Benefits of information technology for small and medium-sized enterprises in the manufacturing industry

I van der Westhuizen

orcid.org/0000-0001-9852-3114

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Supervisor: Prof S van Rooyen

PREFACE

Most objects we see, most objects we use were manufactured by an enterprise. Every day we are surrounded by products from the process of manufacturing. As a management accountant, I wish to expand my knowledge and experience in the manufacturing environment by not only gaining knowledge of management accounting in the manufacturing industry, but also gaining insight into the future of manufacturing in terms of incorporating technology. Hence, this study.

I would like to acknowledge the following people:

First and foremost, I would like to contribute my academic achievements to my mother who has been my biggest supporter since Day One and sadly has passed away. I am also grateful to the North-West University for the knowledge of management accounting I have gained through my years of study. I am especially filled with gratitude towards Prof. Surika van Rooyen for assisting and motivating me throughout the study. I am furthermore indebted to my friends and family for supporting my decisions and my academic path. I am also thankful towards my employers, both Kruger & Co and Telesure Investment Holdings, for providing me with enough time to work on my master's. Finally, I want to thank the Lord for giving me this opportunity and guiding me through the entire process.

ABSTRACT

Small and medium-sized enterprises (SMEs) play a critical part in an economy, driving growth and creating jobs. SMEs are even more vital for developing countries since they are effective tools for poverty alleviation. However, despite their importance to the economy, SMEs are faced with a variety of obstacles such as financial challenges, tax rates, competition, a lack of knowledge, and high operational costs, among others.

Accounting for 8% of the SMEs in South Africa, contributing 25% of total SME turnover, and accounting for 20% of the employment cost associated with SMEs, manufacturing proves to be a key industry for SMEs. Changes in the manufacturing industry for SMEs are inevitable, especially since the competitive nature of the manufacturing industry is based on low input cost in terms of material, labour and additional resources and high-volume output in terms of product manufacturing. Many SMEs in the manufacturing industry have realised the importance of innovation and product development to sustain long-term competitiveness and profitability. Technologies may hold many benefits for manufacturing companies in particular; however, management might be unaware of what these benefits entail.

While SMEs in the manufacturing industry may gain tremendous benefits from incorporating IT, they must ensure that the resources available to them are leveraged to obtain the maximum value for the resources sacrificed for the investment in new technology. Therefore, thorough examination prior to investment is imperative. The value for money performance measurement tool can assist SMEs in the manufacturing industry in determining the benefits of investing in technology in terms of efficiency (speed of production), economy (cost of production) and effectiveness (quality of production).

Keywords:

Benefits, economical, effectiveness, efficiency, information technology, manufacturing, value for money, small and medium-sized enterprises

ABBREVIATIONS

3D	Three-dimensional
AI	Artificial Intelligence
IoT	Internet of Things
IT	Information Technology
RAMI 4.0	Reference architecture for Industry 4.0
SME	Small and medium-sized enterprise

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CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Introduction

This study focuses on the benefits of information technology (IT) for small and medium-sized enterprises (SMEs) in the manufacturing industry. The study sought to determine the potential benefits of IT for SMEs in the manufacturing industry by considering the value for money performance measurement tool.

Since the first Industrial Revolution in 1760, companies have been transforming the manufacturing process, from using water in manufacturing to incorporating digital automation to increase machine simplicity, efficiency, and persistency (Qin *et al.*, 2016). The manufacturing industry accounts for roughly 17% of European countries' gross domestic product and an astonishing 40% of the gross domestic product of developing countries like China, India and Brazil. In addition, the industry creates millions of jobs each year. Evidently, the manufacturing industry has become a critical part of the economy of a country (Qin *et al.*, 2016). In South Africa, the manufacturing industry represented 24% of the total turnover in 2019 (Stats SA, 2019). Of this, SMEs accounted for 18% of the total turnover.

With the manufacturing environment becoming more competitive and shareholders expecting a higher return on their investments, manufacturers are continuously focusing on improving their productivity, quality, and responsiveness (Rogers & Shafer, 1995). Shareholders' growing concern with how their capital is being utilised in the manufacturing environment has put pressure on manufacturers to place a greater emphasis on performance measurement, which comprises a collective of variables that is crucial for sustainability and requires continuous monitoring of the manufacturing performance (Vachon & Klassen, 2008).

The introduction of IT in the manufacturing industry has had a positive impact in terms of innovation and product development through the acquisition of external technologies. While large manufacturers have a considerable advantage in terms of manufacturing process innovation, IT has been of great benefit to SMEs in the manufacturing industry in particular, since they tend to focus on product rather than process innovation (Tsai *et al.*, 2011).

1.2 Background to the study

1.2.1 Manufacturing

The manufacturing industry is constantly changing due to the pressure from the global scale of competition and rapid advancement in process technology. Process technology refers to tools that an organisation utilises to create, monitor, manage and improve the overall manufacturing processes (Simsek, 2023). With the rapid change in process technology, manufacturing companies are continuously becoming limited by outdated technologies. For manufacturers to overcome these limitations, it is important to address and constantly seek methods and techniques to improve lead time for introducing, installing, and implementing new process technologies (Mehrabi *et al.*, 2000).

Manufacturers are adapting and evolving to meet customer demands. This requires them to redefine the manufacturing process to improve products, while lowering costs. This is often achieved by moving from the classical manufacturing form towards automated manufacturing or smart manufacturing that requires less manual interaction and is managed by machines (Kusiak, 2019).

1.2.2 IT in manufacturing

1.2.2.1 The adoption of IT in the manufacturing process

In 1960, manufacturers noticed the benefits of incorporating technology into manufacturing. They realised that technology could assist all three of the traditional manufacturing phases, namely design, process planning and manufacturing, as computers could carry out a set of complex functions in a short period of time without compromising any accuracy. Essentially, the traditional three phases could be transformed towards computer-aided design, computer-aided process planning and computer-aided manufacturing (Al-wswasi *et al.*, 2018).

For optimal computer-aided manufacturing, information in the manufacturing phases must be shared accurately throughout the entire manufacturing process. This allows for easy access to a product's specifications, requirements and methods during the process (Al-wswasi *et al.*, 2018). Being able to access and share this data across different platforms and at high speed is crucial, with additional requirements for information integration and technological advantages. In recent years, numerous different technologies have emerged, with the prominent ones being cloud manufacturing and three-dimensional (3D) printing. 3D printing enables the creation of physical objects from a geometrical representation through successive addition of specific materials (Shahrubudin *et al.*, 2019), while cloud manufacturing consists of a network of cloud computing which is created by the integration of different manufacturing ITs such as Big Data and Internet of Things (IoT) (Quo & Qui, 2018).

1.2.2.2 IoT, Big Data and AI

According to Roblek *et al.* (2016), "the internet transformation of the digital industry is still in progress". This transformation includes technology elements such as IoT, Big Data and artificial intelligence (AI). IoT enables the interconnection of machinery, vehicles, devices, factories and other items through internetworking of the cyberspace and physical objects (Liu & Zhong, 2017), while Big Data allows enterprises to analyse large quantities of data for decision making, and AI enables machines to perform cognitive functions such as perceiving, reasoning, learning and problem solving (Arinez *et al.*, 2020). Undoubtedly, the digital revolution of Industry 4.0 is on its way, and this will completely transform the methods and techniques of manufacturing as we know it.

1.2.2.3 Industry 4.0

For manufacturers to achieve smart manufacturing, it is important to incorporate the concept of Industry 4.0. The concept of Industry 4.0 refers to the Fourth Industrial Revolution that was developed to assist in the development of advanced production systems to increase productivity and efficiency and is currently redefining the manufacturing industry by reshaping the entire value chain of the production cycle (Frank *et al.*, 2019). Industry 4.0 consists of a variety of technologies which include cloud-based manufacturing, smart manufacturing, industrial internet, IoT and many other technological elements. With modern consumers seeking more customisation, Industry 4.0 assists in transforming the mass production of products into a more customisable production process (Vaidya *et al.,* 2018). While enhancing physical products, it also benefits manufacturers through the integration between equipment, labour, factory, supplier and customer (Frank *et al.*, 2019).

1.2.3 SMEs in the manufacturing industry

SMEs often lack the required manpower to look beyond their own product and product ranges towards an additional area. Hence, they might be unfamiliar and uneducated with regard to technology and thus unaware of the benefits technology offers. In contrast, larger manufacturers greatly benefit in terms of value for money by the adoption of technology which improve their productivity, innovation and cost production while simultaneously improving their manufacturing, marketing, selling, presenting and data management function (Ulas, 2019).

Furthermore, SMEs are finding it challenging to invest in emerging technologies as early adaptors due to their limited funds, with the additional possibility of investing in the wrong technologies (Faller & Feldmuller, 2015). However, resistance to the adoption of technology due to the high cost associated with the initial investment make them extremely vulnerable to the disruption of technology in the manufacturing industry.

1.2.4 Value for money

In the private sector, a company's performance is largely measured by the profits generated for the year. However, this concept cannot be directly applied towards state-owned and not-for-profit enterprises as profit is not the main objective they strive for. With the lack of measurements to measure the performance of not-for-profit enterprises, auditors have started to conduct a value for money performance measurement on not-for-profit- enterprises. The value for money performance measurement tool is utilised to measure how the capital and resources of these enterprises are being utilised (Goddard, 1989). This measurement tool is performed on public and non-profit entities to determine the performance of an enterprise in terms of efficiency, economy and effectiveness, considering their limited capital (Daujotaite & Macerinskiene, 2008). Williamson (2010) argues that the value for money performance measurement tool can be used to assess the value for money SMEs in the manufacturing industry can obtain in exchange for the cost associated with the investment of technology, as incorporating modern technology into the manufacturing processes can provide unmatched value for money.

As mentioned above, the value for money performance measurement tool measures performance on the three E's, namely efficiency, economy and effectiveness (Goddard, 1989). The three E's are defined as follows:

- *Efficiency*: Efficiency is concerned with the overall usage of material in the process and producing operation (Goddard, 1989). This measurement is focused on the amount of input in terms of labour and materials, compared to the number of finished products and sales.
- *Economical*: An economical operation is concerned with the correct acquisition of human and material resources in terms of quality and quantity (Goddard, 1989). This measurement is focused on the cost of the input in terms of material and labour in the manufacturing processes.
- *Effectiveness:* Effectiveness is concerned with how well a process or activity is achieving the operation's goals (Goddard, 1989). This measurement is focused on the quality, condition, and the value the finished products offer to customers.

The three E's can either be used as solo measurements or as a collective measurement. The collective measurement is especially important when there is a concern regarding long-term growth and market share, since performance measurement generally measures the performance based on a specific year (Barnett *et al.*, 2011).

1.3 Motivation of topic actuality

Changes in the manufacturing industry for SMEs are inevitable, especially since the competitive nature of the manufacturing industry is based on low input cost in terms of material, labour and additional resources and high-volume output in terms of product manufacturing. Many SMEs in the manufacturing industry have realised the importance of innovation and product development to sustain long-term competitiveness and profitability (Chu, 2003). While technology may hold many benefits for companies, especially manufacturing companies, management might be unaware of what exactly these benefits are (Ulas, 2019).

It has been shown that the value for money performance measurement tool could assist SMEs in the manufacturing industry in determining the benefits that investing in technology can provide in terms of efficiency (speed of production), economy (cost of production) and effectiveness (quality of production) (Naoyuki & Farhad, 2018; Williamson, 2010).

1.4 Problem statement

With the rise of global competition and revolution of technology, large manufacturers have a considerable advantage in terms of manufacturing process innovation. SMEs tend to focus on product innovation rather than process innovation, and while SMEs in the manufacturing industry are aware that IT may provide benefits, they are often unaware of what exactly those benefits are. Moreover, with the high cost associated with investing in IT, SMEs are often reluctant to make such an investment.

Considering the resistance from SMEs in the manufacturing industry, in combination with shareholders' increasing concerns for the value they receive from their investment, it is imperative to establish the benefits that SMEs in the manufacturing industry can obtain by investing in IT.

This raises the following research question: "How can SMEs in the manufacturing industry benefit from investing in IT through focusing on value for money in terms of efficiency, effectiveness and economy?"

1.5 Objectives of the study

1.5.1 Primary objective

The main objective of this study was to investigate and identify the benefits that IT holds for SMEs in the manufacturing industry through focusing on value for money in terms of efficiency, effectiveness and economy.

1.5.2 Secondary objectives

The following theoretical secondary objectives assisted in reaching the main objective:

- To identify the potential benefits that IT holds for SMEs in the manufacturing industry from the literature (Chapter 3).
- To conceptualise from the literature how the value for money performance measurement tool could assist SMEs in the manufacturing industry in determining the benefits that investing in technology can provide in terms of efficiency, economy and effectiveness (Chapter 4).

Furthermore, the main objective was supported by the following empirical objective:

- To evaluate the benefits that IT holds for SMEs in the manufacturing industry in terms of efficiency, effectiveness and economy through analysing data obtained from interviews (Chapter 5).

1.6 Research methodology

1.6.1 Literature review

A literature review firstly provided a brief background and history of SMEs in the manufacturing industry and clarified key words and definitions used in this study. Subsequently, the common advantages technology holds for SMEs in the manufacturing industry were identified. The literature review furthermore investigated the potential benefits of performing a value for money performance measurement in terms of the benefits IT can provide in comparison to the investment cost prior to the initial investment when it comes to investing in IT for the factory.

The literature review mainly utilised journals, articles, websites, books, and previous research. Information for the literature study was gathered from the following available sources: Google scholar, EbscoHost, Discovery journal and Emerald.

1.6.2 Empirical research

Empirical research is defined as the conclusion of the study and entails the method and techniques that were used to gather information through experience observation, events, or experiment to conduct the study (Fletcher, 2017). The current study, which focuses on SMEs operating in the manufacturing industry, utilised data gathered through a literature review, as mentioned above, and through semi-structured interviews with participants at companies the researcher had access to.

1.6.2.1 Study context and paradigmatic assumptions

Ontological assumptions

Ontology is defined as the study of existence, concerned with what is. It is the questioning of the nature of existence and what is assumed as reality (Crotty, 2003). SMEs in the manufacturing industry exist in the hope of producing products which they can sell and make a profit on. SMEs in the manufacturing industry are like any ordinary for-profit company, focusing on the maximisation of wealth of their stakeholders. The ontological assumption of this study was that of relativism which considers a broad range of ideas and positions and lack precious definitions (Sankey, 1997).

The study assumed relativism since the nature of technology may hold different benefits and uses to a variety of manufacturers. Relativism has a variety of forms and takes form according to which events, objects or notions acquire its identity and character according to background factors (Vargas-Silva, 2012).

Epistemological assumptions

Epistemology is about how the knowledge that we currently possess is understood and explained and how we got hold of it. In addition, epistemology is concerned with providing a common ground for deciding what knowledge is possible, while ensuring that the knowledge is adequate and legitimate (Yilmaz, 2013).

This study followed an interpretivist approach, focusing on the interpretation and understanding of information. The interpretivist approach assumes that our knowledge of reality is created through a social construction with individuals as actors (Walsham, 2001).

Methodological assumptions

Methodological assumptions involve the strategy and course of actions behind the selection of specific methods and link the choice of methods with the overall desired outcome (Crotty, 2003). Qualitative research focuses on interpreting and analysing the subject at hand and attempts to make sense of the observed phenomena (Njie & Asimiran, 2014).

This study followed a qualitative research design to obtain a better understanding of the unique experience of seniors or managers at SMEs that operate within the manufacturing industry.

1.6.2.2 Population and sampling

The study population comprised SMEs that operate in the manufacturing industry and are situated within a 200-kilometre radius of Pretoria, South Africa. Sampling was conducted through a combination of two sampling techniques, namely purposive sampling and convenience sampling. Purposive sampling was applied in this study to identify SMEs in the manufacturing industry that incorporate a form of technology in their manufacturing process. This technique is also referred to as judgement sampling where a sample group is pre-selected to provide rich and relevant information for the study (Lopez & Whitehead, 2012).

Convenience sampling was applied due to the limitation of participants available to partake in the study because of accessibility, location and willingness (Lopez & Whitehead, 2012). The sample for this study consisted of eight SMEs in the manufacturing industry. This is based on past studies which do not indicate a precise number of participants for data saturation. However, Turoff & Linstone (2002a) suggest a minimum sample size of five participants for data saturation. For this study, eight willing participants participated in semi-structured interviews. Interviews were conducted until data saturation was reached, which was achieved after eight interviews.

1.6.2.3 Data collection

The data for this study were collected through semi-structured interviews which took the form of a spoken narrative, where most data were gathered through a direct encounter between the participant and the researcher (Lopez & Whitehead, 2012). Eight semi-structured interviews were conducted with management or senior employees within SMEs in the manufacturing industry in different enterprises. These interviews provided qualitative data from an internal perspective in terms of SMEs in the manufacturing industry. A thematic analysis of the qualitative data was then executed.

Due to the ease of access, the interviews were held either virtually through an online platform (Zoom) or at a physical location after both parties agreed on a set date. Interviews only commenced after both parties signed the relevant ethical consideration documents.

1.6.2.4 Data analysis

The interviews were recorded and transcribed. Subsequently, the data gathered from the interviews were analysed and interpreted by means of coding to discover and identify similarities and common variables among the participants to provide information that can be used for this research.

1.7 Chapter outline

1.7.1 Chapter 1: Introduction and background

This chapter introduces the study and motivates the actuality of the topic. It provides an overall background to the important elements in the study and presents the study objectives.

1.7.2 Chapter 2: Research methodology

Firstly, this chapter sets out the philosophical assumptions of the study. Secondly, it outlines the research methods and techniques utilised by the study to assist in reaching the main objective and the secondary objectives.

1.7.3 Chapter 3: Potential benefits of IT for SMEs in the manufacturing industry

A literature review approach is followed in this chapter to determine and identify the potential benefits that IT holds for SMEs in the manufacturing industry.

1.7.4 Chapter 4: Value for money performance measurement tool

The focus of this chapter is on gaining an understanding of the potential benefits of the value for money performance measurement tool for SMEs in the manufacturing industry in terms of efficiency, effectiveness and economy. This is achieved through a review of the literature and analysis of data from previous studies.

1.7.5 Chapter 5: Results

This chapter presents the results of the empirical study. It is focused on the evaluation of the economical, effective and efficiency effects that investment in IT holds for SMEs in the manufacturing industry. The results were gained form the analysis of the data gathered from the semi-structured interviews.

1.7.6 Chapter 6: Conclusion and recommendations

This chapter concludes the discussion of the overall study results. It indicates the degree to which the main objective of the study has been fulfilled, and proposes recommendations based the findings of the study.

CHAPTER 2: RESEARCH METHODOLOGY

2.1 Introduction

This chapter presents the philosophical assumptions adopted in the study. It further outlines the research methods and techniques utilised to reach the main objective of the study, which was to investigate and identify the benefits that IT holds for SMEs in the manufacturing industry through focusing on value for money in terms of efficiency, effectiveness and economy (Paragraph 1.5.1, page 5).

The secondary objectives of the study were to identify the potential benefits that IT holds for SMEs in the manufacturing industry; to conceptualise from the literature how the value for money performance measurement tool could assist SMEs in the manufacturing industry in determining the potential benefits of investing in technology in terms of efficiency, economy and effectiveness; and lastly, to evaluate the benefits that IT holds for SMEs in the manufacturing industry in terms of efficiency, effectiveness and economy (Paragraph 1.5.2, page 5).

2.2 Study context and paradigmatic assumptions

Research paradigmatic assumptions can be seen as a group of beliefs in regard to a study, which influence how a study should be researched and how results can be interpreted. The paradigmatic assumptions imply the philosophical position of the researcher and the nature of matter of a specific study that assist in understanding what information can be known and how knowledge can be obtained (Siddiqui, 2019).

2.2.1 Ontological assumptions

Ontological assumptions concern the nature of reality (Siddiqui, 2019). The two most commonly used ontological assumptions are realism and relativism. Realism can be classified in three different forms, namely naïve realism, critical realism and historical realism. Naïve realism assumes that a phenomenon exists in absolute, based on own experience and understanding, while critical realism assumes that a phenomenon exists not only from own experience and understanding but can exist from observable events (Sturgiss & Clark, 2019). Historical realism assumes that a phenomenon exists that was created over time by a variety of influences (Guba & Lincoln, 1994).

The relativism assumption can be viewed as a stance of interpretivism and assumes that a single phenomenon can have a range of different interpretations. The aim of a relativism assumption is to gain a greater understanding of the phenomenon and its complexity as there is no basic process by which the knowledge can be determined (Siddiqui, 2019).

The current study was conducted on the assumption of relativism as the phenomenon of benefits of technology for SMEs in the manufacturing industry are different for each participant and utilised and incorporated into the enterprise in diverse ways.

2.2.2 Epistemological assumptions

Epistemological assumptions are assumptions regarding the nature of the knowledge as well as the relationship between the individuals with the knowledge and the knowledge itself (Siddiqui, 2019). The two main epistemological approaches are interpretivism and positivism. The positivism approach assumes a natural scientist perspective that engages with observable reality, leading to product generalisation and adopting the belief that other related social entities are the same and share a common view of physical objectives along neutral phenomena. The interpretivism approach, on the other hand, was developed considering critique regarding the limitation of positivism, accepting that the natural world may differ from the social world. The interpretivist approach is therefore more concerned with the different variables and aspects that relate to a specified context. It views physical phenomena subjective to human differences and thus assumes that interpretation can vary from individual to individual (Alharahsheh & Pius, 2020). Unlike positivists, interpretivists' assumptions are concerned with the human experiences in understanding the subjective world as human consciousness is formed by human interaction and behaviours, thus allowing interpretive researchers to concentrate on qualitative matters (Siddiqui, 2019).

The interpretivist approach assumes that individuals have their own distinguishable knowledge and experiences, which indicate that a division exists between objectivity and subjectivity and that knowledge and experience cannot be viewed as a neutral phenomenon (Ryan, 2006). This study was conducted on interpretivist assumptions due to the participants having unique and different experiences based on their interactions and experiences with technology for SMEs in the manufacturing industry.

2.2.3 Methodological assumptions

Methodological assumptions are the main factors in determining the methods, procedures and techniques utilised in collecting and analysing information for research purposes. A quantitative approach relates to measuring the quantity of a specific phenomenon, with the results also expressed in terms of quantity. It will often involve a large quantity of statistical data on which tests are conducted. The qualitative approach, on the other hand, relates to the meaning and processes of a specific phenomenon, and aims to provide an understanding of a phenomenon (Alharahsheh & Pius, 2020).

This study used a qualitative approach to obtain a deeper understanding of the experience of individuals that are senior employees or managers within SMEs in the manufacturing industry that incorporate technology in the manufacturing process. This approach allowed the researcher to understand and interpret the views and experiences of the senior employees or managers. Furthermore, interpretive epistemology assumptions assist in conducting the study in a natural setting through personal contact that facilitates the gathering of personal experiences and understanding (Siddiqui, 2019). The qualitative approach in this study was used to gather a better understanding of different interactions and experiences from individuals and to explain the understanding obtained.

2.3 Literature review

A literature review can be described as a systematic technique of collecting and integrating previous research that assists in creating a foundation for improving knowledge and supporting theory development through the integration of previous findings and perspectives (Snyder, 2019).

The sources for the literature review in the current study were journals, articles, websites, books, and previous research. The information for the literature study was gathered from the following available sources: Google scholar, EbscoHost, Discovery journal and Emerald.

Information for the literature study was gathered by inputting the keywords in the sources mentioned above and identifying possible literature to review. Once possible literature sources had been identified, the information was analysed to determine whether the study was suitable for this research. After suitable studies had been identified, a thorough review was conducted to establish how the study could contribute towards this research. The studies were then analysed and reported in writing.

2.4 Empirical study

Empirical research is defined as a conclusion of the study, the method and techniques that will be used to gather information through experience observation, events or experiment to conduct the study (Fletcher, 2017). Empirical research entails a carefully considered plan that is followed to make observations of a systematic engagement through a thoughtful process. The process of empirical study often includes the following five steps: (i) identifying what to observe; (ii) identifying who to observe; (iii) identifying how to observe; (iv) identifying when to observe; and lastly, (v) considering how to analyse and interpret the data (Patten, 2017).

In the current study, which focuses on SMEs operating in the manufacturing industry, the researcher gathered information by means of a literature review and semi-structured interviews with participants from selected companies the researcher had access to.

2.4.1 Population and sampling

The study population comprised SMEs in the manufacturing industry located within a 200-kilometre radius of Pretoria, South Africa. Sampling was conducted through a combination of two sampling techniques, namely purposive and convenience sampling.

Purposive sampling was applied since it allows the deliberate choice of participants based on the qualities they possess (Etikan *et al.*, 2016). The researcher selected participants employed by SMEs in the manufacturing industry that incorporate a form of technology in their manufacturing process because of the knowledge and understanding that they had of the issue at hand.

Furthermore, the convenience-based sampling technique was utilised to select participants who were readily accessible (Etikan *et al.*, 2016). This technique was selected due to the limitation of participants available to partake in the study because of accessibility, location and willingness. The population for this study was established by searching on Google for manufacturers in the area. Subsequently, the researcher contacted the manufacturers to determine whether the enterprise fell within the definition of SMEs as defined by the National Small Business Amendment Act 23 of 2003 (Paragraph 3.5, page 35). If the manufacturer matched the definition and incorporated a form of technology in their production processes, the researcher contacted the enterprise to discuss the possibility of an interview for this research.

This study sample consisted of eight willing participants from eight different enterprises that had the following attributes: Individuals that are senior employees or managers within SMEs in the manufacturing industry that incorporate a form of technology in their manufacturing processes, and are located within a 200-kilometre radius of Pretoria, South Africa.

Data saturation, which means that no additional information is obtained, is achieved at various levels for different studies; however, it has been established that phenomenological studies can reach saturation with fewer than ten interviews (Moser & Korstjens, 2018). In this study, data saturation was achieved after eight interviews.

2.4.2 Data collection

The empirical data used in this study were obtained through a semi-structured questionnaire that was used during interviews with willing participants. A semi-structured interview is designed to better understand the phenomenon regarding a particular situation by obtaining subjective responses from individuals through a couple of questions (McIntosh & Morse, 2015). In this study, a semi-structured interview was drafted to assist in obtaining a general perspective regarding technologies utilised by SMEs in the manufacturing industry, the benefits they obtained from these technologies, the costs associated with these technologies, and to gain a better understanding of the knowledge and perspectives among SMEs in the manufacturing industry. The interviews were conducted in the form of spoken narrative, allowing for a direct encounter between researcher and willing participants. The interviews provided qualitative data from an internal perspective in terms of SMEs in the manufacturing industry.

Eight interviews were conducted with willing participants that were senior employees or managers within SMEs in the manufacturing industry that incorporated a form of technology in their manufacturing processes and were located within a 200-kilometre radius of Pretoria, South Africa. The interviews assisted in reaching the objective of this study, in that they provided an overview of how SMEs in the manufacturing industry perceived the benefits of IT.

The interviews were performed in person at a physical location at an agreed set time and date or via the internet by utilising software such as Zoom, Teams, etc., based on the participant's preference. Five interviews were performed online and three were in person. Interviews only commenced after both parties signed the relevant ethical consideration documents, and lasted approximately 30 minutes.

Upon conclusion of the data collection process, a thematic analysis was performed on the data collected.

2.4.3 Data analysis

The interviews were recorded and transcribed in the format of the interview, enabling the researcher to analyse and interpret the responses. The researcher made use of coding techniques to discover and identify similarities and common variables among the participants to provide information that could be used for this research.

The transcribes of the semi-structured interviews were recorded in Microsoft Excel in a table format where the questions were on the x-axis (rows) and the participants were on the y-axis (columns). This created a data base of the information for the researcher to use for analytics and interpretations in the following manner:

2.4.3.1 Questions 1 to 6

Questions 1 to 6 were included to gain insight into the participants' understanding of the following key terms: efficiency, effectiveness, economical, technology, IT, and information system.

The participants' understanding of these key terms were compared to the definitions derived from previous literature studies (Paragraph 4.3, page 43), categorising each participant's understanding as a good understanding, a vague understanding, or a clear uncertainty.

2.4.3.2 Questions 7 and 8

Questions 7 and 8 explored the information participants took into consideration when deciding to purchase or implement, and when purchasing or implementing new technology. The participant responses were transcribed in a summary format to indicate any similarities among the participants.

2.4.3.3 Questions 9 to 15

Questions 9 to 15 investigated the additional technology the company had obtained in the previous 5 years and established the investment costs and the benefits associated with the additional technology. The responses of the participants were transcribed and summarised where possible to indicate any similarities among the participants. Where possible, the costs and benefits of each unique technology were recorded.

2.4.3.4 Questions 16 and 17

Questions 16 and 17 established the barriers participants faced regarding the incorporation of technology and how they managed to overcome those barriers. The responses of the participants were transcribed and summarised to indicate any similarities among the participants. Moreover, where possible, the challenges and methods of overcoming the challenges were recorded.

2.4.3.5 Questions 18 to 24

Questions 18 to 24 established participants' familiarity with the new technology used by the industry and evaluated their understanding of the technology. Participants' familiarity with key terms were classified as either a good familiarity, a vague familiarity, or being unfamiliar with the term.

2.5 Ethical considerations

This study adheres to the required ethical considerations.

- Ethical clearance for the study was obtained from the Research Ethics Committee of the Faculty of Economic and Management Sciences of North-West University.
- An informed consent document was signed by all participants before the interviews were conducted. This document explained the purpose of the study, confidentiality, and that participation was voluntary and participants had the right to withdraw at any time.
- Confidentiality was ensured by using pseudonyms for the participants in the study when reporting the results. The list of pseudonyms is securely stored by the researcher as the true identities are not essential for the results.

2.6 Limitations of the study

The relatively small number of participants in this study might be perceived as the main limitation of the study, while the fact that the participants were all located within a 200-kilometre radius of Pretoria, South Africa, could be an additional limitation, since the results might be altered by the inclusion of diverse regions.

2.7 Chapter summary

This chapter set out the philosophical assumptions adopted as well as the research methodology followed to reach the main objective of the study.

Research paradigmatic assumptions can be seen as a group of beliefs in regard to a study, which influence how a study should be researched and how results can be interpreted.

This study adopted the following paradigmatic assumptions:

- The ontological assumption was that of relativism as the phenomenon of benefits of technology for SMEs in the manufacturing industry is perceived differently by each participant and is utilised and incorporated into the enterprise in diverse ways.
- The epistemological assumptions were that of interpretivism due to the participants having unique and different experiences based on their interactions and experiences with technology for SMEs in the manufacturing industry.
- The methodological assumptions adopted a qualitative approach to obtain a deeper understanding of the phenomenon as experienced by individuals who are senior employees or managers within SMEs in the manufacturing industry that incorporate technology in their manufacturing processes.

The chapter further informed that a literature review was conducted, utilising journals, articles, websites, books, and previous research. This was followed by an empirical study, which involves the plan to make observations of a systematic engagement through a thoughtful process. It was explained how data had been collected through semi-structured interviews with eight willing participants who were senior employees or managers within SMEs in the manufacturing industry that incorporated a form of technology in their manufacturing processes and were located within a 200-kilometre radius of Pretoria, South Africa.

Chapter 3 presents the literature review on the potential benefits of IT in the manufacturing industry.

CHAPTER 3: POTENTIAL BENEFITS OF IT FOR SMES IN THE MANUFACTURING INDUSTRY

3.1 Introduction

This chapter focuses on the first secondary objective, namely to identify the potential benefits that IT holds for SMEs in the manufacturing industry. The chapter concludes on this objective through analysing applicable literature.

Firstly, manufacturing is defined, upon which the incorporation of technology in manufacturing is explained. Subsequently, the potential benefits of incorporating technology such as IoT, Big Data, cloud computing and Industry 4.0 in the manufacturing processes of SMEs are identified. Finally, the barriers to entry in regard to the application of technology in the manufacturing processes for SMEs are discussed.

3.2 Manufacturing

Two broad categories of manufacturing exist, namely technological manufacturing and economical manufacturing. Technological manufacturing is the process of converting raw input, also known as material or parts, into finished products by using a variety of different methods and tools such as human labour, machinery, chemical processing, and physical assembly. In the economical manufacturing process, manufacturers seek different methods to convert inputs into finished goods by refining and processing the original input into something more valuable and useful in order to add value to the finished product. The value that is added allows manufacturers to increase the price of the finished product and add a premium for their skills and specialities (Kenton, 2020).

Manufacturing processes can be categorised into the following six broad categories (Kalpakjian & Schmid, 2010), based on the methods and techniques used:

1. Casting process, which involves the moulding of either expandable or permanent material (for example investment casting, sand sating and die casting).
2. Forming and shaping process, which involves the rolling, forging, extrusion and drawing of a material (for example flat rolling, piercing and drawing).
3. Machine process, which involves utilising machines to refine materials or parts (for example turning, boring, drilling and milling).
4. Joining process, which involves the combination of two varied materials or parts to form a new part (for example welding, soldering and bonding).

5. Finishing process, which involves the treatment of material or parts to make them more presentable (for example polishing, brushing and coating).
6. Microfabrication and nanofabrication processes, which involve the fabrication and nanofabrication of material or parts (for example advanced fabrication).

Most manufacturing processes will include a combination of the above categories to achieve their outcome (Kalpakjian & Schmid, 2010). In the manufacturing process, manufacturers seek different methods to convert inputs into finished goods by refining and processing the original input into something more valuable and useful. In concept, manufacturers add value to the finished product which is then sold to customers. The main reason for the existence of manufacturers is their ability to take advantage of economies of scale when making use of efficient manufacturing techniques which ultimately allow for producing the finished products at a lower cost per unit (Kenton, 2020).

The two most basic forms of manufacturing are known as human manufacturing and mechanical manufacturing. In human manufacturing, the inputs are refined and crafted by hand, making use of basic tools. This form is commonly associated with carpentry, decorative art, leatherwork, metalwork, and textile production. Conversely, with mechanical manufacturing, the inputs are processed and crafted by machines and do not require a lot of human interaction. This is mostly associated with mass production (Kenton, 2020).

In modern time, manufacturers are adapting and evolving to be able to meet their customers' sophisticated demands and requirements, not only on the physical product, but also in terms of the associated costs. With labour being the major cost in manufacturing, manufacturers have been expanding their technologies and adapting a global expansion strategy across regions, countries, and continents. With the evolution of technologies in the manufacturing industry, two new manufacturing forms were created alongside the classical manufacturing strategy, namely automated manufacturing and smart manufacturing (Kusiak, 2019).

The three manufacturing forms are illustrated in Figure 3.1 below, highlighting the degree of connectivity between human and machine and the value of the information content (Kusiak, 2019).

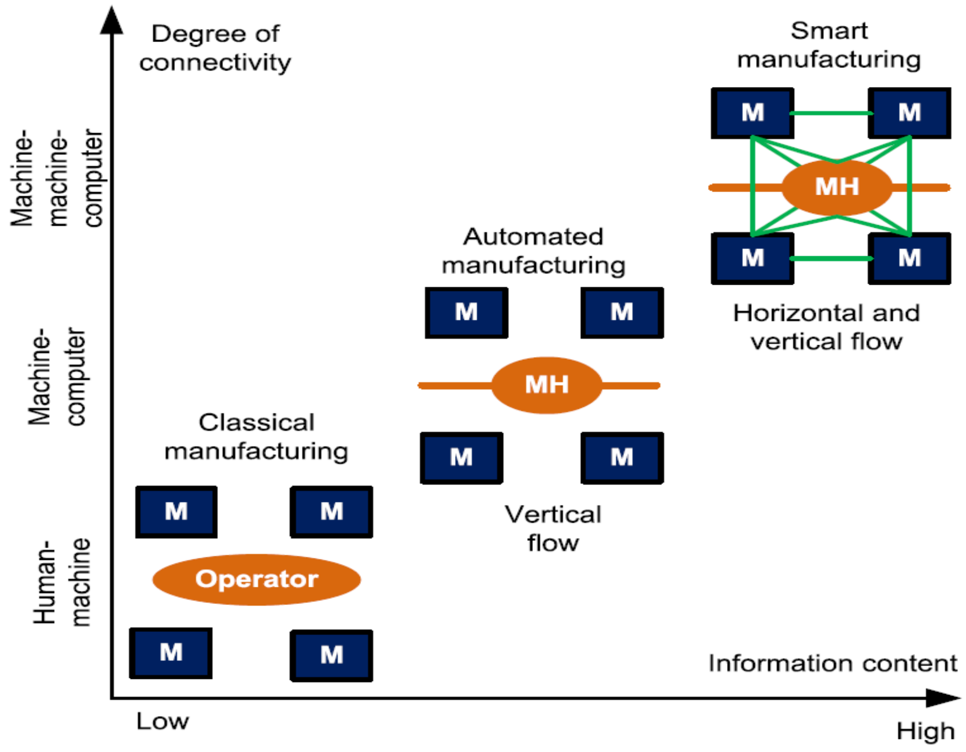

Figure 3.1: Forms of manufacturing

Source: Kusiak (2019)

The three forms of manufacturing in terms of technology, illustrated above, are (Herakovic *et al.*, 2019):

- Classical manufacturing, which consists of a physical system that is manually operated, and manufactured by individuals;
- Automated manufacturing, which requires manual supervisory control and data acquisition, but the manufacturing processes are managed by machines; and
- Smart manufacturing, which requires little to no human interaction and the entire manufacturing process is managed by machine-to-machine interaction.

3.3 Technology in manufacturing

Thong and Yap (1995) define IT as computer hardware and software that assist in management, operations, and strategies in enterprises. This definition was later revised to technologies that are engaged and assist an enterprise with accessing, collecting, operating, retrieving, storing, transporting, and transferring of information in a variety of forms (Thong *et al.*, 1997). More recently, IT was defined by Tan *et al.* (2009) as the application of information and communication with the assistance of electronic instruments which include computer networks, software and hardware that are required for the communication between one another via an internet connection. The new definition was broadened to allow the inclusion of a variety of elements such as the internet, information systems, communication, and infrastructures that include the physical hardware, networks, and software that initially manage the communication of information. Onn and Sorooshian (2013) assert that the term 'IT' should include all computer applications and required packages of any computer application which require packages of computer aided design, computer aided manufacturing, electronic data interchange, hardware, and enterprise resource planning devices.

Before technology was implemented in manufacturing, manufacturing companies used the traditional approach of manufacturing which comprises three phases: design, process planning and manufacturing (Al-wswasi *et al.*, 2018). The design phase is the initial phase of manufacturing a product which entails designing a product to be manufactured and creating a product's description, specifications, and requirements for manufacturing to meet the customers' demands. The process planning phase determines the method of manufacturing, arrangements of manufacturing and the conditions required to convert the initial design into a product (Al-wswasi *et al.*, 2018). Finally, during the manufacturing phase, the initial raw material is converted into finished products to be sold.

In the past, the experts involved in the manufacturing process used their knowledge and experience in the field to set out the methods, arrangements and conditions of manufacturing. In addition, experts had to determine and set out instructions on how each product should be manufactured (Al-wswasi *et al.*, 2018). In 1960, computers started being used to assist with the three phases in manufacturing because they could accurately carry out a set of complex functions in a short time. This transformed the three traditional phases into computer-aided design, computer-aided process planning and computer-aided manufacturing (Al-wswasi *et al.*, 2018).

The first of these three manufacturing phases, namely computer-aided design, allows manufacturing enterprises to be able to use computer systems to assist with creating a 3D solid of products and surfaces. Moreover, computer-aided process planning enables manufacturing enterprises to utilise a computer system to be able to systematically determine the most convenient method of manufacturing a product. Finally, computer-aided manufacturing enables manufacturing enterprises to interpret a product's data to be able to gain a product's specifications and requirements for the manufacturing processes and allows automation within the manufacturing process in order to reduce the need for human guidance or intervention (Henderson & Anderson, 1984).

Notably, the implementation of technology has developed from being an opportunity to being a necessity when it comes to satisfying customers' demands (Kraus *et al.,* 2022). Due to the pressure from the global scale competition, manufacturers have focused on enabling flexible and reconfigurable manufacturing. This is largely enabled through technology that allows manufacturers to add, remove and modify specific processes in response to changing market demands and technologies by replacing or rearranging certain hardware and software (Mehrabi *et al.*, 2000). Emerging technologies such as artificial intelligence, block chain, Big Data, cloud computing and IoT have been renowned as supportive mechanisms for enterprises (Zahra *et al.*, 2021).

The literature mentions a variety of different technologies in regard to the manufacturing industry. Figure 3.2 illustrates the technologies most frequently used, as indicated by the literature.

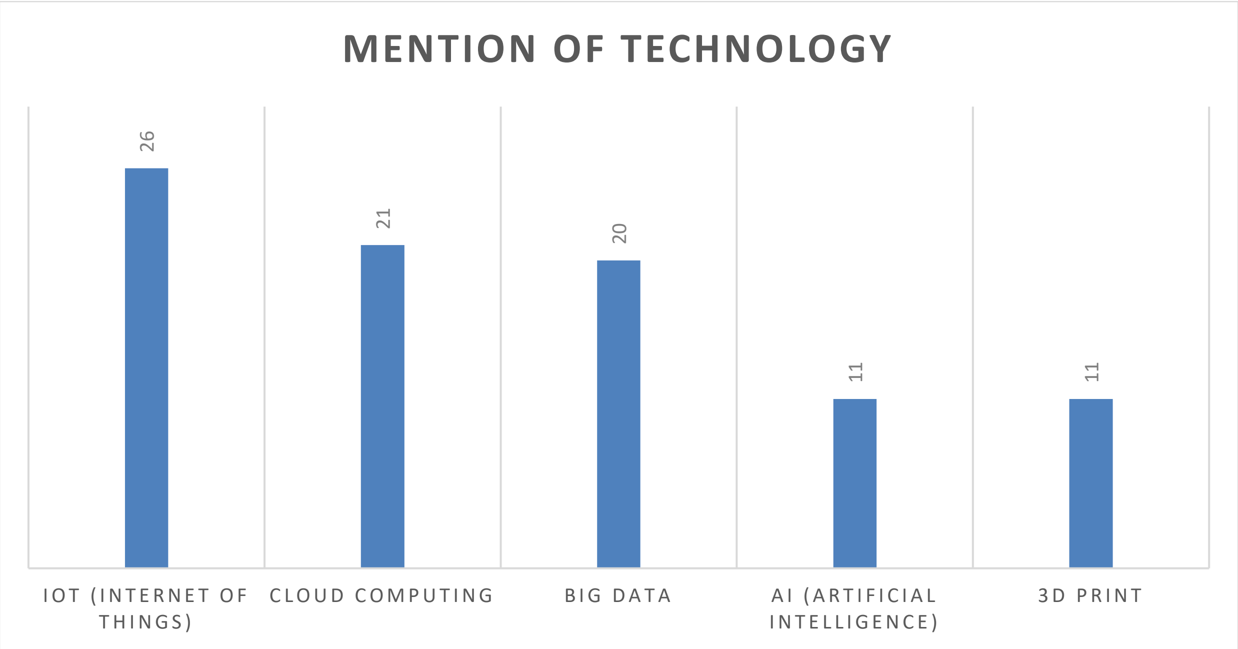

Figure 3.2: Mention of technology in previous literature

Source: Author (2019)

The graph above represents the number of times the specific technology is mentioned throughout 30 previous studies (**Error! Reference source not found.**, page **Error! Bookmark not defined.**) concerning manufacturing with reference to technology. Each of these studies was inspected for any mention of the specific technology throughout the study.

The analysis of previous studies was conducted by focusing on the technologies that were mentioned more frequently. However, it is important to note that a variety of other technologies were also mentioned in these studies. These technologies include cyber-physical systems, ERP systems, integrated engineering systems, autonomous robots, simulations, system integrations, augmented reality, computer-aided technologies and blockchain, among others.

From the 30 examined studies, 26 mentioned IoT, making it the most common technology mentioned. This was followed by cloud computing, mentioned 21 times, and Big Data that was mentioned 20 times. Due to the nature of Industry 4.0 being a collection of different technologies and not a single technology, it was not indicated separately in the above graph, although it was constantly mentioned in the examined studies.

The graph in Figure 3.2 above was drafted from the information in Table 3.1 below, with the mention of a specific technology in previous studies being indicated by "x".

Table 3.1: Mention of specific technology

Study:	**Big Data**	**IoT**	**Cloud**	**AI**	**3D Print**
Big Data analytics for manufacturing Internet of Things: Opportunities, challenges and enabling technologies (Dai *et al.*, 2019).	x	x	x		
Optimization for a three-stage production system in the Internet of Things: procurement, production and product recovery, and acquisition (Fang *et al.*, 2015).		x	x		
Applications of artificial intelligence in intelligent manufacturing: A review (Li *et al.*, 2017).	x	x	x	x	x
Recent advances and trends in predictive manufacturing systems in Big Data environment (Lee *et al.*, 2013).	x	x	x		
A complex view of industry 4.0 (Roblek *et al.*, 2016).	x	x	x	x	x
Transforming to a hyper-connected society and economy – towards an "industry 4.0" (Baeur *et al.*, 2015).		x			
The expected contribution of industry 4.0 technologies for industrial performance (Dalenogare *et al.*, 2018).	x	x	x		x
Industry 4.0 concept: Background and overview (Rojko, 2017).	x	x	x		x
Industry 4.0 implies lean manufacturing: Research activities in industry 4.0 function as enablers for lean manufacturing (Sanders *et al.*, 2016).	x	x	x		

Study:	Big Data	IoT	Cloud	AI	3D Print
A categorical framework of manufacturing for industry 4.0 and beyond (Qin *et al.*, 2016).	x	x		x	
Internet-of-things enabled real-time monitoring of energy efficiency on manufacturing shop floors (Tan *et al.*, 2017)		x			
Visual management system to manage manufacturing resources (Steenkamp *et al.*, 2017)		x		x	
Applications' integration and operation platform to support smart manufacturing by small and medium-sized enterprises (Jun *et al.*, 2017)	x	x	x		
Industry 4.0 – a glimpse (Vaidya *et al.*, 2018)	x	x	x		
Industry 4.0 technologies: Implementation patterns in manufacturing companies (Frank *et al.*, 2019)	x	x	x	x	x
Cost development in logistics due to industry 4.0 (Camska & Klecka, 2020)	x	x	x		
Combination of cloud manufacturing and 3d printing: Research progress and prospect (Guo & Qiu, 2018)	x	x	x		x
A survey on smart automated computer-aided process planning (ACAPP) techniques (Al-wswasi *et al.*, 2018)					x
Distributed manufacturing systems with digital agents (Herakovic *et al.*, 2019)	x	x		x	
Fundamentals of smart manufacturing: A multi-thread perspective (Kusaik, 2019)	x		x	x	
IEC-62264 based quality operations management according to the principles of industrial Internet of Things (Batchkova *et al.*, 2017)	x	x	x		
Reference architecture model industrie 4.0 (rami4.0) (Adolphs *et al.*, 2015)		x			
FDM 3d printing technology in manufacturing composite elements (Dudek, 2013)					x
Industry 4.0 – An Introduction in the phenomenon (Zezulka *et al.*, 2016)		x	x		
Scanning the industry 4.0: A literature review on technologies for manufacturing systems (Alcacer & Cruz-Machado, 2019)	x	x	x	x	x

Study:	Big Data	IoT	Cloud	AI	3D Print
Additive manufacturing: The most promising technology to alter the supply chain and logistics (Attaran, 2017)					x
Cloud computing for cloud manufacturing: benefits and limitations (Wang *et al.*, 2015)		x	x		
Boosting emerging technology adoption in SMEs: a case study of the fashion industry (Zahra *et al.*, 2021)	x	x	x	x	x
Sustainable industrial value creation: Benefits and challenges of industry 4.0 (Kiel *et al.*, 2017)	x	x	x	x	
The fourth industrial revolution (industry 4.0): A social innovation perspective (Morrar *et al.*, 2017)	x	x	x	x	
Totals:	20	26	21	11	11

Source: Author (2019)

3.3.1 Internet of Things

Internet of Things (IoT) is a seamless internetworking of cyber space and physical objectives used in manufacturing that interconnect machinery, vehicles, devices, factories and other items (Liu & Zhong, 2017). This is achieved by embedding small electronics into physical objects and connecting them to a network. The network bridges different areas and machinery, for example smart machines and production facilities (Yang *et al.*, 2016). IoT utilises a variety of different technologies to be able to optimise this process, for example:

- Radio frequency identifications that make use of electromagnetic fields to identify and track objects that store information (Liu & Zhong, 2017).
- Bar-codes which are a diverse data presentation of parallel lines that vary in widths and spacing that can be read by a device and whereby different products can be identified (Liu & Zhong, 2017).
- Wireless communication which facilitates the sending and receiving of data between multiple connectivity points that are not physically connected (Liu & Zhong, 2017).
- Smart sensors that consistently capture a large variety of in real-time data from devices (Liu & Zhong, 2017).
- Big Data that allows enterprises to make sense of the large and complex data gathered (Yang *et al.*, 2016).

- Cloud computing which is used to efficiently manage the quantity of data obtained (Yang *et al.*, 2016).

With IoT, a manufacturer is able to analyse the product life cycle for each product while being able to trace, detect, store and eliminate or mitigate any uncertainties (Fang *et al.*, 2015).

3.3.2 Cloud computing

As one of the newer technologies, cloud computing is being incorporated into manufacturing at a rapid rate to assist with resource utilisation and consumption (He & Xu, 2015). Cloud computing in the manufacturing industry involves transforming resources used in the manufacturing processes to provide them with cloud capabilities that enhance the service control and management ability, enabling management to better manage the resources, operations and transaction during the manufacturing processes (He & Xu, 2015). This allows manufacturing companies to enhance their manufacturing and enterprise systems, transfer real-time data, and improve the enterprise's needs (He & Xu, 2015).

3.3.3 Big Data

With the development of modern technology, the amount of data generated by the manufacturing industry has increased exponentially. Data are being generated on a continuing basis, through various digital devices on a real-time basis, and are typically classified by three V's: volume, variety and velocity. Volume refers to the large amount of data being generated, while variety points to the amount of different data being generated and velocity to the speed at which data is generated, creating new challenges on how the data can be utilised (Wang *et al.*, 2021).

Big Data has already impacted the manufacturing industry in several ways and shifted the design phase from an inspiration and experienced-based design towards data and analysis-driven design, since manufacturers are now given access to data from around the world (Qi & Tao, 2018). To benefit from Big Data and IoT, manufacturing companies must make use of a variety of technology elements and allow the overall manufacturing to be able to implement and make use of Big Data analytics. These technologies can be enabled through three phases, namely data acquisition, data pre-processing and storage, and data analytics (Dai *et al.*, 2019).

3.3.3.1 Data acquisition phase

The first of the three phases that enable companies to benefit from the above-mentioned technologies is seen as the data acquisition phase. In this phase, data are generated and collected from different sectors that are influenced by manufacturing, for example the physical raw material, inventory, work-in-progress, storage, logistics, retailers, and the end-users (Dai *et al.*, 2019). The data in this phase are collected from a combination of devices that will vary from manufacturer to manufacturer. Some of the well-known devices that are used to collect data include bar code and QR code scanners, sensors that are implemented throughout the manufacturing process, electronics that are involved in the production of the products, computers that generate manual and automatic data, feedback that is provided, ordering systems that are used by outlets, and customer feedback (Ding *et al.*, 2020). The data acquired in this phase are then transmitted to the next phase, namely the data pre-processing and storage phase.

3.3.3.2 Data pre-processing and storage phase

The second phase is divided into two separate stages, namely data pre-processing and the storing of the data. In the data pre-processing stage, the data obtained in phase one are processed and structured towards well-formed data (Dai *et al.,* 2019). The raw data that are inputted are cleaned so that the noise of data can be reduced, missing values can be interpolated, and inconsistency throughout the data can be mitigated. After the initial data have been cleaned, the data are integrated to normalise the data and values, to aggregate the data, and to construct the data and assign attributes to the data that have been cleaned. The raw data that have been cleaned and integrated are then compressed so that the number of variables can be reduced, skewed data can be balanced, and the overall data can be compressed.

Once the raw data have been cleaned, integrated and compressed, the manufacturing company will have well-formed and structured data that can be sent to the second stage in this phase, namely the storage stage, where the pre-processed data will be stored. The storing of the pre-processed data is crucial since it allows a company to have a much broader variety of well-formed and structured data available for analytics and allows a manufacturing company to continuously build on previous and current data (Chaiken *et al.*, 2008). However, for a company to store this vast range and size of data, it must have the required storage infrastructure such as hard drives, cloud, server drivers and other additional devices that are constantly connected to the manufacturing company via the internet. The larger the amount of data gathered and kept, the more important the role of data management software becomes as it assists the manufacturing company in managing large amounts of data.

3.3.3.3 Data analytics phase

The last of the three phases that enable manufacturing companies to make use of the benefits of Big Data analytics and other technologies is the data analytics phase. This phase is the most important of the three, because only after the raw data from the data acquisition phase have been successfully analysed during the third phase will the company be able to have information they can utilise to establish a competitive advantage in the market and industry. In the last phase, the data from the pre-processing and storage phase are analysed and converted into information that the manufacturing company can use for decision making.

3.3.4 Industry 4.0

The first industrial revolution occurred in the 17th century when steam engines, waterpower and mechanisation were introduced into the industrial sector. The second industrial revolution occurred early in the 19th century when the industrial sector started using assembly lines, whereas the third industrial revolution occurred in the 1970s when computer automation was incorporated into the manufacturing process. The fourth industrial revolution started in 2011 with the introduction of digital industrial technology (Ghobakhloo, 2018). The Germans created a vision for Industry 4.0 that covers the future of manufacturing in terms of factory, business, products and customers. This vision dictates that factory design and development should allow for conversion into smart factories where sensors, actuators, machines, robots and conveyors are integrated through a common network (Lucke *et al.*, 2008). Through such development, factories will become intelligent enough to predict and manage factory systems in order to control production, including product design and planning remotely (Qin *et al.*, 2016). The vision for a business in Industry 4.0 implies a real-time communication network between a variety of the elements of a manufacturing company which include the popular functions of a business, such as the factory, the supplier, logistics, resource management and customers. A real-time communication network would offer manufacturers the opportunity to be more flexible with their products. It would facilitate better communication among the business functions to enable last minute changes to specific productions and to offer a larger variety of products to customers (Kagermann *et al.*, 2013).

The first crucial element of Industry 4.0 is IoT. Due to the widespread adoption of smart phones and tablet computers, the demand for mobile and wireless applications and technologies has surged. IoT allows for communication between physical objects over an interconnected network by using embedded sensors, actuators and other technological components, which allows data to be collected and transmitted over the internet. The data that are collected are transferred to information systems which then analyse the data and transform it into information that a company can use to optimise production, products, services and other operating aspects. IoT does not only enable greater access to information, but also allows management and operators to forcefully input data. The input of data allows greater flexibility in manufacturing, as changes can be made at the last second through one device. The input is then communicated to another device through the network which allows a change in the production (Bauer *et al.*, 2014).

The second crucial element of Industry 4.0 is Big Data. This element is vital since modern manufacturing facilities are filled with large volumes of valuable data which can be gathered and analysed by advanced analytics to create information manufacturers may utilise to produce manufacturing intelligence (O'Donovan *et al.,* 2015). Big Data is a large amount of structured, semi-structured and unstructured data that are gathered from a collection of resources. This data can be stored and analysed to create value for the manufacturer. Data is gathered in enormous amounts and thus do not always prove to be valuable; however, with the assistance of advanced analytical software, this data can be analysed and converted into information that can hold extremely valuable information to the end-user (Qi & Tao, 2018).

The last of the three elements in Industry 4.0 is AI. With the introduction of AI, the methods that are used have become more complex and even more valuable. AI does not only change a variety of technologies used in the manufacturing industry such as manufacturing systems, system engineers and related products, but also creates an integrated system between the manufacturing process and product development and manufacturing (Li *et al.,* 2017). Evidently, the integration of IT enables enterprises to implement leading-edge technology that offers unmatched value for money (Williamson, 2010).

While relatively new, Industry 4.0 is showing great promises for the manufacturing industry, as it is not a single technology but a combination of technology that enables enterprises to integrate their systems both vertically and horizontally and create collaborative networks and end-to-end solutions for the enterprise across all of their business functions (Zheng *et al.*, 2021). In a previous study, Zheng *et al.* (2021) identified 10 technologies that enable Industry 4.0 cyber-physical systems, namely IoT, Big Data, cloud computing, AI, blockchain, simulation and modelling, visualisation technology, automation and industrial robots and additive manufacturing. It must be noted, though, that Industry 4.0 has no set list of inclusive technologies, and that these technologies identified were the ones considered for their study.

3.3.5 The Reference Architecture Model for Industry 4.0 (RAMI 4.0) and the Industry 4.0 component

Zentralverband Elektrotechnik- und Elektronikindustrie eV, a German electrical and electronic manufacturers' association, in collaboration with their partners, have created the first standardisation of Industry 4.0: the Reference Architecture Model for Industry 4.0 (RAMI 4.0) and the Industry 4.0 component. Together, RAMI 4.0 and the Industry 4.0 component model provide a basis for the developing of future products and business models (Adolphs *et al.*, 2015).

RAMI 4.0, illustrated in Figure 3.3 below, is a three-dimensional model that describes the elements required for Industry 4.0 (Adolphs *et al.*, 2015). The main idea behind RAMI 4.0 is the grouping of a range of diverse aspects into a common model. Rami 4.0’s vertical integration describes the communication and connection between production automation devices or services in addition to the product itself.

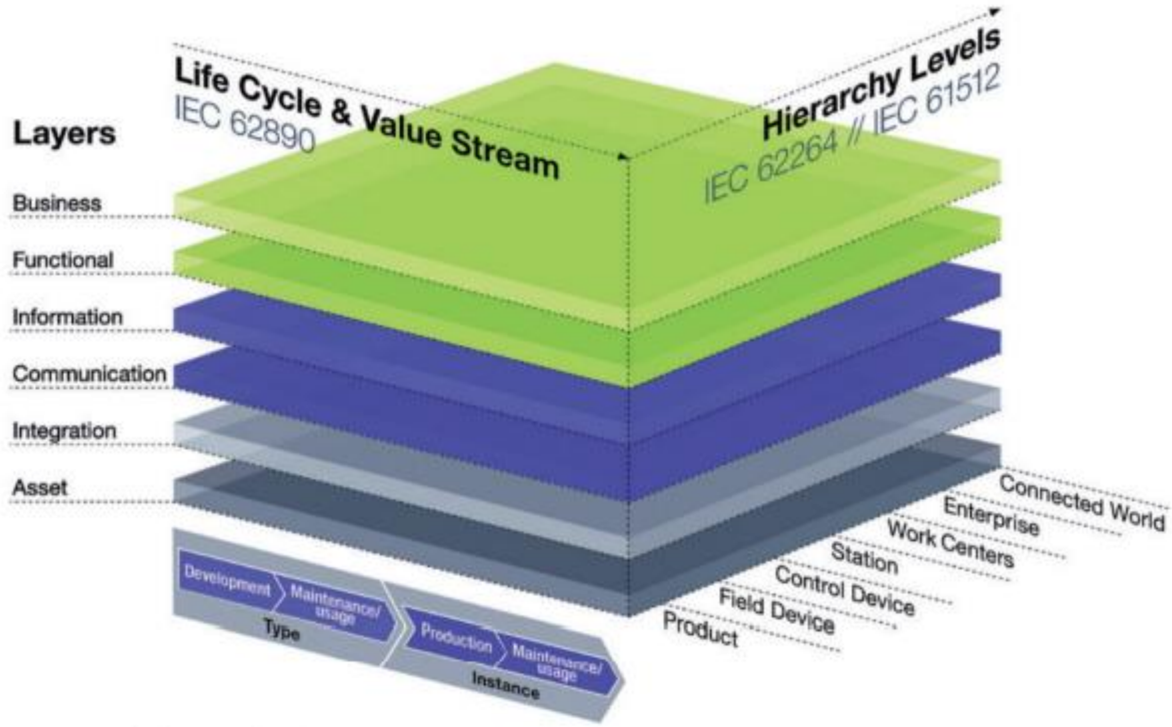

Figure 3.3: The Reference Architecture model for Industry 4.0

Source: Zezulka *et al.* (2016)

The life cycle and value stream layers are indicated on the left horizontal axis. Each layer has a different function that it adds to RAMI 4.0 and the Industry 4.0 component. The asset layer is often referred to as the physical layer as this layer represents the reality and the physical components included in RAMI 4.0. The business layer represents the link between the business processes, setting a legal and regulatory framework for successfully providing value in the enterprise (Zezulka *et al.,* 2016). The communication layer represents the methods in which the physical assets communicate and share data among each other. This includes all data that are shared between the physical assets, including the connection and networks that assist with the communication function. The information layer represents the data that are converted into information that is used throughout all the physical assets to produce products. In this layer, information is provided on which strategies can be developed and shared across all business processes. The integration layer can be regarded as the most important layer for smart manufacturing as this layer integrates information to the physical assets to initiate cyber-physical systems (Zezulka *et al.,* 2016).

The Industry 4.0 component model, which is the first model that is based on RAMI 4.0, describes the core elements which allow enterprises and developers to implement hardware and software to enable Industry 4.0 (Adolphs *et al.*, 2015). It further indicates the properties of the elements involved in cyber-physical systems that allow for real-time production through a network and digital processes as well as the hardware and software which assist in creating a successful cyber-physical system that allows for automation in production. Another important property covered by the Industry 4.0 component model is the ability to communicate associated data and functions in real-time hardware and software elements, which is required for a successful integration of Industry 4.0 (Adolphs *et al.*, 2015).

A core part of the Industry 4.0 component model is the administration shell that is responsible for the safe keeping of all relevant data from hardware and software in production. The administration shell does not only store the data, but performs virtual mapping that is utilised by the manufacturer and allows great possibilities for networked manufacturers (Adolphs *et al.*, 2015). The introduction of the administration shell brought numerous benefits to Industry 4.0. It contains large amounts of data and information which are integrated between the different systems, enabling operators to manually enter important data and connect additional hardware and software. Once the information is stored on the network, it provides accessibility within the enterprise with the potential of unlimited expansion. The integration between different systems facilitates planning, operating and maintaining and produces additional information that can assist enterprises with strategic options (Adolphs *et al.*, 2015).

A variety of enterprises in hardware and software development and manufacturing develop and produce hardware and software which are aligned with the elements of the Industry 4.0 component model. This affords such enterprises an easier method of setting up an administration shell and cyber-physical systems to successfully smart manufacture (Adolphs *et al.*, 2015).

In today’s modern world, enterprises are increasingly relying on the successful integration of cyber-physical systems to perform automated and controlling tasks. The Industry 4.0 component model describes in length the properties of cyber-physical systems (Adolphs *et al.*, 2015).

3.4 Benefits of technology in manufacturing

Roblek *et al.* (2016) found that incorporating technology into an enterprise improved the marketing function as technology assists in obtaining accurate, relevant and valuable information from customers and potential customers. The authors also indicate that the incorporation of technology improves design function as the information obtained from customers and potential customers can be utilised to better satisfy their needs. Furthermore, they argue that the incorporation of technology enhances the production function as it enhances the flexibility, reliability, and efficiency of production. Lastly, they suggest that incorporating technology assists in enhancing logistics as technology improves the overall supply chain and distribution chain with more reliable and realistic data at a much faster pace (Roblek *et al.*, 2016).

These claims correspond with the findings of Teunissen and Bertola (2018) which indicated that introducing technology in an enterprise had a variety of miscellaneous benefits throughout the enterprise as a whole, such as improved transparency with regard to product services, efficiency, leanness, quickness of response, and consistency between customers and quality and offering of products. Furthermore, the authors highlighted the enhanced analytics that technology enables that allows for real-time data to be transferred and received between different departments for information to stay up to date.

In the same vein, Preuveneers and Ilie-Zudor (2017) found that technology improved production and manufacturing systems, noting that with more developed software and intelligence being introduced into manufacturing, manufacturers benefit greatly from reduction in cost, enhanced quality, and greater efficiency and flexibility. Simultaneously, technology allows for improved and constant review and monitoring of products and production. In addition to the enhancement that technology provides for enterprises in terms of different functions, technology greatly improves innovation. Technology does not only allow for greater product innovation with new features and concepts, but also greatly enhances communication in terms of environmental, economic and social aspects, allowing social innovation in terms of sustainability (Morrar *et al.*, 2017).

3.4.1 Benefits of IoT

The incorporation of IoT in manufacturing processes benefits manufacturing through the interconnection between the physical world and the cyber space. While allowing an enterprise to generate a large volume of data which can be utilised for monitoring and reviewing the manufacturing process, it also enhances an enterprise's autonomy, exchange of information, response to triggers, and independent control over the entire process (Yang *et al.*, 2016). Yang *et al.* (2016) highlight that the integration of IoT allows for data to be sent and received in real time, which can improve automation, efficiency, and energy management. Moreover, it makes constant diagnostics possible, which enables proactive maintenance. Lastly, the interconnection of the supply chain can lead to the overall enhancement of the logistics function. Liu and Zhong (2017) point out that the successful implementation of IoT enables virtual tracking of capital assets, processes, resources, and production and provides full visibility to support streamlining the business processes while optimising supply and demand which can result in enhanced efficiency, accuracy, and economic benefits while reducing the need for human intervention.

3.4.2 Benefits of cloud computing

The interconnection of IoT enables manufacturers to utilise cloud computing, which permits users to request and send data in real time through the internet. This can have a severe impact on SMEs in the manufacturing industry as it allows them access to advanced resources and capabilities through the internet (He & Xu, 2015). The introduction of cloud computing also provides unique features which provide several benefits for the manufacturing industry, including elasticity. Cloud computing enables enterprises to instantly respond to any change required and advanced control over resource utilisation. Furthermore, cloud computing provides economic benefits as managers are able to reduce waste during production, reduce operation costs and avoid high investment costs associated with hardware and software, while transferring the maintenance fees associated with a data service to the cloud providers. An additional benefit for SMEs is the fact that the risk of any potential downtime, damage to the system, storage of information or misestimating the computing load is shifted to the cloud provider, who is responsible for the management of the cloud service and its capacity (Wang *et al.,* 2015).

3.4.3 Benefits of Big Data

The interconnection between manufacturing processes and enterprise provides a large quantity of data which cannot be utilised through traditional data processing. However, by incorporating Big Data, big data sets can be analysed computationally to reveal patterns, trends, etc. This information can be processed and generated through four different analytical approaches, namely descriptive analytics, diagnostic analytics, predictive analytics and prescriptive analytics (Dai *et al.*, 2019). Descriptive analytics investigates historical data to determine what has occurred. This approach mainly allows manufacturing companies to identify mistakes and errors in the data capturing, to establish the current product status, and to benchmark against competitors, previous years, and expectations. Diagnostic analytics involves a detailed investigation of events that happened. This approach allows manufacturing companies to detect the root of the problems that arose during the production of products. Predictive analytics utilises historical data and events to allow manufacturing companies to predict certain trends and patterns and provides a better understanding of consumer behaviour, device behaviour and maintenance patterns. Prescriptive analytics make use of information that is gathered from the previous approaches. This approach enables manufacturing companies to maintain and update their information systems to sustain and improve their reliability and adaptability (Menezes *et al.*, 2019).

3.4.4 Benefits of Industry 4.0

Industry 4.0 assists enterprises in incorporating cyber-physical systems in the manufacturing processes. Cyber-physical systems allow the interconnection of physical and technological resources through computers and communication networks and control physical production (Zanero, 2017). Computers receive input from sensors and other technologies through the communication network and enable enterprise to create a control loop which is capable of adapting, automation and improved efficiency (Zanero, 2017).

Industry 4.0 holds substantial benefits for the physical product, since it allows products to be embedded with sensors, unique components and information processors that constantly gather and transfer data to the manufacturing industry. This allows a large volume of data to be analysed for more effective, efficient and economical productions, ultimately offering the end-user better value (Qin *et al.*, 2016). Lastly, Industry 4.0 is not only beneficial for the manufacturing process, but can also be applied to the advantage of customers. It contains new purchasing mechanics which enable customers to order specific products at the press of a button, regardless of the quantities, while still paying the same amount for the physical product that previously was only offered by mass production of identical products. Moreover, Industry 4.0 enables a customer to be able to track the full production and state of a product and to estimate almost precisely when the product will be available for collection or delivery (Qin *et al.*, 2016).

In addition to the benefits Industry 4.0 holds for physical products, it provides benefits for the manufacturing industry with the integration between equipment, labour, factory, supplier and customer. The expected benefits of Industry 4.0 for manufacturers, as listed by Frank *et al.* (2019), are set out in Table 3.2 below:

Table 3.2: Expected benefits from Industry 4.0

List of expected benefits from the Industry 4.0	Factor loadings [a]			
	PRODUCT	OPERATIONAL	SIDE-EFFECTS	Commu-nalities
Improvement of product customization	**0.797**	0.251	-0.171	0.727
Improvement of product quality	**0.766**	0.167	-0.309	0.711
Reduction of operational costs	0.306	**0.865**	0.026	0.843
Increase productivity	0.461	**0.609**	0.071	0.588
Reduction of product launch time	**0.868**	0.028	0.202	0.796
Improving of sustainability (externalities)	0.079	-0.076	**0.935**	0.886
Increase of processes visualization and control	-0.035	**0.818**	0.06	0.675
Reduce of labor claims (worker satisfaction)	-0.311	0.357	**0.767**	0.813

Source: Frank *et al.* (2019)

Frank *et al.* (2019) list the expected benefits as improved product customisation, improved product quality, reduced operational costs, increased productivity, reduced product launch time, improved sustainability, increased visualisation and control, and reduced labour claims. The authors indicate these expected benefits in terms of four functions, namely the product itself, operations, side effects associated and communalities (Frank *et al.*, 2019).

Table 3.2 above illuminates Industry 4.0's possible impact on the three main factors in manufacturing, namely the physical product, the operation, and unforeseen complications. The values presented in the table indicate the additional improvement expected from Industry 4.0, with factorial loading greater than 0.5 being displayed in bold (Frank *et al.*, 2019). For example, product customisation is expected to improve by the current value of 1 plus the additional factor of 0.797, which means the overall improvement will be 1.797 or 79.7%.

Roblek *et al.* (2016) suggest that Industry 4.0 will transform the manufacturing industry in the following three ways:

- *Digitisation of production*: Information systems will be used in manufacturing by the factory and management for production planning and management.
- *Automation*: Manufacturing will be completely automated with little to no human interaction required, from the start of requesting material for production to the shipping of finished products.
- *Linking of business factors with automatic data interchange*: Automated production will result in minimum lead time from placing the order to shipping the product.

With customer demands and expectations becoming more sophisticated, manufacturers start to depend on the advantages of Industry 4.0 for satisfactory quality of the product, speed of production, efficiency of production and higher quantities (Zheng *et al.*, 2021).

3.5 SMEs in the manufacturing industry

The National Small Business Amendment Act 23 of 2003 defines an SME in South Africa by the following three characteristics: having less than 200 fulltime employees, a total turnover of less than R51 million per year, and a gross asset value that does not exceed R19 million. The South African government has recognised the significant role SMEs play in the South African economy and in 2014 has established a new ministry, namely the Ministry of Small Business Development, to assist SMEs (Seta, 2016).

SMEs are seen as a critical driver of economic growth, innovation, job creation, and establishing new markets for sustainability (Seta, 2016). They have managed to achieve these vital contributions while they are constantly battling a fiercely competitive, rapid innovate and ever-changing environment (Skafi *et al.*, 2020). This has forced SMEs to seek new and insightful solutions (Pu *et al.*, 2021). With technology advancing and influencing almost all aspects of life, especially in the manufacturing industry, SME management cannot be resistant towards the implementation and utilisation of technology, but should motivate and encourage the adoption and implementation thereof (Sani *et al.*, 2020).

The demands of globalisation have shifted the mindset of SMEs to not only keep the business running, but to seek methods of advancing performance by identifying new markets and product opportunities, enhancing competitive advantage, keeping up to date with business trends and incorporating comprehensive qualitative and quantitative aspects (Sani *et al.*, 2020). The implementation of technology in SMEs in the manufacturing industry has offered many enterprises enhanced competitive advantage while facilitating greater innovation (Sani *et al.*, 2020).

Previous studies have indicated that technology can have a beneficial effect on SMEs in terms of manufacturing. Moreover, it has been established that technology can also enhance the performance of other functions such as affordability, accessibility, and quality of their production (Sani *et al.*, 2020). Notably, the fact that technology has primarily been implemented by large corporations indicates SMEs' relatively low level of readiness for technological adoption (Zahra, 2021).

While most enterprises today recognise the potential of technology, Horvath and Szabo (2019) highlight that SMEs are in general less prepared to incorporate these technologies, largely due to the lack of funding and available opportunities. Correspondingly, Matt *et al. (*2020) explain that, although technology can enhance flexibility, reduce cost, increase efficiency, and improve the product and service quality, SMEs often lack the resources and competence to utilise these opportunities.

SMEs in the manufacturing industry face specific challenges with respect to the implementation of technology, which include being smaller in size and having less capital and limited expertise and other resources to their disposal (Schönfuß *et al.*, 2021). Orzes *et al.* (2019) highlight six major challenges which they categorise as follows: economical and financial, cultural, competencies and resources, legal, technical, and implementation process. The authors analysed the occurrence of these barriers in previous studies and the results are presented in Table 3.3 below.

Table 3.3: Summary of previous literature review

Barriers	Measurement of barriers	Müller *et al.* (2017)	Otuka *et al.* (2016)	Nylander *et al.*	Heng (2014)	Schröder (2017)	Jäger *et al.* (2016)	Müller *et al.* (2018)	Meißner *et al.* (2016)	TOTAL
Economic and Financial	High investments required						X	X	X	**3**
	Lack of monetary resources	X				X				**2**
	Lack of clearly defined economic benefit									**0**
Cultural	Lack of support by top management									**0**
	Preferred autonomy	X								**1**
Competencies and Resources	Lack of skilled employees						X		X	**2**
	Lack of technical knowledge	X		X		X		X	X	**5**
	Complexity									
	Need to find suitable research partner	X							X	**2**
Legal	Data security concerns		X			X	X	X		**4**
Technical	Lack of standards		X		X	X			X	**4**
	Uncertainty about the reliability of the systems		X							**1**
	Weak IT infrastructure		X				X		X	**3**
	Storage Data									
	Difficult Interoperability/Compatibility		X		X					**2**
	Technology immaturity									
Implementation process	Need for new business models	X		X			X			**3**
	Lack of methodical approach for implementation					X			X	**2**
	High coordination effort									

Source: Orzes *et al.* (2019)

From the table above it can be seen that the technical barriers occurred ten times, the competencies and resources barriers occurred nine times, the economic and financial as well as the implementation process barriers occurred five times, the legal barrier occurred four times, and the cultural barrier occurred once. It is however important to note that the selection of previous studies determined these results and that the analysis of an alternate selection might look different.

Orzes *et al.* (2019) discovered through the utilisation of a focus group regarding barriers of technology implementation for SMEs in the manufacturing industry that several barriers were not highlighted by previous literature and that the majority of SMEs in the manufacturing industry indicated that the high cost, uncertain return on investment, implementation time, and uncertain market potential of technology are the biggest concerns. In similar fashion, Schönfuß *et al.* (2021) found that investing in technology is obstructed by the limitations faced by SMEs in the manufacturing industry regarding financial resources and access to capital. Another concern highlighted in both studies is the limitation of technology awareness when it comes to SMEs in the manufacturing industry. Hence, a lack of knowledge regarding technology is seen as a key barrier for SMEs in the manufacturing industry (Schönfuß *et al.*, 2021).

3.6 Chapter summary

It has been established in this chapter that the pressure from the global scale competition requires of SMEs a new mindset with respect to seeking methods of advancing performance by identifying new markets and product opportunities, enhancing competitive advantage, keeping up to date with business trends and incorporating comprehensive qualitative and quantitative aspects.

The implementation of technology in SMEs in the manufacturing industry offers enhanced competitive advantage while facilitating greater innovation. The implementation of technology in the manufacturing processes can have several advantages for SMEs in the manufacturing industry. The most beneficial of these advantages include the overall increase in efficiency and the improved quality of the products being produced, while simultaneously satisfying the demand for quick and practical information being accessible on demand for strategic decisions, monitoring, and other business decisions.

The incorporation of IoT in manufacturing processes benefits manufacturing with the interconnection between the physical world and the cyber space. It allows an enterprise to generate a large volume of data to be utilised for monitoring and reviewing the manufacturing process, simultaneously enhancing an enterprise's autonomy, exchange of information, response to triggers and independent control over the entire process. Moreover, the interconnection of IoT enables manufacturers to utilise cloud computing, which enables users to request and send data in real time through the internet, allowing SMEs in the manufacturing industry access to advanced resources and capabilities. Furthermore, by incorporating Big Data, big data sets can be analysed computationally to reveal patterns, trends, etc. This information can then be utilised for decision making.

While relatively new, Industry 4.0 is showing great promises for the manufacturing industry, as it is not a single technology but a combination of technologies that enables enterprises to integrate their systems both vertically and horizontally and create collaborative networks and end-to-end solutions for enterprises across all of their business functions. Furthermore, Industry 4.0 allows manufacturers to be more flexible with their products and enables them to offer better communication between the business functions to perform last minute changes to specific productions and be able to offer a larger variety of products to their customers.

CHAPTER 4: VALUE FOR MONEY PERFORMANCE MEASUREMENT TOOL

4.1 Introduction

Chapter 4 is focused on achieving the second secondary objective, namely to conceptualise from the literature how the value for money performance measurement tool could assist SMEs in the manufacturing industry in determining the benefits that investing in technology can provide in terms of efficiency, economy and effectiveness.

Whether large corporate or entrepreneurial start-up, positioning yourself for success in the evolving global competitive environment requires clear choices. It is imperative that enterprises rethink their operations to enhance the streamlining of operation, identifying technology solutions and re-engineering their operations to improve value for money (Williamson, 2010).

Although the success of SMEs can largely be traced back to the business instinct of their directors, additional factors exist that also play a vital role, such as market opportunities, competitive conditions, and business trends. Thus, for SMEs to be successful, management have to rely on more than just their business instincts for decision making; they are compelled to incorporate comprehensive calculations regarding the qualitative and quantitative aspects of the enterprise (Sani *et al.*, 2020). Moreover, for manufacturers to stay competitive in modern times, it is essential that they continuously focus on enhancing their operations. This can be achieved by incorporating technology. However, the benefits that technology can provide must be detailed to ensure that they outweigh the associated costs as SMEs are often resource constrained in terms of manpower, machinery, material, and capital. With these constraints, SMEs, especially SMEs involved in manufacturing, must ensure that the resources available to them are leveraged to obtain the maximum value for the resources sacrificed for the investment (Shaheen & Ahmad, 2015).

4.2 Performance measurement

Performance measurement has been utilised by commercial enterprises for over 500 years, providing stakeholders with a picture of an enterprise's performance. Throughout the years there has been continuous development of systems to provide more economic, efficient and effective methods to provide performance measurement in real time (Kuske & Zander, 2005). Performance measurement has become a vital component of strategy for SMEs to achieve sustainable growth in the competitive global market (Singh & Garg, 2008).

Performance measurement is defined by the United States General Accounting Office (2012) as "the ongoing monitoring and reporting of program accomplishments, particularly progress towards pre-established goals". It is typically conducted by programme or agency management. Performance indicators may address the type or level of programme activities conducted (process), the direct products and services delivered by a programme (outputs), and/or the results of those products and services (outcomes). A 'programme' refers to any activity, project, function, or policy that has an identifiable purpose or set of objectives.

Performance measurement provides enterprises with performance indicators, which again provide the enterprise with measurable units and statistics. A range of financial and non-financial information can be gained in this way, enabling enterprises to be able to better analyse and understand how they are actually performing (Franceschini *et al.*, 2019).

Traditionally, performance measurement was largely focused on financial measurements. However, in 1991, due to the prevailing deficiency of non-financial measurement, Kaplan and Norton designed the Balanced Scorecard measurement tool. Today it is one of many viable options to consider when performing a performance measurement and is still widely used by modern enterprises (Awadallah & Allam, 2015).

The Balanced Scorecard incorporates financial measurement by asking: "To succeed financially, how should we appear to our shareholders?" It is, however, supplemented by three additional measurements (Kaplan, 2009), namely:

- *Internal business process*: "To satisfy our shareholders and customers, what business processes must we excel at?"
- *Learning and growth*: "To achieve our vision, how will we sustain our ability to change and improve?"
- *Customer*: "To achieve our vision, how should we appear to our customers?"

The Balanced Scorecard thus provides management with a comprehensive picture of the company's actual performance, measuring the company's performance in terms of finance, internal business processes, learning and growth, and customers. Furthermore, it enables management to identify whether performance was enhanced by actual procedures or reduction of another procedure. According to Hasan and Chyi (2017), the Balanced Scorecard is regarded as one of the best-known and most useful performance measurement tools.

Over the past few decades, companies have been critiqued on their environment impact, pressuring enterprises to pay more attention towards sustainability. Manufacturers started developing sustainable manufacturing, with a strong focus on reducing the impact of their manufacturing and products on the environment (Singh *et al.*, 2016). Sustainable manufacturing has also been adopted as a strategic approach to enhance competitive advantage and increase market share by improving the enterprise's public perspective. As illustrated in Figure 4.1 below, sustainable performance is measured in three broad categories, namely economic performance, environmental performance, and social performance (Singh *et al.*, 2016).

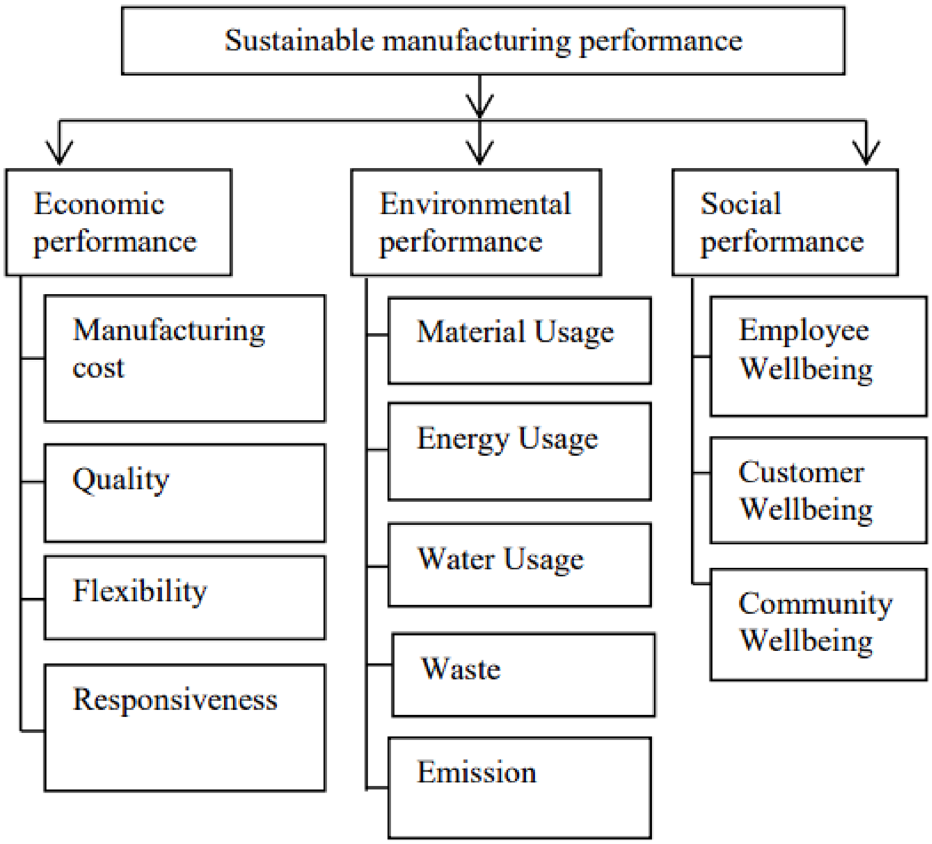

Figure 4.1: Sustainable manufacturing performance

Source: Singh *et al.* (2016)

The economic performance measures are the manufacturing costs in terms of input and waste, quality of production and deliveries, flexibility in demand and productivity, and the responsiveness to changes in lead time or reduction in productions. The environmental performance measures include the amount of material used, also focusing on an expected increase in the recycled material used, the energy consumption of production, the amount of water utilised during production, the amount of waste produced during production, and the amount of gas emission. Social performance measures concern the wellbeing of the employees, the satisfaction of customers and post-sale services, and the approval rate of the community (Singh *et al.*, 2016).

The Balanced Scorecard and sustainable manufacturing performance are two of many performance measurements that have similarities with the value for money performance as both performance measurements focus on financial and non-financial measurement. The Balance Scorecard provides management with a comprehensive picture of the company's performance that enables them to identify whether performance was enhanced by actual procedures or reduced by another procedure. Sustainable manufacturing, on the other hand, focuses on reducing the environmental impact of their manufacturing to enhance competitive advantage and increase market share by improving the enterprise's public perspective.

As technology and enterprises develop, performance measurement is constantly changing in terms of the measurement required to analyse an enterprise's performance to assist stakeholders in understanding the enterprise (Kuske & Zander, 2005).

4.3 Value for money performance measurement

Value for money is often conceptualised as the good business practice of achieving the best utilisation of the available resources and continually improving the utilisation thereof (Emmi *et al.*, 2011). The value for money performance measurement tool is a core measurement of performance that is mainly utilised in government and non-profit enterprises. Its main focus is the value an enterprise obtains from its capital by evaluating the return on investment, based on economy, efficiency and effectiveness. Value for money performance evaluation can be broken down into two indicators, namely cost allocation, which is measured by economy and efficiency, and functionality, which is measured as effectiveness (Seran, 2021).

The main purpose of the value for money performance evaluation tool is achieving maximum benefits over time through strategic utilisation of available resources to be able to deliver the same result at a lower cost, or to provide better results at the same cost (Mckevitt, 2015). As illustrated in Figure 4.2 below, value for money is achieved when there is an optimal balance between economy, efficiency and effectiveness, which allows low input cost, a high productivity level, and the production of high standard products (Matthew & Patrick, 2013).

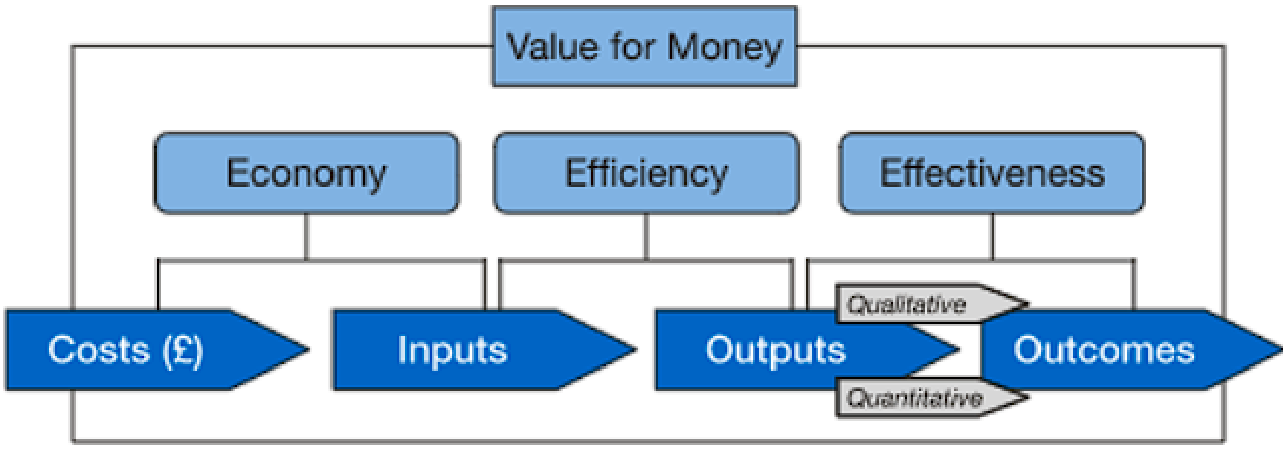

Figure 4.1: Value for money

Source: Barnett *et al.* (2011)

Goddard (1989) advises that the economy component in value for money is concerned with the correct acquisition of human and material resources in terms of quality and quantity, whereas the efficiency component in value for money is concerned with the overall usage of material in the process and producing operation, and the effectiveness component in value for money is concerned with how well a process or activity is achieving the operation's goals. This corresponds with the view of Barnett *et al.* (2011) that economy is a measurement of the inputs required to manufacture a product, whereas efficiency is a measurement of productivity, and effectiveness is a measurement of the intended objective. Barnett *et al.* (2011) further indicate that the economy measurement is concerned with the physical cost associated with the inputs required to produce a product. The input includes direct and indirect costs (such as material and labour) associated with acquiring, running and disposal of assets and other resources during the manufacturing process. The authors also explain that the efficiency measurement is concerned with the relationship between the input and outputs, measuring the relationship between the material, labour and time that was utilised in comparison to the physical number of products the enterprise was able to produce. Finally, they clarify that the effectiveness measurement is concerned with the qualitative and quantitative objectives of the manufacturing process and measures the achievement of the processes and product in terms of quality, condition, and the value that the product offers to customers (Barnett *et al.*, 2011).

In similar vein, Barr and Christie (2015) explain the three E's of value for money measurement as economy, which is concerned with the cost and value of the inputs; efficiency, which is concerned with the cost of transforming the inputs to outputs; and effectiveness, which is concerned with the achievement of the outcome. At its simplest, it can be seen as follows: economy is the cost of products, efficiency is the utilisation of resources, and effectiveness is the outcome of products (Barr & Christie, 2015).

From the above we can derive that the economy measurement in the value for money evaluation is concerned with obtaining the correct inputs in terms of labour, material, and other resources at the most optimal levels in terms of quality, quantity, and costs, while the efficiency measurement in the value for money evaluation is concerned with an optimal relationship between resources utilised and the physical products produced, and the effectiveness measurement in the value for money evaluation is concerned with the achievement of the operational objectives, both qualitative and quantitative, for the production process and physical product produced.

For an SME to achieve maximum value for money, an optimal balance between these three measures is essential. Barnett *et al.* (2011) argue that to obtain maximum value for money, an enterprise should enhance economy, efficiency and effectiveness processes and measurement to ensure that they spend less where possible, spend attentively, and spend discreetly. Incorporating value for money performance measurement for decision making enhances the ability to compare across different decisions to ensure that value for money is obtained (Emmi *et al.*, 2011).

Barr and Christie (2015) developed a framework which can be used to analyse each of the three performance measurements in a 3x3 matrix. (See Table 4.1 below.)

Table 4.1: Barr and Christie's 3x3 Matrix

		Measurement typology		
		Benchmark	Comparison	Stand-alone
Indicator typology	Monetary result			
	Quantitative result			
	Qualitative result			

Source: Barr and Christie (2015)

This matrix evaluates the three value for money measurements (economy, efficiency and effectiveness) individually by identifying the monetary, quantitative and qualitative indicators, while benchmarking, comparing and investigating them.

The monetary results report the output in relation to the costs associated, the quantitative results report the numbers produced in relation to the costs associated, and qualitative results report the results achieved in relation to the costs associated. Furthermore, the benchmark reports on results achieved by similar situations outside the enterprise, the comparison reports on the comparison between different situations, and the stand-alone reports on the achieved results (Barr & Christie, 2015).

4.4 The application of the value for money performance measurement tool for SMEs in the manufacturing industry

As mentioned earlier, pressure from the global scale of competition and technology advancement have forced the manufacturing environment to become increasingly competitive (Mehrabi *et al.*, 2000). Manufacturers are now looking towards technology to overcome limitations as it enables them to adapt and evolve to meet customer demands. It is imperative that they redefine the manufacturing process to improve products while lowering costs. This is often achieved by moving from the classical manufacturing form towards automated manufacturing or smart manufacturing (Kusiak, 2019; Mehrabi *et al.*, 2000). While in today's modern environment and global competition incorporating modern technology into manufacturing processes can provide unmatched value for money (Williamson, 2010), SMEs are extremely vulnerable to the disruption of technology in the manufacturing industry as they face specific challenges due to their nature (Ulas, 2019; Schönfuß *et al.*, 2021). SMEs also face specific challenges to invest in emerging technologies as early adaptors due to their limited funds and the possibility of investing in the wrong technologies (Faller & Feldmuller, 2015).

Since capital is becoming a greater restriction on SMEs in the manufacturing industry (Naoyuki & Farhad, 2018), these enterprises have no choice but to ensure that the resources available to them are leveraged to obtain the maximum value for the resources sacrificed for the investment (Shaheen & Ahmad, 2015). It has been established that obtaining value for money requires the best utilisation of the available resources as well as continually improving the utilisation of resources (Emmi *et al.*, 2011). In this regard, the value for money performance measurement tool could be considered as a foundation for evaluating the balance between the benefits of investing in technology for SMEs in the manufacturing industry and the associated high costs.

4.5 Chapter summary

A study of the literature underscored that for manufacturers to stay competitive in modern times, they must continuously focus on enhancing their operations. Performance measurement provides enterprises with performance indicators to analyse and understand their actual performance. In addition, they reveal a range of financial and non-financial information.

Today, incorporating technology can contribute to enhanced operations; however, since SMEs are often resource constrained in terms of manpower, machinery, material, and capital, they must ensure that the resources available to them are leveraged to obtain the maximum value for the resources sacrificed for the investment. Value for money evaluation is imperative for ensuring the best utilisation of available resources. Through the application of the value for money performance measurement tool, SMEs in manufacturing could evaluate the balance between benefits gained from introducing technology and the associated high costs thereof.

The value for money performance measurement tool consists of three measurements: the economy measurement assesses inputs such as labour, material and other resources with respect to quality, quantity and costs; the efficiency measurement assesses the balance between resources utilised and the physical products produced; and the effectiveness measurement assesses the achievement of the operational objectives, both qualitative and quantitative, for the production process and physical product produced.

An optimal balance between all three of these measures is the requirement for an SME to achieve maximum value for money. Incorporating value for money performance measurement can assist SMEs in decision making and enhance their ability to compare across different decisions to ensure that value for money is obtained.

The next chapter reports on the results obtained through an empirical study to evaluate the benefits that IT holds for SMEs in the manufacturing industry in terms of efficiency, effectiveness and economy.

CHAPTER 5: RESULTS

5.1 Introduction

The main objective of the study was supported by the empirical secondary objective to evaluate the benefits that IT holds for SMEs in the manufacturing industry in terms of efficiency, effectiveness and economy through analysing data obtained from interviews. This chapter discusses the results obtained from the empirical study.

For the gathering of empirical information, semi-structured interviews were conducted with participants that held a senior or managerial position within SMEs in the manufacturing industry that incorporate a form of technology in their manufacturing processes, and that are located within a 200-kilometre radius of Pretoria, South Africa.

5.2 Results of interviews

Eight interviews were conducted, of which five were performed online and three were performed in person with willing participants who were senior employees or managers within SMEs. The first section of the interview aimed to obtain geographical data regarding each participant, namely name, age, position and the name of the enterprise to establish a general idea of the demographics involved in this study (Questionnaire, page 77).

5.2.1 Questions 1 to 6

Questions 1 to 6 were posed to the participants to gain a better understanding of the participants' understanding regarding the following key terms: efficiency, effectiveness, economical, technology, IT, and information system. This provided the researcher with insight into the participants' understanding of the key terms and knowledge regarding technology, IT and information systems.

From the literature, it was established that efficiency in manufacturing concerns the balance between resources utilised and physical products produced (Paragraph 4.3, page 43). Seven of the eight participants' answers were in line with the academic definition, while one participant's answer was vaguely in line. This participant defined efficiency as follows: “If all steps within the measuring process can be conducted with minimal error, then the system would be identified as efficient.”

The literature further indicates that effectiveness in manufacturing points to the achievement of the operational objectives, both qualitative and quantitative, for the production process and physical product produced (Paragraph 4.3, page 43). Five of the eight participants' responses reflected the academic definition, while two of the eight participants' responses were vaguely in line, and one participant's answer was not related with the academic definition.

Of the two participants who were vaguely in line with the academic definition, one responded by stating that "[e]ffectiveness is determined by how time, material, cost, internal and external factors (i.e loadshedding) is managed. All these factors must be managed effectively to ensure effective manufacturing process". The other participant defined effectiveness as "ensuring that the correct product is manufactured at the correct time, utilising resources that are as cost effective as possible. This would also include ensuring that the manufacturing process is as efficient as possible". The participant whose response was not related to the academic definition saw effectiveness and efficiency in the same light.

Economy in manufacturing is academically defined as the correct inputs as regards labour, material and other resources at the most optimal levels in terms of quality, quantity and costs (Paragraph 4.3, page 43). Six of the eight participants' answers were in line with the academic definition, with one of the participants' answer being vaguely in line, and the other participant indicating that he was not familiar with the term.

The one participant whose response was vaguely in line with the academic definition saw economy as "[p]roducing a part in a as lean a way as possible, controlling cost such as tooling, overtime, and maintenance while ensuring quality and output".

When the participants were asked to explain the terms 'technology', 'IT' and 'information systems', five out of the eight were able to accurately explain technology, whereas all of the participants were able to accurately explain IT and information systems (Paragraph 3.3, page 20).

The three participants who could not accurately explain technology defined it as "[t]he use of knowledge to improve consistency of output of products", "the use of computers and computerised programs to achieve desired outcomes" and "[t]ools to achieve an objective".

5.2.2 Questions 7 and 8

Questions 7 and 8 aimed to establish the information participants took into consideration when deciding to purchase new technology, and the reasons why they implemented new technology.

Question 7 explored the main factors participants took into consideration when purchasing or implementing new technology. The responses shed light on the main considerations in a company's decision-making process regarding the implementation of new technology, indicating the most popular consideration when purchasing or implementing new technology to be the competitive advantage it would provide. Competitive advantage was indicated as a factor by seven of the eight participants. Five of the eight participants raised the concern of the cost associated with the new technology. The other two common factors, indicated by four of the eight participants, was the user-friendliness of the new technology and whether it would require any additional training, and whether it was the newest technology available. Notably, three of the eight participants took longevity of new technology into consideration when purchasing or implementing new technology. The main considerations when purchasing or implementing new technology are illustrated in Table 5.1 below.

Table 5.1: The main considerations when purchasing or implementing new technology

Factor	Number of respondents
Competitive advantage	7
Associated costs	5
Latest technology	4
Ease of use	3
Longevity	3
Growth potential	2
Improved measurement	1
Job replacement	1
Safety	1

Question 8 established when the participants would consider purchasing or implementing new technology. This question assisted the researcher in understanding the participants' reasons for purchasing or implementing new technology.

The most popular reason why SMEs in the manufacturing industry purchased or implemented new technology, as indicated by seven of the eight participants, was the additional and new features it offered. The second most popular reason concerned a capacity problem. Participants indicated that they would look towards technology to assist with increasing capacity in production. Furthermore, participants indicated that they would consider purchasing or implementing new technology when their current systems were out-dated and started to show signs of deterioration. Only two of the eight participants highlighted their financial position as a reason to purchase or implement new technology. Table 5.2 below shows the main reasons for purchasing or implementing new technology, as indicated by the participants.

Table 5.2: When the participants would consider purchasing or implementing new technology

Reason	Number of respondents
New features	7
Capacity limits	4
Out-dated system	2
Financial position	2
Maintenance cost	1
Ease of use	1
Economy	1

5.2.3 Questions 9 to 15

Questions 9 to 15 investigated the additional technology companies had obtained in the previous five years, determined the investment costs, and established the benefits associated with the additional technology. This afforded the researcher a better understanding of the purchase or incorporation of technology over the previous five years by the participants' companies and the benefits they believed were gained compared to the costs.

- Question 9 established the additional purchases in the previous five years.
- Question 10 established the benefits the additional technology had added to the company, and the value of the benefits for the enterprise out of ten.
- Question 11 established the investment cost associated with the new technology.
- Question 12 established the increase in productivity or decrease in time utilised associated with the new technology.
- Question 13 established the reduction in material wastage associated with the new technology.
- Question 14 established the cost reduction associated with the new technology.
- Question 15 established the improvement in terms of quality and standards associated with the new technology.

Table 5.3 below shows the new technology purchases in the previous five years (Question 9), as well as the benefits (Question 10) and costs associated with the implementation of those technologies (Question 11).

Table 5.3: Purchases in the past five years and the benefits and costs associated with additional technology

Participant #	Question 9	Question 10 (a)	Question 10 (b)	Question 11
#1	• Cloud-based storage • Integrated to office 365 • Installed bigger and higher capacity hard drives for server	• Employees can work remotely • Improved communication throughout the company	8	• R180 000 – hardware and software • R25 000 - subscriptions and consultation
#2	• Measuring machine • Software to monitor machine and operator output • Milling and cache machines	• Improved the quality and productivity of production • Increased the output per employee • Increased machine operational time	6.67	• R1 500 000 – measuring machine • R75 000 – software to monitor machines and operator output • R1 600 000 – milling and cache machine
#3	• Xero Accounting software • Supervisory control and data acquisition software	• Increased efficiency • Increased net profits • Eliminated human errors • Increased on site safety • Increased output productivity • Increased accuracy	10	• R20 000 – hardware • R370 000 – PLC and Scada • R90 000 – backup system
#4	• Not applicable	• Automated recordkeeping • Production planning through IT	9.5	• Not applicable
#5	• Computers • 3D-Printers • CNC machines • Electronic prunes	• Increased efficiency of operations • Made communication easier	8	• R200 000
#6	• Welding machine • Upgrade of internet and servers • Plasma cutting machine	• Reduction in expenses • Increase in profits • Enhanced ease of use	8	• R250 000 – welding machine • R50 000 – internet and servers upgrade • R800 000 – plasma cutting machine
#7	• Accounting system • Mailchimp and Millerite	• Reduction in time to produce • Increase in product accuracy • Streamline of production	10	• R5 000 – additional software, Mailchimp and millerite.
#8	• WordPress website • Video equipment • Documentation management software • CNC cutting machine	• Overall improvement in efficiency and effectiveness	8	• R2 000 – WordPress website • R20 000 – video equipment • R50 000 – document management software

	• ERP system			• R1 000 000 – CNC cutting machine • R100 000 – ERP system

Table 5.4 below illustrates the benefits of implementing new technology with regard to productivity (Question 12), material wastage (Question 13), cost reduction (Question 14) and quality and standards (Question 15), as indicated by the participants.

Table 5.4: The perceived benefits of implementing new technology with regard to productivity, material wastage, cost reduction, and quality and standards

Participant #	Question 12	Question 13	Question 14	Question 15
#1	• Increased productivity • Made sharing of information easier and faster throughout the company	• Not applicable	• Reduction in overtime; reduction in downtime • Reduction in costly mistakes	• Decreased time to determine which products to manufacturer • Enhanced information for deciding on in-house or outsource manufacturing • Increased client retainment • Opportunity to focus on niche products
#2	• Reduction in cycle time • Increased output per employee	• Additional saving on scrapped items • Reduction in time and material utilised • Reduction in tooling costs	• Reduction of roughly R1 000 000 cost over 4-year period	• Increased consistency of product quality • Reduction in products being returned
#3	• Improved fault finding • Improved production quantity	• Decrease in wastage during production processes	• Not applicable	• Deficiencies detected and rectified before packaging • Products quantified more accurately
#4	• Recordkeeping replaces an entire job • Reduction in procurement planning by 3 hours per day	• Eliminated wastage during production	• Not applicable	• Not applicable
#5	• Able to provide clients with samples, without physically producing • Reduced downtime on prunes • Reduced lead time in production • Provided additional communication	• Fewer errors in production • Enhanced computer efficiency	• Reduction in physical costs	• Enhanced product quality and standards

#6	• Reduction in labour hours • Reduction in cleaning time • Improved welding quality	• Nesting to minimise wastage	• Reduction in material wastage • Reduction in cost as able to cut bigger sheets of steel	• Improved quality • Reduced cleaning • Reduced errors • Enhanced precision • Reduction in labour
#7	• Increase in units produced	• Not applicable	• Not applicable	• Improved overall quality
#8	• Improved output of marketing and controls • Reduction in wastage during printing • Improved quality of production • Improved accuracy and controls	• Reduction in overall wastage of material	• Reduction in physical costs spent on additional parts	• Improved quality of products

The tables above clearly show the priority that SMEs in the manufacturing industry place on acquiring additional technologies. They reveal that all of the eight participants purchased additional technologies in the previous five years. The technologies did require a large capital investment, as the costs indicated for the additional technologies were roughly R6 337 000. However, these costs could be justified by the overall improvement provided by the additional technologies as they provided additional benefits, increased productivity, decreased time utilisation, reduced material usage and wastage, reduced costs, and improved the overall quality and standards of products and productions. The eight participants scored the value of the benefits obtained from the additional technologies at an average of 8.52 out of 10, with the highest score being 10 and the lowest 6.67.

5.2.4 Questions 16 and 17

Questions 16 and 17 established the barriers participants faced when it came to the incorporation of technology and how the participants managed to overcome these barriers. This provided the researcher with a better understanding of the barriers SMEs in the manufacturing industry encountered when implementing new technology and how these barriers had been mitigated.

- Question 16 established the barriers that participants faced when implementing new technology.
- Question 17 established how the participants were able to overcome these barriers.

Table 5.5 below depicts the barriers participants faced when incorporating new technology (Question 16), as well as how they managed to overcome these barriers (Question 17).

Table 5.5: Barriers of incorporating technology

Participant #	Question 16	Question 17
#1	• Downtime of servers • Integration issues	• Installed back-up generators and UPS units • Resolved manually
#2	• Struggle to find the right employee to implement and maintain monitoring software	• Instead of employing a junior person we chose to employ an industrial engineer and we had some positive results.
#3	• Problems in programming of operations • Human errors • Incompatible hardware • Incorrect code • Shutdowns of operations	• Highly proficient team • Immediate action through the system • Retraining staff and adjusting input code
#4	• Staff lack of understanding • Cost of set-up	• We have not personally delt with it.
#5	• Understanding • Incorporation • Skill gaps • Resistance to change • Learning Curve effect	• Upskilling employees • Encouragement • Showed works • Explained improvements
#6	• Lack of knowledge	• Utilise technology. • Exhibits • Research
#7	• Lack of funding	• Additional contribution
#8	• Training & learning new technology • General implementation • Resistance to change • Time to implement • Keeping people motivated	• Communication • Dedicated training sessions • External support consultants • Online resources

The table above highlights the barriers that participants had to face when implementing new technologies, with the biggest factor being the human factor as employees often resist change, lack knowledge and skill, become demotivated and uncertain, and make mistakes. However, these challenges were overcome through clear communication, providing training and encouragement, and explaining the improvements.

5.2.5 Questions 18 to 24

Questions 18 to 24 established the participants' familiarity with technology used by the industry and evaluated their understanding of the technology by means of the academic definitions. This indicated to the researcher the participants' knowledge on and understanding of new and emerging technologies.

- Question 18 established the participants' familiarity with IoT, Big Data, cloud computing, Industry 4.0, and RAMI 4.0.

Of the eight participants, six were familiar with IoT, Big Data, and cloud computing, whereas four of the eight participants were familiar with Industry 4.0. Only one out of the eight participants was familiar with RAMI 4.0. These results are illustrated in Table 5.6 below.

Table 5.6: Participants' familiarity with technology

Participant #	Internet of Things	Big Data	Cloud computing	Industry 4.0	RAMI 4.0
1	Yes	Yes	Yes	Yes	No
2	Yes	No	Yes	Yes	No
3	Yes	Yes	No	Yes	No
4	Yes	Yes	Yes	No	No
5	No	Yes	Yes	No	No
6	No	No	No	No	No
7	Yes	Yes	Yes	No	No
8	Yes	Yes	Yes	Yes	No

Questions 19 to 24 established the participants' understanding of the technologies they indicated to be familiar with. All six of the participants who indicated that they were familiar with the concept of IoT were able to accurately explain it (Paragraph 3.3.1, page 25). When they were asked to explain their understanding of Big Data, five of the six participants were able to accurately explain it (Paragraph 3.3.3**Error! Reference source not found.**, page 26). All six of the participants familiar with cloud computing were able to accurately explain it (Paragraph 3.3.2, page 26), whereas three out of the four participants were able to accurately explain Industry 4.0 (Paragraph 3.3.4, page 28). The participant who indicated that he was familiar with RAMI 4.0 unfortunately could not explain it as he had only heard of it (Paragraph 3.3.5, page 29).

5.3 Chapter summary

Eight semi-structured interviews were conducted with participants that held senior or managerial positions within SMEs in the manufacturing industry that incorporated a form of technology in their manufacturing processes and were located within a 200-kilometre radius of Pretoria, South Africa.

Questions 1 to 6 explored the participants' understanding of the following key terms: efficiency, effectiveness, economical, technology, IT, and information system. The participants indicated a strong understanding of these terms.

Questions 7 and 8 established the information that participants took into consideration during the decision-making phase and when purchasing new technology. The participants highlighted the additional and new features offered by newer technology as the main reason why they would consider purchasing or investing in new technology, followed by expanding of capacity limits, replacing out-dated systems, and having a surplus in capital. When purchasing or implementing new technology, the main deciding factor was the competitive advantaged it offered, followed by the cost associated, whether it was the latest technology, the ease of use, longevity, and growth protentional.

Questions 9 to 15 inquired into the additional technology the different companies had obtained in the previous five years as well as the investment cost and the perceived benefits associated with it. The results showed that the participants had indeed been purchasing or implementing technology in the previous five years and they felt that they had gained additional benefits from their investment in these technologies. Although there was a clear indication that the new technology had increased value in terms of efficiency, effectiveness and economy, the high cost associated with these technologies was also noted.

The results of Questions 16 and 17 demonstrated the barriers participants faced when it came to the incorporation of technology and how they managed to overcome those barriers. While participants mentioned a variety of different challenges with regard to purchasing or implementing new technologies, they also indicated a variety of different resources and techniques that they utilised to overcome them.

Questions 18 to 24 investigated the participants' familiarity with the technology used by the industry and evaluated the participants' understanding of each of those different technologies. The participants indicated a strong understanding of Internet of Things, Big Data and cloud computing. However, only four participants were familiar with Industry 4.0, while only three were able to accurately explain the term. RAMI 4.0 was largely unknown to the participants, except for one participant who unfortunately could not explain it as he had only heard of it.

All in all, the results of the empirical study illustrate that SMEs in the manufacturing industry are aware of the benefits of introducing new technologies; however, this seldom comes without its barriers since SMEs are often resource constrained, they often lack the required knowledge, they are unable to afford downtime or errors, and they are uncertain how to deal with resistance to change.

The final chapter of this dissertation will provide a summary of the research findings in terms of the benefits that IT holds for SMEs in the manufacturing industry, the benefits SMEs in the manufacturing industry can obtain from the value for money performance measuring tool, and the benefits that IT holds for SMEs in terms of efficiency, effectiveness and economy.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This chapter concludes the overall results of the study. It indicates the degree to which the primary objective has been fulfilled and proposes recommendations from the findings.

The primary objective of this study was to investigate and identify the benefits IT holds for SMEs in the manufacturing industry through focusing on value for money in terms of efficiency, effectiveness and economy. This was assisted by three secondary objectives. The first secondary objective was to identify from the literature the potential benefits IT holds for SMEs in the manufacturing industry. The second secondary objective was to conceptualise from the literature how the value for money performance measurement tool could assist SMEs in the manufacturing industry in determining the benefits investing in technology can provide in terms of efficiency, economy and effectiveness. The last of the secondary objectives was to evaluate the benefits IT holds for SMEs in the manufacturing industry in terms of efficiency, effectiveness and economy through analysing data obtained from interviews.

6.2 Summary of research findings

6.2.1 The benefits IT holds for SMEs in the manufacturing industry

The first secondary research objective of the study was to identify the potential benefits IT holds for SMEs in the manufacturing industry through a study of the literature (Paragraph 1.5.2, page 6). The literature review that was conducted pointed out a variety of such benefits. What further emerged was that each technology introduced into the manufacturing processes provides unique benefits. Previous studies highlighted benefits such as, among others, improved marketing, design, and production function; improved transparency throughout the enterprise and advanced analytics; as well as automation and sending and receiving of data in real time (Paragraph 3.4, page 31). It was also established that technology can assist with flexibility, reliability, and efficiency of production, which allows manufacturers to benefit from reduction in cost, enhanced quality, and greater efficiency and flexibility, while simultaneously improving the review and monitoring of production as technology allows for improved and constant monitoring of products and production (Paragraph 3.4, page 31).

The data obtained from the semi-structured interviews confirm the benefits identified in the literature review. The participants rated the impact of new technology incorporated by their companies in the previous five years at an average of 8.52 out of 10 (Paragraph 5.2.3, page 51).

The empirical data correlates with a study performed by Ulas (2019) that demonstrated how technology may hold many benefits for companies, especially those in the manufacturing industry. However, the author also pointed out that management might be unaware of what exactly those benefits were since each technology provides unique benefits (Paragraph 1.4, page 5; Paragraph 3.4, page 31).

Despite all the benefits technology can provide, it must be acknowledged that incorporating new technology seldom comes without its barriers. This is especially true for SMEs since they are often resource constrained, especially in terms of capital (Paragraph 3.5, page 35). In addition, SMEs are often challenged with a lack of knowledge, they are unable to afford downtime or errors, and they often experience resistance to change when incorporating technology (Paragraph 5.2.3, page 51). Yet, these barriers can be overcome by proper preparation for the incorporation of technology by, for instance, implementing back-up systems to reduce any downtime, ensuring that employees have the required experience and knowledge by providing additional training, explaining the need for the new technology, motivating staff and encouraging them to partake, and doing further research on the technology pre-hand (Paragraph 5.2.3, page 53). However effective, these measures require additional resources. Therefore, it is crucial for SMEs to ensure that they obtain the maximum value for the resources sacrificed for the investment. The investment cost on technology for the participants in this study averaged R352 055.56, with a minimum of R2 000 and a maximum of R1 600 000 (Paragraph 5.2.3, page 53).

The literature review pointed to individual technologies such as IoT, cloud computing, Big Data, and Industry 4.0 (Paragraph 3.4, page 31). The unique benefits of each of these are summarised below.

6.2.1.1 Internet of Things

SMEs in the manufacturing industry benefit from the incorporation of IoT as it allows the interconnection between the physical world and the cyber space, enabling them to generate a large volume of data to monitor and review the manufacturing process. Furthermore, it enhances autonomy, exchange of information, response to triggers and independent control over the entire manufacturing process while enabling data to be sent and received in real time (Paragraph 3.4.1, page 32).

6.2.1.2 Cloud computing

Cloud computing provides several benefits for SMEs in the manufacturing industry. Firstly, it enables users to request and send data in real time through the internet, which allows manufacturers to instantly respond to any change required and advanced control over resource utilisation. Furthermore, cloud computing provides economic benefits by reducing waste during production, reducing operation costs and mitigating high investment costs associated with hardware and software (Paragraph 3.4.2, page 33).

6.2.1.3 Big Data

Big Data enables SMEs in the manufacturing industry to process and generate data which can be used to perform descriptive analytics, diagnostic analytics, predictive analytics, and prescriptive analytics (Paragraph 3.4.3, page 33):

- Descriptive analytics enables manufacturers to identify mistakes and errors in the data capturing, establish the current product status and benchmark against competitors.
- Diagnostic analysis enables them to detect the root of the problems that arose during the production of products.
- Predictive analytics enables them to predict certain trends and patterns and provides a better understanding of consumer behaviour, device behaviour and maintenance patterns.
- Prescriptive analytics enables them to maintain and update their information systems to keep up and improve their reliability and adaptability.

6.2.1.4 Industry 4.0

Industry 4.0 enables SMEs in the manufacturing industry to incorporate cyber-physical systems in the manufacturing processes and allow them to create a control loop which is capable of adapting and automation and results in improved efficiency (Paragraph 3.4.4, page 34).

6.2.2 Benefits of the value for money performance measuring tool

It has been established that for SMEs in the manufacturing industry to stay competitive in modern times, they must focus on enhancing their operations. The findings of the literature review highlighted the following efficiency benefits of incorporating IT in this industry: increased productivity levels; enhanced speed of information sharing; reduced cycle times; increased employee output; increased production quantity; time saved on procurement and production planning; reduced time of downtimes; reduced labour hours; reduced time spent on cleaning; reduced wastage during production; reduced tooling costs; and nesting of materials (Paragraph 5.2.3, page 51). However, as SMEs are often resource constrained in terms of manpower, machinery, material and capital, when incorporating new technology they must ensure that the benefits outweigh the associated costs. Differently put, they must ensure that the resources available are leveraged to obtain the maximum value. This can be done through the use of measurement tools. Throughout the years there has been continuous development of measurement systems to provide more economic, efficient and effective methods to provide performance measurement. Performance measurement allows enterprises to better analyse and understand how they are performing.

The second secondary research objective of this study sought to conceptualise from the literature how the value for money performance measurement tool could assist SMEs in the manufacturing industry by determining the benefits of investing in technology in terms of efficiency, economy and effectiveness. As suggested by Naoyuki and Farhad (2018) and Williamson (2010) (paragraph 4.4, page 46), the main purpose of value for money is achieving the maximum benefits over time through strategic utilisation of available resources to be able to deliver the same result at a lower cost, or to provide better results at the same cost. The literature review pointed out clear benefits associated with utilising performance measurement tools.

It was found that the value for money measurement tool in particular can assist SMEs in achieving maximum value for money (Paragraph 4.3, page 43). The value for money performance measurement is essentially utilised by the government and non-profit enterprises due to their limited capital (Paragraph 1.2.4, page 4). Since SMEs are often resource constrained in terms of manpower, machinery, material and capital, SMEs in the manufacturing industry can consider this tool as a foundation to ensure that the resources available to them are leveraged to obtain the maximum value for the resources sacrificed for the investment in IT. The value for money performance measurement tool could assist SMEs in the manufacturing industry in determining the benefits that investing in technology can provide in terms of efficiency (speed of production), economy (cost of production) and effectiveness (quality of production). The efficiency measurement in the value for money evaluation is concerned with an optimal relationship between resources utilised and the physical products produced. The economy measurement in the value for money is concerned with obtaining the correct inputs in terms of labour, material, and other resources at the most optimal levels in terms of quality, quantity, and costs, whereas the efficiency measurement in the value for money measurement is concerned with relationship between the resources utilised and the physical products produced, while the effectiveness measurement in the value for money is concerned with the achievement of the operational objectives, both qualitative and quantitative, for the production process and physical product produced (Paragraph 4.3, page 43). A framework developed by Barr and Christie (2015) can be used to analyse each of the three performance measurements in a 3x3 matrix to identify the monetary, quantitative and qualitative indicators while also benchmarking, comparing and investigating them (Paragraph 4.3, page 43).

Value for money is achieved when there is an optimal balance between the three performance measurements mentioned above to enable low input cost, a high productivity level, and the production of high standard products (Paragraph 4.3, page 43). Hence, for SMEs to achieve maximum value for money, they should aim for the required balance between these three measures and not focus on one in absolute. Incorporating value for money performance measurement for decision making can assist in comparing across different decisions to ensure that value for money is obtained (Paragraph 4.3, page 43).

6.2.3 Benefits of IT in terms of efficiency, effectiveness and economy

The third secondary research objective was to evaluate the benefits that IT holds for SMEs in the manufacturing industry in terms of efficiency, effectiveness and economy through analysing data obtained from interviews (Paragraph 5.2.3, page 51).

The participants indicated a strong familiarity and understanding of technology. It was clear that they continued to investigate and research the development of technology in the industry as they relied on advancement of technology to stay competitive and develop to the complex demands of their customers. (Paragraph 5.2.3, page 51)(Paragraph 3.5, page 35).

Efficiency is defined as a measurement concerned with the relationship between resources utilised and the physical products produced (Paragraph 4.3, page 43). From the eight participants, seven reported efficiency benefits of incorporating new technology into their manufacturing processes, such as an increase in productivity levels and unit output; a reduction in overall labour hours; a reduction in time consumed to plan production; a reduction in material usage in relation to output; a reduction in wastage; an increase in computer efficiency; and additional nesting of materials (Paragraph 5.2.3, page 51).

Effectiveness is defined as a measurement concerned with the achievement of operational objectives, both qualitative and quantitative, for the production process and physical product produced (Paragraph 4.3, page 43). From the eight participants, seven gained effectiveness benefits by incorporating new technology into their manufacturing processes. The effectiveness benefits that emerged were the ability to share real-time information; an enhanced ability to detect faults; the elimination of human errors; the capability of providing clients with samples before production; improved communication throughout the enterprise; improved production quality; greater marketing material; dramatically enhanced precision; accuracy; consistency of production; optimal controls and monitoring; and defects detected and rectified before packaging materials (Paragraph 5.2.3, page 51).

Economy in the manufacturing industry is defined as a measurement concerned with obtaining the correct inputs in terms of labour, material and other resources at the most optimal levels in terms of quality, quantity, and costs (Paragraph 4.3, page 43). From the eight participants, five reported economy benefits from incorporating new technology into their manufacturing processes, which involved additional saving on scrapped items; a reduction in overtime; a reduction in costly mistakes; the capability of buying larger material, allowing for saving; a reduction in additional parts; assistance with deciding whether a part should be bought or manufactured in-house; a reduction in refunds; and a reduction in wage cost (Paragraph 5.2.3, page 51).

From the above it can be concluded that SMEs in the manufacturing industry gain tremendous benefits from incorporating technology. Evidently, it allows the enterprise to be more efficient, effective and economic, as illustrated in Table 6.1 below.

Table 6.1: The benefits of IT for SMEs in terms of efficiency, effectiveness and economy

Participant #	efficiency	effectiveness	economy
1	• Increased productivity • Reduction in overtime • Decreased time to determine which products to manufacture	• Made sharing of information easier and faster throughout the company • Enhanced information for deciding on in-house or outsource manufacturing • Increased client retainment • Provided an opportunity to focus on niche products • Reduction in downtime	Reduction in costly mistakes
2	• Reduction in time and material utilised	• Increased consistency of product quality • Reduction in products being returned	• Additional saving on scrapped items • Reduction in tooling costs • Reduction of cost
3	• Decrease in wastage during production processes	• Deficiencies detected and rectified before packaging • Quantify products more accurately	
4	• Eliminated wastage during production		
5	• Enhanced computer efficiency	• Fewer errors in production • Enhanced product quality and standards	• Reduction in physical costs
6	• Nesting to minimise wastage • Reduction in material wastage • Enhanced precision • Reduction in labour	• Improved quality • Reduced errors	• Reduction in cost as able to cut bigger sheets of steel • Reduced cleaning
7		• Improved overall quality	
8	• Reduction in overall wastage of material	• Improved quality of products	• Reduction in physical costs spent on additional parts

6.3 Conclusion

The main objective of this study was to investigate and identify the benefits that IT holds for SMEs in the manufacturing industry through focusing on value for money in terms of efficiency, effectiveness and economy.

This study has found that SMEs in the manufacturing industry gain tremendous benefits from incorporating IT. These benefits include, but are not limited to improved flexibility, improved reliability, enhanced efficiency, cost reduction, improved quality, better marketing, enhanced design and production function, improved transparency, advanced analytics, greater review and monitoring, data sent and received in real time, and enabling automation. The study also illuminated benefits of individual technologies such as IoT, cloud computing, Big Data and Industry 4.0 as each technology provides unique benefits.

However, despite all the benefits that technology can provide, incorporating technology seldom comes without its barriers. This is especially true for SMEs since they are often resource constrained, they often lack the required knowledge, they are unable to afford downtime or errors, and they are seldom equipped to deal with resistance to change.

For SMEs in the manufacturing industry to stay competitive in modern times, they must focus on enhancing their operations by incorporating technology; yet, it is imperative that they see to it that the resources available to them are leveraged to obtain the maximum value for the resources sacrificed for the investment. Throughout the years there has been continuous development of performance measurement methods that allow enterprises to better analyse and understand how they are performing.

The study revealed that the value for money performance measurement is the ideal tool for SMEs in the manufacturing industry to evaluate the value their enterprise obtains in exchange for their investment in new technology, based on economy, efficiency and effectiveness.

For SMEs to achieve maximum value for money, they should obtain an optimal balance between these three measures and not focus on one in absolute. Incorporating value for money performance measurement for decision making assists with the ability to compare across different decisions to ensure that value for money is obtained.

6.4 Recommendations

SMEs in the manufacturing industry are constantly battling a fiercely competitive, rapid innovate and ever-changing environment and must constantly develop to keep up with complex demands. In addition to these challenges, SMEs in the manufacturing industry are limited with regard to available resources. Hence, they must ensure that they obtain the maximum value for the resources sacrificed. This highlights the importance of ensuring that their investment in technology, with its high capital demands, generates maximum value for money. Evidently, it is crucial for an enterprise to measure and evaluate the benefits of new technologies before investing in them.

The value for money performance measurement tool serves as a great foundation for SMEs from which to measure and evaluate all relevant aspects, both quantitative and qualitative.

6.5 Further research

SMEs in the manufacturing industry should focus on pre-investment measurement and evaluations to ensure that they obtain maximum value for money for the resources sacrificed. Since most measurement and evaluations are done by looking at past results instead of future opportunities, I believe there is a strong possibility to develop a pre-investment value for money performance measurement tool that can be utilised by all companies to quantify the benefits obtained, both quantitative and qualitative, compared to the resources sacrificed for the investment.

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ANNEXURE 1: QUESTIONNAIRE FOR INTERVIEWS

Questionnaire to be used during interviews with employees/managers of a SME manufacturer.

Participant's name:
Participant's age:
Participant's position:
Participant's enterprise:

QUESTIONNAIRE

1. Briefly explain your understanding of **efficiency in the manufacturing process**
2. Briefly explain your understanding of **effectiveness in the manufacturing process**
3. Briefly explain your understanding of **economical in the manufacturing process**
4. Briefly explain your understanding of **Technology?**
5. Briefly explain your understanding of **Information Technology (IT)?**
6. Briefly explain your understanding of **Information Systems (IS)?**
7. When it comes to purchasing and implementation of new **technologies**, (**IT** or **IS)** what are the main factors that you take into consideration?
8. When would you decide to invest in new or additional **technologies, IT or IS?**
9. Can you name and explain any **technologies**, **IT** or **IS,** that your company has recently purchased or implemented? (The last five years).
10. Briefly explain what benefits and changes **technology**, **IT** or **IS** have or may have for your company? And if possible, give the impact the **technologies**, **IT** or **IS** have on the company out of 10.
11. Provide an estimate of the investment cost on these **technologies**, **IT** or **IS** (Rounded to the nearest R50 000).
12. Provide examples of the increased amount of quantity produced or time saved due to these **technologies**, **IT** or **IS**.
13. Provide an estimation on reduction of overall material wastage due to these **technologies**, **IT** or **IS**.

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14. Provide an estimate of physical cost reduction due to these **technologies**, **IT** or **IS**. (These costs can relate to the physical material used as input, setup, decrease in overhead and other costs).
15. Provide an estimate of the improvement in terms of quality and standards of the products or the product range because of these **technologies**, **IT** or **IS.**
16. Provide a brief explanation of challenges that you faced in incorporating technology.
17. Provide a brief explanation on how you managed to overcome these challenges.
18. Are you familiar with any of the following technologies?
    - **a.** Internet of Things
    - **b.** Big data
    - **c.** Cloud Computing
    - **d.** Industry 4.0
    - **e.** Rami 4.0
    - **f.** Other
19. Briefly explain your understanding of **Internet of Things**
20. Briefly explain your understanding of **Big data**
21. Briefly explain your understanding of **Cloud Computing**
22. Briefly explain your understanding of **Industry 4.0**
23. Briefly explain your understanding of **Rami 4.0**
24. Briefly explain your understanding of **Other**

ANNEXURE 1: INFORMED CONSENT FORM

INFORMED CONSENT DOCUMENTATION FOR EMPLOYEES/MANAGERS AT SMALL AND MEDIUM-SIZED ENTERPRISES IN THE MANUFACTURING INDUSTRY

TITLE OF THE RESEARCH STUDY: BENEFITS OF INFORMATION TECHNOLOGY FOR SMALL AND MEDIUM-SIZED ENTERPRISES IN THE MANUFACTURING INDUSTRY

ETHICS REFERENCE NUMBER:

PRINCIPAL INVESTIGATOR: PROF SURIKA VAN ROOYEN

POST GRADUATE STUDENT: INNES VAN DER WESTHUIZEN

ADDRESS: BUILDING E3, OFFICE 129, 11 HOFFMAN STREET, POTCHEFSTROOM

CONTACT NUMBER: 018 299 1479

You are being invited to take part in a research study that forms part of a master's study. Please take some time to read the information presented here, which will explain the details of this study. Please ask the researcher or person explaining the research to you any questions about any part of this study that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research is about and how you might be involved. Also, your participation is entirely voluntary, and you are free not to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part now.

This study has been approved by the Research Ethics Committee of the Faculty of Economic and Management Sciences of the North-West University and will be conducted according to the ethical guidelines and principles applicable to this study. It might be necessary for the research ethics committee members or other relevant people to inspect the research records.

◢ What is this research study all about?

We plan to investigate and identify the benefits that information technology (IT) holds for small-medium enterprises (SMEs) in the manufacturing. Past studies have indicated that IT holds great benefits for the manufacturing industry including SMEs.

Furthermore, this study evaluates the benefit that SMEs obtain from IT in terms of value for money by analysing the benefits obtained from information technology in terms of efficiency, effectiveness, and economy.

With the resistance from SMEs in the manufacturing industry in combination with shareholders' increasing concerns for the value they receive from their investment makes it important to establish the benefits that SMEs in the manufacturing industry can obtain by investing in IT.

In this study we would like to get in contact with key employees/mangers at SMEs in the manufacturing industry, to get a better understanding of the reasons behind their mindset and utilisation of IT.

This study will involve semi-structured questionnaire facilitated by experienced researchers in the field of management accountancy. questionnaire will be conducted until data saturation.

Why have you been invited to participate?

You have been invited to be part of this research based on your experience and involved within a SME in the manufacturing industry.

What will be expected of you?

You will be expected to participate in a semi-structured questionnaire conducted by the researcher. The questionnaire will either be held virtually through an online platform (Zoom) or at a physical location after both participants have agreed on a set date. questionnaire will commence only after both parties have signed the relevant ethical consideration documents.

The questionnaire will consist of 30 questions on the topics of IT utilisation in manufacturing and will last approximately 20-30 minutes.

Will you gain anything from taking part in this research?

Participants will benefit in terms of knowledge regarding the benefits of IT for SMEs in the manufacturing industry from the outcome of the study.

Are there risks involved in you taking part in this research and what will be done to prevent them?

There is no risk associated with participation in this study, the participant will not be experiencing any physical harm or emotional discomfort as result of participating in this study.

How will we protect your confidentiality and who will see your findings?

Your responses to the questionnaire will be kept confidential. No identification in regards to the participant or the participant's enterprise will be disclosed in the study or any future publications. Confidential information will only be available to the researcher, supervisors of this study and possibly members from NWU research ethics committee. All information will be discarded off within 3-years of the conclusion of this study.

What will happen with the findings or samples?

The findings of this study will only be used for this study and presented in a dissertation, and possibly an article in a scientific journal. The participants will remain anonymous in writing up the findings.

How will you know about the results of this research?

After conclusion of this study, all participants will be provided with a summary in regards to the findings of the study. The full dissertation will be made available for participants upon request.

Will you be paid to take part in this study and are there any costs for you?

You will not be paid to take part in the study. There will also be no direct costs involved for your participation in this study, other than time and/or data costs to the company you represent.

Is there anything else that you should know or do?

You can contact Innes van der Westhuizen at 082 492 9504 or Innesvdw@live.co.za if you have any further questions or concerns. Additionally, the supervisor of this study can be contacted at Surika.VanRooyen@nwu.ac.za if need be.

The NWU-Economic and Management Sciences Research Ethics Committee can be contacted via Ms Dalene Vorster at 018 299 1529 if you have any concerns that were not answered about the research or if you have complaints about the research.

You will receive a copy of this information and consent form for your own record purposes.

Declaration by participant

By signing below, I ………………………………………………. agree to take part in the

research study titled: Benefits of information technology for small and medium-sized enterprises in the manufacturing industry.

I declare that:

- I have read this information/it was explained to me by a trusted person in a language with which I am fluent and comfortable.
- The research was clearly explained to me.
- I have had a chance to ask questions to both the person getting the consent from me, as well as the researcher and all my questions have been answered.
- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be handled in a negative way if I do so.
- I may be asked to leave the study before it has finished, if the researcher feels it is in the best interest, or if I do not follow the study plan, as agreed to.

Signed at (*place*) ....………… on (*date*) …………....…….. 20....

....
Signature of participant

Declaration by person obtaining consent

I (*name*) …………………………………………………… declare that:

- I clearly and in detail explained the information in this document to

  ……………………………………………………
- I did/did not use an interpreter.
- I encouraged him/her to ask questions and took adequate time to answer them.
- I am satisfied that he/she adequately understands all aspects of the research, as discussed above
- I gave him/her time to discuss it with others if he/she wished to do so.

Signed at (*place*) ....………… on (*date*) …………...………. 20....

....

Signature of person obtaining consent

Declaration by researcher

I (*name*) …………………………………………………… declare that:

- I had the information in this document explained by

  …………………………………… who I trained for this purpose.
- I did/did not use an interpreter
- I encouraged him/her to ask questions and took adequate time to answer them.
- The informed consent was obtained by an independent person.
- I am satisfied that he/she adequately understands all aspects of the research, as described above.
- I am satisfied that he/she had time to discuss it with others if he/she wished to do so.

Signed at (*place*) ....………… on (*date*) …………...………. 20....

....

Signature of researcher

ANNEXURE 2: LANGUAGE EDITING DECLARATION

Sanri Theron

Text Editing

Certificate in Text Editing Methodology (SU)

M A in African Languages (SU)

84 Patrys Street

Kuilsriver

7580

083 654 6561

sanri.theron@gmail.com

DECLARATION

I hereby certify that the thesis mentioned below was properly language edited. The 'track changes' function was used, and the author was responsible for accepting the changes, as well as for the correctness of the references. The editor will keep a copy of the version with track changes which was submitted to the author for six months from the date below.

BENEFITS OF INFORMATION TECHNOLOGY FOR SMALL AND MEDIUM-SIZED ENTERPRISES IN THE MANUFACTURING INDUSTRY

by

Innes van der Westhuizen

Sanri Theron

Kuilsriver

November 2023