologies	New architectures for computing hardware, such as quantum computing, biological computing or neural network processing, as well as innovative expansion of current computing technologies.
Biotechnologies	Innovations in genetic engineering, sequencing and therapeutics, as well as biological computational interfaces and synthetic biology.
Geoengineering	Technological intervention in planetary systems, typically to mitigate effects of climate change by removing carbon dioxide or managing solar radiation.
Neurotechnology	Innovations such as smart drugs, neuroimaging and bioelectronic interfaces that allow for reading, communicating and influencing human brain activity.
Space technologies	Developments allowing for greater access to and exploration of space, including microsatellites, advanced telescopes, reusable rockets and integrated rocket-jet engines.

(Source: Schulz, Gott, Blaylock and Zuazua, 2018)

The above-mentioned categories of technologies depicted in Table 4.1, are all separate process technologies which can be purchased. The actual test for any organisation is that these technologies require an essential reconsideration of the organisation and its customer responsiveness, suppliers and alliances. Research shown by the WEF (2018b) and organisations, in particular, AT Kearney, reveals that underlying this technological modification is the merging of numerous trends.

The first trend is a move from mass production to the improved efficiency, flexibility and cost saving initiatives of mass standardisation. The afore-mentioned trend is accelerated by increased development initiatives in 3D printing (additive manufacturing), new materials improvement, and smarter standardisation methods supported by the digitisation of production processes. The second trend identified is mass customisation which harmonises with the physical technologies, is empowered by social technologies, and is improved by data processing competences and the enhanced integration of customer needs into procurement and manufacturing. The third trend concerns the frequent utilisation of artificial intelligence to improve the accompaniment and, in several instances actually replace human intellect, and it is frequently established on a buildup of mass data and the implementing of advances in technology (Trade & Industrial Policy Strategies, 2018).

These trends are supported by widespread advances in information handling competences, connectivity, amalgamation of various platforms and automation. The trend towards integration and interdependency between technology platforms is becoming advanced and connectivity plays a major role between platforms to promote direct engagement with all stakeholders. This will require essential modifications in the manufacturing process to accommodate the required connectivity and integration of all processes (Trade & Industrial Policy Strategies, 2018). The WEF (2018b) summaries four fundamental changes that are anticipated in the short and medium- term in the manufacturing industry:

- Manufacturing becoming self-assembling and more self-sufficient as a result of a more advanced line operators or a highly integrated and smart factory.
- Impeccable end-to-end connectivity of value chains enabling manufactures to promote innovative products at a rapid speed.
- The enabling of business integration through a broader supplier Ecosystem.
- Business models will change due to the drive by data in creating new services.

Supporting these trends are vast modifications in connectivity (technology such as sensors and the internet of things), data intelligence (computing power, big data, image and speech recognition) and flexible mechanisation.

This is facilitated by an extensive array and profundity of specialised roles in ICT, science, technology and management, adequate funding devoted in extensive investment in research and development procedures, as well as the immediacy of refined demand (Trade & Industrial Policy Strategies, 2018).

4.2.2 Global trends shaping the FIR

Cornish (2004) proposes that the unexpected changes being encountered in humankind and the accelerated pace of the changes indicate that the world is undergoing a spectacular enhancement. Cornish, labels this enhancement the 'Great Transformation'. According to Du Plessis (2016), the international environment is encountering substantial changes in respect of technology, the economy and social establishments.

Schwab (2016) anticipates that the essential and all-inclusive character of the 4IR implies that it will impact on all countries, market spaces and people. Du Plessis (2016) further elaborates that the broad impact of the interconnected worldwide trends and their effects on it will redesign and disrupt the economic and commercial sphere, as previously noted in the past. As cited by Du Plessis (2016), by claiming that "global trends are the great forces in societal development that will very likely influence the future in all areas for many years to come" and, in addition, that the trends exemplify information about the probable future. Table 4.2, below, encapsulates some of the current, major international trends that are recognised by prominent publications and companies.

TABLE 4.2
OVERVIEW OF INTERNATIONAL MEGATRENDS

Source	Global megatrend
McKinsey & Company	Mobile internet Automation of knowledge work The Internet of Things Cloud technology Advanced robotics Autonomous and near-autonomous vehicles Next-generation genomics Energy storage 3D printing Advanced materials Advanced oil and gas exploration and recovery Renewable energy
EY	Digital future Entrepreneurship rising Global marketplace Urban world Resourceful planet Health reimagined
PwC	Artificial intelligence Augmented reality Blockchain Drones Internet of Things Robots Virtual reality
	3D printing
Organisation for Economic Co-operation and Development (OECD) (Megatrends affecting science, technology and innovation)	Demography Natural resources and energy Climate change and environment Globalisation Role of governments Economy, jobs and productivity Society Health, inequality and well-being

(Source: EY, 2015)

The capability of emerging countries to embrace new technologies, information and to be up to speed with the international cutting-edge technology is important. Fagerberg and Srholec (2017) have established a methodology to evaluate the technological competence to a high degree with a specific emphasis on developing countries. In relation to technological competence, the factors considered in the model contain the quality of a nation's research structure, development and innovation and expansion of the ICT infrastructure. A nation's social competence is measure by two broader aspects; firstly, the level of the skillset of the inhabitants (as echoed in primary, secondary and tertiary achievement and literacy) and secondly, the quality of the authority in the nation, determined by how efficient the government is, the magnitude of corruption and, the extent to which the rule of law triumphs (Fagerberg & Srholec, 2017).

4.2.2.1 Role of Government

The WEF (2018) asserts that the rise of new competitive forces amongst countries will arise due the 4IR, in conjunction with rising uncertainties amidst manufacturing countries. Leaders of states must be more deliberate about precise initiatives to distribute and embrace technology, frequently accumulated under an umbrella national programme. It has been reported that in six years, eight out of the top ten manufacturing countries have deployed national initiatives, namely Industry 4.0 strategies to obtain efficiency gains and reinforce their place worldwide (WEF,2018). The list below reflects the reasons relating to the focus on manufacturing, with technology being a key introductory pillar.

- Adoption of new technologies enables countries to catapult their industrial expansion.
- A supporting environment inclusive of information technology connectivity and infrastructure and suitable intellectual property legislation must be established to enable industries to implement new technologies extensively.
- To enable the lower costs of technology adoption and diffusion for small,
- medium and large enterprises, an economy's advancement is based on driving research, development and innovation (WEF, 2018).

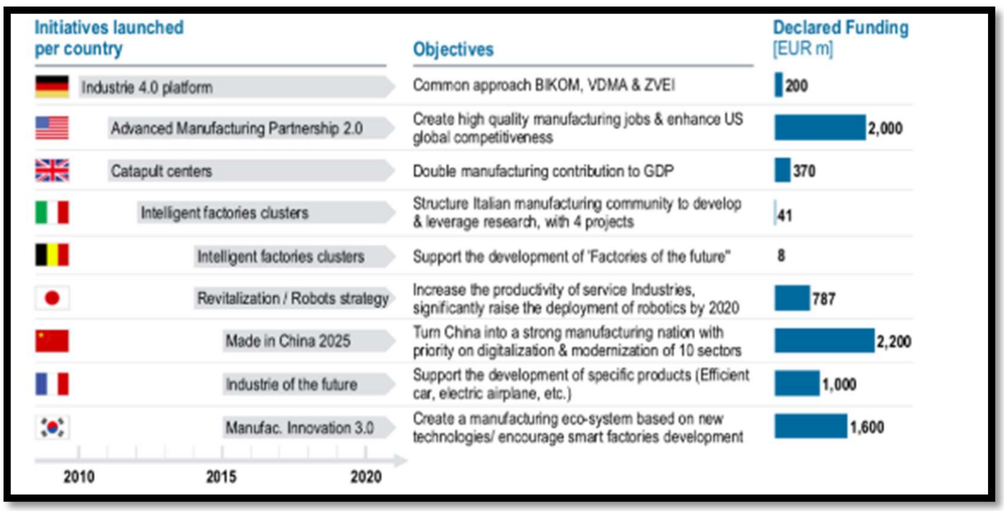
The WEF (2018) classifies seven methods of government-specific national initiatives for adopting and diffusing new manufacturing technologies, all of which require customisation to fit specific countries' requirements and industrial sector mixes. These are the following:

- Creating awareness by emphasising the significance of national initiatives and programmes' contribution towards industrial policy.
- Instituting monetary incentives, in the form of tax credits or public loans, which aid the acquisition and expansion of 4IR technologies relating to small, medium and large entities.
- Forming a strong legal structure to regulate segments affected by new technologies.
- Encouraging certification of organisations which effectively implement 4IR technologies, nationally and globally.
- Growing connectivity and data-security safety with distinct initiatives in manufacturing, such as the formation of devoted task teams, associations and structures on information security.
- Encouraging research, development and innovation for 4IR technologies applicable to production.
- Aligning and preparing the future of manufacturing workers by designing new educational programmes which incorporate Industry 4.0 readiness (WEF, 2018b).

The prediction is that production will move from being labour intensive to information and skills intensive as a result of the fourth industrial revolution. Nations will require a suitable array of relevant proficiencies in management and commerce and the, technical and digital, capabilities to boost the direct adoption and utilisation of developing technologies (Schulz et al., 2018). Whilst automation, which might contribute towards unemployment, is a substantial matter of concern, the WEF (2018b) disputes the opinion that technology will enhance current jobs and might aid in creating new jobs.

The creativity and inventiveness of mankind may develop more, not less, and significantly in the future of manufacturing. The instant short-term requirement, predominantly for countries with a big manufacturing labour force, will be to equip through training and re-training their labour force to replenish skill shortages formed by job changes (Schulz et al., 2018). The main emphasis of the WEF (2018b) discussions revolve around the function of government, organisational leaders, conformation and civilisation. The phrase ‘Fourth Industrial Revolution (4IR)’ seems to be well recognised in South Africa. The particular 4IR initiatives and objectives are illustrated in Figure 4.1, and the foundations of the initiatives are shown in Figure 4.2.

FIGURE 4.1
DESIGNATED INDUSTRY 4.0 INITIATIVES INTERNATIONALLY



(Source: WEF, 2018)

The general content of the initiatives relates to strategic placement and global competition and these ‘revolutions’ and strategies have appeared in various countries from diverse social backgrounds. For example, European countries currently have a shortfall of young labourers keen on technical professions. In addition, many European countries are lagging behind in digitisation, yet countries such as Singapore and the UAE are taking the lead in competitiveness in the digital sphere. South Africa’s circumstances are different due to a demographic alignment tending to be towards the youth. South Africa faces a decline in jobs in the sectors of manufacturing and mining and unemployment rates are very high. The social frameworks are uniquely different relating to the level of education, transport costs and growing inequality (WEF, 2018a).

FIGURE 4.2
FOUNDATIONS FOR FIR NATIONAL INITIATIVES

(Source: WEF, 2018)

The WEF (2018a) claims that the organisations that have conventionally had the obligation of affecting the societal effects of these technologies, together with governments, businesses and civil society, are challenged with keeping the momentum with the swift change and exponential effect. The present state of affairs of attempting to progressively and sequentially manage institutions, policies and programmes amidst rapid developments in technology, has enormous consequences for the public sector management and governance. The rapid pace and influence of technological change at the stages of products or services, processes and business models requires that government departments and programmes accelerate the swiftness and concentration of collaboration to boost the economy, governance structures and the governing environment (Trade & Industrial Policy Strategies, 2018).

4.2.2.2 South Africa's Readiness for the 4IR

The consistent legacy of apartheid has impacted upon South Africa and has resulted in excessive structural difficulties, both economic and social. In the face of these challenges the country is left to cope with the rapid technological transformation resulting within a new working world, responsible for reshaping the worldwide economy and reframing social constructs.

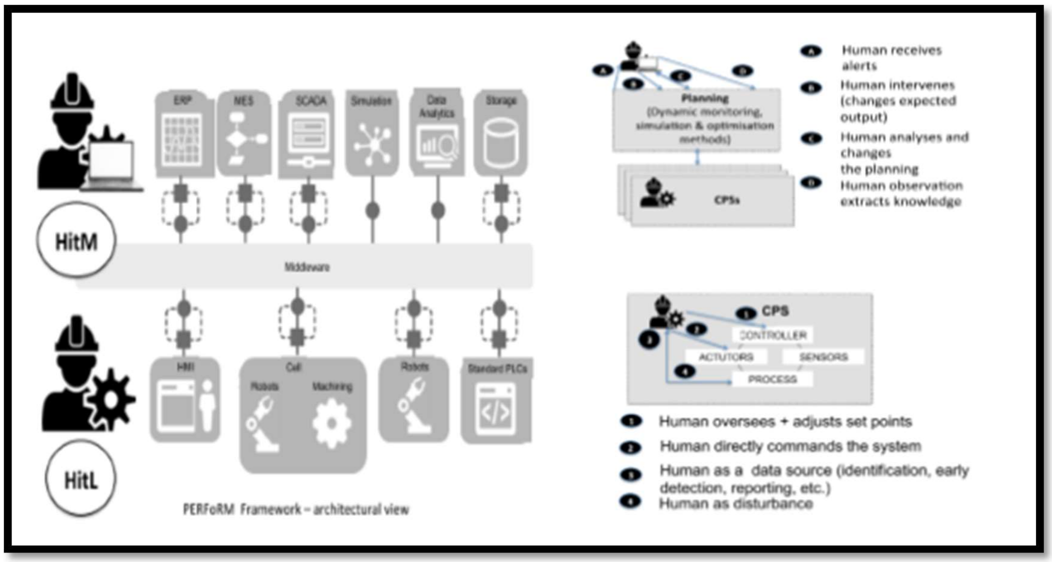
Government will have to continue to develop programmes to guarantee that economically omitted youth are ready for the working environment and are immersed into segments where ‘jobs demand’ is flourishing. These segments include international commercial processing services, agricultural value chains, technical systems, repair and maintenance and new prospects delivered through the digital economy and the 4IR. Approximately seventy-five percent of South Africans will be residing in the urban areas by 2030. The President of South Africa posed the question, “Has the time not arrived to build a new smart city founded on the technologies of the Fourth Industrial Revolution?” (RSA, 2019). The 4IR can be compared to a “fast train coming through town” and presents both challenges and possibilities in the manner in which South Africa approaches long-term economic preparation (Kemp, 2016).

4.2.2.3 Possible Scenarios Within the Fourth Industrial Revolution

There is no ordinary process of developing scenarios. The scenarios that will be depicted in this chapter are four possibilities of what might transpire. The purpose of researchers and decision-makers is to establish multiple scenarios at the same time in order to better understand their opportunities or possibilities. Scenarios should leave the reader questioning which opportunity is more likely or possible. Thus, this stimulates the reader to think and be inquisitive. Scenarios should be organised and developed to educate and not to hypothesise the preferred future (Adendorff, 2014). Therefore, none of the scenarios which will be developed will be classified as a preferred scenario (Adendorff, 2013). Peter Brödner (1990) proposes two possible paths in which manufacturing could follow (Brödner, 1990; Dworschak & Zaiser, 2014). One perspective is that of the technocentric path whereby the objective is to reduce direct labour costs by implementing technology to industrialise every feature of production and, therefore, decrease the requirement for human labour. The opposite can be said for the anthropocentric path which lays emphasis on the utilisation of skilled labourers rather than automation. These mutually exclusive (man or machine) scenarios could have worked in the earlier industrial revolutions. Evidence suggests that the 4IR will result in a rise in man-machine collaboration (Gorecky, Schmitt, Loskyll, & Zühlke, 2014). Therefore, a new scenario is required if the necessitated flexibility of the 4IR is to be accomplished.

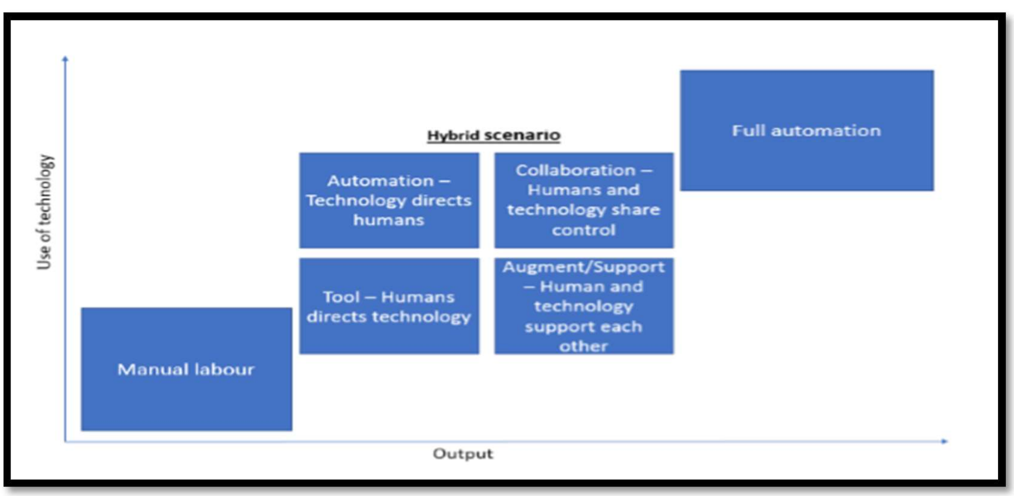
Figure 4.3 below depicts a hybrid manufacturing scenario between the technocentric and anthropocentric scenarios, whereby man and machines effectively share the physical, intellectual work and possibly the most cost-effective scenario (Lotter & Wiendahl, 2006; Matthias, 2011; Schmidtler, Harbauer, et al., 2014). Therefore, the hybrid scenario will possibly be the most preferred in the current manufacturing industry.

FIGURE 4.3
COST OPTIMUM AT SEMI-AUTOMATION (LEFT); OPERATING RANGE OF MANUAL, HYBRID AND AUTOMATIC ASSEMBLY (RIGHT)



(Source: Fantini, Tavola, Taisch, Barbosa, Leitao, Liu, Lohse, 2016)

FIGURE 4.4
POSSIBLE MANUFACTURING SCENARIOS



(Source: Author's construction)

Figure 4.4 was constructed to outline the possible scenarios which will be prominent in the 4IR. The hybrid scenario comprises of automation and tool scenario and the collaborative and augment/support scenario. The afore-mentioned was added as the technologies stated earlier (AR, VR, AI and co-bots) resolutely point to the existence of further collaboration between mankind and technology. The technologies, scenarios and careers stated above will result in radical changes in the operational environment, particularly in the manufacturing industry, as mankind is the focal point of technology, both as operator or collaborator. The operator will be required to adjust or change in this innovative working environment. The future worker will be required to attain new capabilities, abilities or intellect to enable the individual to collaborate and cognitively comprehend the new and enhanced technological environment.

For this research paper, the focus will be on the hybrid scenarios as the research considers it as being the most cost-effective scenario. Additionally, the emphasis of this paper is on the required, suitable levels of altered intelligence which is based on the ideology that the hybrid scenario would involve greater human-machine interaction in a future smart factory.

4.3 ANTICIPATION

When anticipating the future, data collated throughout the mapping stage is interpreted through the review of emerging issues to distinguish areas in which new social innovation arises (Inayatullah, 2008). Anticipation of the future is based on known assumptions and consequently does not challenge its legitimacy (Gould, 2008).

Inayatullah (2008) emphasise that the process is aimed at the identification of challenges before it becomes uncontrollable and costly, and, simultaneously, pursues new prospects and possibilities, as well as assessing emerging issues that could also consist of disrupters. As stated by Gould (2008), in this process the aim is to envisage the possible path of current challenges or issues and what possible futures these issues could produce. This will lead to the unearthing of responses to vital questions that are fundamental to the creation of foresight (Du Plessis, 2016). In this research paper, such questions consist of:

- What does the 4IR really mean for South Africa’s manufacturing industry?
- What are the possible issues that could challenge the actualisation of the future of South Africa’s manufacturing industry?
- What can be done about these issues in the current dispensation?

4.4 TIMING THE FUTURE

The third pillar of Inayatullah’s six pillars of futures studies consists of timing the future, which relates to the discovery of the grand design of history and the identification of the models of change (Inayatullah, 2008). Macrohistorians and grand thinkers have had difficulty with these questions for thousands of years, with these fundamental concepts and varying opinions resulting from their thinking:

- The future is linear, stage like, with growth ahead and through hard work individuals will result in the achievement of a good future (Inayatullah, 2008).
- The future is cyclical, and individuals ‘at the top’ will in the future be designated ‘at the bottom’ resulting in the inability of leaders at the top to adjust and adapt to changes in the world, as their accomplishments relate to a mastery of yesterday’s circumstances and they are unable to reinvent the required basic values (Inayatullah, 2008).
- The future is spiral, with fragments that are linear and development-based, and fragments that are cyclical. Courageous leaders possessing foresight are able to establish a positive spiral. The views of the past are tested but the past is not prohibited; rather it is amalgamated in a journey toward a better future (Inayatullah, 2008).
- New futures are frequently determined by an innovative minority challenging the concept of a used future, and as an alternative to imitating everyone, and who choose to innovate, whether that be social, political, cultural, spiritual or technological innovation. The culture of these change agents envisages a different future and they motivate others to follow suite (Inayatullah, 2008).

Timing the future focuses on the cautious use of macro and micro patterns of adaptation to better impact upon social truth (Inayatullah, 2010a). The 4IR in the South African context is faced with a number of multifaceted challenges and difficulties, including infrastructure limitations, the effect on labour, a shortage of skills, regulatory uncertainty, the effect on the fiscus and inequality. The idea of a used future must be disputed through social, environmental and technological innovation in envisaging a transformed future and subsequently inspiring the numerous technology industries to work towards this desired future (Du Plessis, 2016). Government and organisations will be required to be courageous and agree that the 4IR is a reality and late starters will be at a disadvantage compared to the rest of the world. The sustainability of South Africa’s competitive advantage will be based on innovation, the presence of entrepreneurial insights and the implementation of economic incentives to drive change (Balkaran, 2016).

4.5 DEEPENING THE FUTURE

Futures studies are distinctively focused on addressing the use of methods like causal layered analysis (CLA), which permits the systematic and in-depth assessment of difficulties (Kotze, 2010). Derived from theories of poststructuralist discussion and developed by Inayatullah (1998), CLA offers a foundation for evaluating the social hypothesis of the ‘real’ and recommends a layered approach with which to analyse the outcomes of the crucial focus areas of research (Inayatullah, 1998). Puglisi (2001) describes the CLA method as adopting four levels of analysis:

- The *litany* is a study of future trends and problems, predominantly in terms of features that are frequently disconnected and where assumptions are hardly questioned.
- The *systemic view* considers social causes and analysis that provides understanding of qualitative data, including social, cultural, economic or political factors.
- The *discourse or worldview is* a deeper level of analysis and is associated with discourses and debates, for example, globalisation processes, population and consumption debates.

- The *myth or metaphor* refers to the deep ‘stories’, the cataleptic dimensions of a problem or predicament (Puglisi, 2001).

The above-mentioned four levels are utilised by futurists to uncover the full array of stories, the conscious, unconscious and emotive view of the problems. CLA’s capability to create new ways of knowing by interpreting and reinterpreting problems and their solutions delivers a rich method for the analysis of scenarios and case studies (Gould, 2008). Based on the opinion of Puglisi (2001), CLA utilises numerous forms of knowledge, integrating the analysis of non-textual and poetic or artistic expression with sets of knowledge from other civilisations in the futures methods, on the assumption that it is not only the visions of the future that shape our activities but also the means by which those visions are shaped and the means by which problems are framed. CLA unlocks platforms for the execution of constitutive discussions which can then be shaped as scenarios. CLA can categorise the numerous different views of realities while remaining sensitive to horizontal and vertical spaces (Puglisi, 2001). Therefore, CLA is a search for integration in methodology, seeking to combine different research traditions (Inayatullah, 2005). According to Inayatullah (2004), CLA permits and encourages the introduction of authentic alternate scenarios and preferred futures (Du Plessis, 2016). Thus, it is critical to deepen the exploration into the future of the 4IR in the South African environment by exploring the causal stories, assumptions, social causes, metaphors and worldviews about the South African technology across various industries and segments.

4.5.1 Litany

The ‘litany’ level of analysis is the approved public narrative of the issues (Inayatullah, 1998) or the day-to-day future, the habitually established headlines of how things either are or ought to be (Inayatullah, 2008) and in which issues, events and trends are not linked but appear discontinuous (Inayatullah, 1998). Nonetheless, this research has acknowledged that the improvement made in technologies in the 4IR has strongly emphasised the realities that are apparent in the litany layer. Slaughter (2002) substantiates this by specifying that technology is one of the key trends in the litany layer.

Technology is the principal component in the 4IR and this phenomenon is considered disruptive, not only to individuals but also to business. Technology can be viewed in relation to its possible economic impact and its ability to disrupt; and these effects go hand-in-hand and both are of vital importance to leaders (Manyika et al., 2013). The 4IR is an international trend which may result in new ways of creating value, novel business models and improved networking and collaboration between several partners in international networks of value creation (Sendler, 2013). The consequences for nations and businesses that do not embrace and adapt to the incidence are gloomy (Pretorius, 2016), however, thus far, only a few international investors and leaders have observed and reacted to the revolution. Already, they have earned the benefits, thus, in order not to be left behind, South African business leaders, economists and investors, must reevaluate and adjust to this phenomenon (Beck & Schwab, 2016).

This research has emphasised the first matter at hand, i.e. the uncertainty about the readiness of South Africa to embrace the 4IR and maintains that despite the seemingly slow progress in the acceptance and embrace of the 4IR, certain segments or departments in the South African government have admitted the importance and potential impact of the 4IR on the country. From a business perspective, businesses recognise both the magnitude of embracing the 4IR, as well as the devastating impact of ignoring it. What is significant to consider, especially for South Africa, is the experience of a digital nation. The country should take note of Kenya's investment into its own 'Silicon Savannah' which is accelerating that country into the most exhilarating technology progression on the African continent (Jacobs, 2016). There is good news in that significant headway is already being made in South Africa, as IoT projects are in progress, including the progress of smart cities which utilise a number of the disruptive components and technologies of the 4IR (Sha, 2017). Nevertheless, the operative 'smart city rollout' is constrained as there has been no managing body or even a set of coordinating regulations to facilitate or assist with the rollout. A further stumbling block for coordinated urban planning is the country's unstable political environment and ever-changing leadership dynamic (Hubbard, 2017).

Schiessl (2016) states that a large share of technology and intellectual property (IP) may have been initiated in developed economies, but it is perhaps in emerging economies where the changes will be most extreme. Below are a few of the challenges that South faces with respect to technology advancement into 2030:

- The apparently slow-moving headway being achieved in creating an enabling environment for rapid technology advancement, and which is reflected to be primarily government's domain of responsibility.
- An extreme scarcity of the skills necessary to drive innovation, maintenance and the distribution of technologies.
- The dreadful state of the South African economy, which results in reduced levels of disposable income, which translates into slow-moving adoption and usage rates, and further diminishes the acceptance of new technologies by businesses.
- The poor condition of the public education system, translating into reduced technology literacy rates among the population.
- Rand weakness versus major international currencies, making the acquisition of technology that much more expensive, which further restricts deployment and acceptance rates (Jacobs, 2016).

The technological changes in all of the digital domains, connectivity, robotics and big data will have a far-reaching impact on the manufacturing labour market on to 2030. A foremost concern, from a South African viewpoint, is the lack of skills needed to take advantage of the 4IR. A key strategic initiative identified by Pretorius (2016) is that all industries need to invest in the reskilling of current employees as part of the organisational transformation and future workforce planning initiatives. Companies are great 'universities' for teaching the labour force of the future; investing in this frequently amounts to specialised instruction and hands-on capability that cannot be obtained at even the most prestigious universities (Benioff, 2017). With the phenomenal growth in AI competencies, many careers previously considered resistant to replacement are now at risk.

Modern AI structures are now capable of dislodging humans in professional practices such as accounting, engineering and law, all of which have conventionally depended on the extreme, narrow knowledge of experienced subject matter experts (Stuart et al., 2015). Regardless of worldwide acknowledgement that advanced manufacturing may, in fact, be significant in reversing de-industrialisation and creating well-paying jobs, there remain persistent observations, noted earlier, about diminishing job opportunities in the manufacturing sector intensified by the introduction of advanced technologies and automation (Williams, Cunningham & de Beer, 2014). In the researcher's opinion South Africa has to intensify its efforts to resolve its current challenges in unemployment and skills shortages to ensure that it benefits from the innovative changes and opportunities that the 4IR will bring to the manufacturing industry towards 2030. Sustainability, along with challenges such as climate change, must appeal to society to become more futures-oriented (McGrail, 2011). The longer-term viewpoint is vital in ensuring that a concern for inter and intra-generation equity is built into planning methodologies (Puglisi, 2001). A sustainable society would govern foresight, have a futures responsive culture and would be resolute and prudent in its futures creation (McGrail, 2011). While society cannot entirely control the future, it can impact on the course of history by making a valuable effort to consider the balance between what is desired and what is possible (Glenn, 2004). In order to be sustainable, the 4IR would need constant and collective support from government, business and society and would require for these to be knitted into the daily fabric of routine for all populations into 2030.

Disruptive technologies have the potential to assist in the resolution of real problems of poverty and inequality found in growing African cities and essentially driving structural transformation (Mtongana, 2016). While the 4IR is definitely relevant, it does not deal with the unrelenting realities of increasing inequality and growing unemployment in many developing markets, including that of South Africa (City Press, 2016). The potentially higher levels of inequality in the short-run and a need for labour market flexibility to harness the 4IR benefits in the long-run, would both need to be taken into account to limit the impact of extreme automation (Baweja et al., 2016). Pretorius (2016) maintains that organisations can no longer be responsive in their upskilling of the nation's labour force and, as such, a change in mind-set is required when upskilling talent, and such should concurrently address societal needs.

The 4IR integrates cyber-physical structures with production processes, permitting industries to automate and sustain production in real time. Smart technologies open new international markets and grow the international economy, yet there are some challenges linked with the execution such as the shortage of skilled manpower, social inequality, possible disruption in labour market and cyber-risks. South Africa's manufacturing industry and current labour force will need upgrades to match skills necessary for smart factory adoption. Smart factories might displace the labour force with robotics. Conversely it will also generate new types of jobs. Some industries are at present using flexible production and manufacturing customer-specific goods, which specifies that these businesses will definitely transform to mass customisation.

Cyber-risks and confidentiality problems of the digital revolution offer a platform for current ICT specialists to participate in research and development and in addition generate new jobs linked to the development of security systems and software. Industries and society are presenting certain level of acceptance, yet are not entirely engaged in the adoption of the smart factory concept (Pradhan & Agwa-Ejon, 2018).

4.5.2 Systemic Causes

Inayatullah (1998) states that this layer of analysis considers the systemic factors of the interconnected social, cultural, economic, political, technological, environmental and historical factors of a problem and the causal data. This layer differs from the litany level because the second level examines the trends and information in an effort to gain an understanding through analysis rather than blind acceptance, and is categorised by the implementation of technical techniques and models built on a robust academic foundation (Kotze, 2010). This research study is aligned with the systemic layer to detect drivers and trends that cause the issues emphasised by the litany analysis as they seem to the world, and with specific reference to South Africa.

4.5.3 Worldview

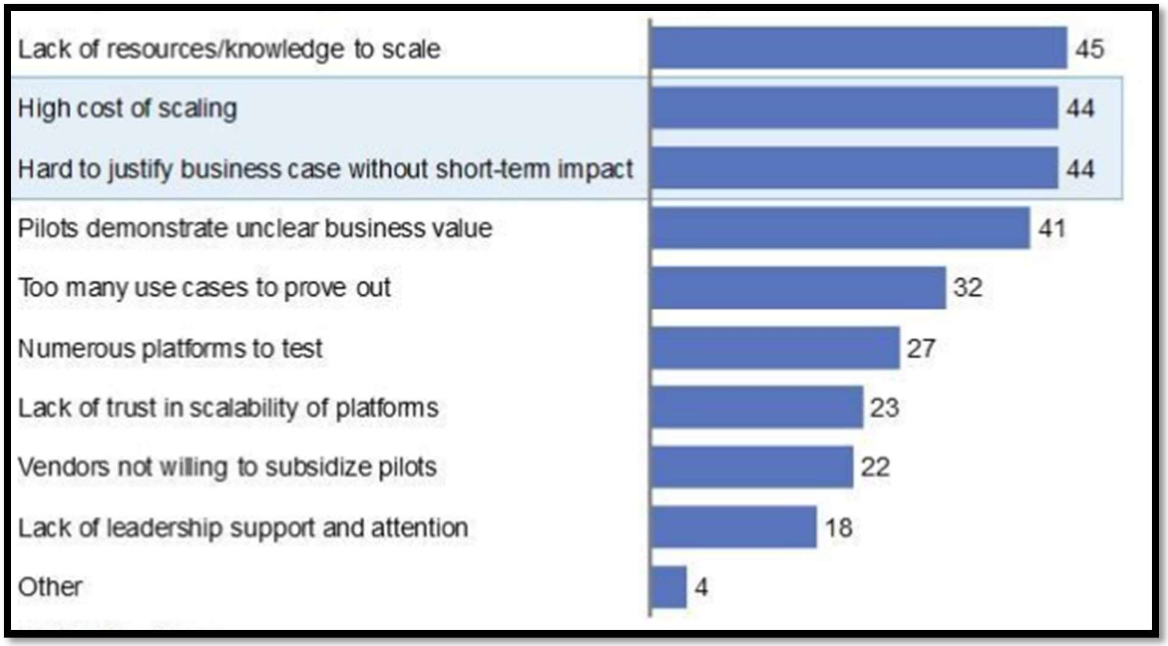
The third layer of futures studies analysis attempts to determine the worldviews central to the trends and problems identified. This presents an opportunity to outline the problem in the 'litany' layer, by not only considering how the various discourses cause and withstand the trends, but also by legitimising and strengthening them (Kotze, 2010). This level is less about the technical inquiry but more about how factors such as political views, culture and religion impact upon people's views about the world (Inayatullah, 2005). Whereas the second layer has a strong technical grounding, this layer uses language to reveal the meanings and diverse ways of knowing (Kotze, 2010). From a basis of diverse worldviews, discrete alternate scenarios can be derived by adding a horizontal aspect to the layered analysis (Inayatullah, 2008).

4.5.4 Myth or Metaphor

The fourth layer of analysis in futures studies explores what is labelled the 'myth or metaphor' layer. This concerns the discovery of the unarticulated, deeply rooted, highly emotional and unconscious 'stories behind the story' (Inayatullah, 2005). It endeavours to deconstruct the worldview into images which can go beyond other structures of interpretation; images are of chief importance to this layer, due to the limitations of language (Kotze, 2010). DuBrin (2011) maintains that a carefully selected metaphor or analogy appeals to the imagination, to the intellect and to values.

According to the WEF (2019) report *Four myths about manufacturing in the Fourth Industrial Revolution*, manufacturing frontrunners mention "high cost of scaling" and "hard to justify business case without short-term impact" as top reasons for avoiding the complete implementation of 4IR technologies across the entire spectrum of the organisation, as depicted in Table 4.3 below.

TABLE 4.3
REASONS FOR PREVENTING THE MOVE FROM PILOT TO ROLLOUT: % RESPONDENTS CHOOSING THE REASON AS ONE OF THEIR TOP THREE.



(Source: WEF, 2019)

The WEF (2019) analyses the four most substantial 'myths' which have surfaced and are currently preventing transformation to this new age of manufacturing.

4.5.4.1 Myth one: 4IR technologies are too expensive

The Report by WEF (2019) states that the viewpoint for centuries relating to the terms 'technology' and 'innovation' has been associated with the term 'expensive', although the brilliance of the 4IR means that much can be achieved without incurring exorbitant expenditure. For instance, by linking analytics software bundles to a 'data lake' comprising of current plant information, in amalgamation with a data recorder from the relatively low-cost Internet of Things (IoT) devices, businesses can create in-depth knowledge from the vast amount of actionable data to support agility and efficiency (WEF, 2019).

The short-term requirement might be the implementation of up-front activities to start the process, but it usually transforms into improved processes, reduced cycle times, superior quality, reduction in energy losses, less downtime as a result of maintenance and enhanced equipment efficiency. With capital-intensive 4IR projects investing in such as progressive robotics, the cost-benefit remains the yield of positive returns on invested capital for manufacturers deploying these technologies. Labour costs are directly in proportion to robotic and automation capabilities, thus an increase in labour cost yields an increase in robotic capabilities. For instance, the array of motion for robotic arms has amplified six times in the past 25 years. User interface enables operators on the line to modify the patterns of behaviour and operate 'on the fly' with recorded programming. The robots' competence to assist human activities has increased as safety criteria have increased and improvements in artificial intelligence (AI) are assist in lowering the cost of the amalgamation of the afore-mentioned systems. International manufacturers comprehend that state-of-the-art machinery, equipment and robotics will radically transform the manner in which business is conducted.

For this reason, many manufacturers wait for prices of technology to decrease before they scale-up on a broad spectrum. This concept is known as the 'smart follower' approach which do not pay off in the 4IR as a result of the distinctive economics linked to data and connectivity. The McKinsey Global Institute model proposes that the leaders in the implementation of AI, will grow cash flow by 122%, whereas followers only yield a 10% cash flow growth. The key driver is determined by the translation of greater transition costs and capital outflows of the leaders in the industry and results in greater gains (WEF, 2019).

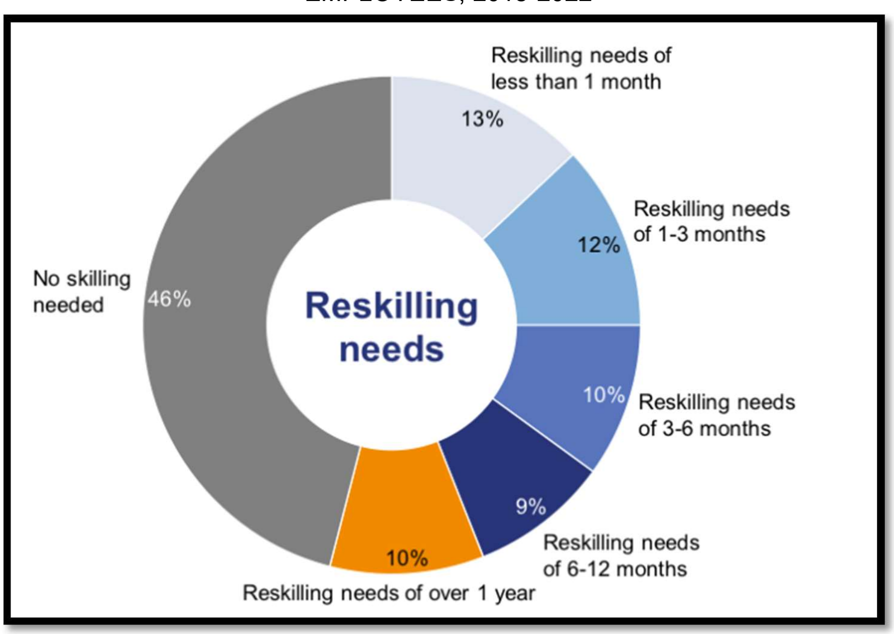
4.5.4.2 Myth 2: 4IR will cause widespread unemployment

The 4IR in manufacturing is linked with automation and smart systems replacing jobs performed by mankind, forming the impression of 'lights-off factories' in which humans are perceived to be redundant, and which creates unrest and uncertainty pertaining to employment and the continuity of certain roles (WEF, 2019). It is to be expected that specific repetitive functions in jibs will decrease although current reports reveal an optimistic view for the labour force. *The Future of Jobs* report by the World Economic Forum (2019) illustrates that 75 million jobs will be redundant and 133 million new employment opportunities will be created by 2022 as a direct result of the 4IR, throughout all industries and roles.

Repetitive jobs will be replaced with new jobs which are more attractive, with innovative and complex tasks with an emphasis on problem-solving and the enhanced interpersonal skills of the workforce. In production, the functions performed by operators, material controllers, quality department, and technicians will decrease and will be offset by an escalation of roles in the arenas of data analytics, artificial intelligence, software and application improvement and technologies. The trial to overcome is the re-skilling of the current labour force.

Initiatives to shape competencies are at the pole position for prominent organisations. It is claimed that 'lighthouse' illustrations from some of the most cutting-edge 4IR factories see the endowment of substantial resources on change management and the upskilling of labour forces with digital institutions established to prepare and equip staff. The re-skilling initiatives are based on the ideal that newly implemented technologies are becoming easier to implement. For instance, staff without IT training can study how to develop applications by means of code-free applications for the development of platforms and collaborative robots can be 'trained' without programming (WEF, 2019).

FIGURE 4.5
EXPECTED AVERAGE RESKILLING NEEDED ACROSS COMPANIES, BY SHARE OF EMPLOYEES, 2018-2022



(Source: WEF, 2019)

Figure 4.5 illustrates that essentially; the 4IR is likely to have a vast disruptive influence on the labour force in manufacturing. It is crucial that more establishments have an active part for reskilling the current labour force; and that people view lifelong learning proactively and that governments support learning initiatives to guarantee that the labour force and the general public will have an advantage from the prospects that are brought about by the 4IR.

4.5.4.3 Myth 3 – Businesses must relinquish profits to achieve sustainability

The implementation of new technologies can aid in increasing both the efficiency and the sustainability of businesses. Many leaders of organisations view sustainability as both a marketing plan and a sign that the organisation will relinquish bigger profits to attain 'green' status. The mindsets of leaders must evolve in the way sustainability is defined, which is more than planting trees or putting a few solar panels on the roof. Therefore, sustainability is viewed in relation to obtaining sustained success and adding positively to the labour force, the broader society and the environment. Acquiring intelligent lighting controls provides 40% of energy saving, optimises a factory's energy usage, which can save up to 30% of energy consumption by controlling off-time scheduling more accurately (WEF, 2019).

4.5.4.4 Myth 4 – The Fourth Industrial Revolution is only for large multinational corporations in advanced markets

There is an assumption that only large, multinational corporations in developed markets can implement and benefit from 4IR technologies. According to a current World Economic Forum report *Fourth Industrial Revolution: Beacons of Technology and Innovation in Manufacturing*, which specifies 16 of the world's most progressive 4IR factories, this is not the case. For instance, a 'lighthouse' factory owned by Rold, an Italian SME with 250 employees, executed 4IR technologies with a small team and restricted investment. The business formed full transparency of its manufacturing process to aid in highlighting and resolving root causes for quality abnormalities and performance losses. The resultant impact after a year was the achievement of 7-8%t growth in revenue, supported by an 11% increase of the overall equipment efficiency (OEE).

Enno de Boer, a top leader at McKinsey, stated that: "The high number of lighthouses in China is a clear sign of China's ambition to retain and enhance its manufacturing base while labour costs increase, to avoid a migration of manufacturing jobs to countries with lower wages" (WEF, 2019). Manufacturers must cooperatively view the above-mentioned four myths as self-imposed barriers to accomplishing new levels of success and which will enable the application of the complete potential of the 4IR for businesses and will hasten progress towards a new dispensation of innovation, productivity and equivalent growth (WEF, 2019).

4.6 CREATING ALTERNATIVES

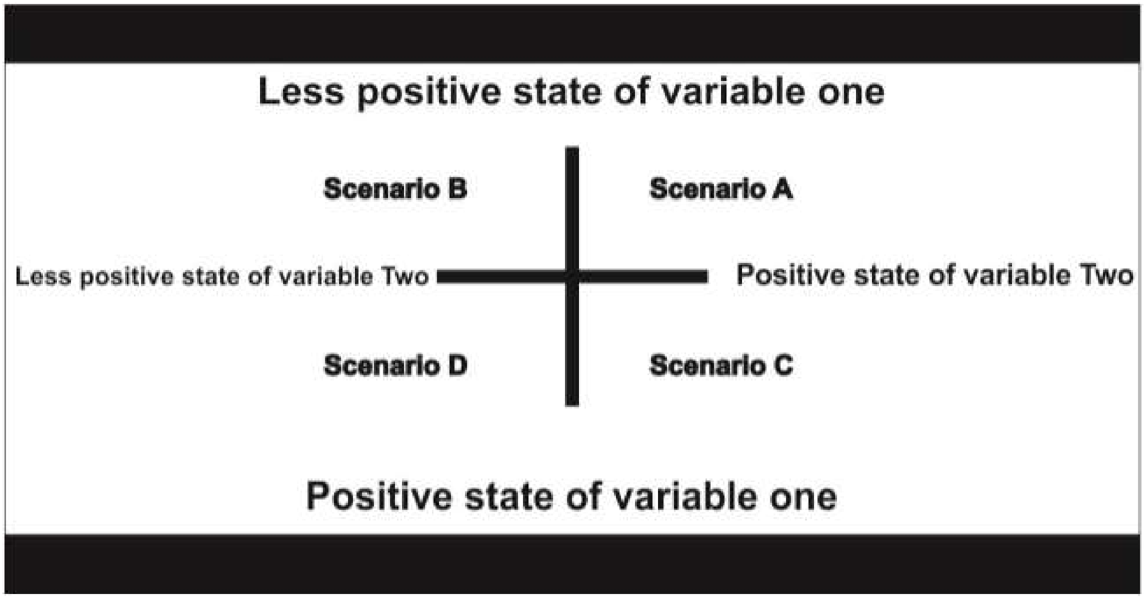
Meeting the requirements of the essential guidelines of Inayatullah (2008), the next section will now create alternatives achieved through the creation of scenarios, to expand upon the future of the 4IR in South Africa. Slaughter (2002) perceives this as the "tool par excellence" of futures studies, whilst, for Inayatullah (2008), scenario planning is a respected method of unravelling the present, forming a level of uncertainty and proposing alternatives. In the stage of creating alternatives, the critical aim is to implement the scenario methodology by reviewing the probable scenarios and by confronting the challenges faced by the South African community and private sectors in implementation the 4IR into 2030. Kreibich et al. (2012) reviews the fact that many scenario analysts lay emphasis on the fact that scenarios are assumed ideas, thus failing to proclaim that the scenarios generated actually signify reality. Scenarios are inclined to be created from technological, social, environmental, economic and political understandings about what the future is estimated to contain (Gould, 2008) and as, by nature, the future is fundamentally unknown, none of the scenarios established will inevitably unfold as imagined (Puglisi, 2001). Scenario planning is founded on the following ideologies; multiple scenarios must imitate uncertainty but be restricted to four plausible futures; they must be internally dependable, with related events; they must be relevant to the issues of concern, constructing challenging concepts against which future approaches and planning can be considered (Du Plessis, 2016). Adendorff (2015) states that a good set of scenarios is required to leave the reader questioning that option which is highly likely or probable to occur, thereby encouraging the reader to ruminate even further on the subject.

The broad scenario-building model presented by Peter Schwartz, which lays emphasis on the organisation and offers definite guidelines with which to plot and develop scenarios, has been embraced for the purpose of this research (Adendorff, 2015). This research presents four scenarios to better understand South Africa's future towards 2030. The scenario structure is composed of the following four possible variables, which have been christened with sci-fi movie titles to emphasise the intrinsic 'stories' of the scenario analysis:

- Best case (what the organisation desires to become) – *I Am Mother* - in which positive essentials come to function and are equally beneficial.
- Worst case (where everything goes bad) – *Avengers: Age of Ultron* - in which poorer governance prevails, but where a prosperous environment and firm national management permit South Africa to become competitive and benefit from satisfactory economic growth.
- Outlier (a surprise future based on a disruptive emerging issue) *Transcendence*; – in which fundamental driving forces unfold in an uneven pattern or have a wide-ranging effect on South Africa.
- Business as usual (no change) (Inayatullah, 2010a) – *Stay the same, never change* **-** in which negative regional drivers of change cause the deterioration of positive initiatives in a method which compounds the previous pressures on South Africa's growth towards 2030.

Guidance was taken from the method whereby the Dinokeng scenarios were created around the future of South Africa. Two major variables were recognised and mapped on two axes (see Figure 4.6 below).

FIGURE 4.6
COMPILATION OF SCENARIOS SIMPLIFIED



(Source: Roux, 2010)

4.6.1 *I Am Mother* – the best-case scenario

The movie 'I Am Mother' from which this scenario's title was taken is about a teenage girl who is the first of a new generation of humans raised by Mother, a robot designed to repopulate the earth after the elimination of mankind. This all centers around the hope of one day rebuilding the human race. This scenario proposes that by the year 2030 the acceptance of the 4IR is complete and successful.

Government and the manufacturing sector have joined forces to gain the supreme advantage that the 4IR has to provide, for the greater good of the country's populace. AI gains dominance over mankind, as the 'singularity' predicted, but has been integrated into society and is seen to assist and aid mankind. The feared employment challenges and under-developed skilled have not occurred but, many new jobs have been generated and these require new skills. This has required investment in new technology for instance, AI, collaborative robots, IoT, augmented reality, block chain and machine learning implementation in future factories within the manufacturing industry to enhance productivity and efficiency, whilst keeping costs low. This enables the implementation of smart production systems within future factories within the 4IR towards 2030.

The new jobs that have been generated presents better opportunities for the youth and have drastically reduced the unemployment rate. Government leaders and private businesses have invested heavily in the infrastructure needed to support the 4IR to enable smart factories to erupt. In 'smart cities', self-sufficient transport and electric vehicles are the standard, the internet is freely available and is considered a basic right of humans. In 2030, drone technology has progressed to a level where the technology is used for deliveries, transporting individuals in 'drone taxis' and thus reducing the congested roads. The resultant impact is less air pollution, reduced carbon emissions, fewer road accidents and fewer deaths. It also sees completely automated production lines where man and machines work in collaboration to achieve mass standardised production. It has augmented reality where design and innovation are enhanced and manual labour in design and technical specifications are eliminated. Reliance on 3-D printing of parts has shortened the time from concept to manufacturing and rapid prototyping.

4.6.2 *Avengers: Age of Ultron* – worst case scenario

The movie chosen to best reflect this scenario focuses on the creation of an AI system built by Toni Stark, named Ultron. Ultron is an AI system created initially as a peacekeeper for mankind. While Ultron tries to determine the reasons for crime, the AI intelligent system concludes that mankind is the reason for crime and attempts to wipe out the human race. It is the year 2030 and humans have been substituted in all jobs by AI and robots, and general public are now fighting for survival as there are no job opportunities available for them to make a living. The value of currencies has dropped as AI does not recognise money as a means of exchange for goods and services. Humans have been involuntary forced out of the cities and now reside on the borders in squatter camps, with many moving into disadvantaged areas fighting for survival. There is no distinction between classes anymore, as every person is matched by the AI view of the human race. The government infrastructure fails as AI now controls all features of the economy, with no need for human collaboration or input. Raw materials and other resources are housed by AI to build and preserve the AI and robotic workforce. There is no need for fossil fuels for power stations and cars, as alternative energy sources, like solar, wind power and batteries (with improved storage capacities) are used by the new owners of the Earth.

Medical advances and infrastructure decline as AI never falls ill, possibly only redundant, so remaining hospitals ultimately start to fall apart and there is nowhere else for the ill to go. Shortly, life expectancy of humans is reduced; there is an increase in neo-natal and child deaths and the population is no longer increasing, but rather diminishing. The economy crumbles under the reign of AI as robots are designed to recreate their own, with no cognitive and reasoning ability to manufacture products needed to enhance mankind's lives, the core purpose for AI's introduction into the economy.

4.6.3 *Transcendence* – the outlier scenario

Dr Will Caster is a scientist who examines the nature of man and AI. He and his team work to create a sentient computer and envisage that this computer will create technology that will transcend man and AI. After his conference, Dr Will is shot by anti-technology terrorists. To stop him from dying, his team decides to upload his consciousness into the sentient computer. With his virtual form and his wife's assistance he uses his new abilities to construct a technological utopia. He leads the development of ground-breaking technologies in medicine, energy, biology and nanotechnology.

The singularity is the new standard in 2030. Mankind's physical and intellectual capabilities have been enhanced with bio-technological augmentation and implants such as memory and energy storage. This leads to the emergence of a new human - a 'transperson' as technology and bio-medicine have considerably improved the human condition, essentially enhancing the human's physical, cognitive and psychological abilities. Transpersons complete intricate tasks in a fashion similar to humans, taking over routine jobs from construction to agriculture and from office to manufacturing automation. Transpersons enjoy healthier living and implanted, with a 100% success rate, are developed by means of limitless stem cells. Bio-computers and 'nano-bots' are the common means for diagnosis and treatment, thus extending both ongoing vitality and lifespans. In 2030 the internet has been magnified as the global connector. Improvements in core technologies and the prerequisite to support increasingly sophisticated application scenarios rapidly bridge the gap between the virtual and the physical worlds, trading trillions of bytes of data monthly.

This allows forecasts and decisions, based only on scientific data and people's desires, to be implemented more easily and faster than ever. Technology will continue to transform the production processes, the nature of work, the dynamics of businesses and the workforce. The 4IR has brought about countless new jobs, with innovative careers replacing many of the earlier unskilled jobs. The new and enhanced 'transperson' has no further need to be upskilled as upgrades and applications are readily available to enhance capabilities. Autonomous vehicles are the future and truck drivers will not be needed. The conventional taxi drivers will be replaced by driverless vehicles and bus drivers will be extinct. This will impact extensively upon the future of transport.

4.6.4 *Stay the same, never change* – it is 'business as usual'

For the next section the title of the movie was selected with no correlation with the depicted scenario but purely for its title relating to the theme 'business as usual'. The concept explored is the failure of government and key stakeholders in the business sphere to comprehend the benefits of the 4IR for the broader society'. Thus no meaningful effort is made to propel the country forward and so it still remains in an eternal loop of non-development and non-progress. It is the year 2030 and the manufacturing industry continues struggle along a path with no clear direction regarding how the 4IR will be absorbed into the economy and the broader society's daily lives. Government leaders continue to allow the likely benefit of the 4IR and arrange workshops and task teams to discuss the phenomenon, but do not implement a plan of action.

In the interim, in a different place on the African continent, countries have been embracing the 4IR robustly and, as a result, have leap-frogged South Africa to become more innovative and the new economic capitals. Industries recognise that accepting the 4IR is critical to the existence and success of organisations, but, due to the pressures from government and unions to sustain jobs, the push to amalgamate AI into industries is not as robust as they would like. This inability to absorb AI efficiently has resulted in businesses employing unskilled, incompetent labour at unsustainably high wages and this has resulted in the country having priced itself out of the global market, with lower demand for its products and services.

Furthermore, the slow acceptance of 4IR has meant that the required reskilling of the labour force has also been slow, even, in some instances, non-existent. On a positive note, improvements in medical technology have aided some of the country's populace. The technology is still costly due to the underdeveloped acceptance by industries of technologies such as nano- and bio-technology, and is thus, only accessible to the select few. South Africa is still severely dependent on fossil fuel driven technology and the predicted three million electronic vehicles on the road have not materialized.

4.7 COMPARING THE SCENARIOS FOR SOUTH AFRICA'S MANUFACTURING INDUSTRY AND IDENTIFYING DRIVERS OF CHANGE

The next section identifies the drivers of change, and key driving factors influencing the afore-mentioned formulated scenarios relating to how the future of South Africa's manufacturing industry could change due to the implementation of 4IR principles in future factories towards 2030. Technology is categorically one of the most significant drivers of change due to its transformative role, with both positive and negative impacts (Adendorff, 2013).

Major developments in science, technology and society have been witnessed in recent years (European Commission, 2014). Bishop and Strong (2010), claim that currently the most important driver of change is technology and the rapid speed at which data is able to travel around the world. The digital revolution has generated a greater capacity to distribute information to more people and at different places than ever before.

Table 4.4 below, represents an overview of the manufacturing industry scenarios for South Africa.

TABLE 4.4
OVERVIEW OF THE MANUFACTURING INDUSTRY SCENARIOS FOR SOUTH AFRICA

Drivers of Change	**I Am Mother – the best-case scenario'**	**Avengers: Age of Ultron – worst case scenario**	**Transcendence – the outlier scenario**	**Stay the same, never change – it is 'business as usual'**

Technological Progression	Very Positive	Negative	Positive	Neutral
Economic Growth	Very Positive	Negative	Positive	Negative
Governance	Very Positive	Negative	Positive	Very Negative
Quality	Very Positive	Negative	Positive	Positive
Infrastructure Development	Very Positive	Negative	Positive	Positive
Consumer Demand	Very Positive	Negative	Positive	Positive
Innovation	Very Positive	Negative	Positive	Positive
Management of Resources	Very Positive	Negative	Positive	Positive
Government legislation	Very Positive	Negative	Positive	Negative
Global Competition	Very Positive	Negative	Positive	Negative
Business Opportunities	Very Positive	Neutral	Positive	Negative
Cyber Security	Very Positive	Positive	Positive	Very Negative
Employment Opportunities	Very Positive	Negative	Positive	Positive
Environmental Laws	Very Positive	Negative	Positive	Positive

(Source: Researcher's Own Construction)

As part of the South Africa's manufacturing industry's scenario-based planning process, Table 4.2 has taken into consideration the authentication for internal consistency and has endeavored to recognise the substantial differences. The first scenario, *I Am Mother – the best-case scenario* is the only scenario whereby both the uncertainties are positive. It is also the scenario that seems to meet the manufacturing industry stakeholder's desired outcomes. This scenario lay emphasis on the fact that business succeeds when good technological progression, good governance, good economic growth and a favourable government legislative environment are maintained at adequate levels. The manufacturing industry is performing comparatively well but global competition is rife due to technological progression in manufacturing factories abroad.

Smart factories, artificial intelligence, robots and the introduction of co-bots resulting in production costs being lower than global rivals, means that strain is placed on South African manufacturing industry to compete. The second Scenario, *Avengers: Age of Ultron – worst case scenario*, highlights that South Africa is its own worst enemy. The economic surplus generated from manufacturing product exports is wasted by the politically elite instead of serving the general population of the country. Socio-economic problems such as poor infrastructure, bad technological progression, unemployment, public protests and crime are very high due to the economy of the country not serving the interests of the general population. A lack of technological infrastructure makes the implementation of smart technology in future factories difficult. The manufacturing industry is not performing the same in South Africa as elsewhere, and as such, the industry is missing out on the effective and efficient solutions that are driven by technology and enjoyed by their rivals.

The third Scenario, *Transcendence – the outlier scenario*, emphasises that manufacturing industry leaders can use technology to produce efficient and effective products in aiding the booming economy. The technological implementation is a success and can assist in sustaining businesses and lead to the eradication of social ills such as unemployment, poverty and crime. Smart factories are infiltrating the South African market as a result of good technological progression and embracing innovation.

The fourth Scenario is *Stay the same, never change – it is 'business as usual'*. This scenario shows a failed South Africa and socio-economic problems are high. Corruption and bad governance deter foreign direct investment and other international funding. Investors are transferring their investments out of South Africa. The four scenarios proposed above are multi-faceted and thus, many different messages can be received. The suggested scenarios are not predictions, but only four possible scenarios of how the South Africa's manufacturing industry could develop, centered on important variables and critical uncertainties. The importance of these scenarios is to learn from them in establishing the strategic path for the future (Adendorff, 2014).

4.7.1 Critical Uncertainties Facing South Africa and 4IR

A technique of exploring the future is found in the concept of ‘critical uncertainty’. This permits the consideration of a few plausible futures and turns out to be more robust to the challenges it has. It decreases the risk of blind spots and undesirable surprises and also assists in identifying methods in which the future can be proactively shaped. The following is a list of the variables and critical uncertainties that were identified as likely to impact upon South Africa towards 2030:

- Good Governance
- Economic Growth
- Post-Apartheid Rehabilitation
- Corruption and Nepotism
- Free Education
- Poverty and Alleviation
- Technological Advancement
- Denomination
- Human Development
- Crime Control
- Civil Unrest
- Ethnic and Regional Tension
- Medical Support
- Elderly and Regional Tension
- Medical Support
- Elderly Care Facilities and Support
- Legal Rights
- Environment Protection
- Fair Policies
- Globalisation
- Bold Initiatives
- Foreign Investment
- Modernisation

- Training of work force
- Middle class Ratio

4.7.2 The 2 x 2 Scenario Matrix

Scenarios are built by selecting and plotting two critical uncertainties in a 2 x 2 matrix. The 2 x 2 matrix results in four quadrants which are utilised to articulate four different future scenarios. The selected critical uncertainties for the 2 x 2 scenario matrix must have a high (+) and low (-) value given to each critical uncertainty. When the two critical uncertainties (with a high and low value for each critical uncertainty) are designed on a Cartesian plane, the themes of the four scenarios become clearly visible (Chermack, 2011; Wade, 2012).

As a result, a 2 x 2 matrix offering the four possible scenarios that will be developed for futures of the South Africa's manufacturing industry is depicted in Chapter 2, Figure 2.7. As such, two critical uncertainties were selected for developing the scenarios for the futures of the South Africa's manufacturing industry:

- Technological progression within then 4IR – with high and low values, i.e. good technological progression and bad technological progression.
- Economic growth – with high and low values, i.e. good economic growth and bad economic growth.

4.8 CONCLUSION

To some extent of the above four diverse scenarios could possibly materialise over the next two eras in the build-up to 2030. The above-mentioned four storylines are illustrative of the possible developments that the FIR could have from a South African perspective. The truth is that it is nearly impossible to foresee which of the scenarios will occur and form the future of the manufacturing industry in the implementation of 4IR principles in future factories in South Africa.

What is important to note is the ability of the manufacturing industry to implement 4IR's new technologies in current factories to reap the innovative benefits they produce for areas of productivity and efficiency, and to prepare for the possibility of any of these scenarios and contemplate even the most unlikely events that may occur to shape the future.

The manufacturing sector must abstain from choosing one of the scenarios above any of the alternatives, in the hope that a certain scenario will undeniably become the realised future. The 'golden thread' through all the above-mentioned scenarios is the significance of the impact of the 4IR on the workforce and the creation of new jobs for the future, the reskilling of the workforce and the enhancement of capabilities of future factories in embracing the implementation and incorporation of advanced manufacturing principles in production processes. This must form a substantial consideration in the preparation of the vison of the "Incorporation of smart production in future factories within the fourth industrial revolution towards 2030".

Chapter 5 will pursue an idyllic, possible future for the 4IR in the manufacturing industry of South Africa, through the implementation of a vision and a set of contextually-aligned, suitable recommendations.

CHAPTER 5
RECOMMENDATIONS AND CONCLUSIONS

5.1 INTRODUCTION

The future of the 4IR from a South African perspective was explained at length in the previous chapter, forming alternative futures through the emergence of scenarios. Plausible scenarios were presented in order to oppose the possible and probable challenges that the manufacturing industry is likely to encounter in the embrace of the 4IR in South Africa towards 2030. Additionally, possible resolutions to approach the suggested research questions which were emphasised in this research paper have also been proposed, with the final purpose of addressing the research objective as depicted in Chapter 1. This chapter will endeavour to present recommendations and conclusions to the questions raised by this research paper.

This chapter commences by concentrating on the sixth and final pillar of Inayatullah's method-linked theory of futures thinking: the pillar of transforming the present and creating the future (Inayatullah, 2008). During this stage of transformation, the future is concentrated in the most preferred outcome, portraying 'win-win' solutions and lacking compromise. The issues which require reflection consist of the formulation of the preferred future for all role players of South Africa impacted upon by the 4IR as the country progresses towards the ideal, sustainable future for the populace towards 2030.

This research espouses the outlook that a progressive, optimistic future can be shaped and formed by current endeavours of all South African stakeholders who has adopted the 4IR. Inayatullah (2008) makes mention of the afore-mentioned in his definition of the fifth basic concept of futures philosophy. The objective is to lay emphasis on the range of alternatives to improve uncertainty preparation as South Africans execute the 4IR in the country's progression towards 2030. The South African manufacturing industry needs to ascertain the suitable scope of adjustment required and needs to determine the consequences of existing choices in manipulating the ideal world in which future prosperity is found.

The primary objective is to elevate the position of the numerous stakeholders and to assist with the establishment of a preferred future, taking cognisance of the 4IR through the formation of additional effective strategies and innovative rational and shaping competences that will guarantee long-term growth of businesses and the decline of perceived job losses.

5.2 USING THE FUTURE

Inayatullah (2008) proposes that the sixth fundamental approach of futures thinking is the use of the future. Whilst futures thinking can be entirely centered on foresight learning and assisting businesses with new competencies, at a deeper level it can assist with the formation of operational strategies (Du Plessis, 2016), thus generating capacity. Determining the right strategy is imperative, but more importantly it is to use the appropriate tools and to inspire self-confidence to create the preferred future. The method in which the future is approached impacts upon all aspects of the human mind, implying that theories of the future should be assessed by incorporating their overall impact on humans and human psychology (Lombardo, 2008). Futures thinking helps to construct the scene for a paradigm shift. The business or industry foresees a new future, empowers stakeholders, produces new strategies, uses tools and then a new future transpires (Inayatullah, 2008).

5.3 FUTURE CREATION

In order to evolve from the present and craft the future that encapsulates the influence and effect of the 4IR in South Africa, it is important to evaluate the essential issues and related choices that must be made in generating a preferred future for the stakeholders of the manufacturing industry, including government, business, the workforce, society, local communities and other concerned groups. The objective is to determine the correct tools and to assist in establishing the confidence needed to generate the preferred future of the 4IR in the South African context: a “Future Vision of the incorporation of smart production in future factories within the fourth industrial revolution towards 2030”. Lindgren and Bandhold (2003) define a vision as a positively encumbered idea of a desired future.

The vision should afford all stakeholders a sense of what is possible, and mobilise them to move in the same direction and align individual goals and drives with that of the collective or institutional.

There are a number of questions which need required to be considered when reviewing the desired future:

- Which decisions need to be taken today to warrant continuity and a positive impact of the 4IR on the fortunes of the South African's manufacturing industry?
- What decisions need to be made to ensure the success of the implementation of the smart factory concept in South Africa?
- Which decisions need to be made to establish the readiness of the South African manufacturing industry for the incorporation of smart production within the 4IR?
- The acclaimed "Future Vision of the incorporation of smart production in future factories within the 4IR towards 2030" exemplifies an attainable, realistic and desirable future that possibly will become the foundation for the expansion and advancement of the 4IR within the manufacturing industry in South Africa. This is crucial for attaining the vision of the transformation of the manufacturing industries concerning the realisation of a preferred future. The previous chapter emphasised the opportunities for the future in four scenarios, the most positive of which was, the "'Fifth Element' scenario, which propositions a future in which all stakeholders accept and embrace the 4IR in South Africa, and the benefits are optimised for all interested stakeholders. Additionally, the scenario affords some ideas on the critical steps required for the innovation and transformation of the manufacturing industry and for individual industries impacted upon by the 4IR as it grows at an exponential rate.

5.4 ENVISIONING THE PREFERRED FUTURE

The desired future of the 4IR in South Africa is directly related to industry transformation and an embracing of the phenomenon; the acceptance of an all-encompassing and innovative approach to introduce new technology, create new job opportunities and upskill and reskill the workforce and of greater productivity in the manufacturing process. Within this scenario, the embrace of the 4IR is complete and successful by the year 2030. Government and the private sector have joined forces to exert the maximum advantage that the 4IR provides and, through innovation, South Africa is a transformed, innovative, key role player with the introduction of 4IR elements within future smart factories. The preferred future to be envisaged for South Africa is one where the 4IR in manufacturing is a robust, sustainable and major contributor to the advancement and wealth of the South African economy. The prophesied ‘singularity’ has not come to pass; instead, AI has been assimilated into society and is viewed as a support and aid to people. Humans stay the masters of AI and not contrariwise. As a result of dynamic technological innovation, South Africa will be recognised as a key role player as a technological ‘disruptor’ and is prominent for its excellence in a number of the 4IR elements and implementation with smart factories, including AI, electronic vehicles (EV), big data (BD) and alternate and sustainable energy generation, resulting in extensively enhanced productivity and reduced production costs, all of which contribute to the country’s internationally, competitive stance.

The dreaded unemployment has not materialised and as an alternative the 4IR has created several previously non-existent jobs that necessitate new skillsets. There has been major investment by the government and the private sector to incorporate smart production in future factories so as to benefit from the opportunities as presented by the 4IR. There has been a considerable increase in the implementation of collaborative robots in manufacturing processes by embracing the 4IR concept in smart factories and thus permitting humans and machine to work harmoniously in a collaborative environment to enrich the quality of workmanship and enhance the production processes with the presence of smart technology.

In 2030, other essential themes come it to play, namely; the enhanced level of skills and accessible skilled jobs, increased international competitiveness, better-quality working conditions, information accessibility, progressive economic growth for the manufacturing industry and South Africa, reduction in development times of new products and equipment, an intensification in the flexibility of manufacturing factories and the progressive results on the environment related to the 4IR. A skills development programme has been developed to aid unskilled labourers who have been impacted on by the implementation of the 4IR, in factories where the automation of production processes has been implemented. This manageable skills training programme has been implemented throughout all industries as a measure to provide labourers with skills relevant to other industries, in the event of job losses.

Government and the manufacturing industry have invested heavily in the infrastructure required to aid the 4IR. This has considerably enhanced the attractiveness of South Africa and has caught the attention of the international community and has given rise to an influx of foreign direct investment (FDI), which has further assisted in funding the infrastructure investment. There has been a noticeable increase in the number of 'smart cities' in the country, following on the rapid demand for autonomous transport and EVs being the standard requirement by all inhabitants. The internet is generously available and is perceived as a basic right. Big data has been efficiently mined and has given rise to critical and enlightening insights being revealed, thereby improving the control of financial, medical and environmental resources. Drone technology has progressed to a stage where drones are utilised to support the police force to sustain law and order, for deliveries and for conveying people in 'drone-taxis', thus reducing congestion on the roads, resulting in less air pollution and in the reduction of carbon emissions and vehicle accidents.

5.5 THE FUTURE VISION OF THE 4IR IN SOUTH AFRICA

The desired future of the 4IR in the South African context is highly dependent on collaboration and transformation with all stakeholders involved, as the main objective is to progress the country towards the position of becoming an active role player in the implementation of advanced technologies in the smart factory concept development and for the 4IR to be a major contributor to South Africa's growth and economic wealth.

This would be attained through innovation, alongside a robust smart production infrastructure in order to deliver advanced production processes, improved products and the achievement of collaboration between man and machine. The question that needs to be examined is: How does the 4IR in South Africa contribute and what is required to transform the manufacturing industry into an advanced, integrated key role-player contributing to the economic growth of the country? As indicated in Chapter 4, the ‘golden thread’ noted in the research is the significance of the impact of the 4IR on the workforce and in the creation of new jobs for the future, the reskilling of the workforce and the enhancement of capabilities of future factories in embracing the implementation and incorporation of advanced manufacturing principles in production processes.

Consequently, the vision must make provision for, and construct drastic plans, to reduce job losses and potentially create more jobs than were lost. Navigated by the principles and strategic essentials acknowledged and discussed earlier, the “Future Vision of the incorporation of smart production in future factories within the fourth industrial revolution towards 2030” can be formulated as below.

5.5.1 A Collective Vision

All stakeholders in the manufacturing industry must agree to the importance of a collective vision that benefits the entire South African population. The rapid growth and global nature of the 4IR means that setting the collective vision is an essential priority for all stakeholder and any delay will result in a further falling behind South Africa’s global counterparts. The ‘Future Vision’ is dependent on the creation of a practical and long-term strategy and on a collaborative approach by all stakeholders. Thus, collaborated in. and approved by, all stakeholders, the strategy has to facilitate a standard for future technological development, accepting the industries’ views on the realisation of lasting, sustainable benefits from the country’s technological innovators.

The collective vision of South Africa’s manufacturing industry needs to include strategies that deliver a number of outcomes:

- Drastically improve teamwork, collaboration and communication among all stakeholders.
- Recognise manufacturing industry challenges and provide solutions.
- Determine the skills shortage and provide required training and education.
- The enhancement of investment initiatives in the essential infrastructure required to incorporate the many elements of the 4IR.
- Support a culture of continuous of research and development in the manufacturing industry.
- Accelerate the growth of innovative technologies to advance the 4IR's performance in all sphere of industry.
- Grow the manufacturing industry and thus see resultant economic growth.

The primary aim of the collective vision is to deliver an impartial, collaborative strategy to promote sustainability and the development of the manufacturing industry. Thus, all stakeholders need to contribute in developing the collective vision. Therefore, all stakeholders need to embrace a long-term mind-set to support the expansion of value creation.

5.5.2 International Competitiveness

The vision endeavours to inspire all contributing stakeholders, such as government, businesses, suppliers, local communities, the workforce and society, to work together and develop a competitive manufacturing industry, thus contributing to lasting fortune for all, whilst, concurrently, supporting national growth and progress. All stakeholders need to adopt a long-term frame of mind to support the development of value creation and a value-adding framework for the manufacturing industry. The vision's objectives are to increase efficiencies, productivity improvement and, concurrently, reduce direct manufacturing costs. Technological innovation can contribute to South Africa's manufacturing industry becoming prominent as an active player in the implementation of disruptive technologies such as AI, robotics, augmented reality, big data and IoT.

5.5.3 Education, a Skilled Workforce and Job Creation

All stakeholders must realise that in order to achieve this vision, essential and crucial changes need to be made to the education system. The President of South Africa, Cyril Ramaphosa, in the state of the nation's address proposed that the country and its educators need to adjust the course of secondary school education to improve pertinent skills required to match the 4IR (RSA, 2019). The South African government has dedicated itself to a 'skills revolution' that will give the country the needed human capital required for a digital economy towards 2030 (RSA, 2019).

As part of this initiative, the president proposes that in excess of over a million youth would be educated in data science and associated skills by 2030. Numerous technology-focused subjects will in future be included to the South African school curriculum in particular (RSA, 2019):

- Data science and analytics
- Blockchain and distributed ledger technologies
- Additive manufacturing
- Artificial intelligence
- Robotics
- Quantum technologies
- Digital Content Production
- 3D Printing
- Cybersecurity
- Drone Piloting
- Software Development
- Cloud Computing (RSA, 2019)

A robotics curriculum will in future be introduced from Grade R to Grade 9. The curriculum will have a robust groundwork in engineering and will permit students to build and control robots through encoding.

The South African department of education will grow the preparation of both educators and students to respond to emerging technologies, including the internet of things, robotics and artificial intelligence. In addition to coding and robotics, new technology subjects and specialisations will be presented. (RSA, 2019):

- Technical mathematics
- Technical sciences
- Maritime sciences
- Aviation studies

In the workforce there is a requirement to fill the new types of occupations formed by the 4IR. Programmes are implemented that aggressively endorse a competitive, knowledge-driven manufacturing industry in which dedicated skills and research-enhancement programmes are followed in partnership with education and research groups. Transferrable skills training programmes are executed nationwide at various centres to offset the negative impact of AI proliferation, automation and mechanisation on employment in the various, affected industries. These programmes are envisioned to prepare employees with the essential new skills that can be transferred to other industries.

5.5.4 Innovation

In the 'Future Vision', the FIR industry supports the country in advancing towards international exposure and this results in dynamic and consultative social, environmental, technological and commercial innovation. Additionally, it enables the execution of a nationwide strategy that embraces commercial enhancement programmes, to uplift operating and management practices to best practice and to assist with the prompt identification of technologies with the potential to alter many industries.

The vision encourages businesses to apply innovation to the complete manufacturing environment and to fast-track the process by entering into contracts with technology providers as entities which at present only harness organisational intelligence.

5.6 CONSIDERING RESEARCH QUESTIONS AND RESEARCH OBJECTIVES

The problem statement was formulated in Chapter 1, after consideration of the key drivers that would change the structure and shape of the manufacturing industry in South Africa. A number of research objectives (primary and secondary) and research questions were raised. The primary research objective of the study was to investigate the extent and impact of the readiness of the South African manufacturing industry for the 4IR and for the incorporation of smart production in future factories towards 2030. The primary objective was attained through the formation of innovative strategies in which the manufacturing industry, government and the private sector can collaboratively as stakeholders embrace and implement the 4IR in future factories to enhance the competitiveness of the industry. One of the objectives of this research was to offer the manufacturing industry practical, yet advanced, solutions on how to tackle some of the challenges faced by South Africa as a result of the possible 'game-changing' status of the 4IR.

The research method selected was the six pillars of futures studies of Inayatullah, in which prominence was placed on scenario planning and the creation of alternative scenarios for the 4IR in South Africa manufacturing industry towards 2030. CLA was applied as a technique to deepen the future and to assist with the observation of challenges from several viewpoints in creating transformative spaces. The secondary research objectives, as depicted in Table 5.1 below, makes reference to certain factors that were reflected upon in determining whether South Africa's manufacturing industry is indeed ready for the 4IR.

TABLE 5.1
SECONDARY RESEARCH OBJECTIVES

RO_1	Conduct an in-depth analysis of FIR in South Africa and establish whether or not the manufacturing sector is aligned with the requirements of 4IR readiness.
RO_2	Evaluate the developing threats and opportunities that will influence the future of 4IR in South Africa by determining various alternative futures in accordance with specific drivers.

RO_3	Encourage information flow throughout the manufacturing industries, at all levels of stakeholders, to develop an inclusive, consistent strategic plan to embrace the 4IR implementation in factories.
RO_4	Gain a better understanding of the best possible future for South African manufacturing factories.
RO_5	Analyse the manufacturing industries' progress and failures in terms of the 4IR implementation in factories.
RO_6	Develop a simple yet practical set of recommendations to address the main factors that hinder the possible implementation of the 4IR in manufacturing factories, with the purpose of improving the level of technology management and implementation in the manufacturing industry in South Africa.

After considering the objectives discussed as above, the study formulated questions to support the objectives of the research. The research aim was to create strategies explaining how South Africa can adjust to the challenges it faces in the manufacturing industry by implementing the 4IR elements in future factories. The research questions for this study were expressed, assimilated and addressed in order to support the research, thereby ensuring the achievement of the research objectives.

TABLE 5.2
SECONDARY RESEARCH QUESTIONS

RQ_1	What are the factors to be considered in determining readiness of the South African manufacturing industry for the incorporation of smart production within the fourth industrial revolution (4IR)?
RQ_2	What are the potential implications and impact on the South African manufacturing industry as a result of the 4IR movement?
RQ_3	What are the key success factors related to the introduction of smart production in future factories and the impact on the economy?
RQ_4	What is the composition of future factories in South African manufacturing industry likely to be?
RQ_5	What are the key success factors of introducing co-bots in smart factories and the resultant impact on the labour force in South African Automotive Industry and economy?

Blyth (2005) suggests that scenario planning progressively frees humans from accustomed worldviews and traditions and exposes them to new viewpoints and behaviours, which improves decisions made about the future and directs strategic choices for future success. In this study, scenarios were further used to articulate alternative, probable paths into the future, accepting present selections and actions with a collective vision on how they could possibly shape the future. Scenario planning, a rounded, comprehensive methodology, was utilised to improve understanding and cultivate insight into the all-encompassing implications of the challenges and driving forces influencing the 4IR. This method assists the various stakeholders to visualise the future in several plausible ways. These shaped scenarios fashioned the groundwork of a “Future Vision of the incorporation of smart production in future factories within the fourth industrial revolution towards 2030”, ultimately providing the mechanism for a preferred future for the 4IR.

5.7 THE CONTRIBUTION OF THE RESEARCH

This research effort sought to contribute by adding theoretical, methodological and practical value:

- Theoretical value**:** The research allowed a review and an in-depth assessment of various literature sources on the methodologies and pillars of futures studies, the numerous stages of scenario planning, CLA and strategic visioning. The objective was to contribute to the current knowledge base with the complete amalgamation of these futures approaches.
- Methodological value**:** The research focused on the future of the FIR within the manufacturing industry from a South African perspective by applying the six pillars method and structure of futures studies to assist all stakeholders with identifying the preferred future for the implementation of 4IR principles within future factories.

- Practical value: The scenarios formulated will offer several 4IR manufacturing industry stakeholders diverse insights and analysis into a number of explanations of the potential paths that could be embarked upon in the 4IR future. From the research, all-inclusive and robust strategies could be articulated and adopted into flexible plans for the future manufacturing in South Africa towards 2030.

5.8 THE PROPOSED CHANGE NAVIGATION PROCESS FOR SOUTH AFRICA TOWARDS 2030

A change navigation process must contain the steps normally incorporated into the scenario-based planning process. The steps consist of laying the foundation for the scenario-based planning agenda; determining the pivotal question; categorising and ranking the foremost local and global factors, deciding on the scenario logics, expanding on the scenarios, examining the influences of the scenarios for South Africa, formulating new as well as existing strategies founded on the developing scenarios, choosing the leading signposts/indicators to administer the change navigation process and the implementation of scenarios and being cautionary when unfolding scenarios and sustaining ongoing business learning (Chen, 2011; Geldenhuys, 2006; Herrington, 2007).

This debate displays the intricacy of change and raises a question: Who guarantees that change context, process, and content relate effectively and that change space is designed to guarantee readiness for change and alignment in the change process? Although some differ, most researchers would answer, “That is the role of leadership!” (DiMaggio & Powell, 1983; Fernandez & Rainey, 2006; Hannan & Freeman, 1984; Scott, 2003). Several leadership scholars link leadership to change as well, including Burns (1978) who asserts that leadership manifests most in the change perspective, and Linsky & Heifetz (2002) who presents leadership as enabling adaptive change. Yukl (2002) contends that, “Change is the essence of leadership and everything else is secondary”. The leadership literature embraces a fragmented set of viewpoints balkanised into “various clusters of theories and approaches” (Fernandez, 2005).

Researchers relate unwaveringly to schools of thought which appear exclusive and challenging to assimilate with sporting terms like 'trait theory', the 'leadership behaviour', 'power and influence approach', 'situational and contingency theory', 'transactional and transformational leadership', 'collaborative leadership', 'connective leadership', and 'followership'. These schools of thought have a tendency to postulate different opinions relating to essential questions, such as: Who is the change leader? Why? What is the leader's responsibility in the change process? How? How does context influence leadership in change?

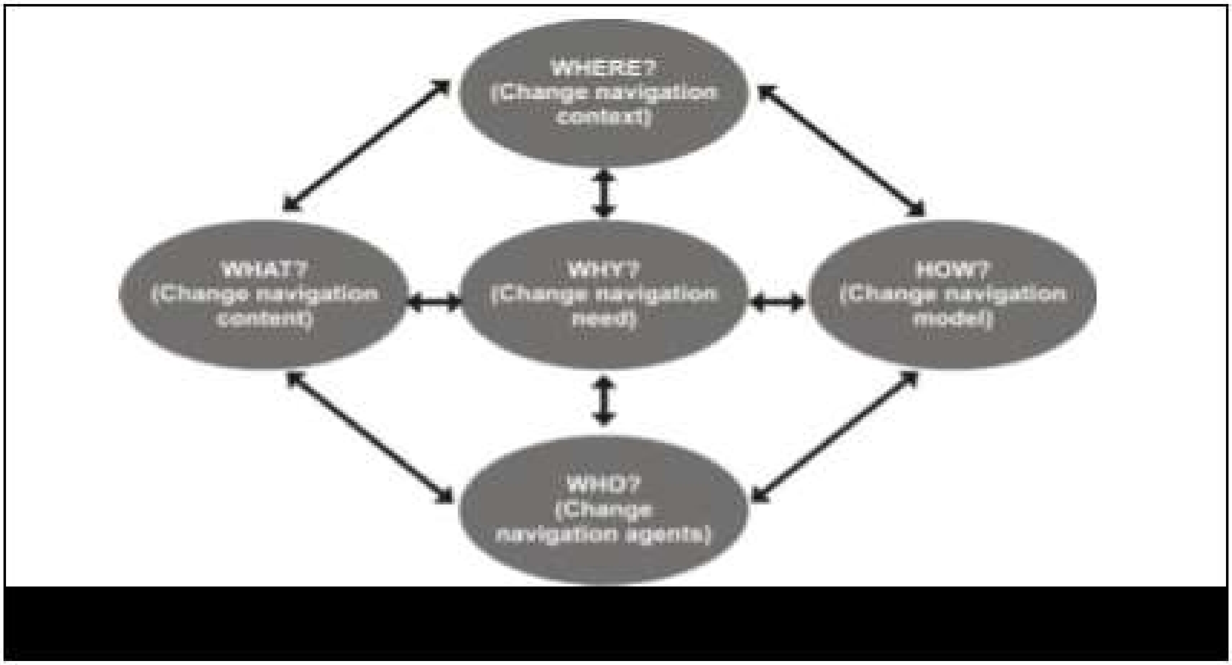
This research attempted to consider these vital questions to better comprehend how leadership makes a difference in the change process. This research paper addresses it below and raises research suggestions based on the effort at an inclusive analysis of the literature and the change space perception already discussed.

5.7.1 Building blocks for the change navigation process

The change navigation process includes three distinctive circumstances as identified by a number of authors such as Beckhard & Harris (1987); Tushman & O'Reilly, (1997) and Veldsman (2002):

- The desired future state (i.e. where the leaders want the country to get to).
- The present state (i.e. where the country is currently).
- The transition state (i.e. the set of strategies, and actions that the country must encounter to shift from the present to the future).

FIGURE 5.3
BUILDING BLOCKS OF THE CHANGE NAVIGATION PROCESS



(Source: Veldsman, 2002)

The five building blocks of change navigation depicted in Figure 5.3 can be consolidated (Pettigrew, 1987; Veldsman, 2002) as below:

- The ‘why’ of change: the competence to understand and own the foundation for change completely (which is the change navigation need).
- The ‘where’ of change: the ability to draw the required boundaries in space and time around the country (that is the change navigation framework).
- The ‘how’ of change: the capability to plan, implement and follow a viable and applicable change process (which is the change navigation model).
- The ‘who’ of change: the ability to describe and position the change roles properly throughout the course of the change (that is the change navigation agents).
- The ‘what’ of change: the ability to recognise the essential and vital organisational factors that must be changed as a result of the change need (which is the change navigation content).

Table 5.4 below contains the building blocks of change and the values most regularly cited to guide one in navigating through the pandemonium of change under hyper-turbulent conditions.

TABLE 5.4
GUIDING VALUES FOR CHANGE NAVIGATION EFFORTS FOR SOUTH AFRICA TOWARDS 2030

The "Why"

- A visible and constant belief in the actualisation of a clear vision of the change outcomes must exist.
- The expected benefits flowing from the vision must be effectively communicated to South Africans by sharing possible challenges and areas of uncertainty.
- Change must be linked to the strategic intent, central/overall theme and the necessary significance.

The "Where"

- The way in which the change overall must be a mirror of the desired future state. In this circumstance, South Africans obtain a preview of the 'should/must be' state, the latter of which is being strengthened on a continuous basis.

The "How"

- Congruence among all aspects of the change must be maintained.
- South Africans must be given adequate/high-impact training and emotional support to equip them to make a success of the journey.
- Change requires a substantial investment in resources.

The "Who"

- The more intensive and extensive the change, the greater the need for visible and active transformational leadership.
- Responsible and active participation/engagement of South Africans must be encouraged throughout the unfolding of the change.

The "What

- It may be helpful to develop a model as an intellectual map to assist in conceptualising and systematising the changes South Africa has to undergo. Piloting the change programme can be implemented on a trial basis

(Source: Geldenhuys (2006)

5.9 CONCLUSIONS AND RECOMMENDATIONS FOR THE FUTURE OF THE 4IR IN MANUFACTURING INDUSTRY WITHIN SOUTH AFRICA

The acceptance of the 4IR by the manufacturing industry in formulating a preferred future for South Africa requires more than scenario planning, even though it is a desired methodology which generates new insights and knowledge concerning the manufacturing industry and its array of futures. What is necessary, above all, is the commitment and dedication from all stakeholders relating to the implementation of the smart production within future smart factories to successfully change the future through the design of an action plan and strategy that can achieve the “Future Vision of the incorporation of smart production in future factories within the fourth industrial revolution towards 2030”. This “incorporates the goals and determines the readiness of all South African manufacturing stakeholders, including businesses, society, government, suppliers and the workforce in the embrace of 4IR.

South Africa will undoubtedly be left behind the rest of the world if it does not embrace progressive technology within future factories and will lose out on the positive impact that this technology can have on the manufacturing industry and collective economy of the country. Government is focusing on aligning South Africa towards embracing the 4IR, with President Cyril Ramaphosa being at the forefront of initiating strategies to ensure the readiness of South Africa to benefit from all that the 4IR has to offer the country towards 2030. The implementation of innovative strategies, an unwavering regulatory environment, the distribution of common values, and the formation of an environment of trust, shared purpose and benefits for all in the manufacturing industry, enables the “Future Vision of the incorporation of smart production in future factories within the fourth industrial revolution towards 2030” to be achievable.

The 4IR is able to assist with positive progress and transformation in South Africa through social, technological and environmental innovation. By implementing this process, it can address the challenges that restrict productivity in the manufacturing industry and take the lead in challenges facing the manufacturing industry, crucial to the protection of South Africa’s probable position as a key stakeholder in international technology enhancement within future smart factories leading up to 2030.

A collective vision, remarkable leadership and a desire for innovation will make sure that the readiness, acceptance and execution of the 4IR elements by the manufacturing industry continue to drive the economic progress for South Africa into the future towards 2030 and beyond.

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DECLARATION BY CANDIDATE

NELSON MANDELA UNIVERSITY

DECLARATION BY CANDIDATE

NAME: Megan Abdoll

STUDENT NUMBER: s197114910

QUALIFICATION: MBA

TITLE OF PROJECT:

The incorporation of smart production in future factories within the fourth industrial revolution towards 2030.

DECLARATION:

In accordance with Rule G5.6.3, I hereby declare that the above-mentioned treatise/ dissertation/ thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

SIGNATURE: [signature]

DATE: 18/11/2019

ETHICS CLEARANCE

NELSON MANDELA
UNIVERSITY

PO Box 77000, Nelson Mandela University, Port Elizabeth, 6031, South Africa mandela.ac.za

Chairperson: Faculty Research Ethics Committee (Human)
Tel: +27 (0)41 504 2504

Ref: [H19-BES-BUS-040] / Approval]

24 July 2019

Prof C Arnolds
Department: Graduate School

Dear Prof Arnolds,

TITLE OF STUDY: THE INCORPORATION OF SMART PRODUCTION IN FUTURE FACTORIES WITHIN THE FOURTH INDUSTRIAL REVOLUTION TOWARDS 2030 (MBA)

PRP: Prof C Arnolds
PI: M Abdoll

Your above-entitled application served at the *Faculty Ethics Committee of the Faculty of Business and Economic Science*, (*14 June 2019*) for approval. The study is classified as a negligible/low risk study. The ethics clearance reference number is **H19-BES-BUS-040** and approval is subject to the following conditions:

1. The immediate completion and return of the attached acknowledgement to Lindie@mandela.ac.za, the date of receipt of such returned acknowledgement determining the final date of approval for the study where after data collection may commence.
2. Approval for data collection is for 1 calendar year from date of receipt of above mentioned acknowledgement.
3. The submission of an annual progress report by the PRP on the data collection activities of the study (form RECH-004 to be made available shortly on Research Ethics Committee (Human) portal) by 15 December this year for studies approved/extended in the period October of the previous year up to and including September of this year, or 15 December next year for studies approved/extended after September this year.
4. In the event of a requirement to extend the period of data collection (i.e. for a period in excess of 1 calendar year from date of approval), completion of an extension request is required (form RECH-005 to be made available shortly on Research Ethics Committee (Human) portal)
5. In the event of any changes made to the study (excluding extension of the study), completion of an amendments form is required (form RECH-006 to be made available shortly on Research Ethics Committee (Human) portal).
6. Immediate submission (and possible discontinuation of the study in the case of serious events) of the relevant report to RECH (form RECH-007 to be made available shortly on Research Ethics Committee (Human) portal) in the event of any unanticipated problems, serious incidents or adverse events observed during the course of the study.
7. Immediate submission of a Study Termination Report to RECH (form RECH-008 to be made available shortly on Research Ethics Committee (Human) portal) upon unexpected closure/termination of study.
8. Immediate submission of a Study Exception Report of RECH (form RECH-009 to be made available shortly on Research Ethics Committee (Human) portal) in the event of any study deviations, violations and/or exceptions.
9. Acknowledgement that the study could be subjected to passive and/or active monitoring without prior notice at the discretion of Research Ethics Committee (Human).

Please quote the ethics clearance reference number in all correspondence and enquiries related to the study. For speedy processing of email queries (to be directed to Lindie@mandela ac za), it is recommended that the ethics clearance reference number together with an indication of the query appear in the subject line of the email.

We wish you well with the study.

Yours sincerely

Prof M van Eyk

Cc: Department of Research Capacity Development
Faculty Research Co-ordinator: Lindie van Rensburg

ACKNOWLEDGEMENT OF CONDITIONS FOR ETHICS APPROVAL

I, **Prof Cecil Arnolds** (PRP) of the study entitled **THE INCORPORATION OF SMART PRODUCTION IN FUTURE FACTORIES WITHIN THE FOURTH INDUSTRIAL REVOLUTION TOWARDS 2030 (H19-BES-BUS-040)**, do hereby agree to the following approval conditions:

1. The submission of an annual progress report by myself on the data collection activities of the study by 15 December this year for studies approved in the period October of the previous year up to and including September of this year, or 15 December next year for studies approved after September this year. It is noted that there will be no call for the submission thereof. The onus for submission of the annual report by the stipulated date rests on myself.

2. Submission of the relevant request to Faculty RECH in the event of any amendments to the study for approval by Faculty RECH prior to any partial or full implementation thereof.

3. Submission of the relevant request to Faculty RECH in the event of any extension to the study for approval by Faculty RECH prior to the implementation thereof

4. Immediate submission of the relevant report to Faculty RECH in the event of any unanticipated problems, serious incidents or adverse events.

5. Immediate discontinuation of the study in the event of any serious unanticipated problems serious incidents or serious adverse events.

6. Immediate submission of the relevant report to Faculty RECH in the event of the unexpected closure/discontinuation of the study (for example, de-registration of the PI)

7. Immediate submission of the relevant report to Faculty RECH in the event of study deviations violations and/or exceptions.

8. Acknowledgement that the study could be subjected to passive and/or active monitoring without prior notice at the discretion of Faculty RECH.

Signed: ______________ Date: 25/7/2019

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DEGREE: MBA

SURNAME, INITIAL: M Abdoll

STUDENT NUMBER: s197114910

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[signature] 5 December 2016

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TO WHOM IT MAY CONCERN

This is to certify that the treatise written by Megan Abdoll and entitled:

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CHAPTER 1

THE RESEARCH PROPOSAL

1.1 INTRODUCTION

The manufacturing industry is on the edge of revolution, with smart factories and the prominence of digitisation in the lead (Govindan, 2014). In order to remain sustainable, manufacturing companies are required to be flexible, adaptable, proactive, responsive to change and able to produce a variety of products in minimum time at a lower cost (Kumar, Karunamoorthy, Roth, & Mimalinee, 2005).

The manufacturing sector is vital to the economy and continues to be a central driver of growth for economies worldwide (Gehrke, et al., 2015). It contributes towards the gross domestic product (GDP) and influences infrastructure development and job creation (Deloitte, 2016). In South Africa (SA), vehicle and component production is the largest sector within the manufacturing environment. In 2016, the broader automotive industry contributed 7.4% towards GDP (AIEC, 2017).

As a result of technological advances, the current increase in manufacturing productivity has been the greatest since the dawn of the industrial revolution. Today's economy is at the cusp of the Fourth Industrial Revolution (4IR), which is also known as 'Industry 4.0'. Industry 4.0 is a new rubric referring to technological forces and innovations that will disrupt and transform lives in extraordinary ways. It is characterised by a fusion of technologies that are blurring the lines between the physical, digital and biological spheres (Schwab, 2016).

Industry 4.0 is a new manufacturing paradigm, which focusses on creating smart products, procedures and processes (Kagermann, Wahlster, & Helbig, 2013). A smart factory is a component of Industry 4.0 and is a self-organised, modular, highly flexible and reconfigurable factory that enables the production of customised products at low cost, thereby maximising profitability (Wang, Wan, Li, & Zhang, 2016a).

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