The implementation of digital technologies in South African fast moving consumer goods factories

BY

YOGANDRA NAIDU
1276691

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Declaration

I, Yogandra Naidu, hereby declare that this research project for the Master of Business Administration submitted to the Wits Business School at the University of Witwatersrand has not been submitted previously for any degree at this or another university. It is original in design and in execution, and all reference material contained therein has been duly acknowledged.

Student **Yogandra Naidu**……….. **Date** **27/02/2024**…………

Abstract

The advent of the Fourth Industrial Revolution (4IR) has seen the implementation of digital technologies, or digitalisation, spread across several different industries on a massive global scale. As technologies improve, the applications for their uses can be expanded into different industrial sectors, and more specifically manufacturing. This study focuses on the implementation of digital technologies in South African fast moving consumer goods (FMCG) factories and what enables and deters their successful rollout. A thematic, qualitative analysis of the data, obtained from conducting semi-structured interviews with participants within the industry, allowed for ten unique enablers and deterrents to be identified. The Technology-Organisation-Environment (TOE) framework was utilised to categorise these factors into relevant categories. The study was also able to establish a baseline for currently installed digital technologies in these firms, and what future technologies would be the most beneficial to the industry. In South Africa prohibitive costs, socioeconomic issues and a lack of infrastructure deter the implementation of digital technologies, while operational benefits, top management drive and global competitiveness drive digitalisation. A strategic roadmap was also created to allow firms to better leverage their time and resources during the implementation stages of digitalisation.

Key words: Industry 4.0, digitalisation, manufacturing, TOE-framework

Contents

List of Abbreviations and Acronyms

4IR	Fourth Industrial Revolution
AGV	Automated guided vehicles
CAD	Computer aided design
CAPEX	Capital expenditure
DAS	Digital, Automation/Autonomy and Smart
FMCG	Fast moving consumer goods
ICT	Information and communication technology
IoT	Internet of things
LGV	Laser guided vehicles
MES	Manufacturing execution systems
OEM	Original equipment manufacturer
OPEX	Operational expenditure
ROI	Return on investment
SME	Small and medium enterprises
TOE	Technology Organisation Environment

Title

The implementation of digital technologies in South African fast moving consumer goods (FMCG) factories

Statement of Purpose

Industry 4.0 and digitalisation have been associated with several benefits in the manufacturing industry such as decreased downtime, production flexibility and reduction in manufacturing costs (Liere-Netheler, 2018). In Europe and North America, the implementation of digital technologies, or digitalisation, has already begun on a large-industrial scale. However, in South Africa there are numerous challenges to implementing these concepts based on the local conditions (Maisiri et al., 2021). This research project aims to answer the research questions as to what the enablers and deterrents of digital technology implementation are in South African FMCG factories. The research shall also answer the question as to which digital technologies would be most beneficial to FMCG firms in future and identify what the most advanced technologies are within the current installed base.

Research Article

As a part of this research project a corresponding submission to the IEEE Transactions on Engineering Management is being prepared. This journal paper will highlight the findings of the research project and allow for them to be presented to a wider audience.

Chapter 1 – Introduction b

1 Background of the Study

Industry 4.0 was first introduced in Germany in 2011, and has since been adopted and rolled out across the globe (Dewa et al., 2018). Some of the benefits of Industry 4.0 implementation include reductions in manufacturing costs and waste, while quality and flexibility are seen to increase (Tortorella et al., 2022a). Digitalisation, advanced manufacturing technologies, artificial intelligence (AI) and the Internet of Things (IoT) are just a few of the facets that are included in the rollout of Industry 4.0 technologies. These technologies are ushering in the age of the smart factory where smart, personalised products can be created and there is a high level of collaboration and flexibility between all processes (Veza et al., 2015).

Despite the adoption of Industry 4.0 and digital technologies in various industries and countries, South Africa has its own unique obstacles to overcome in relation to implementation of the se technologies. Information and communication technology (ICT) infrastructure in SA is severely lacking in some areas, while the problematic supply of electricity may play a part in the rollout of these technologies. There are also socioeconomic reasons why digitalisation may not be rolled out at a large level, namely the low skill level of the workforce, where workers are reliant on earning a living through manual labour. Automation and digital technologies may be seen as a threat to employment (Maisiri et al., 2021).

The overall aim of this research project is to firstly determine the enablers and deterrents of digitalisation. These factors shall then be utilised to establish a roadmap or framework that policymakers and managers can utilise to reap the most benefit when implementing digital technologies.

The dissertation shall begin with defining the background of the research question to be answered and the associated justifications. Thereafter a literature review shall be used to determine what existing research exists on identifying the enablers and deterrents of digitalisation in the manufacturing sector. The literature review shall not be limited to South Africa but also encompass similar research from other regions to analyse how those methodologies were carried out.

The grounded theory framework shall be utilised to answer the research questions and allow for an open-ended collection and analysis of data. By utilising the grounded theory framework, the research project will not just focus on testing an existing hypothesis but rather have an inductive method by which data can be gathered, analysed and the research questions answered.

Data collection shall be obtained through a series of semi-structured interviews conducted at the identified locations (factories and head offices) in several South African fast moving consumer goods (FMCG) firms. A coding approach shall then be used to identify similar codes in the responses and highlight the relationship between recurring themes. Once this has been finalised a selective coding approach shall be used to determine the core theme that answers the research question.

Finally, the analysis of the data shall be used to create a strategic roadmap identifying enablers and deterrents of digitalisation in the South African FMCG sector. This roadmap can be used by decisionmakers to better create a strategic approach to digitalisation in their own organisations.

1.1 Context of the Study

Whilst there has been research into the implementation of digital technologies in other developing countries there is limited research into this field in a South African context. The enablers and deterrents of digitalisation in this country are of a varied nature compared to other developing countries such as India and Brazil (Dewa et al., 2018; Rocha et al., 2021). This study aims to focus on the implementation of digital technologies, or digitalisation, in a South African context within FMCG factories. Understanding the factors deterring the implementation of digital technologies will help create a strategic outlook to overcome these problems and equip South Africans for Industry 4.0 technologies. Identifying these factors are essential to creating a digital transformation study by addressing the most crucial of the deterrents affecting the implementation of Industry 4.0 principles. Understanding these deterrents is not just essential for government and public entities but also for the corporate space, where executive decisions for the rollout of digital technologies can sometimes have a lack of guidelines and no clear strategic plan. (Birkel & Wehrle, 2022)

The implementation of digitalisation, or digital technology implementation, spreads beyond that of the information technology (IT) department. The IT department however can be a major bottleneck in executing and installing the necessary infrastructure to allow for the rollout of other technologies (Birkel & Wehrle, 2022). In a modern sense the implementation of digital technologies can be seen across the entire organisation, however this research study will focus on the implementation at an operational level at several manufacturing sites.

Hartley and Sawaya (2019) focused on how the use of robotic process automation (RPA), blockchain and AI can benefit the manufacturing and supply chain process. Their analysis of 14 large manufacturing companies allowed them to provide data on how a supply chain can be prepared for digital transformation (Hartley & Sawaya, 2019). In a similar context, this research study focuses on how digital technologies can better improve manufacturing facilities for the rollout of smart factories.

The study was able to gather information to establish a baseline of the most prevalent digital technologies that were already installed in these plants. Secondly, the data was able to identify ten unique enablers and deterrents that were unique to digitalisation within this industry and finally the data were able to identify which future technologies should be leveraged to gain the most benefit for these firms.

1.2 Research Problem

The research problem is to investigate the enablers and deterrents of digitalisation in South African FMCG factories. In South Africa there are various factors that extend beyond financial reasons for hampering the implementation of digital solutions – including infrastructure problems, human capital issues and socioeconomic factors (Maisiri et al., 2021).

A large portion of digital technologies are still imported from suppliers in Europe and North America. ABB, Schneider Electric and Siemens are some of the largest suppliers of automation equipment and digital technologies – all three of which are based in Europe. Other large automation companies such as Mitsubishi Electric, Omron and Yokogawa are based in Japan, while there are few or no providers of automation and digital technologies from African firms (Abdullahi, 2022). This impacts the cost of digital technology implementation and limits the number of South African organisations that are able to afford these technologies. Although digitisation and automation aim to reduce operational costs in the medium to long term, there is a large capital outlay that may be required to purchase and install these products.

The workforce in Africa is the youngest in the world, however this workforce is still limited in terms of technological skills (Mamphiswana & Bekele, 2020). Several socioeconomic factors have impacted the skills of the workforce which further challenges the implementation of digitisation as it is seen as a threat to employment. A part of the research questions is to determine whether these socioeconomic factors are major deterrents to the implementation of digitisation or whether they are seen as a less obstructive factor in this case.

1.3 Research Questions

The primary research questions (RQs) to be answered are:

- *RQ1: Which factors are the main enablers and deterrents of digital technology implementation in South African FMCG factories?*
- *RQ2: How do these enabling and deterring factors vary across different organisational levels in the firms?*
- *RQ3: What strategic roadmap can be created for implementation of digital technologies in this sector?*

These questions will be answered through the semi-structured interviews conducted at several factories, across multiple organisational levels (Operators to Senior Managers) in order to gain insight at various organisational levels to determine which factors act as the main deterrents and enablers.

A further research question is to determine the organisational attitude and likelihood to implement digitisation in various locations and whether these differ across an operational hierarchy. Dewa et, al (2018) highlighted a lack of awareness regarding digital technology implementation. (Dewa et al., 2018). Gaining data about future rollouts and the long-term ICT strategies of the factory will allow for insight on the preparedness of the site for implementation of digital technologies.

1.4 Research Objectives

The main research objectives are to:

- determine what the main inhibitors and enablers of digitalisation are in the SA FMCG sector.
- determine whether the proposed enabling and deterring factors differ across various levels of seniority and management in the organisation.
- develop a strategic roadmap that can be used by industry, policymakers and strategists to guide digitalisation in this sector.

1.5 Justification/Rationale of the Study

This research project aims to identify the enablers and deterrents that are specific to the South African FMCG industry when it comes to digitalisation. The identification of deterrents and enablers of digitalisation also provides a basis to create a strategic plan to overcome these issues. For example, if low technological skills are seen as an issue, then private entities and governments should aim to embark on a strategic drive to develop these skills. Gajdzik et. al (2021) identify that although there are numerous research studies into the implementation of Industry 4.0 there is still no standard strategic framework for the rollout of digital technologies. The execution methods by which digital technologies are rolled out is still a novel area of research and should be explored further (Gajdzik et al., 2021).

One of the several possible deterrents to executing digitalisation in these factories could be cost. If this deterrent is proven to be valid, then this allows for further investigation into a business case for localisation of these technologies. High costs of digital technologies can be linked to the reliance on overseas suppliers – mostly based in Europe and North America. If a local supplier were to begin supplying digital technologies, manufactured and supported within South Africa, then there is a competitive business case and an already defined market that would benefit. Local factories would be able to execute digitisation at a much lower cost, as well as creating growth in this sector for local firms.

Implementation of digital technologies has the advantages of lowering operational costs, improving flexibility, meeting customer demand for specific products and optimising efficiency (Veza et al., 2015). Implementing smart production planning and optimising changeovers leads to increased manufacturing time and lowering standing time in a factory. While the creation of 3D printed parts will lower maintenance costs and reduce the downtime incurred during a breakdown as parts can be readily printed and the site will not have to wait for delivery of replacement spares (which could be located overseas). Predictive maintenance principles such as smart monitoring will also assist in increasing reliability by preventing catastrophic breakdowns before they occur. The implementation of digital technologies for spares and raw material management can also lead to lower costs and improve manufacturing efficiencies (Dewa et al., 2018; Rocha et al., 2021; TWI, 2023).

Jain and Ajmera (2020) identified 17 enablers of Industry 4.0 technologies in the Indian manufacturing sector. Their research aimed at assisting managers and policymakers understand the relationships between these enabling factors and how best to implement these technologies within the Indian industrial sector (Jain & Ajmera, 2020). Once the research questions are answered, a similar roadmap can be created that will also assist the South African manufacturing industry in determining which factors are enablers and which are deterrents. Thereby reducing time spent on strategies that do not work and having a better allocation of resources by prioritising enabling factors.

1.6 Delimitations of the Study

The research project focuses on digitalisation implementation in South African FMCG factories. These factories have a minimum of 150 employees and are part of a larger manufacturing network i.e., the firm has multiple manufacturing sites. These factories all operate in a comparable production environment and produce either food products, beverages, personal or home care products. FMCG factories that produce products outside of these categories are excluded as the types of machinery and digitalisation will differ.

The project aims to gather data from at least six different factories and two head offices to ensure that the sample of data covers all aspects of the operational structure. The factories and offices are located across South Africa, in both inland and coastal areas. Although these manufacturing firms have production sites outside of South Africa, these are excluded as the research is focused on a purely South African context of digitalisation.

The participants of the study were not limited to senior management or specialists but a sample was obtained that encompasses permanent employees that interact with digital technologies at different levels. The participants exclude logistics, warehouse and supply chain employees and focuses on those that work directly in the production or manufacturing processes. The following table identifies the professional groupings that are used:

Table 1.1 - Participant grouping matrix

Group	Description	Experience
Senior management	Plant managers, Sectional Managers and Head Office Management	> 10 years
Middle management	Engineers, Project Managers	> 7 years
Lower management/Specialists	Unit Managers, Team Leaders and specialist technical personnel	2 – 7 years
Operational level	Technicians and Operators that work on/with machinery. These participants will be	> 2 years

	directly involved with the manufacturing process	

Once the data are gathered and analysed one of the key questions to be answered is whether the attitude towards digitalisation differs across these participant groups or whether there is a consistent relationship unaffected by management status.

1.7 Operational Definitions

The following definitions have been highlighted for the context of this research study:

1.7.1 Digitalisation and digital technology implementation

A traditional definition of digitalisation is the "adoption or increased use of digital or computer technology by an organisation, industry, country etc." (Schumacher et al., 2016). In the context of this study digitalisation, within the manufacturing industry, includes the implementation, or increased usage, of robotics, automation and computerisation for the aim of reducing costs, and improving efficiencies and production flexibility. (Hole et al., 2021)

1.7.2 Fourth industrial revolution (4IR)

The fourth industrial revolution indicates a period of time wherein technology allows for the creation of smart factories where digital and physical systems of manufacturing are able to be integrated. This allows for a more flexible manufacturing process and for new operating models to be introduced. (Schwab, 2016) The scope of the fourth industrial revolution expands much further and includes sectors such as nanotechnology and renewable energy, however in the context of this research project the focus shall be on the creation of smart factories within the manufacturing industry.

1.7.3 Industry 4.0

Industry 4.0 was created by Henning Kagermann in 2011 while he was working at SAP and allows for the manufacturing and Information Technology (I.T.) sectors to be integrated in order to create a highly developed and efficient production plant (Gajdzik et al., 2021) (Pasi et al., 2020b). Industry 4.0 consists of digital technologies such as robotics and automation, 3D printing, collaborative robots, the Internet of Things (IoT) and cloud computing. In the context of this research study these technologies and their applications shall be studied in the terms of smart factory implementation and usefulness. (Gajdzik et al., 2021) Industry 4.0 is driven by digital transformation (the implementation of digital technologies) and automation (SAP, 2023).

1.7.4 FMCG (Fast Moving Consumer Goods)

FMCG can be defined as products that are produced in a large quantity with a low value. Examples of FMCG products include food items, pharmaceuticals, household cleaners and bottled liquids (soft drinks, water and beet etc.). FMCG products have a high demand, are usually consumed quickly and have a high availability (Pahwa, 2022).

1.7.5 Internet of Things (IoT)

The Internet of things links physical devices, such as machines, process plants and robots, through the Internet. This allows all devices on the network to exchange information and data. In terms of manufacturing facilities, the IoT can be used for smart manufacturing processes, improvement of safety and reliability by improving predictive maintenance and conditional monitoring (TWI, 2023).

1.7.6 ICT Infrastructure

ICT (information and communication technology) infrastructure can be defined as the devices, networks, protocols and procedures that are employed in the telecoms or information technology fields to foster interaction amongst different stakeholders (Cruz-Cunha & Moreira, 2011).

1.7.7 Smart factories

Smart factories are those where devices are interconnected through the Internet or other network technologies. The smart factory uses digital technologies to optimise production outputs and processes. The smart factory has a clearly defined operating ecosystem that is driven by the digitisation rollout where all processes, data and operations are analysed (SAP, 2023).

1.8 Structure of the Dissertation

The dissertation is structured as follows:

- Chapter 1 (the current chapter) outlines the study's background, research problem, research questions, research objectives, justification/rationale, delimitations, operational definitions and structure.
- Chapter 2, the literature review, gives an overview of similar research that has been conducted in both South Africa and internationally with regard to digitalisation, and the challenges associated thereof.

- Chapter 3 gives an overview of the methodology that was used and how the data collection took place. Specifically, a series of semi-structured interviews took place at several FMCG firms to gather data with regard to digital technology implementation. The data was then analysed using a qualitative coding approach.
- Chapter 4 analyses the data and provides further discussion with regard to the results that were obtained. This chapter also presents the roadmap which can be used to focus on digitalisation.
- Chapter 5 gives a summative conclusion to the research project. This chapter indicates the results of the research questions and recommendations towards future work.

2 Chapter 2 - Literature Review

2.1 Introduction to Literature Review

The literature review focused on gathering information related to Industry 4.0, digital technology and the implementation thereof. First the definition of Industry 4.0 and its relevance will be established. Thereafter the various types of digital technologies, relevant to the manufacturing industry, will be reviewed. Finally, the literature review will undertake to define methods by which digital technologies have been established and what some of the deterrents and enablers have been. The implementation of Industry 4.0 and digital technologies encompasses a wide field and as such this study will be limited to topics related to the manufacturing sector. The literature review aims to assist in determining the main research question: **What are the key enablers and deterrents to the implementation of digital technologies in South African manufacturing firms?**

2.2 Empirical review

The empirical literature review was required to establish that the research topic had associated literature of importance to the study. Based on existing research, projects and literature a series of potential gaps related to the topic could be identified. Common themes were also able to be identified where researchers had come to common conclusions.

2.3 Industry 4.0 and digitalisation

Pillay et. al (2015) state that Industry 4.0 will make manufacturing much more competitive and the advent of digital technologies may see the reversal of manufacturing moving from developed countries back to industrial giants such as the USA and Germany (Pillay et al., 2015). In terms of Africa this would result in the advantage brought about by having cheaper labour nullified and an investment in digitalisation required in order to keep up with other industrial nations.

However, African countries face further challenges in terms of poor infrastructure, accessibility and connectivity. South Africa, in particular, faces a challenge of increasing electrical costs while supply remains erratic (Mamphiswana & Bekele, 2020). Simultaneously the workforce remains largely unskilled, when compared to developed countries, and have a negative viewpoint of digitisation due to fear of job losses. (Maisiri et al., 2021)

2.4 Advantages and disadvantages of digital technology

Industry 4.0 will result in the creation of smart factories, that are able to use digital technologies to overcome manufacturing challenges and provide competitive advantage. The topic of digitalisation and digital technologies includes the use of automation, robotics, smart sensors, etc. to improve efficiency and production management, while providing flexible solutions to both operations and customers (Cinar et al., 2021) (Hole et al., 2021) (Jain & Ajmera, 2020).

Implementation of Industry 4.0 requires workers with a high level of skill and technological know-how. Although Africa has the youngest working population, it lags behind in terms of skill level compared to other continents. The implementation of digital technologies may have a negative socio-economic effect on the South African working population, which is already suffering from high levels of unemployment. Workers may feel that digital technologies, such as automation, will make their jobs redundant and result in widespread job losses (Maisiri et al., 2021).

In order for digital technologies to be installed and utilised there needs to be sufficient infrastructure in place in terms of Internet connectivity and electrical supply. South Africa struggles with electrical supply, while a strong Internet presence is not available at all locations (Mamphiswana & Bekele, 2020).

2.5 Digital technologies

There are several types of digital technologies that can be implemented in both the public and private sectors, however this literature review will focus on the three commonly implemented technologies namely: additive manufacturing (3D Printing), the Internet of Things (IoT) and Big Data Analytics.

2.5.1 Additive manufacturing

3D printing or additive manufacturing (AM) consists of using different manufacturing techniques to join materials together, in layers, to form new parts. The printer is programmed through a Computer Aided Design (CAD), or similar program, to input the desired part and the machine can autonomously produce the final product (Korpela et al., 2020). Initially AM was limited to polymers, but new developments have resulted in products being created in metals, ceramics and even composites (Shahrubudina et al., 2019).

In terms of manufacturing, 3D printed parts will result in lower inventory management, as parts are able to be printed on site rather than pulled from warehouses. Breakdowns and production downtime can also be mitigated through AM, as plants are no longer required to wait for spares to be delivered from storage sites. Instead, a breakdown spare can be printed on site to minimise both downtime and working capital of spares inventory.

2.5.2 Internet of Things

The IoT consists of hardware, software, sensors and networks which join everyday systems and objects. As a result of the systems being interconnected, they are able to exchange data and signals and adapt to this information accordingly (Dewa et al., 2018).

In terms of manufacturing the IoT can assist with predictive maintenance, fault finding, inventory management and production flexibility (Kumar et al., 2019). For example, sensors on machinery are able to determine when failures are about to occur based on vibrational analysis and can alert technicians accordingly. Planned maintenance activities are also able to be coordinated in advance based on the data measured from operational activities. Spare parts packages can be ordered autonomously by the machines when upcoming maintenance and services are due. The IoT can be of great benefit in developing countries where a lack of technical skills can be overcome with technology.

2.5.3 Big Data Analytics

The use of data for the creation of executable analytics can benefit manufacturing firms by improving efficiency, quality, and productivity. In manufacturing plants, the main sources of data are machines, people and companies. Machines, such as pumps, sensors, motors, compressors and meters produce data with regard to their operating conditions, maintenance condition and output information. Big data analytics are how an operation can collect, validate and utilise big data for information transactions (Ashaolu & Musa, 2021).

The manufacturing industry aims to utilise big data analytics to drive productivity, efficiency and influence decision making. Data from machines and processes can positively impact flexibility and quality in the operation, with actions being taken proactively instead of reactively. In terms of flexibility an example would be to utilise data analytics to predict customer buying patterns and adjust production accordingly (O'Donovan et al., 2015).

In terms of manufacturing operations, the use of big data analytics for predictive maintenance and production management are two of the more popular areas. Predictive maintenance can be planned based on the operational data produced by machinery, for example high running temperatures can trigger a technical intervention to determine the problem. Production can also be planned based on upstream production activities, raw materials information from the supply chain warehouses and customer requirements. These production activities will be based on the big data being analysed and produced in the various systems. However in South

Africa, there is a hesitancy to use big data analytics due to the threat of cyber-attacks and having poor security systems in place (Dewa et al., 2018).

Some of the other benefits of big data analytics include:

- Increased production yields
- Improved production efficiency
- Reduction of downtime
- Improved forecasting

2.6 Empirical review of literature

The following table summarises the findings from the Empirical literature review:

Table 2.1 - Empirical review of literature summary

Author(year)	Methods	Arguments/Findings	Who do they agree with?	Who do they disagree with?
(Gillani et al., 2020)	Surveys (n = 931)	The study aims to define the importance of technological, organisational and environmental factors on the implementation of digital manufacturing technology (DMT) The study also highlights how implementation of DMT affects performance in terms of design, flexibility, quality and delivery	Opazo-Basaez et. al (2023)	N/A
(Opazo-Basaez et al., 2023)	Surveys (n=351)	The implementation of smart manufacturing (SM) can improve performance and competitiveness The study focuses on how smart manufacturing affects both operations and customers, and whether there is a beneficial improvement to this relationship after the adoption of SM technologies	Gillani et. al (2020)	Buer et. al (2020)
(Hole et al., 2021)	Literature review	That digitalisation, in the pharmaceutical industry, will reduce operational costs, improve efficiency, productivity and flexibility To study the factors that will influence digitalization rollout in the pharmaceutical industry	Gillani et. al (2020)	N/A
(Pasi et al., 2020a)	Surveys (n = 16) and semi-structured interviews (n = 7)	The study aims to define the concept of Industry 4.0 amongst the Indian manufacturing sector and how the implementation of these technologies is affected	Jain and Ajmera (2020)	N/A

		Another outcome was to develop a road map for the implementation of digital technologies Finally, the socio-economic effect of the implementation of digital technologies was also analysed (job losses and job creation, firm's profits and worker skill level). A finding of the study was that implementation of Industry 4.0 was creating a fear of job losses and could be seen as a major deterrent	Agarwal and Ohja (2022) Gupta et. al (2020)	
(Jain & Ajmera, 2020)	17 enablers were discussed with industry experts and analysed through a literature review	The study aimed to determine the enablers of Industry 4.0 in the Indian manufacturing industry Cost, financial support from government and training and skills development were identified as the main enablers	Agarwal and Ohja (2022) Pasi et. al (2020)	N/A
(Gupta et al., 2020)	Best Worst Method (BWM) – linear modelling of literature review findings	The aim was to identify and prioritise a list of digitisation enablers that would positively affect supply chain management and create competitive advantage The ranking of these enablers will allow organisations to focus on specific areas in order to create the most benefit. Big data analytics, tracking and localisation of products and creating feasibility studies for the selection and implementation of digital	N/A	Jain and Ajmera (2020) Agarwal and Ohja (2022)

		technologies were identified as the three most important enablers of digitalisation in SCM		
(Santos et al., 2022)	Case study (n=5) of Portuguese SME Semi-structured interviews	The study focused on defining the resources and capabilities required by Small and Medium Enterprises (SME's) to execute Industry 4.0 technologies Further the study analysed how these resources and capabilities could be developed to aid implementation of digital technologies in SME's	N/A	N/A
(Tortorella et al., 2022b)	Surveys (n = 165)	The study analysed the relationship between different manufacturing strategies and Industry 4.0 implementation using adoption of critical success factors. The influence of these strategies on the successful outcome on the implementation of digital technologies was also identified In companies with low readiness for adoption of Indsutry 4.0 technologies there was no difference in weighting of manufacturing strategies – however in companies with high levels of readiness the choice of manufacturing strategy greatly affects the implementation of these technologies	Cinar et. al (2021)	N/A

(Buer et al., 2020)	Surveys (n = 212)	The study identifies the relationship between digital technologies and their usage in different sized companies and production environments There is a direct correlation between the level of digitalisation and the size of the organisation, while there is no correlation between production environments and digitalisation	N/A	Opazo-Basaez et al., 2023
(Butt, 2020)	Literature review	Identification of the enablers and barriers of Industry 4.0 technologies Enabling technologies include big data analytics, additive manufacturing, augmented reality, cloud computing, cyber security, vertical and horizontal integration and the IoT Barriers include lack of knowledge, poorly skilled workforce and an inability to determine the ROI of investments Creation of a strategic roadmap for the implementation of Industry 4.0 technologies using a six-sigma methodology	Enrique et. al (2022) Dewa et. al (2018)	N/A
(Enrique et al., 2022)	Case study with interviews	The study aims to understand how Industry 4.0 technologies can affect flexibility in manufacturing. Cloud services, IoT and data analytics provide for flexibility improvement	Dewa et. al (2018) Butt (2020)	N/A

(Cinar et al., 2021)	Literature review Questionnaires	Creation of a roadmap and readiness framework for Industry 4.0 implementation	Pasi et. al (2020)	N/A
(Agarwal & Ojha, 2022)	Literature review and focused group interviews	The research identified the challenges associated with Industry 4.0 implementation in micro, small and medium Indian industries. The top three challenges identified were: top management support, incompatible resources and costs	Jain and Ajmera (2020) Pasi et. al (2020)	N/A
(Weerabahu et al., 2022)	Literature review	In the Sri Lankan manufacturing sector a lack of strategy was identified as a key detterent adopting digitalisation	Agarwal and Ojha (2022)	N/A
(Dewa et al., 2018)	Surveys (n=150)	The study sought out to identify the readiness levels of South African manufacturing firms to implement digitalisation and which technologies were enablers – namely cloud computing platforms, barcode technology and mobile devices were identified as the top three	Enrique et. al (2022) Butt (2020)	N/A

2.6.1 Enablers and deterrents of digitalisation from Literature

Jain and Ajmera (2020) identified financial support from government programmes and upskilling the workforce as being key enablers of digitalisation in the Indian manufacturing sector, while high costs made these projects prohibitive (Jain & Ajmera, 2020). While Agarwal and Ojha (2022) noted that the top three challenges facing Industry 4.0 implementation in the Indian manufacturing sector were a lack of top management support, incompatible resources and high associated costs (Agarwal & Ojha, 2022). A lack of buy-in from senior management and an indiscernible strategy when it came to rollout of digital technologies greatly affected the implementation. Weerabahu et. al (2022) also identified a lack of strategy for the rollout of digitalisation as being a major deterrent (Weerabahu et al., 2022). Incompatible resources included infrastructure that was lacking, but also initial investment into technologies that were not compatible or lacking a technical roadmap as to future requirements. This highlights the need for technological road mapping in order to ensure proper investment of resources into a solution that is long lasting. The high associated costs of digital technology were also seen as deterrents as India is also partially reliant on importing technological solutions which leaves them to suffer at the hands of fluctuating exchange rates.

The different types of digital technology being implemented are also met with varying degrees of success – with Pasi et. al (2020) identifying smart sensors and robotic arms having a higher level of sustainability once implemented, while cyber physical systems and big data analytics have lower sustainability in the Indian manufacturing sector (Pasi et al., 2020a).

Dewa et. al (2018) identified that the Internet of Things (IoT) was not widely implemented and this could be attributed to a lack of awareness, insufficient Internet infrastructure and lack of cyber-security in the South African manufacturing sector (Dewa et al., 2018). Dewa et. al (2018) and Jain and Ajmera (2020) further elaborated that a lack of tangible government policies was also seen as a deterrent, with policies being discussed but nothing concrete being rolled out. This is interesting to note as the research by Dewa et. al (2018) took place in South Africa and Jain and Ajmera (2020) conducted their research in India – linking the requirements for strong government policies in developing countries to assist with digitalisation in manufacturing industries.

Gupta et. al (2020) have identified that big data analytics, localisation of technologies and conducting feasibility studies to determine which technology is best suited for the process as being the most important enablers of digitalisation in supply chain management (Gupta et al., 2020). Localisation of technologies has a direct impact on cost factors deterring implementation of digitalisation in developing countries, where high import costs may affect their rollout. Designing, manufacturing and supplying these products locally will assist in better enablement of digital technologies and also offer a sustainable competitive advantage when compared to overseas firms.

Pasi et. al (2020) identified that one of the deterrents to sustainable implementation of Industry 4.0 technologies in India was a fear of job losses in the manufacturing sector (Pasi et al., 2020a). India also has a large workforce, with a low skill level, when compared to developed nations and this workforce is reliant on manual or low-skilled jobs to earn a living.

Opazo-Basaez et. al (2022) proposed that the geographical location of the manufacturing firms had a direct relation on the effect of smart technology implementation (Opazo-Basaez et al., 2023) Their research further indicated that companies with larger geographical footprints have a greater benefit from the implementation of smart manufacturing.

A link between the level of digitalisation and the size of the manufacturing company was identified by Buer et. al (2020), namely that larger firms would have a greater level of digitalisation when compared to small and medium sized firms (Buer et al., 2020). Lower productivity, growth and comparatively fewer financial resources were attributed to this disparity in digitalisation. The link between cost and implementation of digital technologies can again be demonstrated by this relationship, where firms with greater levels of capital have associated higher levels of digitalisation. Larger firms were also found to have more sophisticated ERP (Enterprise Resource Planning) systems installed which formed the basis for digital processes in their operations, whilst small and medium firms were unable to afford such systems (Buer et al., 2020).

2.6.2 Benefits of Digital Technology and Industry 4.0

Enrique et. al (2022) were able to demonstrate that digital technologies, such as cloud services, IoT and data analytics were beneficial for the creation of flexible manufacturing operations (Enrique et al., 2022). Flexible manufacturing operations offer a competitive advantage as the processes are able to offer mass customisation, better adherence to customer requirements in terms of sales and also adapt to meet operational requirements. An example of the latter would be changing from manufacturing one product to another that has a more widely available raw material to prevent downtime on the line.

The implementation of digitisation was also shown to positively impact the performance of manufacturing companies in terms of design, flexibility, quality and delivery (Gillani et al., 2020) (Opazo-Basaez et al., 2023). In terms of the pharmaceutical manufacturing industry, Hole et. al (2021) identified that digitalisation will improve manufacturing efficiency, productivity and flexibility (Hole et al., 2021). In a South African context, the ability to have these factors positively affected will lead to a sustainable competitive advantage when competing against other manufacturers.

2.6.3 Roadmap for digital technology and digitalisation implementation

A roadmap for the implementation of digitalisation was proposed by Cinar et. al (2021) and highlighted some of the following as being key to a successful rollout:

- conducting cost-benefit analysis and concepts for pilot projects
- improving and quantifying the benefits of data collection
- developing improved methods of information sharing in the organisation
- analysis of the production process to determine where automation and digitalisation can be most beneficial
- improvement of cyber-security systems
- developing a maintenance strategy
- the cost-benefit analysis of Industry 4.0 technologies should be reviewed in management meetings to highlight the efficacy of the projects

Tortorella et. al (2022) identified the relationship between the manufacturing strategies and whether Industry 4.0 implementation was carried out successfully or not. The level of technological readiness in a firm impacts the implementation success of digital technologies and should be considered when creating a roadmap – maximising on those strategies that have a positive effect. They also determined that the use of IoT, big data analytics and, cloud computing and wireless sensors were more prevalent in firms that had large production volumes and repetitive production strategies. (Tortorella et al., 2022b) In the FMCG industry these technologies would be especially well suited as the sector focuses on producing high volumes of products with little or low deviation. These products are usually produced at a low cost with high repeatability. In this research study it will be determine as to what digital technologies are being used, or planned to be implemented, in the sites surveyed.

Butt (2020) focused on the creation of an implementation roadmap using six sigma and continuous improvement. This was due to the fact that most of the manufacturing organisations considered were already familiar with six sigma principles and the reduction of waste and variability during operations (Butt, 2020). The creation of this roadmap was defined using a modified DMAIC (Define Measure Analyse Improve and Control) framework which instead consisted of the following subsections: Define, Measure, Evaluate, Optimise, Develop, Validate, Implement. Butt (2020) utilised this new framework as a more suited approach to creating a roadmap for digitisation.

2.7 Research Gaps

2.7.1 Geographic limitations

A wide variety of literature is available to highlight the enablers and deterrents of digitalisation and Industry 4.0 adoption in Asian and European manufacturing firms but research into the adoption of Industry 4.0 in the South African manufacturing sector is limited (Maisiri et al., 2021). Dewa et. al (2018) conducted interviews to determine the readiness levels of South African manufacturing firms to adopt Industry 4.0 technologies, however their participants were limited to mostly being in the Western Cape (Dewa et al., 2018). Gaglio and Mbula (2022) limited their research to small and micro enterprises in the Johannesburg area alone (Gaglio & Mbula, 2022). In this study, a broader population sample across South Africa will be interviewed, including those in both inland and coastal regions to determine if there are any similarities in results between these localities.

2.7.2 Industry gap

Researchers such as Agarwal et. al (2022), Khin and Kee (2021) and Pasi et. al (2020), have included a variety of manufacturing industries in their research such as metal processing, heavy engineering, automotive manufacturing, chemical industry, pharmaceuticals and food processing (Agarwal & Ojha, 2022) (Khin & Kee, 2021) (Pasi et al., 2020a). Although these belong to the wide umbrella of manufacturing firms this research project aims to focus specifically on the FMCG industry with a special focus on food production and bottling. The FMCG industry has its own unique challenges that set it apart from heavy manufacturing, mining and other production sectors. Digitalisation would greatly benefit this sector as flexibility, speed and high quality are required, while still maintaining a relatively low price per unit produced, all of which can be positively influenced by the implementation of digital technologies (Jain & Ajmera, 2020).

Agarwal and Ojha (2022) and Khin and Kee (2021) also included a large range of manufacturing firms which ranged from SMEs to large corporations (Agarwal & Ojha, 2022)

(Khin & Kee, 2021). This research project will focus on established large manufacturing firms with factories having 150 employees or more.

2.7.3 Participant limitations

Jan and Ajmera (2020), Gupta et. al (2020) and Weerabahu et.al (2022) conducted interviews with experts in both the Indian and Sri Lankan manufacturing industries, which included Senior Managers, Technical Specialists, Senior Consultants and Professors – all of whom had worked in the industry for at least five years (Gupta et al., 2020) (Jain & Ajmera, 2020) (Weerabahu et al., 2022). Maisiri et. al (2021) interviewed 16 South African specialists to determine what factors inhibit Industry 4.0 implementation in the manufacturing industry (Maisiri et al., 2021). These interviews did not include operators, technicians or lower-level staff and therefore did not fully capture the socioeconomic aspect of digitalisation enablers and deterrents. In the South African context one of the research questions to be answered is how socioeconomic factors, such as job losses, impact digitalisation in the FMCG sector. In this study, participants were interviewed at both Head Office and factory levels to ensure that a broad enough sample size is captured and the results between various seniority positions can be analysed.

2.8 Theoretical framework

2.8.1 Introduction to Technology-Organisation-Environment (TOE) model

The TOE model was developed by Tornatzky and Fleischer to analyse the implementation of information technologies at an organisational level (Tornatzky & Fleischer, 1990) (Zhong & Moon, 2023). The TOE model can be used to determine the enablers and deterrents of digitalisation by examining the relationships between technology, organisational factors and the external environment (Arnold et al., 2018). The TOE framework is appropriate in the context of this research project as it holistically looks at several factors that may prove to challenge digitalisation in FMCG factories and is not limited to a single dimension. The framework also takes into account socio-economic challenges, such as low job skills, and environmental factors, such as a lack of infrastructure, which may deter digitalisation.

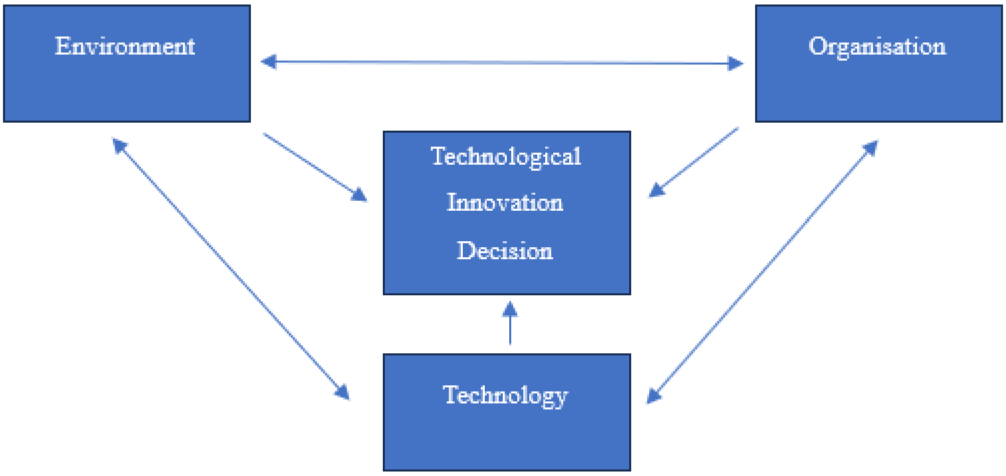

Figure 2.1 - TOE Framework (Tornatzky & Fleischer, 1990)

2.8.2 Rationale of theory

2.8.2.1 Technology

The Technology aspect of the TOE framework identifies the relevant digital technologies that will be available for implementation by the FMCG sector in SA – this is not limited to evaluating the technology to be implemented but should also take into account the existing systems and compatibility (Srivastava et al., 2021) (Zhong & Moon, 2023). This sector considers challenges associated with such technologies such as cost, complexity, installation and integration with existing systems (Bryan & Zuva, 2021). In this sector, the research project analyses which technologies are most suitable for digitalisation in the concerned area.

2.8.2.2 Organisational factors

This sector examines the internal factors within the organization that influence the implementation of digital technologies. This could include aspects such as the organisational structure, culture, employee capability and willingness to accept change and top management support. The level of resources, both financial and human capital related, must also be analysed in this dimension (Srivastava et al., 2021) (Zhong & Moon, 2023). In the research context this dimension would be used to analyse how organisational culture, hierarchy and top management would provide enablers or deter digitalisation. The level of training and support provided to employees to develop the necessary digital skills must be analysed as well.

2.8.2.3 Environmental factors

The environment sector analyses the external factors that impact the implementation of digital technologies in the manufacturing sector. It includes factors such as industry regulations, infrastructure, market competition, government policies, and customer demands (Bryan & Zuva, 2021) (Srivastava et al., 2021) (Zhong & Moon, 2023) Socio-economic factors such as the skill of workers, education levels and training opportunities in the region will also be analysed to determine the effect on digitalisation. Other external factors such as infrastructure, connectivity and ease of access to technology will be considered to determine their effects.

2.8.3 Use of framework in literature

Several journal articles were reviewed as a part of the research to determine if the TOE framework was suitable to determine digitalization enablers and deterrents. Although not all of these research articles were linked to the manufacturing industry, they were able to provide confirmation that the theoretical framework was suitable for this purpose The table below lists the suitable articles and their findings using the TOE framework to determine enablers (or deterrents) to digitalisation, digital technology implementation or digital transformation:

Table 2.2 - List of relevant literature utilising the TOE framework

Construct	**Outcome**	**Methodology Used**	**Reference**
Identifying the factors that determine the adoption of Industry 4.0 technologies by manufacturing companies utilising the TOE framework	The study determined which factors would provide an advantage when implementing these technologies and which factors provided little or negative effects	Literature review	(Arnold et al., 2018)
The study aimed to use the TOE framework to identify the factors	Eleven propositions were identified and sorted into the three	Literature review	(Lippert & Govindarajulu, 2006)

that affect adoption of web services	main TOE dimensions		
A TOE based framework was utilised to investigate Industry 4.0 adoption in manufacturing and service industries	The results highlighted technological compatibility, top management support as drivers of Industry 4.0 adoption	Questionnaires were used to sample participants in China (n = 340)	(Zhong & Moon, 2023)
The study utilised the TOE framework to analyse the implementation of Industry 4.0 technologies in TEIs (Technical Education Institutes)	Factors such as top management support, internal resources and employee skills were critical for the adoption of these technologies	Surveys from 134 participants	(Srivastava et al., 2021)

2.8.4 Triadic model: factors influencing Industry 4.0 adoption

Khin and Kee (2021) created a Triadic model to explain the factors that affected Industry 4.0 adoption (Khin & Kee, 2021). However, these were not divided into any particular dimensions when compared to the TOE framework which was divided into social, technological and organisational factors. Instead, the researchers segregated these factors into drivers, facilitators and imposing categories.

Figure 2.2 - Triadic model for Industry 4.0 adoption (Khin & Kee, 2021)

2.8.5 Conceptual Model

For this research project a conceptual model has been proposed where the enablers and deterrents of digital technology implementation shall be separated into the TOE framework dimensions. This framework shall determine if the factors identified by Khin and Kee (2021) shall still be relevant for SA FMCG factories and if they can be categorised into the relevant social, technological and organisational sectors.

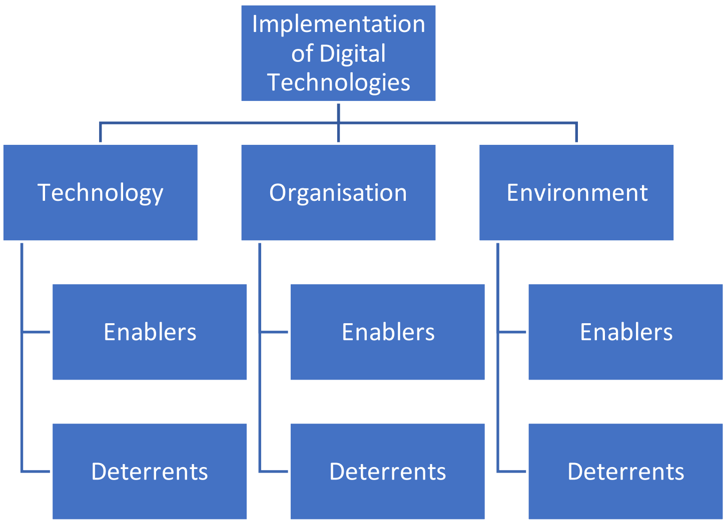

Figure 2.3 - Conceptual framework for digital technology implementation

2.9 Summary of the literature

The literature identified several benefits to the implementation of digital technologies such as improved production efficiency, inventory management, safety and an overall economic benefit. These benefits of the new technologies were seen as the core drivers for digitalisation across multiple research studies. High implementation costs and compatibility were seen as two of the most common drawbacks to digitalisation, however the benefits seem to outweigh these.

The literature review helped inform the creation of the questionnaire for the semi-structured interviews. The research that was reviewed identified several enablers and deterrents of digitalisation such as: lack of upper management strategy, lack of finances and resources, a lack of skills and IT infrastructure. The importance of these factors varied depending on the industry in which the research was conducted and the geographical location.

3 Chapter 3 – Research Methodology

3.1 Introduction to research methodology

The primary aim of this research is to identify the enablers and deterrents of digitalisation, or digital technology implementation, in South African FMCG factories. The secondary aim is to determine what the current level of digitalisation is within these firms, by establishing the most prevalent advanced digital technology already installed. A further secondary aim is to identify the digital technology that will produce the most benefit if it is installed within these firms at a future date. The qualitative data were obtained from both existing literature and the participants of the semi-structured interviews. As such, a thematic analysis was applied to identify recurrent themes in the data (Delve & Limpaecher, 2020). Once these were determined a roadmap was created for the specific purpose of highlighting the main factors that will either hinder or accelerate digitalisation in South African FMCG factories.

3.2 Research approach

The research questions shall be answered using an inductive qualitative approach and thematic analysis. Thematic analysis is a method using qualitative data to identify patterns and create themes (Delve & Limpaecher, 2020). In thematic analysis, the overarching themes and their relationships are identified which assists in answering the research questions for this project. The following methodology is proposed to address the research questions in this study:

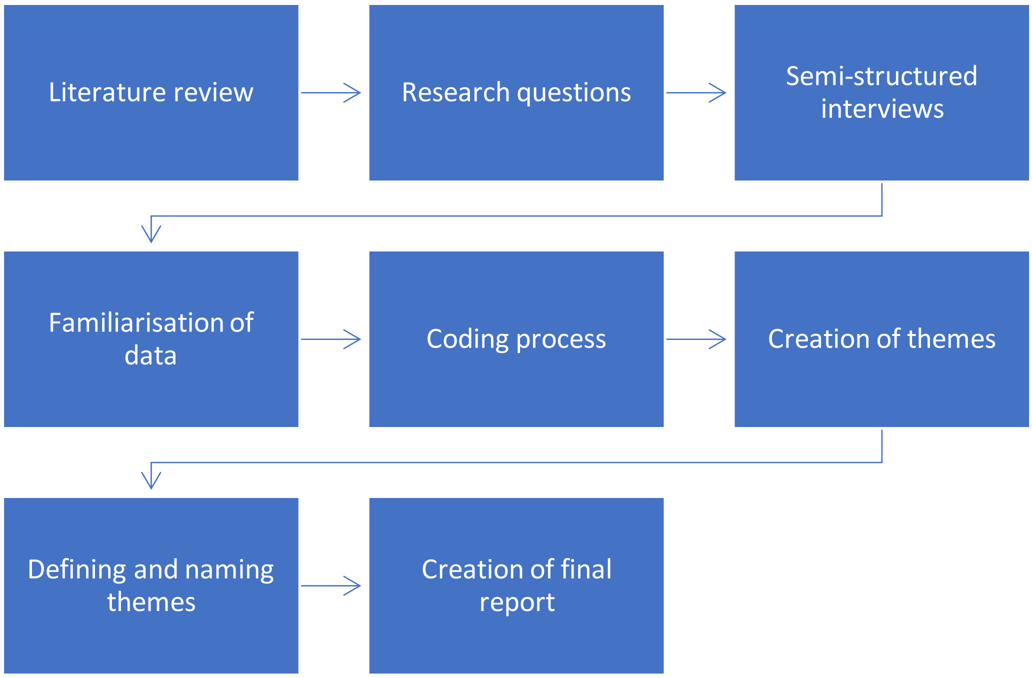

Figure 3.1- Proposed methodology

A detailed literature review was conducted from which the questionnaire was formulated. A series of semi-structured interviews were undertaken with the participants employed in the FMCG sector across several South African firms. All participants had to be involved in the manufacturing of either food, beverages, personal or home care products and to be permanently employed by the firm.

The interview transcripts were analysed by the researcher and initial observations were noted. Thereafter a coding approach was undertaken. Coding can be defined as the process of assigning codes (labels) to incidences that occur in the data. Strauss and Corbin (1990) have simplified the coding process into the act of "concept labelling and categorising", while Charmaz (2006) has defined the process as "the link between collecting data and creating a new theory" (Charmaz, 2006) (Cho & Lee, 2014) (Strauss & Corbin, 1990).

The codes were then be sorted into themes and reviewed holistically to determine their relevance to the data. Each theme contained the relevant data to substantiate their validity for the study. The relationship between themes was then analysed and themes with insufficient data or irrelevance were removed. In the final step the narrative was created to answer the research questions and the report was finalised.

3.3 Research paradigm

A constructivist paradigm was utilised for this research project as people construct their own understanding and knowledge of the world through their experiences and reflecting on those experiences (Adom et al., 2016). This aligns with the qualitative research methodology that was utilised to gather data and analyse the subjective experiences of interview participants with regard to digitalisation. Utilising a qualitative approach allowed for the participant's experiences with digitalisation to be accurately captured as the data were transcribed in the manner in which they were produced during the interview and then analysed. A quantitative approach would limit the manner in which the respondent is able to express their experiences when it comes to digitalisation.

The constructivist paradigm considers that the participants will have different understandings and experiences of digitalisation. Participants will also align their views based on personal understandings and experiences. For example, it would be expected that an Operator may feel threatened by digitalisation and automation in a factory as this may result in job losses. Whereas a Plant Engineer may look at digitalisation in a more positive light in that it would be a means to more effectively achieve their production targets and reduce overall costs.

The constructivist paradigm also deals with an inductive approach wherein the researcher shall gather data then analyse it to identify common themes related to digitalisation. The researcher has utilised the data obtained to draw conclusions with regard to digital technology implementation.

3.4 Research design

The research questions to be answered were open-ended in nature to elicit a detailed response from the participants of the semi-structured interviews. All participants were directly involved in operations and had a direct link to digital technology in their day-to-day duties. Utilising a semi-structured interview approach allowed for better collection of qualitative data that could be used to define the recurring codes related to this topic. The interview guide can be found in Appendix C.

In terms of the research project the researcher has been working the FMCG field for twelve years, having held various operational roles, including site engineering manager. The researcher currently works with a firm responsible for designing and implementing digital technology solutions in FMCG factories across the world. This experience shall be utilised to identify the core themes during the qualitative interview process.

3.5 Data collection

3.5.1 Sample population

The sample size used for this research project was based upon capturing the various levels in most FMCG factory organograms. Figure 3.2 - Generic factory organogram, gives an overview as to the hierarchical levels present in an FMCG factory. This organogram was based on combining existing organograms from the respondent's firms and coming up with a generic layout that could be segmented for responses. Four of the respondent's firms were used to obtain organograms from the manufacturing departments. These departments were most involved with digital technologies at a production level and were used to create the hierarchical levels for this study. At the lower level are the factory floor staff such as the Operators and Technicians and they directly operate and maintain the machinery and production equipment on a daily basis. At the next level are the Unit Managers and Technical Specialists – even though they have the same reporting structure as the general Technicians they are regarded as being more adept as they have specialised vocations within the plant environment. In the middle management category, the Engineers, Project Managers and Production Managers control their respective teams or departments. At the highest level the

Plant Manager oversees all operations on the site. During this research project, participants were obtained from each of these levels in order to gain a representative sample indicative of the factory environment.

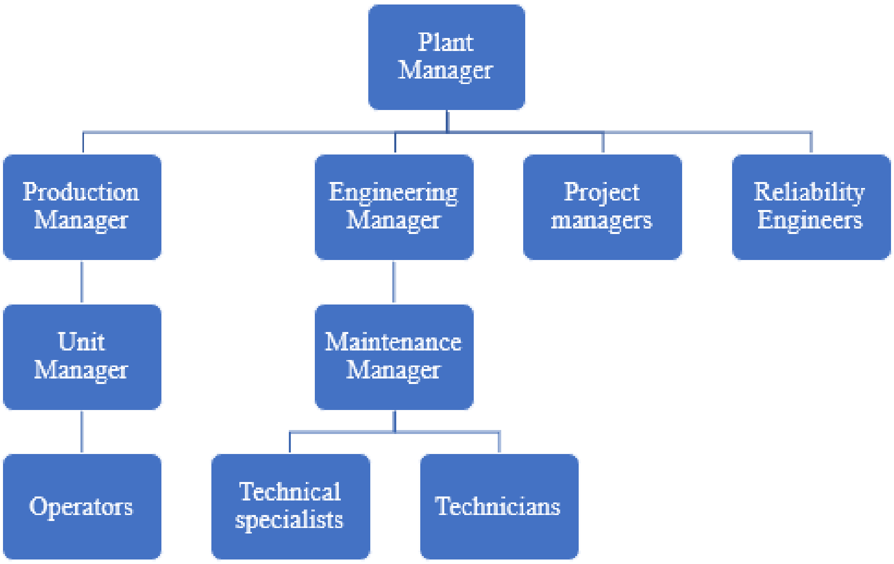

Figure 3.2 - Generic factory organogram

The semi-structured interviews were undertaken in-person in order to better gain direct information without misrepresentation. The interviews took place over a almost four-month period while the researcher travelled to various sites (11/09/2023 to 31/12/2023). The respondents were based in several locations across South Africa including Johannesburg, Pretoria, Durban, Port Elizabeth and Cape Town. Data and responses were gathered until theoretical saturation was obtained – the initial sample size was predicted as 28 respondents in Table 3.5.1:

Table 3.1 - Representative sample size for data collection

Group	Description	Population size
Senior management	Plant managers, Sectional Managers and Head Office Management	3
Middle management	Engineers, Project Managers	10
Lower management/Specialists	Unit Managers, Team Leaders and specialist technical personnel	10

Operational level	Technicians and Operators that work on/with machinery. These participants will be directly involved with the manufacturing process	5

3.6 Ethical considerations

Please refer to Appendix B for all ethics related documents.

Participants were kept anonymous during the semi-structured interviews. In the dissertation and journal article, they shall be referred to using job descriptions and generic names e.g. Respondent A. Personal information shall not be published or obtained except for their job titles and years of working experience. The ethics clearance process outlined by the Wits Business School were followed in order to gain ethical clearance certification.

3.7 Conclusion

Inductive qualitative analysis can be used to explain a particular phenomenon. In this particular case, the research questions are specific to the South African manufacturing industry where unique socio-economic, infrastructure and financial circumstances all affect digital technology implementation. This unique environment does not allow a researcher to easily adopt similar findings that occur in other countries or industrial sectors and compels research into this specific focus area. The coding process also allows the researcher to review several aspects and how they are interrelated rather than just focusing on a single facet.

4 Chapter 4 – Results and Discussion

4.1 Introduction

A total of 24 respondents were interviewed through semi-structured questionnaires. The respondents came from a total of nine different firms which were focused on FMCG manufacturing (bottling, homecare and pharmaceutical and food manufacturing). These firms constituted two entities that had their operations entirely in SA, while the other seven were located in SA and other regions, however only their South African production entities were considered. The respondents were asked to answer the research questions based on their experiences in the South African FMCG sector and not a firm biased response. The population distribution of the respondents is captured below:

Table 4.1 – Respondent population distribution

Levels	Description	Number of respondents	Percentage of population
1	Senior management	4	17%
2	Middle management	8	33%
3	Lower management/Specialists	7	29%
4	Operational level	5	21%

The largest respondent sample was taken from Lower and Middle Management and Specialists. This was essential as these respondents work with digital technologies on a day-to-day basis and are responsible for maintaining and implementing these projects in the factory environment. They are also seen as key decision makers as to which systems are implemented and senior management relies on them to assist with roadmaps for digitalisation.

4.2 Baseline technologies

The first research question asked to respondents was to establish a baseline as to what digital technologies were currently installed in South African FMCG factories. Understanding the current level of digitalisation can be used to determine what these systems are being used for and whether plants are interested in adopting these technologies on a wider scale.

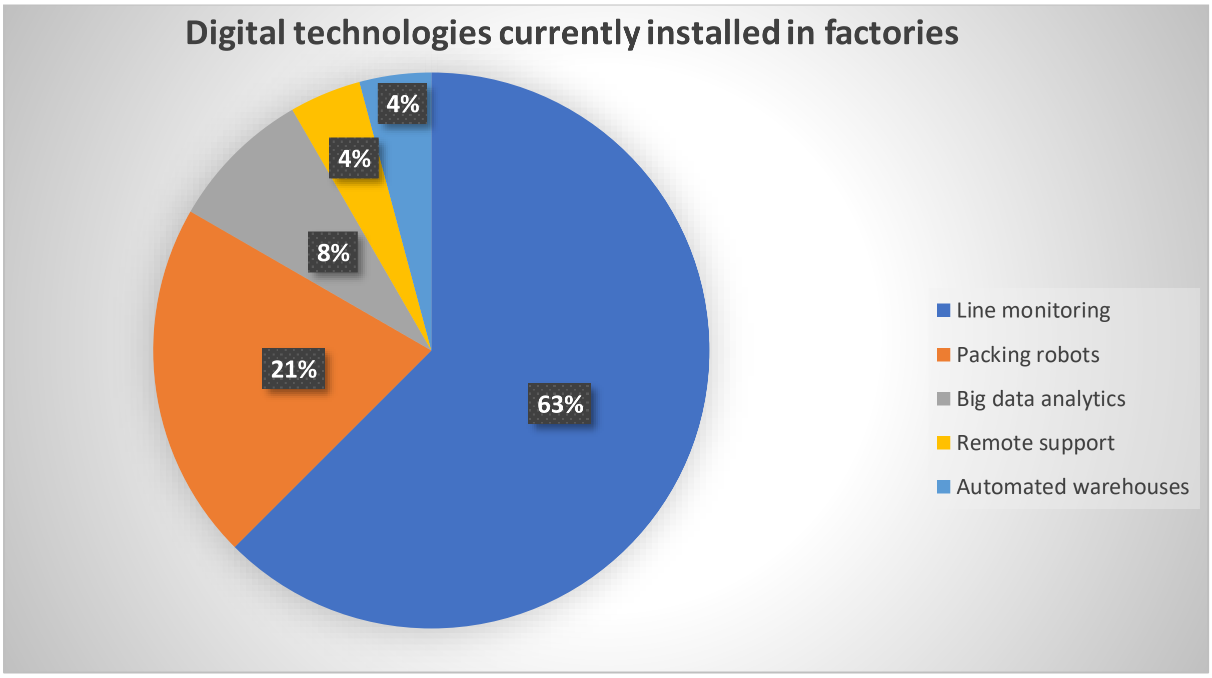

Figure 4.1 - Digital technologies already installed in South African FMCG Factories

The most common response centred around line monitoring systems and automated data collection. In a factory environment line monitoring is essential as it allows the firm to determine where their losses, downtime and bottlenecks occur in a process. This could be as a result of several factors such as incorrect process design, incorrect plant layouts, operator issues or maintenance problems. An added benefit of having real-time line monitoring is that it allows the site to react proactively based on the behaviour of the manufacturing line, instead of waiting for an issue to occur and fault-finding thereafter. This also contributes to operational benefits such as improving line efficiency, reducing stoppages and promoting more flexible production scheduling. Line monitoring also allows for the manufacturing system to self-adjust between various machines when stoppages or bottlenecks occur. Machines are able to receive data from one another, and ramp up or down their running speed accordingly. This prevents the line from coming to a complete stoppage.

"...line monitoring system which links machinery with the Internet to monitor them in live time and react in real time. Not waiting for a breakdown to occur but instead you can be proactive. Not looking at yesterday's downtime to react"- Respondent 6 (Lower Management/Specialists)

Some plants also have a basic form of condition monitoring on the line, where vibrational sensors are installed at critical machine points such as pumps and bearings. These sensors provide real-time feedback as to running condition and alert the site technical team as to when potential failure could occur. By tracking the running condition of these components, the plant will be able to determine when possible catastrophic failure occurs, e.g. when a bearing is about to fail, the vibrational frequency will increase. The site technician can monitor this and predict when it will be time for a change before having the component break and possibly cause additional damage to the system.

Automated packing robots were the second most prevalent response, with these robots being used for palletising cases, packing bottles or containers and removing raw materials from their original packing format.

"Packer and unpacker robots are the most advanced systems I have seen installed. They don't need any human intervention and can work for (up to) 2 years if the maintenance is being done correctly. Very little human intervention and interference is needed. Robotic arms are self-operating and have minimum downtime" – Respondent 9 (Middle Management)

Big data analytics, with tools such as Power BI, are also prevalent in South African FMCG firms. These allow for an analysis to be undertaken of the entire manufacturing and supply chain process and for the firm to determine where losses, stoppages and bottlenecks occur. The use of big data analytics in firms with multiple sites or manufacturing lines also allows for better decision making to take place. The senior management team is able to gain a holistic view of the entire manufacturing operation and make decisions accordingly that will allow for the most efficient production possible. Big data analytics can also be utilised to determine maintenance costs, in terms of time, manpower and physical parts, to determine where costs are being spent and plan production according to the most efficient manufacturing lines.

"Power BI for big data analytics which makes things visual and captures a lot of data to understand it at a higher level. In the past five years this has improved a lot. A firm can have a global view on line performance, supply chain and logistics costs. Maintenance costs can also be determined in different regions to compare performance. This affects decision making abilities when it comes to production scheduling. You are able to pick up trends and patterns to make better operational decisions"- Respondent 6 (Lower Management/Specialists)

Remote support is another digital technology that is already installed in some plants. This can be used to assist for fault finding when a support technician is no longer in the nearby vicinity. This has an added benefit for digital technologies which are supported by overseas firms, whereby a technician can remotely dial into the machine and fault-find then problem solve any issues. There is an added cost benefit for the plant as these remote support costs are usually cheaper than having a technician physically travel to the site, or a reduced headcount can be maintained with support being rendered remotely. An added benefit of remote support is for factories in remote locations where it would be too costly to wait for a technician to travel to the site and problem solve issues, instead they can gather instantaneous support from anywhere in the world through a remote connection. In terms of installing or commissioning machines the costs can also be reduced as this can be done remotely without the travel expense of bringing in foreign technicians.

"You don't need a technician on site anymore, it can be done remotely where Germany dials into the machine and can do the commissioning and fault finding from anywhere in the world. Setups and adjustments can be done remotely" – Respondent 10 (Lower Management/Specialists)

"(You can) log in remotely to assist with a problem instead of being at the plant. After hours breakdowns could be attended to remotely and certain technologies allowed the guys to log in from home and reduced the downtime"- Respondent 3 (Lower Management/Specialists)

Automated warehouses which use self-driven forklifts can be found in a few South African FMCG plants. Although not very common they are already in existence and promote greater efficiency and safety when compared to traditional warehouses. Automated warehouses greatly improve the picking and packing processes which can sometimes be delayed by human operators. A major advantage is that an automated system can run continuously without the need for breaks and will be well suited for a 24-hour operation where production is continuous.

"They have fully automated warehouses without people inside, which are very advanced" – Respondent 23 (Senior Management)

4.3 Enablers and Deterrents

Respondents were asked to identify the enablers and deterrents of digitalisation based on their experiences working in FMCG factories. These responses were then grouped by common and prevalent themes and categorised according to the TOE framework.

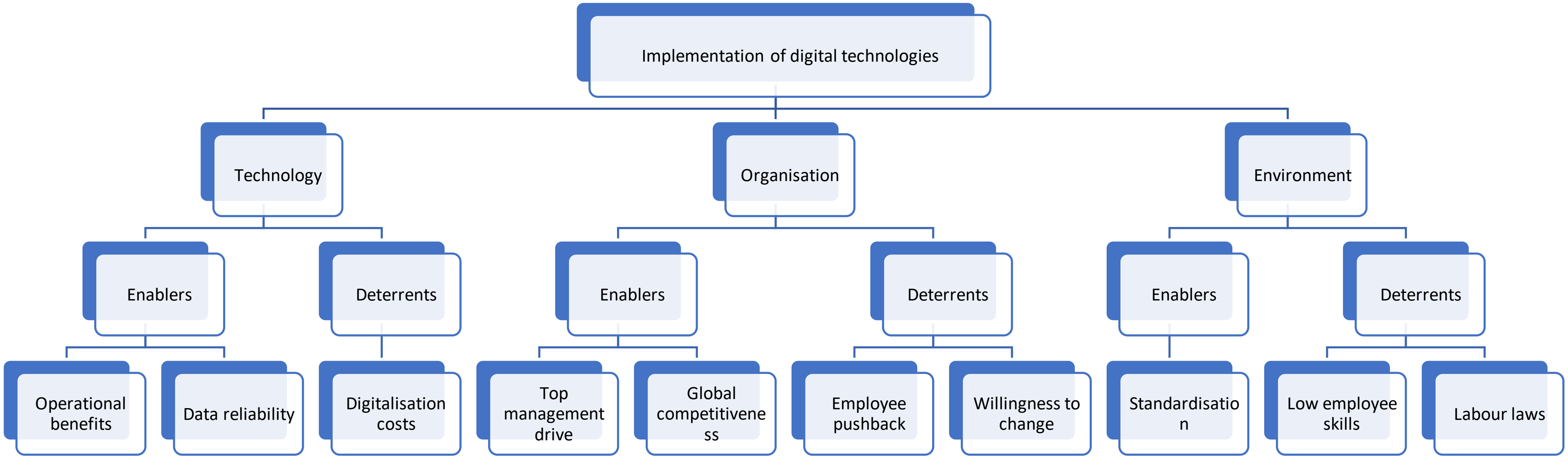

Figure 4.2 - Enablers and Deterrents of Digitalisation in South African FMCG Factories

4.3.1 Technology Enablers

4.3.1.1 Operational benefits

The most prevalent technology enabler for digitalisation was the operational benefits, which translated into calculable returns on investment (ROI). Firms were driven to implement digital technologies based on the perceived benefits that they achieved. These benefits could be seen across the manufacturing facility in production, maintenance, quality and logistics departments.

Operational benefits were measured in the following methods:

- Reduction in waste
- Reduction in head count
- Reduction in human error
- Reduction in downtime
- Increase in efficiency
- Quality improvements

Each of these reductions ultimately leads to cost savings for manufactured goods, which allows for firms to be more competitive and offset other rising costs, such as increasing raw materials prices.

The most common response was to utilise digitalisation to reduce waste and downtime in the manufacturing process. By utilising digital solutions, such as smart sensor monitoring, the IoT and automated preventative maintenance, the firm can prevent catastrophic machine failures, proactively conduct maintenance and resolve machine issues and have greater control of their spare parts holdings. Smart sensor monitoring and automated predictive maintenance would work together to determine which components are going to fail, and then order the replacement parts or create an associated intervention request for a technician to attend to the problem before it occurs. This is an added benefit when it comes to reducing fault-finding time by having baseline and real-time data available, as well as reducing asset costs through minimising spart part holding inventory and only ordering parts when a potential breakdown is going to occur. The ultimate aim of reducing downtime in a manufacturing process is to keep the operation running for as long as possible which results in a greater efficiency.

"A lot of the automation was driven by quality and efficiency gains." – Respondent 18 (Lower Management/Specialists)

In terms of reducing headcount a more automated line can reduce the number of operators, technicians or warehouse personnel required to conduct manufacturing activities. Employees will be required to feed raw materials to the automated machines rather than manually conducting manufacturing processes themselves.

"In a South African context, it would be cost saving. There hasn't been a place where automation has not been involved in trying to reduce product cost either through downtime reduction or other methods"- Respondent 17 (Lower Management/Specialists)

A further operational benefit is reducing the risk of human error and improving overall manufacturing quality. Having a fully automated process allows for the same standard to be replicated with every batch, and using digitalisation for raw materials inspection and quality control will ensure that what materials enter the process will adhere to the firm's requirements and reduce deviations. Production batches that are reliant on human operators to inspect and bring together raw materials will always be subject to a greater range of deviations, and possible erroneous batches of product. However utilising digitalisation will assist in creating batch conformity during the manufacturing process. An example of this is within the beverage manufacturing sector, where an automated blending plant can monitor and take readings of the batch and adjust input materials, such as water and concentrate for example, as per the actual situation within the blending tank in order to adhere to the firm's quality control regulations.

"People will get calculations wrong for batches and processes – which compromises the quality of the product. People will add incorrect ingredients and then there is no consistency. There is also no trace of who did what and when. With digital technology you have traceability and surety that the batch will remain consistent each time" – Respondent 7 (Senior Management)

Automated methods help in reducing these losses in the factory by creating fail-safes, improved processes and more efficient manufacturing steps. Digitalisation can assist with inspection technology, such as smart cameras or X-rays, to identify quality errors in the production process and stop it before too many waste products are created.

"A lot of the automation was driven by quality and efficiency gains. In an organisation that promotes quality and food safety this drives automation."- Respondent 18 (Lower Management/Specialists)

Safety is also improved by implementing digitalisation in areas where the work is hazardous to people and can be more readily completed by machines or robots. An example of this would be fully automated warehouses where AGVs (Automated Guided Vehicles) can replace forklifts and reduce the change of injuring pedestrian traffic.

4.3.1.2 Data reliability

Some FMCG firms are still reliant on the manual capturing of data which leads to inconsistencies when analysis is undertaken. Operators, technicians and section managers can manipulate the data to improve on their own process efficiencies while incorrectly blaming other steps in the process for wastage and downtime. This may result in the firm spending resources to investigate issues in the incorrect area of the plant. By utilising an automated line monitoring and data collection system, it removes any bias from the results being analysed. All data is objective as it is being recorded and transmitted from the machine or system itself.

"Companies are focusing on reducing the reliance on people and (increasing the) focus on robotics and systems. For example, things are (now) done with people checking stock levels, recording downtime etc. and this results in inaccuracies in reporting. Data will be more reliable if it is taken by a machine or system"- Respondent 20 (Operational Level)

4.3.2 Technology Deterrents

4.3.2.1 Digitalisation costs

Digital technologies require constant maintenance in order to keep the system functioning. As compared to more manual systems the digital system must be kept maintained at a high level in order to prevent catastrophic failure and stoppages in the factory. This may result in increased maintenance costs for more expensive spare parts and greater technician costs (as more skilled artisans are employed to maintain the digital technologies the cost per hour will increase). Digital technologies are also more reliant on the supplier to provide hardware to maintain the system, whereas manual systems may be more easily maintained with local parts and solutions. This further increases the reliance on the supplier and onus to purchase OEM parts rather than third-party components which may not be compatible with the digital technology that has been installed.

"Two key things – first one being CAPEX and OPEX because the initial capital outlay is excessively high. And ROI may take long, unless you are addressing things like material losses." –Respondent 16 (Lower Management/Specialists)

Digital technologies have a large initial investment cost which places a burden on the firm to come up with the capital expenditure resources. Even upgrading existing machinery, process facilities and systems comes at a high resource cost in terms of direct costs (capital expenditure), and indirect costs such as employee training, downtime to implement and a learning curve before the organisation achieves the benefits of the technology.

"More CAPEX money for digitalisation would assist, as there are numerous project proposals and they (the firm) focus on other things."- Respondent 19 (Senior Management)

A large portion of the digital technology cost comes from the reliance on overseas firms to supply and install the systems and hardware. There is also a monopoly in terms of these technologies and suppliers are able to dictate the costs they wish to charge.

"There is a limited market in SA that can implement digital technologies – and only a select few companies will be running with it" – Respondent 22 (Operational Level)

4.3.3 Organisation Enablers

4.3.3.1 Top management drive

Digital technology implementation that has been driven from upper management has been better received, according to the respondents that were interviewed. When digital technologies are implemented by upper management there are several benefits, such as having adequate resources (time, people and funds) assigned to the project. Employees also seem to be positively responsive when there is a top-down drive for these technologies. A further benefit to having upper management drive digitalisation implementation is that they are able to link the success of the project to the KPIs of the firm, which in turn results in greater employee buy-in.

"No drive from the senior management to implement the systems. Top-down management was missing during the process, and there was no buy-in from the management"- Respondent 3 (Lower Management/Specialists)

"A top-level drive also promotes digitalisation. If it is driven down from top management then there are benefits and the firm is quicker to implement the technology. If it is a group goal where they are getting measured against it, bonuses attached etc., then priorities will be shuffled."- Respondent 8 (Operational Level)

4.3.3.2 Global competitiveness

FMCG firms compete on a multinational level in terms of price, quality and volume. Digitalisation is seen as a method by which competitiveness can be exploited as a part of the firm's strategy. For example, automation may be used to reduce headcount and overall production costs to give the firm an advantage in terms of costs of goods sold. Digitalisation in the predictive maintenance sense may reduce downtime which allows for greater volume to be produced during a set production period. Firms that are not utilising digital technologies to gain a sustainable competitive advantage will have to rely on other methods to make up for this shortfall such as increasing reliance on cheap manual labour, which may result in quality issues and so forth.

Digitalisation can also be utilised to provide cross-collaboration between research and private institutions, as well as providing data as to what the market and competitors are doing. Large scale databases which highlight the work that research firms and institutes are conducting will allow for private sponsorship and collaboration where there is mutual benefit.

"*Alignment with global trends to be competitive in the market… Digitalisation will give the data as to what is happening on a global platform e.g. between competitors and research institutions. Are institutions developing new materials e.g. is Harvard for example developing a plastic that can be dissolved in salt water" – Respondent 4 (Operational Level)*

4.3.4 Organisation Deterrents

4.3.4.1 Employee pushback and willingness to change

Employees at an operational level are reluctant to learn new systems and technologies based on the feedback provided by the respondents. During the interviews it was noted by several respondents that employees prefer to stick to historical systems and technologies and are unwilling to learn new systems or attend trainings for these new technologies.

"…what stopped most of the projects from going forward, (was that) the Operators felt reluctant to assist the project team. The Operators are lazy to learn new processes and want to stick to the old methods."- Respondent 7 (Senior Management)

A lack of understanding is associated with employee pushback with regard to the benefits of digital technologies. Employees are not always aware of the potential benefits resulting from digitalisation and how operations and personal situations can be improved in this regard.

"One the biggest things that I saw was that factory people were against automation. They thought that if you automate then you reduce the headcount. Unions are slightly, or vocally, against it." – Respondent 18 (Lower Management/Specialists)

"Ignorance – not knowing the benefits and having short term thinking. People at level one will think that their jobs are at risk e.g. in a year's time the robot might replace them"- Respondent 4 (Operational Level)

"The shortfall is that the guys who are on the floor are not involved and then have pushback because they don't understand the benefits of the project and how it is there to help them. They see it as a threat to replace their jobs instead of upskilling themselves and becoming part of the new processes. (there needs to be) More training is needed for them to understand what is happening. Give them a development plan so that they aren't just stuck doing manual labour but can be developed"- Respondent 2 (Middle Management)

4.3.5 Environmental Enablers

4.3.5.1 Standardisation

The standardisation of systems, both internally and externally, results in accelerated implementation of digital technologies. There is a *"fear of being left behind and you want to compete on a multinational field and compete at worldwide level. Everything is now integrated" – Respondent 11 (Middle Management)*. In the current operational environment integrated systems between factories, suppliers and logistical companies assist in promoting efficiency between stakeholders. Standardisation to the industry norm will allow the firm to integrate their systems with customers and suppliers. One of the benefits is increasing production flexibility where an FMCG firm can have direct access to the supplier's raw material holdings which allows them to plan production more efficiently. A further benefit of standardisation comes with linking to customer systems to facilitate safe and efficient monetary transactions. Rather than relying on third-party banking systems, an integrated system can utilise a technology such as blockchain for supplier-customer transactions.

Standardisation also results in training and efficiency benefits for firms, as the workforce can be trained on universal systems and equipment. This results in a more specialised workforce that is able to share knowledge and assist one another throughout the operational process. An example of this is being able to rely on technicians from other factories within the firm to assist with breakdown support, or else training specific technicians to work on a defined technology that is present in all factories and have them offer support through remote connectivity. Training can also take place on a larger scale with the operators and technicians being trained in large batches and utilising the same production processes across various sites.

Standardisation also assists in reducing working capital by lowering the number of spare parts, or value of spare parts, that a firm will keep in stores. The firm is able to leverage economies of scale and by utilising standardised systems and technologies across their organisations, they can share parts between factories. If the firm is aligned to the latest industry standards, then parts can be shared amongst different firms during breakdown situations or suppliers will increase the quantity of stock kept for customer usage.

"Also, a tendency in many plants to standardize in order to reduce spare parts inventory" – Respondent 17 (Lower Management/Specialists)

4.3.6 Environmental Deterrents

4.3.6.1 Low employee skills

In South Africa, the low skills exhibited by the majority of the operational workforce impedes the installation of digital technologies and the wide rollout thereof. A cheaper workforce, that is heavily dependent on manual labour is not receptive to automation and digital technologies being implemented as it is seen as a direct threat to their livelihood.

"Our unemployment rate is very high and implementing certain technologies will put people's jobs at risk. We need to find a balance in SA to combat unemployment and see if it is practical within the country. Workers should grow as the technology is implemented."- Respondent 8 (Operational Level)

When compared to the job requirements for comparable operational roles, the skillset required in First World countries is a lot higher than what is required in South Africa. A respondent cited that technicians and operators in first-world plants would need an associated degree for certain roles, however in South Africa the same role would be conducted by an employee with only a Matric qualification due to the manual nature of the job and the lower salary paid here.

"Local employees are not as skilled as first world employees. Third world education levels are less. Operators only need a Matric here vs. overseas where you would need a Bachelor's degree."- Respondent 6 (Lower Management/Specialists)

Employees who are not used to interacting with digital technologies will require an increased training cost. This may be prohibitive for some firms, or some digitalisation projects, whereby the cost of re-training the entire workforce may outweigh the benefits of the technology. Realistically, firms also do not want their operations disrupted for prolonged periods that would be required to train the workforce, which may result in the project being impeded. Firms also have a fear that once they have invested time and capital into uplifting their employee pool, then they will leave and join other firms who gain the benefit of the training conducted by them. One of the ways to resolve this is to initiate training and development contracts whereby skilled employees are retained for a set period after being upskilled.

"Skills are a major issue – because you first need to invest in developing people and look at the cost of running the system and training the people. But once the training is done the guys will change to another company and this results in high turnover. There are low skills available in the (job) market which makes hiring difficult." – Respondent 20 (Operational Level)

A low level of employee skill within the workforce can have several negative effects on operations. One of these is the incorrect use of the technologies in order to gain the maximum benefit. Operators may not fully understand the system or machinery, and this may result in an inability to properly utilise them for production purposes resulting in lower efficiencies and greater manufacturing costs being incurred.

Employees may also struggle to resolve maintenance issues on newer technology systems, which results in an overall negative effect on operational efficiencies. Problem solving will take longer with a low skill employee base as there needs to be a level of digital know-how when it comes to fault finding on the systems. When trying to resolve bottlenecks the employees may also spend far too much time and resources on the incorrect focus areas as they do not have an in-depth understanding of the technology. Firms may become reliant on support from international firms to resolve their issues, rather than upskilling the South African employee base, just as a result on the need for operational output. These factors ultimately result in further costs being incurred.

“There is a lack of skills – where we don’t have the local skillset and then require specialists to come in from overseas to resolve our problems and initiate digitalisation” – Respondent 10 (Lower Management/Specialists)

“What hinders digital technology (implementation) is short term results – if we put a system into place then it won’t automatically get the results right away. We don’t see return on investment with the newer digital technology – we need a lot more in terms of training and upskilling to gain benefit. Firms might not be patient enough to conduct this exercise.” – Respondent 5 (Operational Level)

4.3.6.2 Labour laws

South African legislation (such as labour laws), trade unions and an already high level of unemployment are factors that prevent fully automated systems from being implemented. Legislation controls the rate at which firms are able to reduce their headcount and implement digitalisation in order to curb the levels of unemployment. If factories were to fully automate, and dramatically reduce the overall headcount, then the country would be faced with an exponentially increasing unemployment rate. Factories are required to maintain certain levels of headcount and digitalisation is seen as a method to reduce headcount and is thus seen unfavourably by trade unions. *“Labour laws (are another deterrent) – cannot get to the level of automation where headcount is reduced. There is a backlash from government” - Respondent 16 (Lower Management/Specialists)*

4.4 Comparison to Literature Review

The enablers and deterrents identified during this research project were compared to those which were identified in the literature review (Chapter 2). This was done to compare results between different industries and regions where the previous research had taken place. Most of the data from the literature review were based on research that took place outside of South Africa, and Africa entirely, and encompassed industries beyond just FMCG. Table 4.2 gives a summary of this research project’s findings and which journal papers they align with. Note that not all enablers and deterrents align completely with the reference material and there are areas of commonality where other researcher’s work aligned with this project.

Table 4.2 – Comparison of results to literature review

TOE Framework Sectors	Deterrents or Enablers	Results	Aligned with
Technology	Enablers	Operational benefits	(Khin & Kee, 2021)
		Data reliability	(Khin & Kee, 2021)
	Deterrents	Digitalisation Costs	(Agarwal & Ojha, 2022) (Jain & Ajmera, 2020) (Zhong & Moon, 2023)
Organisation	Enablers	Top management drive	(Agarwal & Ojha, 2022) (Zhong & Moon, 2023)
		Global competitiveness	(Khin & Kee, 2021) (Zhong & Moon, 2023)
	Deterrents	Employee pushback	(Khin & Kee, 2021) (Pasi et al., 2020a)
		Willingness to change	(Jain & Ajmera, 2020) (Khin & Kee, 2021)
Environment	Enablers	Standardisation	(Jain & Ajmera, 2020) (Zhong & Moon, 2023)
	Deterrents	Low employee skills	(Butt, 2020) (Khin & Kee, 2021)
		Labour laws	N/A

Table 4.3 – Regional and industrial summary of journal sources

Journal	Industry	Region
(Agarwal & Ojha, 2022)	Micro, Small and Medium Enterprises	India

(Butt, 2020)	Manufacturing	Literature review from several sources
(Jain & Ajmera, 2020)	Manufacturing	India
(Khin & Kee, 2021)	Manufacturing	Malaysia
(Pasi et al., 2020a)	Manufacturing	India
(Zhong & Moon, 2023)	Manufacturing & Service Industry	China

The sources from the literature review identified enablers and deterrents of digitalisation in a wide variety of manufacturing sectors including petrochemical, pharmaceutical and automotive manufacturing to name a few, but none were constrained to the FMCG industry. The results were also obtained from several regions including India, China and Malaysia however nothing from Africa. However, in spite of the industrial and regional differences to this research project, there were still commonalities in the identified enablers and deterrents. Digitalisation costs were a common deterrent in the Chinese and Indian research papers, while Top Management Drive was seen as an enabling factor in these regions. The deterrents identified in the Organisation and Environment Sectors of the TOE Framework namely: Employee Pushback, Willingness to Change and Low Employee skills were also identified in the Malaysian and Indian studies., however the Chinese study did not include these factors which can be attributed to having a different workforce and digitalisation culture.

A key point to note is that none of the studies identified Labour Laws as being a deterrent towards digitalisation while in South Africa this was seen as a definite impeding factor. This contrasts with the labour laws or legislation in these regions as being more favourable than the laws in South Africa. The current high level of unemployment in SA would be an contributing factor to the negative attitude towards digitalisation, where it is seen as a catalyst for job losses. Further research should be undertaken with regard to how current labour laws affect digitalisation and how collaborative work between government, industry and academic institutions can promote digitalisation in the area rather than impede it.

"Labour laws – cannot get to the level of automation where headcount is reduced. There is a backlash from government"- Respondent 16 (Lower Management/Specialists)

4.5 Hierarchical results analysis

The data analysis was divided into four hierarchal levels based on the respondent's role within the factory organogram. This was done to determine if there was a variation in opinions towards digitalisation linked to the respondent's role within the firm.

Table 4.4 - Enablers and Deterrents of Digitalisation by Organisational Level

Level	Description of group	Most prevalent enabler	Most prevalent deterrent
1	Senior management	Data reliability improvement	Low employee skills
2	Middle management	Operational benefits	Low employee skills
3	Lower management/Specialists	Operational benefits	Low employee skills
4	Operational level	Operational benefits	Low employee skills

The most common theme, with regard to digitalisation implementation, are operational benefits such as reduction in losses, manufacturing costs, downtime and improvements in quality. Senior management respondents identified an improvement in data reliability improvement as the most common enabler, however it should be noted that the respondents were inclined to use the data to drive operational improvements.

Low employee skills were identified as the key deterrent to digitalisation across all four respondent levels. However, this is directly linked to the job security factor and operational capability of employees. Firstly, employees have a fear of job losses through automation and digital technologies, which were brought up by respondents in the operational level 4. Secondly there is a concern from management that the workforce would not be able to utilise digital technologies nor would they have the skillset to problem solve issues or maintain the systems at their optimal level.

"They [employees] see it as a threat to replace their jobs instead of upskilling themselves and becoming part of the new processes"- Respondent 2 (Middle Management)

A senior management respondent had noted that the low skills also contributed to the efficacy of the technologies as they would not be able to be maintained over time due to the employee's skillsets. This would in turn result in the system either being abandoned, not functioning properly or the firm not reaping the operational benefits from the system.

"With the skillset that we have, over time the installed system will be semi functional so you only reap part of the benefit."- Respondent 16 (Lower Management/Specialists)

A further respondent noted that there was a reluctance to learn new systems and improve employee technical knowledge. Instead, the employees were prone to stick to what they were accustomed with and not want to learn newer or more complex systems. *"To get people to buy into the technology is quite a challenge. There is a resistance to change – introducing new concepts is met with reluctance. If members [employees] do not understand the rationale behind new procedures and technology they become hesitant"- Respondent 17 (Lower Management/Specialists)*

4.6 Future implementation of Digitalisation

All respondents were asked if they would increase, decrease or maintain the current levels of digitalisation in South African FMCG factories based on their experiences within the manufacturing sector. Although there are tremendous benefits for increasing digitalisation, there is also a case for reducing or maintaining the level of digitalisation within a firm based on numerous factors such as cost, employee skill level and added complexity to name a few.

The overwhelming majority of respondents (88%) agreed that they would increase the level of digitalisation in SA FMCG factories, while only two respondents (8%) said they would decrease digitalisation and revert to more manual systems, and a single respondent (4%) said they would maintain it.

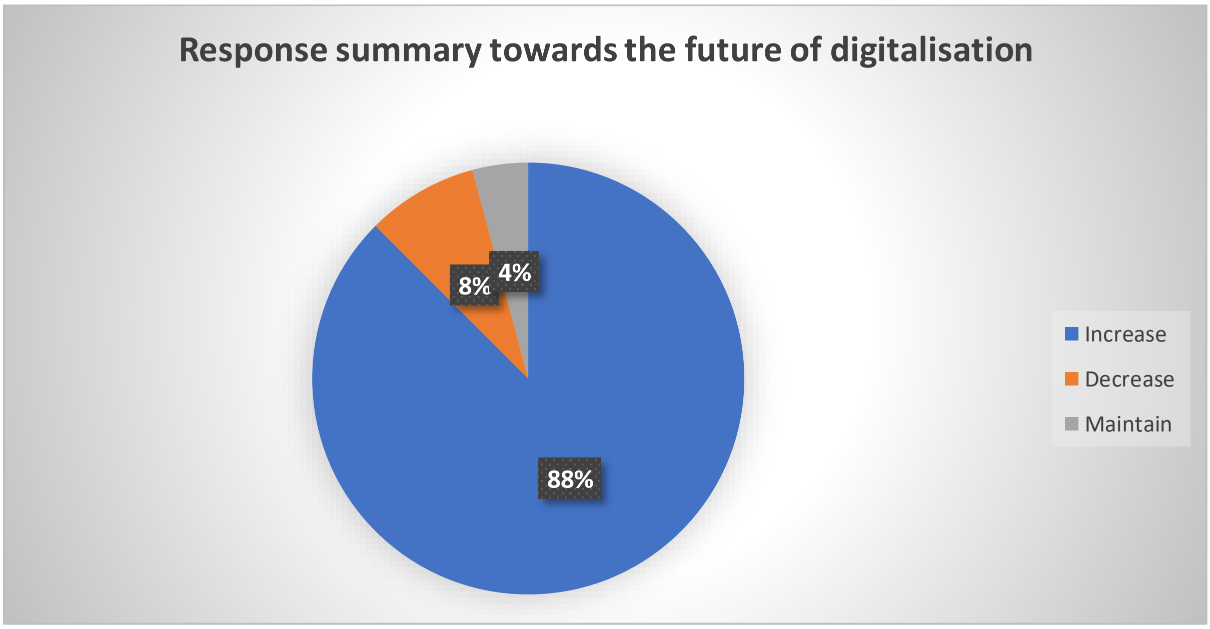

Figure 4.3– Response summary towards the future of digitalisation

In terms of increasing digitalisation, the respondents saw the benefits that digital technologies could bring about in terms of data reliability and analysis, improving efficiencies and reducing costs and downtimes. Operational benefits were the key driver behind increasing digitalisation in the firm. However, the respondents also noted that this increase in digitalisation should be implemented with an upskilling of the current workforce to ensure that the operational level employees are competent enough to work with these technologies and maintain them to their fullest capacity. *"Definitely increase it – (I have) yet to meet anyone who didn't want to know what was happening across the plant. There is no organisation where the whole supply chain is integrated – supply might make a product in extra volume that sales don't need. Maintenance might need to fix an issue but the operator has already done so – no clear communication. If we have more automation then it helps with the allocation of resources"- Respondent 5 (Operational Level). "If operators are adequately upskilled then they will be able to work with digital technology and automation. Digital technologies will work optimally if we have the correct skills" - Respondent 10 (Lower Management/Specialists)*

The reluctance of the few respondents to increase the levels of digitalisation was based on the current technical skills available in the country to operate and maintain digital systems, the lack of stable ICT infrastructure, fear of not being able to gain the fullest operational benefit and the overall cost of maintenance. The respondents also stated that implementing more complex systems would result in further downtime when it came to fault finding and human errors. *"Maintain the current system as we don't have a stable enough infrastructure to install these levels of automation"- Respondent 16 (Lower Management/Specialists)*

In terms of reducing the level of digitalisation this was based upon the complexities involved in maintaining, fault-finding and operating complex digital systems. The respondents felt that within their experience a more manual system would ultimately be easier, more cost efficient and overall cheaper to operate. *"I would have more manual systems for the following reasons: firstly a person can see what the issues are and act accordingly and secondly when you rely heavily on technology then you rely on your technicians and their skills" – Respondent 21 (Middle Management)*

A further concern was related to the lack of cyber security systems in place, and the need to first have a clearly defined plan for improving these systems before further digitalisation takes place. Having a fully digital system can result in the plant or firm being susceptible to cyber-attacks, data breaches and outside interference with the manufacturing process. If the manufacturing process is affected by outside parties this could result in quality and safety issues with regard to employees and consumers. Firms can also be brought to a halt by malicious cyber-attacks who are able to affect automated systems through remote access, so it is imperative that the cyber-security of a firm is also upgraded when increasing the level of digitalisation. *"Another limiting factor is a lack of understanding of cyber security in the digital space. People don't understand the security aspect of it and would need to have this implemented first with a proper road map on the security side before implementing anything further. People are going into factories and getting data and sabotaging industrial systems." – Respondent 11 (Middle Management)*

4.7 Prioritising digital technologies

The study also aimed to determine which digital technologies would be the most beneficial to FMCG firms in South Africa. The respondents were asked to state which areas of digitalisation would bring about the greatest benefit without considering the constraints of environmental or organisational factors. A total of seven themes were determined from the analysis as per the graph below:

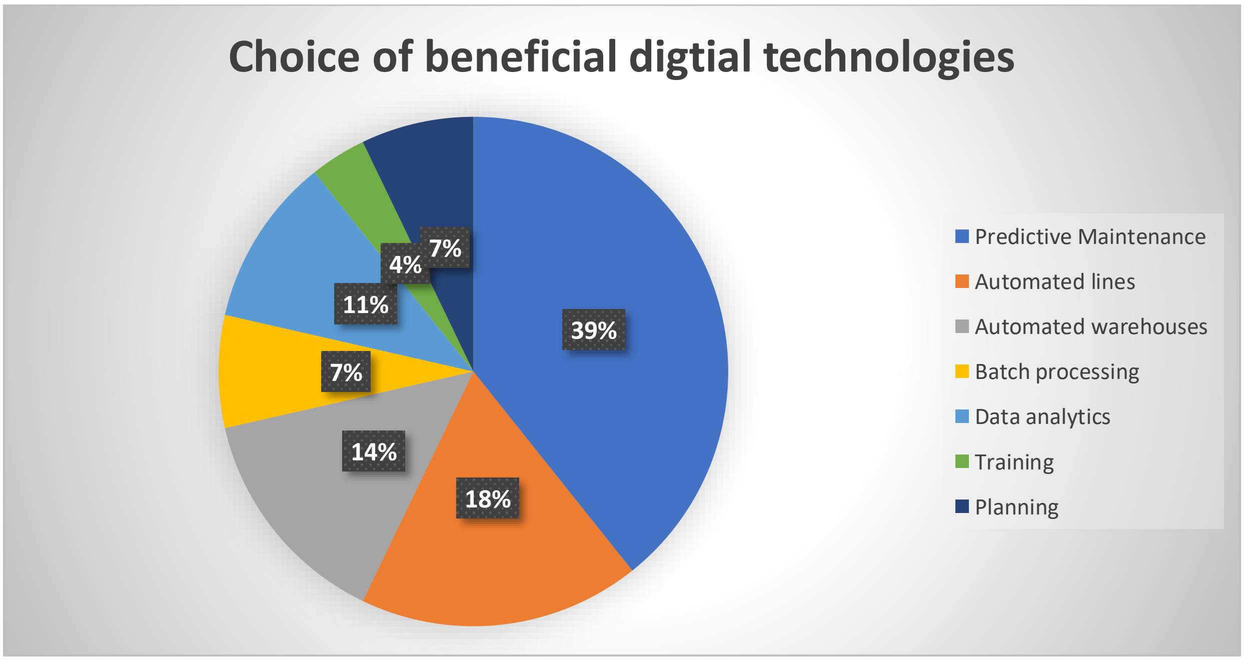

Figure 4.4 – Most beneficial future digital technologies

The most prevalent themes in terms of beneficial digital technologies were: predictive maintenance systems, automated manufacturing lines, automated warehouses and data analytics. Other technologies such as the use of digital technologies for training, batch processing of raw materials, training and automated planning were also noted but not as prevalent.

The largest number of respondents felt that predictive maintenance systems would bring about the most benefit in terms of digital technologies in the plant environment. This can be attributed to the direct benefits in terms of operational cost reduction through spare parts management, downtime reduction and efficiency increases. The use of digital technologies for predictive maintenance could entail installing smart sensors on critical components to determine when failure would occur. These components could then be pre-emptively repaired or replaced before a catastrophic failure occurs. The use of digital technologies for machine monitoring also assists in terms of diagnostics to determine where faults and bottlenecks occur in the manufacturing process. Operators and technicians do not have to waste time trying to determine line issues from the ground up, but the available data can already narrow down the fault areas thus improving productivity and reducing operational costs.

"From a preventative maintenance point of view, you can look at lubrication levels, bearing run time etc. How can you monitor equipment to prevent breakdowns? Instead of doing physical inspections you would check remotely and digital monitoring instead. Alarms are already installed on the machine for low lubrication, but can it send a message on the cellphone to the team leader, artisan or specialist technician so that they can then walk up to the machine and check what is happening?"- Respondent 10 (Lower Management/Specialists)

"Smart monitoring for predictive maintenance – for instance if you are driving a car it gives you a low oil level warning. We should be getting this information based on actual running information e.g. conveyer is running, need information from the gears for tripping. If you could get a sensor telling you there is a misalignment then you can save on the downtime. Save on diagnostic time. Identify, resolve problems vs. current system where you need to follow the trail and see what has broken"- Respondent 12 (Senior Management)

"Preventative maintenance alerts (IoT) – filtration systems, motors, bearings as a part of the routine the techs would go check temperatures and do vibrational analysis. If this can be automated then it would save time and costs"- Respondent 15 (Middle Management)

"In production we need to introduce more AI – where we have more self-diagnostics on the machine, predictive maintenance and predictive interventions where the machine already intercepts things that will go wrong."- Respondent 23 (Senior Management)

Automated manufacturing lines, which relied on very little to no human intervention, were seen as another beneficial digital technology. Respondents felt that a lot of downtime and production issues came about due to the human interface of operation production facilities. The implementation of fully, or mostly automated, production lines would result in greater efficiency, reduced downtime and lower operating costs.

"Automation to be fully integrated on production lines [would be the most beneficial]. [The] Best PLCs, best drives and things that are most robust. They don't break too easily. Minimise operator intervention and have more reliable machines. Lines to be fully connected and machine to do its own analysis for maintenance scheduling"- Respondent 14 (Middle Management)

Automated warehouses were another area where respondents could see the greatest benefit in terms of digitalisation. Warehouses have traditionally had higher safety risks due to the movement of forklifts, conveyers and trucks. The implementation of a fully automated warehouse, without the need for employees to walk in the racks, greatly improves the level of safety in the area while simultaneously improving the efficiency of the factory operation.

"Automated warehouses without people for safety – LGVs (laser guided vehicles) for warehouses. Truck turnaround time is better, safety is improved." - Respondent 22 (Operational Level)

"Employ more robotics on the material handling side. They are quicker than people, always at work, safer and more reliable. Moving materials from warehouse to the line and vice versa. Safety is a big concern – avoid fatal accidents as there are no humans involved."- Respondent 20 (Operational Level)

Improving data analytics was another area in which a benefit could be seen. This was due to the reliance of data received from the factory floor where manual recordings were taking place. There were incidences of data bias when breakdowns and issues were reported by the operational level employees and this resulted in more time and resources being spent in incorrect areas instead of resolving the root causes of issues.

"A handwritten report at the end of the line is not worth the same as digital data collection"- Respondent 13 (Middle Management)

"ERP systems have been used for everything – but SAP is very difficult in terms of user interface. Now they have visual ERP systems to draw information out of SAP. Data is all dependent on SAP. And then it can be copied across to a digital platform. Need to reduce the duplication of data analytics. Have an all-in-one system for big data analytics"- Respondent 6 (Lower Management/Specialists)

The use of digital technologies to improve training and fault finding was another theme that was brought up. Utilising digital technologies to simulate faults and problem solving would allow technicians and operators to hone their operational skills in a virtual environment without causing damage to real life systems. This would also allow the employees to simulate various error messages or production conditions and determine how the employee would react.

"The first thing (to implement) would be using digital tools to create interactive training e.g. 3D modelling and virtual reality training for technicians and operators. Individuals would be able to simulate faults in the plant and see how the guys react. Have proper reliability issues coming up. When you normally go for training then you get a perfect plant – but in this case you get a more realistic version of how the factory/plant will behave" – Respondent 11 (Middle Management)

The final theme that was identified was to utilise digitalisation for production planning. This would see digital technologies be utilised beyond an ERP system, but rather have a holistic view of the manufacturing operation and plan production in accordance with the most efficient method to meet sales demand.

"Sales and marketing try and determine what is going to be sold but the supply chain process can take up to 3 months to get raw materials and convert them. So when the sales forecast is inaccurate the supply chain suffers – AI can look at the system and determine where the bottleneck is going to be e.g. in terms of raw materials where one plant may not have labels for example but have the other items. The system will identify the most efficient method to manufacture that product which may mean moving raw materials to another plant that has capacity. Also (the system can) check which factories have capacity to take up volumes and plan in the most efficient manner." – Respondent 6 (Lower Management/Specialists)

4.8 Recommendations

One of the outcomes of this research project was to develop a roadmap that SA FMCG firms could utilise when planning the implementation of digital technologies or digitalisation. This would allow such firms to prioritise resources and time to the areas where they could gain the most benefit with regard to digitalisation. The conceptual model was utilised for this roadmap and the most prevalent theme in each of the TOE sectors was highlighted as the main focus area for the firms.

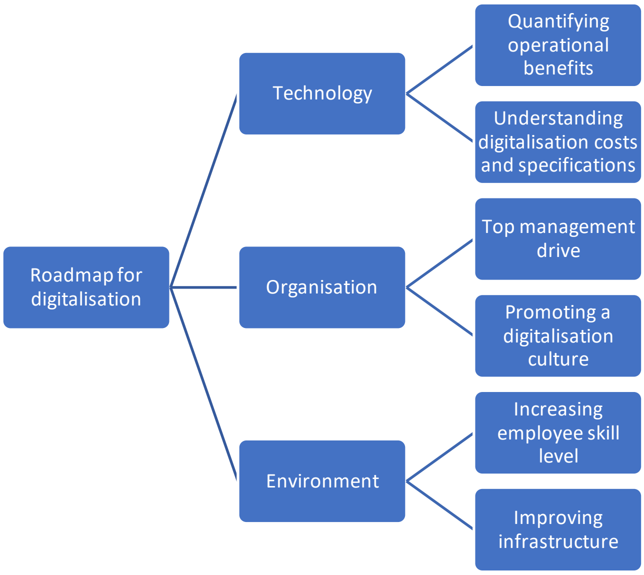

Figure 4.5 – Roadmap for digitalisation within South African FMCG firms

4.8.1 Technological factors

A deeper technological understanding of the digital technology or system should play a key role in selecting suitable technologies from which the maximum benefit can be derived. Digitalisation projects are driven by operational benefits such as cost reduction, quality and efficiency improvement and safety benefits. Before implementing any digitalisation project, the resultant benefits should be quantified in order to have realistic expectations from the technology. These benefits should be weighed against the initial and operating/maintenance costs to gain an idea of whether the project shall be worthwhile or not. Too often there is an unrealistic expectation that a digital technology will resolve all the plant issues that are being experienced and when there isn't an immediate ROI the system will be scrapped or fall into disrepair.

Firms should also research and understand the costs of implementing digital technologies, not just in terms of initial capital costs but also the maintenance costs to keep the systems running optimally. Unlike purely mechanical systems which can be run at partial functionality, digital technologies will usually need to be kept in perfect working condition in order to see benefits and will either be fully working or bypassed. An example of this would be smart sensor technology, where the sensors need to be fully functional in order to take readings and provide communication between machines.

The overall cost of ownership should be factored in when selecting a digital technology and the firm should look at after-sales support in terms of parts and services when selecting a service provider, as the maintenance costs may become exponentially more expensive over several years when compared to the initial asset cost. Firms should also be cognisant of the after sales support for digital technologies, as many of these suppliers are located outside of SA and may not have local support. If the digital system has a failure then it would be imperative for the plant to be able to request support in the form of parts and services.

Technologies should also be selected with regard to global trends and compatibility. Supplier and customer systems should be able to be integrated with the FMCG firm's digital technologies in order to make processes more efficient. The lifespan of the digital technology should also be determined before implementation and selection. This is to ensure that a system is not installed that will become redundant within a year or two.

4.8.2 Organisational factors

The focus on organisational factors should emphasise the human element associated with implementing digitalisation such as a top-down management approach and promoting the understanding of the benefits of digitalisation as a part of workplace culture.

A top-down approach should be utilised by senior management to gain buy in when it comes to digitalisation projects and help employees understand the benefits of these projects. The linking of an employee's KPIs to the successful operation and maintenance of digital technologies, and not just the installation thereof, will ensure that the systems are operated to gain maximum benefit. Employees are also more willing to utilise a technology when they are cognisant of the senior management push for its successful deployment.

Promoting a digitalisation culture will assist in reducing employee pushback, whereby employees are engaged and asked to participate, at all hierarchical levels, in digitalisation projects. If the employees have an understanding of the benefits of the digital technology and can offer their input into the process then there will be a greater buy-in and reduced pushback, which shall generate a greater chance of the overall project's success. Employees should be given distinct timelines as to how long the projects shall be, what is required from them in terms of training and what the overall benefits shall be in terms of operational and labour benefits.

4.8.3 Environmental factors

These factors are dependent on the external factors within a scenario that shall affect the success of the digitalisation project. In South Africa the overall skill level of the workforce was highlighted as the major deterrent to the implementation of digital technologies and a greater impetus needs to be placed on upskilling the operational employees within the factories. Training and development should occur simultaneously with any digitalisation project and needs to be carried out for technicians and operators respectively. Operators need to be able to understand the digital technologies being installed and how to properly run the systems to gain the maximum benefit, while technicians need to be upskilled to fault-find and diagnose issues within the factory.

To combat the risk of training programs impeding on operational processes, the firm should create a long-term development plan whereby continuous training, with regard to the latest systems, takes place. By investing in continuous upskilling of the employees it helps negate the disruption to operations and also gains employee buy-in by creating a digitalisation culture where people are exposed to the latest trends and technologies.

Respondents also believed that there is a risk of rolling out widespread training and skills development programs, only to find that employees soon leave the firm and seek employment elsewhere with their newfound talents. To address this issue the firm should look at having retention plans whereby employees sign a contract stipulating a duration of work within the firm after attending training programmes. The utilisation of retention clauses shall ensure that the firms do not waste their resources on training only for competitors to benefit.

The second major deterrent within the environmental factors that needs to be improved is the available infrastructure. An improvement to the ICT infrastructure of the firm should also take place before any digitalisation project to ensure the maximum benefits are achieved and that the system works without hinderances. Poor Internet connectivity within the plan has resulted in digital technologies not being fully functional or being able to be remotely accessed. The digital technology shall only be as effective as the base infrastructure that is being used to carry the system. Cyber security should also be increased with the implementation of digitalisation so as to prevent third-party access to automated machinery.

Unwanted access to a fully automated production line could have serious quality, safety and data concerns where malicious attacks on the system could result in recipes being changed, hygiene and quality standards being bypassed and loss of human life when machines can be remotely activated.

5 Chapter 5 – Conclusion

The Fourth Industrial Revolution has seen positive implementation of digital technologies across various industrial sectors. Manufacturing firms have begun to leverage digital technologies to gain advantages on the global stage. The growth and sustainable competitive advantage of these firms is positively influenced by digital technologies by allowing for more flexible production, reduced manufacturing costs and operational benefits, such as improving quality, safety and efficiency.

This research project sought to identify the challenges faced by South African FMCG firms when implementing digital technologies in their factories. European and North American firms are able to utilise and implement digitalisation to gain a competitive sustainable advantage by reducing manufacturing costs and bring produced volumes back home from outsourced locations. However, in South Africa the unique environment of having a young workforce with a lower comparable skill base, infrastructure issues and a reliance on foreign suppliers to name a few, have negatively affected the rollout of digitalisation within this industry (Maisiri et al., 2021). An improvement in manufacturing within the country shall allow for economic and social benefits, as well as allowing local firms the chance to compete on a global scale in terms of serving a wider marketplace.

The importance of implementing digitalisation within the FMCG environment will allow South African firms to compete on an international scale by having lower manufacturing costs, improved quality and larger economies of scale when moving from manual to automated manufacturing systems. European and American firms are moving manufacturing back to their local sites with the advent of digital technologies allowing them to compete with low-cost, overseas manufacturing. This provides an economic benefit in terms of driving manufacturing exports and lowering reliance on international suppliers which can be negatively affected by supply chain issues, as seen during the Covid-19 pandemic. Local manufacturing firms compete with international companies to try and gain market dominance, and in an economy that is price sensitive when it comes to food and household goods the implementation of digital technologies adds a competitive advantage when it comes to reducing manufacturing costs through digitalisation.

Although research studies had been completed to determine the enablers and deterrents of digitalisation in a broad industrial context, there were none specific to the South African FMCG environment. Previous studies had taken a broad approach to find enablers and deterrents across all manufacturing sectors (including both heavy and light production which vastly differ), while there was limited research completed on the specific drivers of digitalisation within the FMCG industry. Studies were also focused on digitalisation in other countries such as India, Malaysia and Brazil to name a few.

All of the research questions were successfully answered using semi-structured interviews that were conducted with individuals who were involved with digital technologies across various organisational levels. Semi-structured interviews were utilised in order to gain a more in-depth response to the questions and determine the most prevalent themes for each of the research questions. A qualitative, thematic analysis was used to identify and analyse the prevalent themes found in each dataset. The TOE framework was chosen to allow for the respondent's feedback to be categorised into three different sectors with regard to technology implementation, rather than having all themes collated in a single sector such as human factors. The implementation of digital technologies should be seen as an organisational shift which focuses on people, plant and capital benefits and not just a technology project to bring in the latest and most expensive systems, as the true benefit may not be realised.

The first research aim was to determine what the most advanced digital technologies were that were already installed in FMCG factories. Line monitoring and automated packing robots were the two most prevalent technologies. Firms were reliant on automated line monitoring to obtain accurate data with regard to operational performance. Automated packing robots provided an efficient and safe manner in which product could be processed and sent to the warehouse.

The core aim of this research project was to determine the enablers and deterrents faced by South African FCMG firms in implementing digitalisation on a similar scale to foreign firms, and whether they differed across different organisational levels. Operational benefits, data reliability, global competitiveness, top management drive and standardisation were seen as the enablers towards digitalisation. While digitalisation costs, employee pushback, willingness to change, labour laws and most prevalently a low employee skill base were deterrents towards large scale digitalisation.

A major difference of these results when compared to the literature review, (Jain & Ajmera, 2020) which cited government assistance as an important enabler, was that the respondents did not identify this as a prevalent theme. This can be attributed to South African FMCG firms being privately owned and having very little reliance on the government for technology implementation.

The low employee skill level was a consistent deterrent amongst the majority of respondents and should be an area of concern for strategists and managers in the region. The upskilling of the local workforce, to be able to work with digital technologies, should be a focal area of any FMCG firm looking to implement digital technologies. The low employee skill level is also directly linked to employee pushback when new technologies are implemented as the workforce feel that their livelihoods are threatened and automated systems will replace them.

The next research question to be answered was whether these enablers and deterrents would vary across different organisational levels, from the floor workers through to Senior Management. The data analysis indicated that they did not in fact vary across hierarchical or organisational levels, with operational benefits and improving data reliance seen as the two main enablers. While low employee skills were seen as the main deterrent for all respondent levels.

The majority of respondents (88%) also agreed that digitalisation in the plants should be increased in order to gain operational benefits. While a small majority of respondents felt that the level of digitalisation should be reduced or remain the same due to staff limitations and the inability to operate and maintain the systems to their fullest potential based on the current skill level within their firms.

The final research question was to determine what digital technologies would be the most beneficial to factories looking to implement them at a future date. The most prevalent response was based on implementing digitalisation for predictive maintenance. This included have the IoT between machines and processes, having smart monitoring to determine when failures would occur on components and having integrated systems to monitor performance data and request repairs or spare parts through digital platforms. The overall theme was centred around having maintenance systems that were data driven and could be somewhat self-sufficient. This would be beneficial to plants as to workload of maintenance is reduced and would allow for efficiencies to be increased by reducing breakdowns.

A roadmap was also created to highlight the areas of focus for firms that wish to implement digitalisation projects and where resources and focus should be in terms of the TOE framework sectors. Private firms can build on the results of this project to streamline their digitalisation approach and create a holistic framework that will bring about the greatest benefit by overcoming challenges and maximising on digitalisation drivers.

Further work in this research field can be done to compare the results of digitalisation enablers and deterrents within other industrial sectors such as automotive, chemical and heavy industry manufacturing. The FMCG sector is unique in terms of the operational speed, size and methodologies being used within the production environment. Other industries may have similar or differing issues based on their unique situations. However, if the other industries also identify similar issues, such as low employee skills for example, as being deterrents to digitalisation then there can be plans to share resources and strategies to address these issues. For example, to combat low employee skills the industrial sectors can look at grass-roots development in schools and training academies, there can also be cross-training amongst firms where the costs are shared thereby leading to a benefit in terms of economies of scale.

In terms of geographical expansion, the research can be expanded to include respondents within the same manufacturing sector, but within other Sub-Saharan countries and eventually countries across the African continent. This would be beneficial as there is very little research being done on the continent when compared to Asia, Europe and North America and the challenges for African countries may be common across several regions. If this is true then decision makers and strategists can determine a region-wide rollout policy to address the issues associated with digitalisation and foster collaboration amongst each other.

A major deterrent of digitalisation was the high costs of maintaining and purchasing digital technologies is further influenced by the reliance on foreign suppliers, whereby the costs of parts and services are affected by fluctuating exchange rates. A business case can be made to develop and supply digital technologies locally where there is a gap in the market. Future research can be conducted to determine the market proposition to develop and supply certain digital technologies from within South Africa. A part of this business proposition should also include providing after sales support for existing and locally developed digital systems, thereby minimising the reliance on importing parts and having to bring in technicians and specialists from overseas.

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Appendix A – Research Plan

The following Table A1 provides an overview of the overall research plan and the dates by which each milestone will be achieved. The overall research project shall be completed by the 27 February 2024.

Table A1 – Research Plan

Item	Description	Start Date	End Date	Outcome
1	Compilation of research proposal	01/02/2023	28/05/2023	Research methodology, Literature review, questionnaire and background study shall be established
2	Ethics clearance	01/07/2023	11/09/2023	Submission of ethics clearance documents and issuing of certificate
3	Data collection	11/09/2023	31/12/2023	Semi-structured interviews shall be conducted and data shall be transcribed
4	Data analysis and coding	01/01/2024	07/01/2024	Using a thematic, qualitative approach the data shall be analysed during the data collection

				phase. Coding shall occur during this phase
5	Development of strategic roadmap	07/01/2024	14/01/2024	A strategic roadmap identifying the enablers and deterrents of digitalisation in the SA FMCG sector shall be created
6	Final writeup	15/01/2024	27/02/2024	Completion of the research project
7	Submission	27/02/2024	28/02/2024	Final copy of research to be submitted for review

Appendix B – Ethical considerations

Appendix B1 – Request permission to collect data within organisation

University of the Witwatersrand,

Wits Business School

Clinton Farndell – Managing Director

Krones SA

Stand 324/5, Avant Garde Avenue,

Northlands Deco Park,

North Riding

Johannesburg

2194

27/05/2023

Dear Sir/Madam,

Re: Permission to conduct research at Krones SA and Customers

My name is Yogandra Naidu and I am completing my Master's Degree at the Business School at the University of the Witwatersrand. I am seeking permission to do research at Krones SA. I am conducting research on digitalisation in South African FMCG factories and aim to determine what factors inhibit and enable digital technology implementation. The research will entail collecting data from permanent employees such as Project Managers and Engineers.

I will invite individuals from your organization to participate in this study. These will be permanent employees who deal with digitalisation on a day-to-day basis such as engineers. If they agree, they will be asked to attend a semi-structured interview. The interviews will take approximately 30 minutes and the participant's responses shall be recorded on audio files only.

Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially, and identities (their names and the name of the organisation) will be anonymous unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study.

The results will be communicated through an academic journal and upon completion of the dissertation.

The research participants will not be advantaged or disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study. All research data will be preserved for a year and then destroyed. Data shall be stored on a password protected computer.

I therefore request permission in writing to conduct my research at your organization. The permission letter should be on your organization's headed paper, signed and dated, and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

Researcher:
Yogandra Naidu
1276691@students.wits.ac.za
+27 82 3387199

Supervisor:
Prof. M. Mzyece
+27 117173649
mjumo.mzyece@wits.ac.za

Appendix B2 – Request for an interview

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Dear Sir/Madam

My name is Yogandra Naidu and I am a Masters student (Student Number 1276691) at the University of the Witwatersrand, Johannesburg. My supervisor is Prof. M. Mzyece. I am conducting a research study about digitalisation in South African FMCG factories.

I am inviting you to take part in an interview. If you decide to take part, your participation in this research study will last about 30 minutes. The interview will take place at your workplace at a date of your convenience.

During the research activity, I will need to ask for some personal information about you, including your job title and years of working experience.

The interview will be confidential and anonymous. When I share the results of the research study, I will not include your name or anything else that could identify you. With your permission, other researchers may use the data collected from this research study, but your name and any personal information will not be used or passed on.

If you decide to take part in the research study, it should be because you want to volunteer. You do not have to take part. You can stop being in the study at any time. You do not have to answer any questions if you do not want to. You will not get any direct benefits if you choose to join the research study. You will not lose any services, benefits or rights you would normally have if you decide not to join. Taking part in the research study will not cost you anything. You will not be paid for being in this research study.

The risks for this research study are no more than what happens in everyday life. If any of the questions asked may make you feel sad or upset then I will stop the interview and continue another time or cancel the interview entirely and delete your details and data.

This research study will be written up as a research report. The report will be available on the university library website. If you would like to receive a summary of this report, I will be happy to send it to you.

If you have any questions during or afterwards about this research study, feel free to contact me or my supervisor on the details listed below. If you have any concerns or complaints about the ethical procedures of this research study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za.

Yours sincerely,
Yogandra Naidu

Researcher:
Yogandra Naidu
1276691@students.wits.ac.za
+27 82 3387199

Supervisor:
Prof. M. Mzyece
+27 117173649
mjumo.mzyece@wits.ac.za

Appendix B3 – Request for consent

Title of project: The implementation of digital technologies in South African Fast Moving Consumer Goods factories

Name of researcher: Yogandra Naidu

I, ………………………………….., agree to participate in this research project.

I agree to the following:

(Please circle the relevant options below)

The research study was explained to me. I understand what this study is about.	YES	NO
I understand that I can volunteer to take part in the study	YES	NO
I agree that the interview may be audio recorded	YES	NO
I agree that direct quotations from my interview may be used by the researcher in their dissertation and journal paper	YES	NO
I agree that my participation will remain anonymous (my name or other identifying data will not be used by the researcher in their research report/manuscript/book chapter)	YES	NO

…………………………………… (signature)

…………………………………… (name of participant)

…………………………………… (date)

…………………………………… (signature)

…………………………………… (name of researcher seeking consent)

…………………………………… (date)

Appendix C – Interview Guide

The following interview questions will be asked to the participant during the semi-structured interview. The aim is to conduct this interview within a 30-to-45-minute period. The responses from the participant will be based on their personal view and not the company view.

Participant information

Job Title:

Semi-structured interview questions:

RQ1 - What level of Digitalisation occurs in a plant that you are currently or have previously worked in? Can you please give examples of what you think are the most advanced digital technologies that you have seen already being installed?

RQ2 - What do you think are the major enablers of digital implementation in SA FMCG firms?

RQ3 - What do you think are the major deterrents of digital implementation in SA FMCG firms?

RQ4 - Do you think the level of digitalisation should be increased, maintained or reduced in the SA FMCG environment? Why?

RQ5 – What digital technologies do you think would be advantageous to implement in a plant environment based on your personal expertise and experience?

Appendix D – Respondent List

The following table documents the list of interview respondents and their relevant titles and organisational levels, based on the categorisation for this research project.

Table D1 – List of respondents by title and organisational level

Respondent Number	Title	Level
1	Engineer	2
2	Maintenance Planner	3
3	Engineer	2
4	Regional Engineering Manager	1
5	Automation Lead	2
6	Site Engineer	2
7	Maintenance Planner	3
8	Project Manager	3
9	Maintenance Planner	3
10	Project Manager	3
11	Automation Lead	2
12	Automation Lead	2
13	Head of Engineering	1
14	Technician	4
15	Engineer	2
16	Director	1
17	Quality Manager	3
18	Engineer	2
19	Technician	4
20	Technician	4
21	Technician	4
22	Director	1
23	Technician	4
24	Head of Maintenance Planning	2

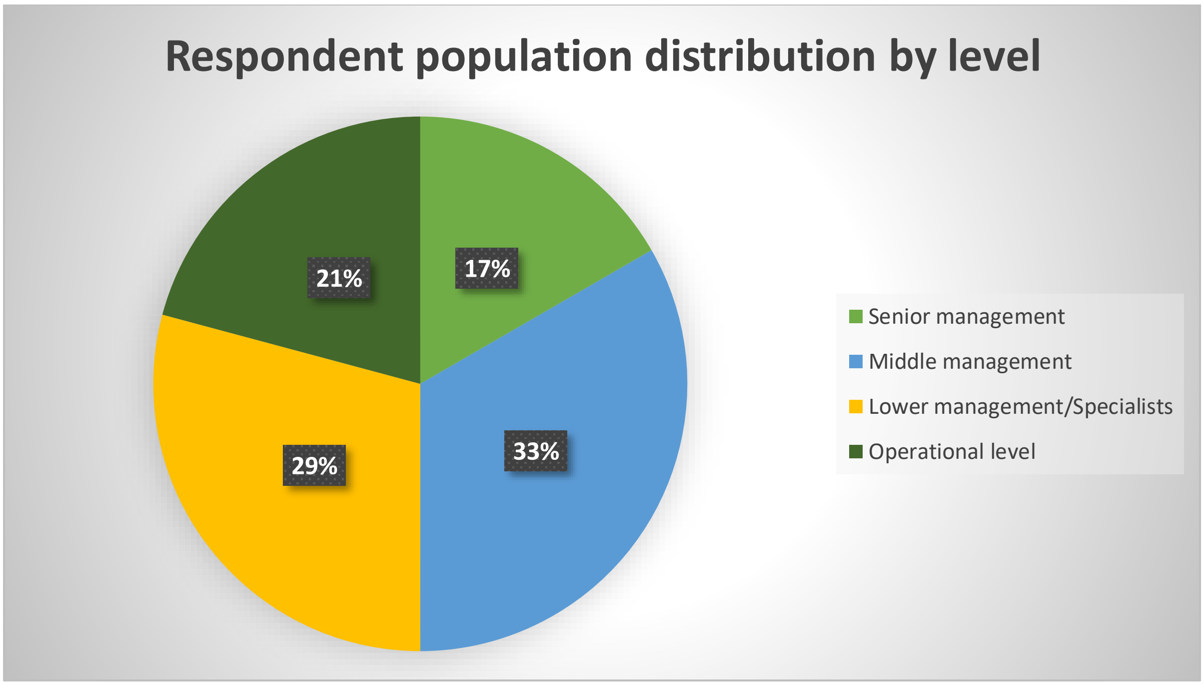
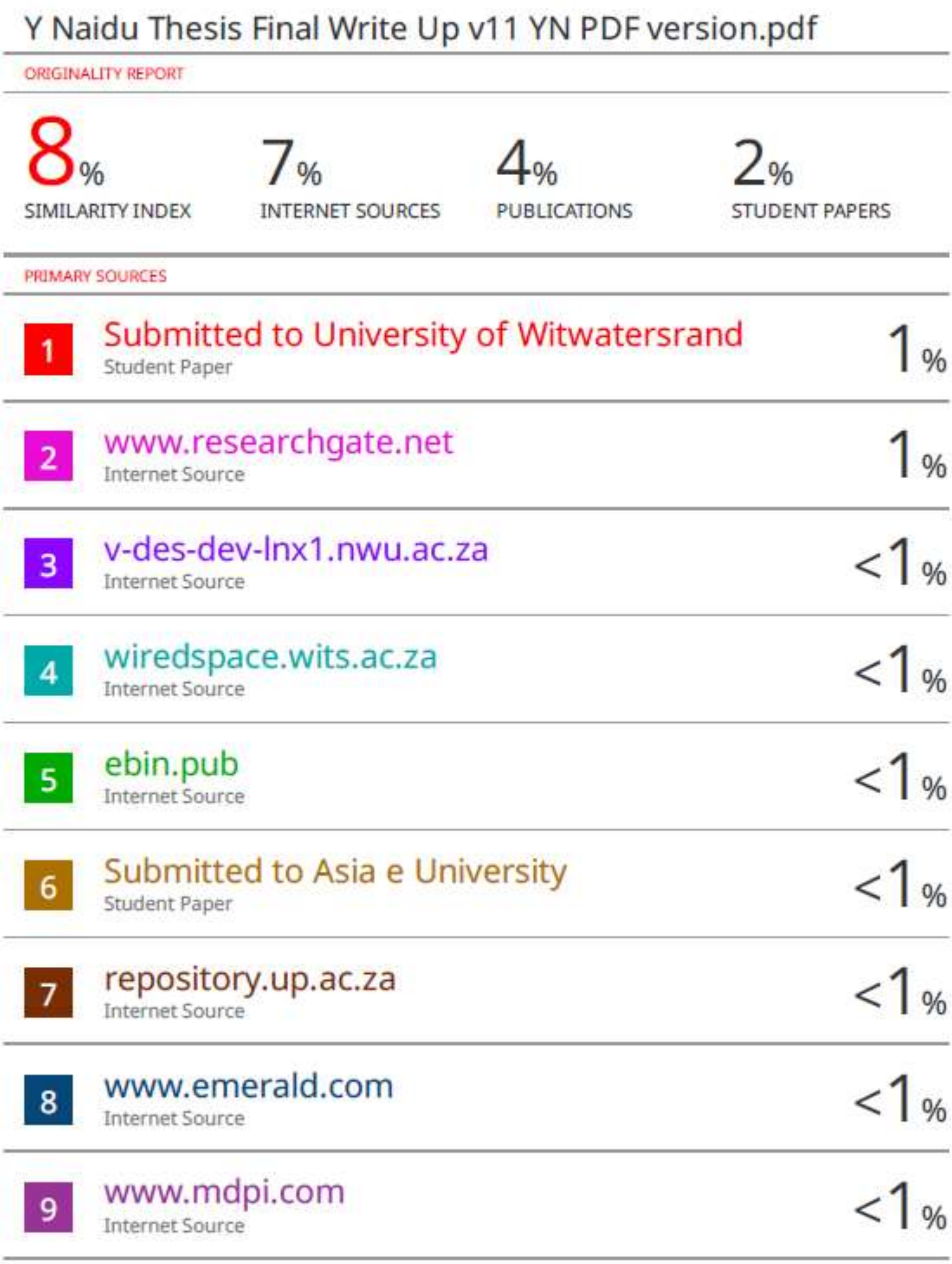


Figure D1 - Respondents split by organisational level

Appendix E- Turnitin report

The following similarity index was found when completing the Turnitin report:



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ORIGINALITY REPORT

8%	7%	4%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to University of Witwatersrand Student Paper	1%
2	www.researchgate.net Internet Source	1%
3	v-des-dev-lnx1.nwu.ac.za Internet Source	<1%
4	wiredspace.wits.ac.za Internet Source	<1%
5	ebin.pub Internet Source	<1%
6	Submitted to Asia e University Student Paper	<1%
7	repository.up.ac.za Internet Source	<1%
8	www.emerald.com Internet Source	<1%
9	www.mdpi.com Internet Source	<1%

Appendix F – Ethics clearance certificate

The following ethics clearance certificate was received from Wits Business School after completing the ethics application process prescribed by the school:

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/BA1276691/643

This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below).

This certificate is only valid if accompanied by formal permission from the relevant stakeholder(s).

Project title	The implementation of digital technologies in South African fast moving consumer goods factories
Investigator / Researcher	Mr Yogandra Naidu
Nature of Project	MBA (Research Article)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	9/11/2023
Expiry date	Date of submission of the project / research report
Chairperson	Dr Pius Oba ☎ +27 11 717 3976 +27 82 733 6587 pius.oba@wits.ac.za

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Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Y Naidu
Signature

14/09/2023
Date: