A framework for best practice supply chain management in the chemical manufacturing industry

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PREFACE

I would like to extend my heartfelt appreciation to our Heavenly Father for providing me with opportunities and abilities to have reached successes in life and in my academic tenures.

To my wife Diane, thank you for your support and perseverance through the period I have spent completing this study. Your support and love is appreciated.

I dedicate my MBA designation to my daughters Dené and Wandri, I hope that this accomplishment will be a catalyst and inspiration for you to follow in my footsteps.

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I would like to thank Sasol Base Chemicals and associated business units for granting me approval to conduct the empirical studies of this research project on the supply chain management systems of the organisation. I would also like to extend my appreciation to the participants who provided valuable inputs that assisted to derive a credible outcome to this study. Thank you for freely and openly sharing your expertise and experience with me during the study.

ABSTRACT

Supply chain management is dynamic, complex and require specialised skills from a wide spectrum of disciplines. The complexity is exacerbated in the context of the chemical manufacturing industry under normal operating conditions. The chemical industry and as a matter of fact all industries across the globe are gearing its readiness to peruse opportunities and protect itself from threats brought about by the impending 4th industrial revolution or otherwise known as the digital age. The pressures brought about by the changing business and competitive landscape within the chemical manufacturing industry give rise to the need to conduct targeted research into the principles that will underpin strategic decisions for supply chains entering the new digital frontier of business management.

The first section of this report focused on providing context on the purpose of conducting this study by means of a scientifically generated problem statement. A number of research objectives was developed to guide the various processes applied during the research process. The primary objective of this study was to develop a best practice framework form supply chain management in the chemical manufacturing industry.

A comprehensive literature review was conducted, providing an overview of the South African chemical manufacturing industry. This was followed through an in-depth review of supply chain management concepts, challenges and best practices.

The third section of the report focused on providing a research design for the execution of empirical research. The qualitative research methodology was applied through the collection of data by means of semi-structured interviews. A total of 22 interviews was conducted with participants who possessed the required skills and experience to participate in this study. The interview data was transcribed and analysed on ATLAS.ti, applying the constructivists grounded theory methodology. During the analysis phase of the empirical data collected, 1 006 open codes was categorised into 60 axial codes, resulting in the generation of five themes of data findings.

The findings generated through the data analysis processes was recorded in the report, linked to the five main themes generated. The themes was primarily directed by the questions posed to participants during the interview process. A combination of researcher

reflexivity and participant direct quotations was integrated to provide holistic findings generated through primary and secondary data collected.

Finally, a synthesis of the literature review and empirical study revealed research conclusions. The conclusion generated established a sound scientific foundation from which recommendations could be developed in response to the problem statement generated. The report was concluded through an assessment of the primary and secondary research objectives to identify whether the aim of the study was successfully achieved.

Key terms: Supply chain management, Digital, Agile, Lean, Total Cost of Ownership, Chemical Industry, Best Practices, Challenges

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DEFINITION OF KEY TERMS

Agility	Is the ability to quickly and effectively respond to changes (Dictionary, 2017).
Best Practice	Is a system, process or object that has consistently and optimally provided results to the organisation (Dictionary, 2017).
Business Model	Is a framework that attempt to elaborate on how a business intends deriving value for its customers (Times, 2018).
Commodities	Is normally utilised during the input process for the production of final products (Investopedia, 2017).
Competitive Advantage	Is the ability to respond to market demand in a comparable manner however more effectively and efficiently (Economist, 2017)
Data analytics	Is a process of qualitative and quantitative analyses of continuous data sources to establish business gain and to facilitate decision making (Techopedia, 2017)
Economies of scale	Is directly related to the size of an organisation and its ability to supply increasing product demands and lower cost. The main principle is that quantity of products produced is leveraged by the fixed cost of the organisation (Amadeo, 2017).
Efficiency	Is the ability to generate value with the least expense of time and effort wastage (Dictionary, 2017).
First-In-First-Out	Is an inventory management technique that dictates older production should be moved prior to newer product preventing margin loss due to cost of sales impacts (Institute, 2018).

Institutionalised	Is a process of entrenching a concept, process or thinking pattern within the make-up of an organisation. This is also referred to as organisational thinking (Dictionary, 2017).
Minimum viable product	Is a product development methodology that is based on prototyping. The aim is to provide a product with minimum features that add value to the customer. The product is then developed further utilising inputs from consumer (Times, 2018).
Perfect Order Fulfilment	Is a principle of supplying products to a customer on time and in full (Dwyer, 2017).
Strategy	Is a specific plan that aims to achieve a long term objective (Dictionary, 2017).
Supply Chain	Is a network of interrelated processes or components within an organisation that deals with the procurement of raw materials, production of final products and the delivery of the products to end users and customers (Dictionary, 2017).
Triple Bottom Line	Is a reporting methodology utilised by organisations to comprehensively report on the sustainability of an organisation from a profit, people and environmental point of view (Edwards, 2018).
Value Chain	Kumar and Rajeev (2016:74) state that a value chain is defined as a collaboration of people, systems and processes which transition products and services in value adding commodities for stakeholders through a life cycle management process.

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AXC	Axial Coding
BBBEE	Broad Based Black Economic Empowerment
Bcom	Bachelor of Commerce
BSc	Bachelor of Science
CA	Chartered Accountant
CEO	Chief Executive Officer
CSCO	Chief Supply Chain Officer
DC	Distribution Centre
Dr	Doctor
DRP	Distribution Requirements Planning
ERP	Enterprise Resource Planning
FIFO	First-In-First-Out
GDP	Gross Domestic Product
HR	Human Resources
IoT	Internet of Things
IT	Information Technology
JIT	Just In Time
KPI	Key Performance Indicator
M&S	Marketing and Sales

MBA	Master of Business Administration
MVP	Minimum Viable Product
NPI	Net Promoter Index
NWU	North West University
OPC	Open Coding
OTIF	On-Time-In-Full
P&O	Planning and Optimisation
PGD	Post Graduate Diploma
POF	Perfect Order Fulfilment
PVC	Polyvinyl Chloride
RFQ	Request For Quotation
SA	South Africa
SaaS	Software as a Service
SAP	System Application Program
SBU	Strategic Business Unit
SC	Supply Chain
SCM	Supply Chain Management
SCOR	Supply Chain Operations Reference Model
SOPS	Sales & Operations Plans
SRM	Supplier Relationship Management
SSQS	Semi-Structured Qualitative Studies

STI	Short Term Incentive
STO	Stock Transfer Order
SVP	Senior Vice President
TCO	Total Cost of Ownership
THC	Theoretical Coding
USA	United States of America
USD	United States Dollar
VDI	Vendor Data Interchange
W/H	Warehouse
WIP	Work in Progress

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CHAPTER 1 NATURE AND SCOPE OF STUDY

1.1 Introduction

In the past decade, organisations have realised that the operational component of the business has been emphasised to such an extent that it has lost focus of its supply chain management (SCM) activities. SCM is arguably the most important function of any business, in that it has an impact on most of the critical aspects of business success. Supply chain activities involve the procurement of raw materials, the alignment of production and sales forecasts, and delivery of the final product to the customer. By optimising SCM, activities can provide significant benefits to an organisation, the most notable being cost reduction and creating a competitive advantage in a marketplace where there is fierce competition. One of the most notable trends in SCM is the ability of an organisation to adapt its supply chain activities to customer requirements and market forces in an agile way. Agility translates into the organisation's ability to quickly and cost effectively adapt its operations. A significant factor in achieving agility is the availability of real-time reliable data analytics (Robinson, 2016). The focus of this research is on identifying a best practice supply chain model for the chemical manufacturing industry in South Africa (SA), with due consideration given to current SCM trends and global best practice.

This chapter aims to provide context for selecting the study topic, which focuses primarily on the critical aspects of SCM.

1.2 Problem Statement

Supply chains are complex, resource intensive and data-driven eco systems that are reliant on the interdependence of people, processes and equipment (Park *et al.*, 2013:12). Kleab (2017:397) states that organisations will increasingly rely on their supply chains in order to compete with their competitors by delivering sustainable competitive advantage in the end-to-end supply chain. Carroll *et al.* (2016:32) caution that conventional business models, those typically developed and refined using the principles of the Industrial Revolution will struggle to be effective, efficient and competitive in the newly-entered digital age, should organisation not revise their strategies to be more responsive to the challenges and disruptive forces exerted by industry. Peters (2018) paints a grim picture regarding the sustainability of large chemical manufacturers when stating, "*International chemicals companies scramble to fast-track their digital transformation journeys as Cisco*

confirms that 40% of Fortune 500 companies will not exist in a meaningful way in ten years." However, Peters (2018) states that this scenario can be prevented by companies: *"To seize the Industry 4.0 opportunity, Cisco believes that chemical companies should leverage digital tools and capabilities to detect shifts in markets, develop more accurate and agile planning, heighten customer awareness and collaborate with business partners throughout the value chain".* Kell and Madsen (2015:189) contribute to the dilemma faced by the chemical manufacturing industry by suggesting that failure to transform the organisation in line with the key business principles of the digital age will result in unprecedented risks from a financial, competitive and sustainability point of view. According to Schofield *et al.* (2017:17), industry leadership should adapt their mindset towards more innovative, responsive and customer centric strategies that will be the catalyst for supply chain excellence in the digital era.

1.3 Research aim and objectives

The aim of this research study was to identify and proposed best practice solutions in order to make SCM in the chemical manufacturing industry responsive to the pressures and challenges presented by the digital era.

In order to comprehensively address the research problem and aim of this research study, both primary and secondary research objectives were constructed.

1.3.1 Primary Objective

The primary objective of this study was to develop a strategic SCM ecosystem framework that assimilate industry best practices and principles at each phase of the supply chain life-cycle in the chemical manufacturing industry.

1.3.2 Secondary Objective

In support of the primary research objective, the following secondary research objectives were developed:

a) Understand and disseminate the unique supply chain challenges encountered by the chemical manufacturing industry.

b) Identify the relevance and importance of individual challenges in order to prioritise the impact of recommendations.

c) Discover feasible solutions that can create sustainable competitive advantage for SCM in the chemical manufacturing industry.

d) Establish integrative performance metrics for the holistic determination of SCM effectiveness and efficiency.

1.4 Significance of the study

Marr (2018) suggests that, contrary to speculation, the 4th Industrial Revolution has already commenced and will challenge all facets of how we perceive and do business. More popularly referred to as the technology age, Industry 4.0 will disrupt and transform social interactions, business strategy and labour and technology (Bourgois *et al.*, 2018:2 - 3). Industry 4.0 is characterised by constant and rapid changes in the business environment, which paves the way for innovative and disruptive business models to be developed, which then establish new and relatively unchartered competitive landscapes. Lehmacher *et al.* (2017:4) state that conventional methodologies applied to SCM are inferior in attempting to curb the macro forces being exerted on the supply chain. They further state that organisations should apply the necessary level of strategic introspection to evolve its supply chains into digital capable ecosystems that can adapt with agility to various scenarios impacting it.

Targeted research is thus required to identify and develop end-to-end supply chain strategies that can assist in positioning SCM in response to disruptive trends brought about by Industry 4.0.

1.5 Research Methodology

The methodology for this research study was conducting both theoretical and empirical research on SCM practices.

1.5.1 Literature Study

According to Learning (2018:1) a literature review is conducted for the primary reason of identifying, analysing and explaining current research available on the research topic. In order to provide a sound theoretical foundation and context for this research study, a comprehensive literature review was conducted on SCM in the local and international

context. Therefore, various literature on current developments and the historical background of SCM were consulted during the compilation of the literature review.

The research problem and objectives acted as the boundaries for the literature review that was conducted, which had two themed categories:

- An overview of the South African chemical industry and the key role players that exert competitive forces on this industry.

- An overview of SCM, its components and characteristics, which provide the necessary context in determining best practice in the supply chain field.

1.5.2 Empirical Study

Empirical research entails the observation, analysis and measurement of actual experiences, opinions and beliefs, as opposed to relying on theoretical deductions (Libraries, 2018). The complexity of the study necessitated the utilisation of qualitative research methodologies to explore and dissect the research topic in detail, and based on participants' experience and qualifications related to SCM.

1.6 Scope of the study

1.6.1 Delimitations

The scope of the study was limited to the identification of best practice SCM within the operations of large chemical manufacturing organisations in SA and the bodies of knowledge that support and guide this industry.

1.6.2 Limitations

The research conducted was extensive and complex in nature. In order to address the research problem and achieve the study objectives, the following limitations were applied:

- The study was performed with a focus on the South African chemicals industry.

- Smaller chemical manufacturers, distributors and re-sellers were excluded from the scope of the study.

- Empirical data was collected from a single source organisation - Sasol Limited - which has a notable footprint in the industry.

- Complex supply chains provide more suitable opportunities to determine sustainable best practice management. For this reason, focus was placed on the large chemical manufacturing industry. However, it is noteworthy that the results from this study are scalable to the micro and the medium chemical manufacturing industry, as the supply chain chains closely resemble those of another, from a process and flow point of view.

- The research study primarily focus on the strategic level of SCM and does not consider tactical or operational level activities that impact on SCM.

1.6.3 Assumptions

The key assumptions utilised during the execution and analysis of the study included:

- The participants, who were selected in accordance with the study sampling strategy, will participate openly and accurately during the data collection phase.

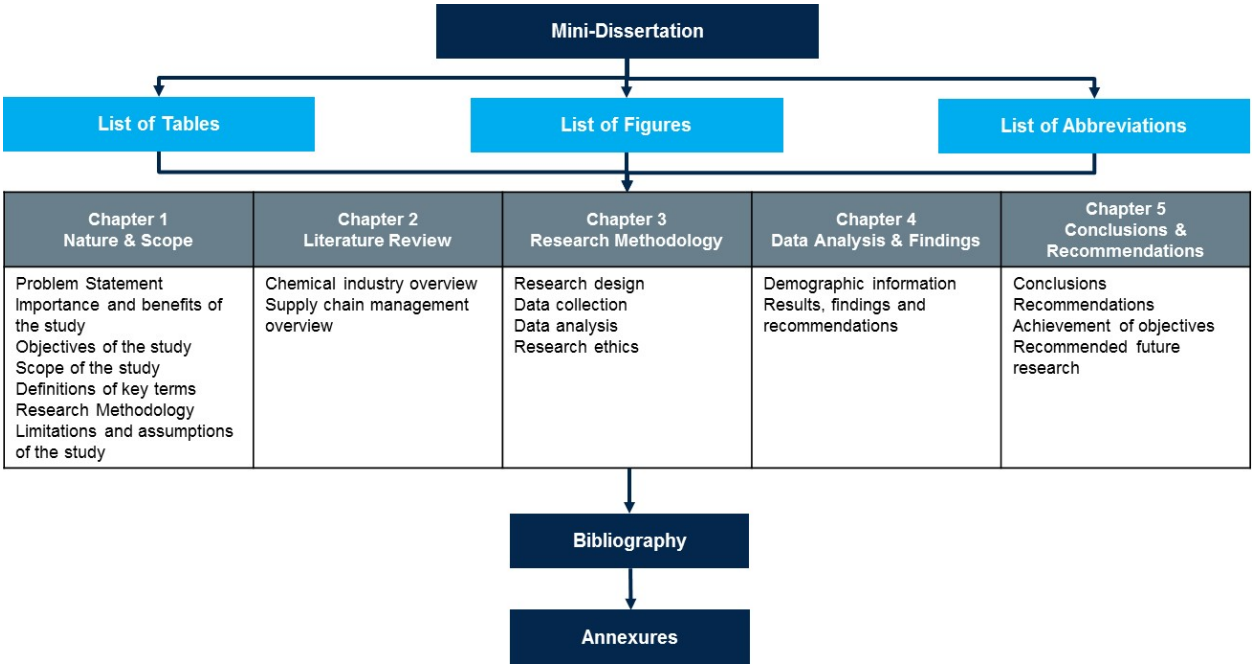
- The sampling strategy selected is representative of the study population and will yield reliable data from which to deduce conclusions.

- The data collection instruments that were designed and applied are sufficient to collect the required data and to establish a meaningful conclusion.

1.7 Layout of the study

The most effective layout by which to present the research that was conducted is in the mini dissertation format. The layout depicted in Figure 1-1 is consistent with that proposed for master's studies at the North West University (NWU) and is sufficient to address all the relevant and important aspects that must be considered when presenting the research (University, 2017).

Figure 1-1 Layout of the study



Chapter	Description	Purpose
1	Nature and scope	Provides the context for the motivation for conducting the research study, as well as an overview of how the study was approached.
2	Literature review	Provides an overview of the available literature on the topic of SCM and how the various pieces of literature influence, contradict and support each other.
3	Research methodology	Indicates the methodology utilised to gather, analyse and interpret the empirical data obtained.
4	Data analysis and findings	In this chapter, the responses from participants are identified and analysed, in order to address the research objectives.
5	Conclusions and recommendations	Integrate the literature review and empirical analysis to deduce a conclusion in support of the research objective. Recommendations are made to solve the research problem that was stated.

1.8 Summary

This chapter provided the context for the research study that was performed. More importantly, the problem statement that gave rise to the study was detailed in this chapter. Other notable points included in this chapter:

- Large chemical manufacturers face a real challenge to remain competitive and relevant in the digital era.

- The primary research objective is to derive a framework that can assist the chemical manufacturing industry to align its SCM methodologies to be more responsive to pressures brought about by the 4th Industrial Revolution.

- The 4th Industrial Revolution has already commenced and expose chemical manufacturing supply chains to real business risk, due to disruptive technology and innovative business models.

- The study focused primarily on SCM of large chemical manufacturers in South Africa.

- The mini-dissertation format forms the foundational layout of the study.

CHAPTER 2 LITERATURE REVIEW

2.1 Introduction

Bryman *et al.* (2016:92) state that an in-depth review of available literature is imperative for the researcher to form a solid scientific foundation on which recommendations can be built. The literature review dissects, interrogates and identifies communalities and contradictions between individual sources of literature and builds a holistic framework of what can be regarded as reliable and trustworthy foundational data.

The literature review was approached in a holistic manner and focused on two predominant themes. Firstly, an overview of the chemical manufacturing industry was provided, in order to demystify the dynamics and scope of the industry. Secondly, the selected SCM literature was unpacked. The literature review of SCM concepts was done using the funnelling methodology. Firstly, SCM was reviewed to obtain a comprehensive overview of the purpose, objectives, principles and challenges facing SCM in the industry. Next, more detailed analysis was conducted to identify best practice solutions for SCM challenges and how these solutions can create sustainable competitive advantage in the digital era, or Industry 4.0, as it is referred to in the literature.

During the literature review, constant comparison and reflexivity was applied, in order to identify integration points between the various data sets identified. Also, during this process, the research problem and the objectives were constantly compared to the selected literature, in order to ensure that the review was aligned to the aim of the study and that it yielded accurate and reliable foundational data that could be used when deriving conclusions and recommendations.

While only credible pieces of literature that were obtained from verified sources were used, emphasis was also placed on reviewing and comparing as many sources as possible, so as to ensure compliance with reliable literature review standards.

2.2 South African chemical manufacturing industry overview

2.2.1 Overview

Apart from the gold rush in in the early 1880's, the chemical industry in South Africa is largely responsible for South Africa being regarded as the economic hub of Africa. The chemical industry in South Africa has a rich history of development, innovation and

prosperity, with the focus being on the production of multiple types of application chemicals that are widely used for the production of consumer goods. The background and evolution of the South African chemical manufacturing industry is important in providing the necessary background on how the industry shaped the SCM principles of the current day.

The chemical industry in South Africa essentially started in the Vaal Triangle in South Africa and to this day is still inhabited by some of the largest chemical manufacturers in South Africa. In 1895 Anglo mined coal on both sides of the Vaal River in the larger Vaal Triangle basin. During 1896 Paul Kruger, the then president of South Africa, established the "The Dynamite Company" which initiated the need to manufacture more speciality type chemical to support the mining industry. The first company to produce chemicals in South Africa was Cape Explosives Works who commissioned a dynamite factory in 1903 based in Somerset West. The most notable history of the South African chemical manufacturing industry came about in 1950 when the South African Government established the Coal, Oil and Gas Corporation, which is known as Sasol today. Sasol has subsequently grown into the largest and most diversified manufacturer of chemicals in South Africa (Olofsson, 1999:71 - 77).

2.2.2 Large chemical producers

According to Tullo (2017), seven of the top 50 chemical manufacturing companies in the world have a footprint in South Africa. Although not the biggest producer of chemical products in the world, Sasol is the largest producer of diversified petrochemical products in South Africa. According to the Sasol Limited (2018:9) integrated report for the 2018 financial year, the organisation appointed about 31 270 employees and contributed substantially to the South African economy through the R39.5 billion in taxes that it paid in that financial year. Some of the other large chemical producers in South Africa that could benefit from the results contained in this study are: AECI, Omnia, Bayer, Dow Sentrachem, Engen, Shell, Protea Chemicals and Chevron.

2.2.3 Products

The South African chemicals industry is highly diversified, producing products for a wide range of secondary industries and applications. Products produced by the industry can be classified into three main categories, namely petrochemicals, base chemicals and speciality chemicals. Petrochemicals is a synthetic subsidiary of oil and it is partitioned into two classes, i.e. particular olefins and aromatics. Olefins are created from oil refineries, while aromatics are derived from liquid reactant splitting. These products are used to make various items that are used regularly, as many products contain petrochemicals, including electrical merchandise and oil-based items. Moreover, it is a key component used to protect crude materials. It delineates many significant hydrocarbon sources, for example, methane, ethane, benzene and gas (Petropedia, 2018). Coqui *et al.* (2011:19) state that base chemicals or otherwise referred to as commodity chemicals are products such as polymers and fertilisers which are produced and consumed in larger volumes with the composition specifications being quite stable. In the strictest sense, speciality chemicals are substance items that are sold based on their execution or capacity and not on their make-up. They can be single-compound elements or definitions with a synthesis that forcefully impacts the execution and handling of the customer's requirements (Markit, 2018). Majozi (2015) states that the three main categories of chemicals are sub-divided into 11 sub-categories. Figure 2-1 is extracted from Majozi's report and illustrates the various product categories and the segment quantities of each in the industry.

Figure 2-1 South African chemical industry diversification

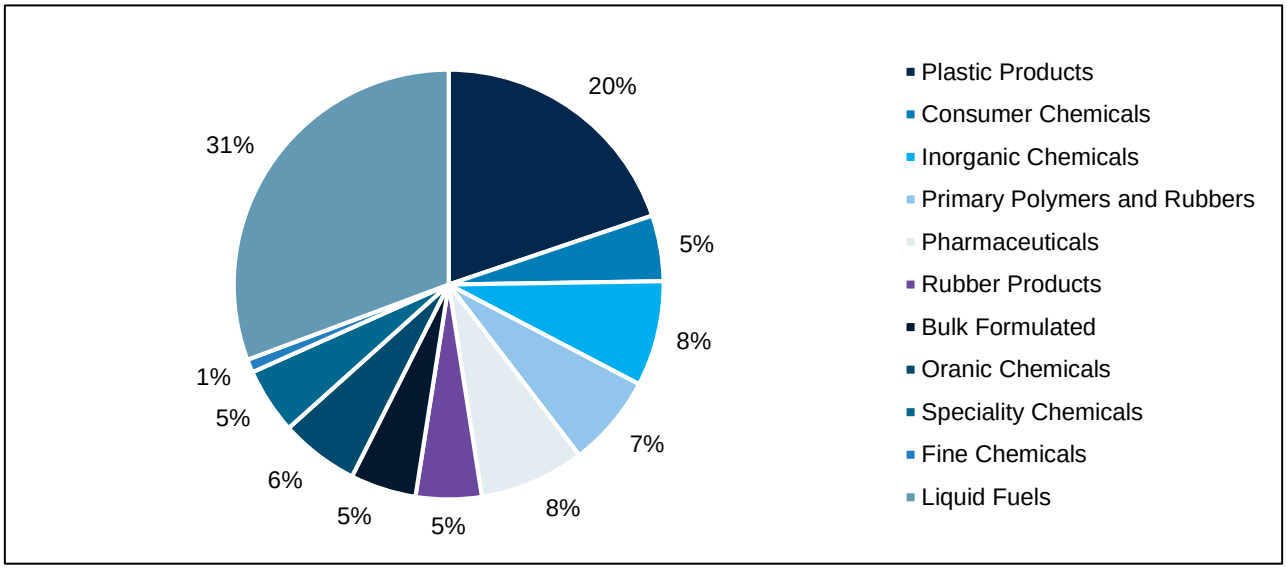
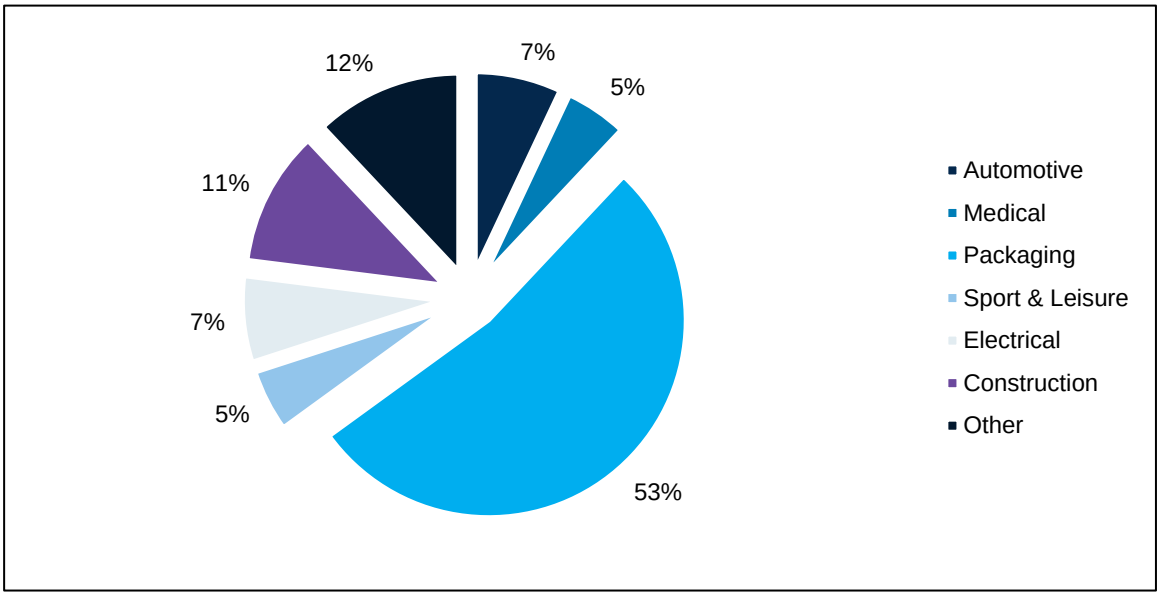


Figure 2-2 Plastic Consumption



The plastic industry produces both upstream and downstream input materials for many consumer goods that are produced both locally and internationally (Steyn, 2015). The wide variety of consumer goods produced from input plastic materials can be classified into seven consumption categories, Figure 2–2 illustrates the consumption patterns of the plastic industry.

Produced chemical products can be provided in wet or dry form, depending on market requirements and the composition of the chemical product. Manufactured materials can be packaged in various packaging modes, which determine the complexity and methodology of logistics. Dry bulk product is normally stored in holding tanks and distributed to customers by means of tanker trucks. Packaged dry bulk product is packaged into small or jumbo bag configurations in quantities normally dictated by market requirements and in order to optimise cost of sales. Bulk liquids and gasses are also kept in holding tanks prior to being despatched to customers in tankers via road or rail. Smaller configurations of liquids are normally packaged into drums; these are constructed of different types of materials, as dictated by the safe storage requirements of each chemical product.

2.2.4 Regulation

There are various laws, regulations and standards that direct and govern the chemical manufacturing landscape and the legal and regulatory system in South Africa is regarded

as one of the best and most progressive in the world. For a chemical manufacturer, it can prove to be a significant challenge to comply with these various regulatory frameworks, which can affect cost and effectiveness in the supply chain. Standards of practice can, however, create a sustainable competitive advantage for chemical manufacturers as, through compliance to these standards, they can prove to customers that the organisation is supplying a product that complies with health and safety, quality and environmental best practice. Due to the large number of regulations imposed on the chemical industry, it will not be possible to explain each of these in detail in this study.

2.2.5 Industry trends

The South African chemical manufacturing industry faces tough obstacles to deliver sustained growth in the face of increasingly competitive forces and world-wide economic down-turns. In a report issued by Sarathy (2017:8 - 10), three strategic imperatives are suggested, which the chemical manufacturer should focus on to stay competitive in light of the current market conditions. Firstly, there must be a clear change of focus from capturing value over volume. Companies should refrain from increasing their production capacity and holding large volumes of final product in storage, which reduces cash flow, and should instead focus more on producing and delivering according to customer demands (Sarbjit, 2017:495). This implies that there is a move away from a push demand requirement, in that customers' actual demands dictate production volumes, rather than forecasted demand volumes. This demand fulfilment methodology is risky, however, as the possibility of a stock-out is high. The success of the demand driven supply chain is based on its ability to proactively anticipate customer demands through sophisticated data analytics systems (Schrauf & Berttram, 2016a:27). Secondly, investment in new generation digitisation capabilities should be top priority. Adaptability and responsiveness to changing market demands will become imperative in creating sustainable competitive advantage in the chemical manufacturing industry (Burke *et al.*, 2017). This can only be achieved through sophisticated data analytics and predictive software that can learn customer behaviour and adapt the operations of the organisation to the demand signals in a pre-emptive manner (Joos *et al.*, 2016:22). Thirdly, pre-emptive coherence of product and service portfolios will become imperative to long-term sustainability. Due to the increasing changes in demand from households, increased pressure will be placed on the chemical manufacturing industry to develop the ability to supply new products and services in an agile manner, in order to fulfil the requirements of the market.

2.3 Supply chain management overview

2.3.1 Supply chain management

In the broader sense, SCM can be regarded as the management system or process that controls the procurement, production and delivery of products to various stakeholders, in order to create value for the organisation through the creation of competitive advantage (Fuzile, 2015:4 - 5). SCM is the field of study that concerns itself with the flow of products throughout an organisation (Nguyen, 2016:8).

Pasanen (2016:13) states that supply chains are normally divided into three main segments. The first segment is referred to as upstream operations, where input resources are sourced from external providers (Case *et al.*, 2016:44). The second segment relates to midstream processes, which convert the input resources into a tangible product (Tordo *et al.*, 2011:14). The last segment is referred to as downstream operations, which focuses on the sale and distribution of the products that are produced - either to holding facilities or to the customer base (Devold, 2013:4). Input materials are sourced from reputable suppliers and these are transformed into final products during the production process (Hartwich *et al.*, 2011:4). The final stage is the logistics involved in supplying the final product to the customer (Rajgopal, 2016:9).

SCM is regarded as one of the most complex functions in the manufacturing industry, because of the various components, flows and expertise required at each phase of the chain or flow of materials (Kondratjev, 2015:31). Various SCM models exist, and selection of the appropriate model is determined using various parameters, e.g. size, complexity, agility and responsiveness to change.

According to Du Toit and Vlok (2014:37), there are multiple limitations when studying SCM, the main being the lack of research regarding the detailed components of the supply chain model. An effective and efficient supply chain is developed on the basis of robustness of design and structure strategy (Biswas & Sen, 2016:4). The organisation should invest in developing a detailed design of the chain, in order to ensure that an adequate organisational fit is achieved (Badenhorst-Weiss & Nel, 2011:15). Although organisations acknowledge the importance of supply chain design, most rarely invest in proper design processes.

When designing a supply chain, it is imperative to follow a phased approach, so that all the critical aspects are covered (Alzawawi, 2014:5). Phase 1 involves understanding the demands of the end user and the most effective methods that can be used to align business processes with the identified demands. Phase 2 involves the identification and selection of a fit-for-purpose supply chain strategy. Phase 3 involves detailed scoping of the requirements to establish the supply chain structure (Nel & Badenhorst-Weiss, 2010:201).

An optimal supply chain strategy is established when the organisation effectively integrates, standardises and coordinates the flow of products, resources and information seamlessly along the supply chain (Ambe, 2012:126-147). To ensure the most effective supply chain strategy is adopted, resources structuring becomes an important consideration in delivering a sustainable supply chain (Crandall, 2016:14). A sub-optimal supply chain structure results in increased risk and disruption across the breadth of the organisation (Fredriksson & Glas, 2012:17).

One of the most important elements of a supply chain structure is the human resources (HR) base, its expertise and the method by which these resources are structured to manage and coordinate the activities within the supply chain (Bharthvajan, 2014:10166). There is a direct relationship between the organisational structure and the level of risk posed by the supply chain network (Sayed & Sunjka, 2016:132), as a relationship exists between SCM success and the structure that is employed to manage the chain. A feasible option for establishing a cost effective and efficient supply chain is the adoption of a best practice supply chain model. There is significant business benefit to implementing such a supply chain model, the most notable being (DeBenedetti, 2016):

- A *seamless flow* of products and information throughout the organisation, which reduces cost and creates competitive advantage.

- Mitigation of **supply and demand risks** that might adversely affect business operations.

- Balance between demand and supply **variables**, which results in lower inventory volumes and improved response times.

2.3.2 Supply chain management objectives

There are a number of objectives related to SCM, with the key objectives identified by Nagurney (2013:11) being as follows:

- The activities performed in the chain should add value to stakeholders. The typical value expected by the various stakeholders include: cost; availability of products; attractiveness of the organisation's value proposition; and the effectiveness of the overall triple bottom line (Amarah, 2015:223).

- Customer service excellence, so as to ensure that the key stakeholders receive the required utility from the products and services rendered.

- Effective and efficient utilisation and integration of resources across the entire supply chain.

- Leveraging the unique services, skills and resources of key partners, which is critical to the success of the chain.

2.3.3 Supply chain management benefits

Koksharov (2016:34) states that effective SCM in business is of strategic importance in generating profit and creating sustainable competitive advantage. In addition, Wei and Xiang (2014:280 - 281) state that supply chain management provides key benefits to organisations. Firstly, SCM reduces and contains cost throughout the various organisational processes. Secondly, interaction and communication between the various SCM stakeholders is facilitated and optimised. Thirdly, the effective management of SCM can reduce risk from internal and external uncertainties. Fourthly, it enables the organisation to effectively execute its corporate social responsibility, so as to impact positively on communities.

2.3.4 Principles of supply chain management

As already confirmed, SCM is an integral component to business success and requires constant improvement and optimisation to remain relevant and competitive. To achieve this, it is imperative that SCM is based on best practice principles, to which the entire organisation should subscribe. According to Du Toit and Vlok (2014:26), effective SCM

is anchored in several principles that should be integrated into the organisational strategy. These principals are:

Principle 1: According to Omera *et al.* (2016:24), supply chains must be designed around serving customer needs. The organisation must conduct proper market research to identify the unique requirements of each customer segment and customise the design of its supply chain in terms of these needs. This means that a supply chain consists of multiple supply chains, each individually contributing to the success of the larger supply chain.

Principle 2: The logistics network must be set up in such a way that it delivers on customer requirements effectively, but it must also be optimised to secure and improve profit margins.

Principle 3: A report produced by Ernest & Young (2014:25) state that organisations should develop systems that are able to continually harvest market data and analyse this data to provide the organisation with reliable intelligence that will help in making rapid strategic decisions.

Principle 4: According to Hanninen (2017:24), SCM is about one crucial business objective and one alone, that is to serve the customer of the organisation in an optimal, cost effective and world-class manner that exceeds the expectations of customers.

Principle 5: Strategic sourcing of materials should be central to the supply chain strategy, in order to optimise supply chain cost and create sustainable relationships with suppliers, which will ensure reliable and consistent enablement of the supply chain as a whole.

Principle 6: Dougados and Felgendreher (2016:9) state that digitalising SCM is imperative to establishing a collaborative and integrative ecosystem that is geared to serve the customer.

Principle 7: According to Kritsotakis and Maarni (2014:67), the effectiveness of SCM must be measured utilising integrative and holistic measurements that are aimed at determining customer satisfaction and meeting customer requirements.

2.3.5 Supply chain concepts

In SCM, there are many processes and activities that should be monitored and controlled to ensure the effective functioning of the supply chain. A major component of SCM is the flow of products from one point to another through a chain of interconnected functions. These products are sourced from external organisations that provide products in return for compensation and further purchasing relationships (Waithaka & Waiganjo, 2015:139). According to Mankiw (2008:67), the dilemma in this exchange resides with the central economic problem, which states that markets are rarely in equilibrium and that supply and demand variables determine the quantity and price of products going in the market. Supply of input materials is thus not ascertained and needs to be closely managed by the organisation.

A concept that is central to SCM is the establishment and maintenance of buyer-supplier relationship Supply chain flows can be classified into two main processes, namely physical and information flows. According to Grabis (2013:3), physical flows in the supply chain context refer to the touch-and-tag principle, i.e. any area within the supply chain where a physical material handling or production process occurs. Grabis (2013:4) state that the information flow component of the supply chain typically refers to the transactional recording of physical flows and the collaboration between the various channel partners. According to Grunt and Grabara (2013:96), there is an interdependent relationship between physical and information flows, which impacts on the accuracy and transparency of SCM when it is not in equilibrium.

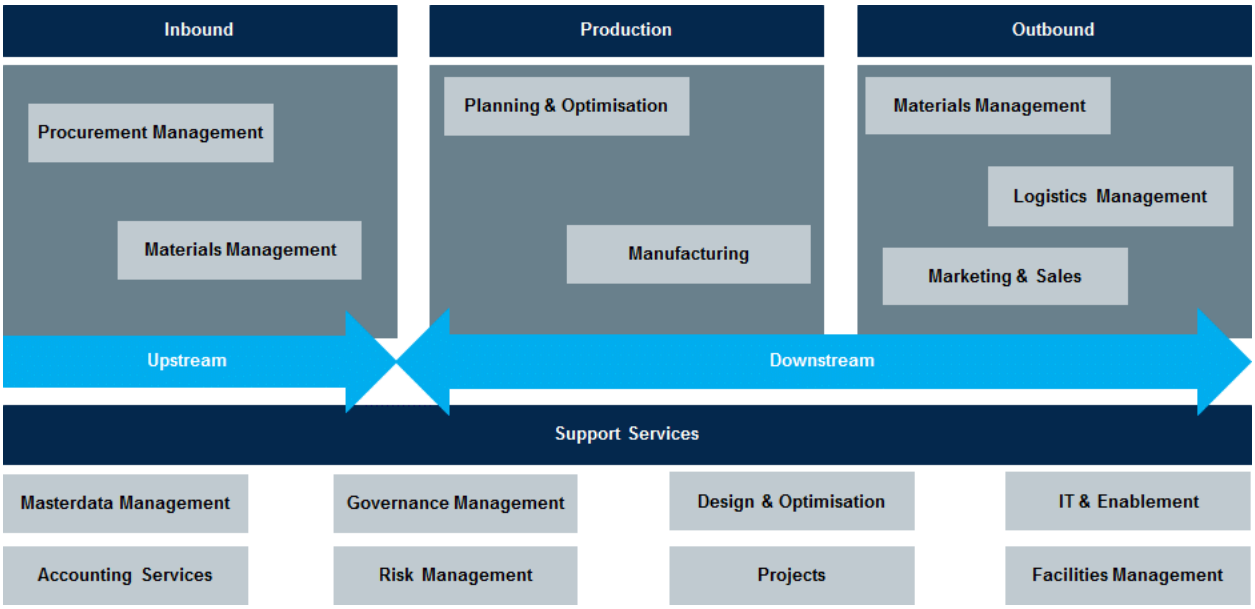
Total cost of ownership (TCO) is an important concept in SCM, in that it creates a financial framework within in which all the activities and costs associated with each activity can be tracked and accounted for (Lawrence *et al.*, 2016:4 - 6). Delesalle *et al.* (2014:6) state that companies that are able to track TCO in real time and introduce strategies that optimise or eliminate costs have a competitive advantage over their competitors.

2.3.6 Supply chain management functions

There are several functions that are combined to form the typical structural configuration of the chemical manufacturing supply chain. Each of these departments have a unique role to play within the larger supply chain, and they cumulatively ensure the success of

the chain. Figure 2-3 provides a visual rendition of the traditional functions within supply chain management and their interdependency.

Figure 2-3 Supply chain functional configuration



Adapted from the Sasol Limited (2014:18 - 21) supply chain service delivery model

2.3.6.1 Inbound supply chain

2.3.6.2 Procurement

Musau (2015:16) established that procurement management is a critical element of the supply chain, in that it sources and secures a constant and reliable flow of products and services into the organisation in support of supply chain effectiveness. Roberta Pereira *et al.* (2014:627) elaborate on the strategic role of procurement management in the success of the organisation, by stating that the function is mainly responsible for sourcing, contracting and managing external vendors, in order to create and maintain reliable flows of products and services required by downstream functions, which, in turn, allows them to deliver on customer requirements. Also referred to as the procure-to-pay process, procurement management typically comprises four departments, namely: strategic sourcing, contract management, purchasing management and supplier relationship management (SRM).

Parniangtong (2016:5 - 6) indicates that strategic sourcing is a critical process in the supply chain, in that it aims to create competitive advantage through inbound supply

channels. Strategic sourcing takes the end-to-end procurement process into consideration and aims to identify reliable sources that can supply the critical resources required by the organisation in a sustainable manner (Furlotti, 2014:22). Its core focus is reducing cost through analysis of the TCO of such procured products and services and it attempts to establish mutually beneficial relationships between the organisation and its supplier base.

Increased pressure on SCM is forcing a mind-shift change to one of being more responsive, so as to enable the downstream SCM processes. According to Kehoe *et al.* (2017a:9), an organisation that wants to optimise and improve its supply chain processes should invest in systems that automate contracting processes, which will enable fluency within the supply chain and continuous analytics of contracting portfolios.

According to the British Institute of Facilities Management (2015:3), it is critical to establish strong mutually beneficial supplier relationships through a formalised SRM platform. Sasol (2015:2015) mention that SRM consist of three main components namely: supplier accreditation, supplier development and spend analysis. Supplier accreditation essentially entails analysis to establish whether there is a compatible relationship between the organisation and the vendor (Lammi, 2016:12). It further establishes whether the vendor has the necessary skills, resources and channels to effectively and efficiently deliver the goods and services required by the organisation, and to do so in a sustainable and compliant manner.

The most feasible supplier base might not be able to fully align with the requirements of the procuring organisation, due to stringent strategic supply requirements. It is thus in the interests of organisations to invest in the development of their suppliers, which ultimately reduces the risk of supply to the organisation. In the South African context, an additional burden is placed on the supply chain through the Preferential Procurement Policy Framework Act, 2000: Preferential Procurement Regulation 2017. According to the South African Treasury (2017:23 - 27), organisations are required to identify opportunities where procurement spend is increased with organisations that support the advancement of previous disadvantaged individuals. The development of monitoring measures is an important measure in complying with this act to ensure tracking and reporting of preferential spending patterns.

Schuh *et al.* (2018:3) caution that organisations wishing to stay competitive in the new disruptive business era will need to transition from conventional procurement processes towards end-to-end customer value creation. Schreiber *et al.* (2016:1) indicate that the hyper-competition between organisations brought about by Industry 4.0 requires organisations to evolve the procurement function into an optimised value generator for the organisation, through the adoption of Procurement 4.0. Weissbarth *et al.* (2016:6) indicate that Procurement 4.0 is constructed of six main areas, within which it is the Procurement Officer's strategic task to evolve the procurement processes of the organisation into a world-class, customer centric model. The value proposition of the organisation will then need to be aligned to customer requirements. The procurement process should be fully integrated, digital and highly fluid when acting on stakeholder demands. The interaction and management of the organisation's supplier base should be integrated into the main supply chain processes, in order to ensure seamless collaboration between the channel partners.

Analytical capability to leverage procurement data is the precursor to effective strategic sourcing and optimisation of external spend. The skills sets of employees requires re-development from process-centric skills to digital and analytical capabilities. A major enabling factor in the transition to procurement excellence, is the ability of the organisation to fully integrate data and information processes across the entire supply chain (Badeshia, 2015:14).

2.3.6.3 Materials management

Materials Management is present in both the inbound and outbound areas of the supply chain. Inbound Materials Management focuses on the receiving, put-away, picking and issuing of direct and indirect procured material utilised in the production process, which is used to transforms raw material into final products. Outbound Materials Management is mainly responsible for receiving, put-away, picking and despatch of packaged final product to customers - both locally and internationally (You, 2016:6).

The communality between these two operating units is that warehouse management is a core strategic focus. Being directly customer facing, it is important that the warehouse (W/H) fraternity within SCM is equipped with the necessary systems and processes to ensure that optimal service delivery standards to the customer are maintained. In order

for warehouse management to be a successful contributor to supply chain success in the 4th Industrial Revolution, it needs to evolve into a highly responsive, value-adding and reliable component of the supply chain.

In order to optimise cost and leverage on economies of scale, there should not be a distinction made between or a separation of warehouse management in the larger supply chain context. According to Li *et al.* (2014:10), warehousing should be integrated, centralised and standardised, based on geographical considerations and the need for warehousing in these regions. In order to achieve this objective, there should be a drive by organisations to transition conventional warehousing methodologies to align with the principals of Warehousing 4.0, which was developed to position organisations to deal with the pressures brought about by Industry 4.0.

Taliaferro and Sampat (2016:3) state that, as far as is reasonably possible, warehousing should transition from physically driven operations into smart digitally automated ecosystems that eliminate human error and respond instantaneously to customer demands. In a report published in Supply Chain 24/7, 3PL Central (2014) indicate that automated W/Hs have been available for more than a decade; however, Warehousing 4.0 requires a quantum leap from automation to smart warehousing. Smart warehouses are fully automated facilities that can handle any type, shape or form of object in an interconnected network of sensors and monitors, by sending continuous data signals to the integrated ERP system, which has the ability to analyse the data and learn from it, in order to determine optimal operating conditions (Veenman & Tagscherer, 2018:13). From a warehousing perspective, automation refers to both autonomous material and information flows.

The presence of a W/H is not of strategic importance in reducing supply risk to the customer, the organisation should invest in the development of cross-docking capabilities, in order to achieve JIT supply chain processes, which will further optimise TCO.

2.3.6.4 Planning & Optimisation

The role of planning and optimisation (P&O) is simplistic in definition, but complex in execution. The core function of P&O is balancing supply and demand variables through focussing on forecasting, predicting and analysing the most feasible value-adding route,

in an attempt to optimise cost and ensure that customer service levels are maintained (Thunberg, 2016:15). P&O is thus highly dependent on accurate and constant streams of data from all the processes in the supply chain. The absence on reliable data streams and analytical systems transforms the P&O function from a critical value-adding and forward-thinking element of supply chain into continual crisis management mode. Siepen *et al.* (2018:9) state that SCM success ultimately resides with its capability to shorten the forecasting, prediction and planning timeframe. They indicate that this capability is brought about through targeted focus and implementation of the following Supply Chain Planning 4.0 principles:

- **Seamless planning processes –** Supply chain planning should be integrated across all supply chains and driven from a single accountability point of view. Boundaries between upstream and downstream planning processes should be transitioned into a planning continuum. Upstream and downstream supply chain planning are interdependent processes that require high levels of integration and standardisation.

- **Collaborative interconnectivity –** The supply chain planning function should be effectively integrated with all facets of the organisation and should be able to collect master data that can be hard-coded into the digital systems, in order to improve planning accuracy and decrease planning horizons.

- **Advance scenario planning –** There should be systems in place that continually collect and analyse data from across the total supply chain and translate it into credible scenarios that the planning function can utilise for strategic decision making purposes. Machine learning should be introduced into the analytical planning systems to enhance the predictive planning capability.

2.3.6.5 Manufacturing

The manufacturing process is an integral component of supply chain success, in that it transforms the procured materials and services into products required by customers. Manufacturing is a major variable in the supply chain process, in that any upsets or bottlenecks in the process result in a direct impact on the downstream processes and, ultimately, on the customer. The industrial era focus is still prevalent in organisations, as:

most focus and investment is directed toward the product and SCM is regarded as a support function for manufacturing. Sanders *et al.* (2016:817) caution that organisations that maintain this strategic focus in the 4th Industrial Revolution will eventually battle to compete with competitors that are using innovative business models brought about by technology innovation.

There should be an inverse strategic focus going forward, so that SCM becomes the core business focus and manufacturing is transitioned into an integrated support function within the supply chain. Geissbauer *et al.* (2016:13) state that the alignment of manufacturing processes to Industry 4.0 is just as important as any of the other supply chain processes. In order to provide visibility and integration in the supply chain, strategies should be developed to digitalise manufacturing processes, with the end goal being to substantially improve reliability and performance. Geissbauer *et al.* (2016:13) argue that aligning the manufacturing process with the principles of Manufacturing 4.0 is imperative in ensuring SCM success, with the ultimate goal being customer-centric SCM.

Sensors, instruments and monitoring devices along the manufacturing process are required to provide the necessary supply chain visibility. The data obtained from the various monitoring points should be analysed and real-time management information should be made available in a transparent way. The monitoring points, systems and analytics should be integrated to such an extent that it enables predictive failure capability and a continuous improvement methodology.

2.3.6.6 Outbound supply chain

2.3.6.7 Logistics management

According to Grant *et al.* (2017:12), the main function of logistics management is to ensure the mobility of products, in order to satisfy customer needs. Logistics management focuses on three major activities. Firstly, network planning is executed to identify the optimal distribution networks that will ensure that customer service levels are achieved. Logistics planning also focuses on optimising cost and determining the most feasible option for transporting material (i.e. air, land or sea). Secondly, relationships are formed with transportation vendors, in order to ensure reliable availability of the various modes of transport. Lastly, logistics management schedules the transport function in line with

customer requirements and manages the transportation life-cycle to ensure execution of effective logistics management.

Rybakov (2017:7952) state that logistics management is an aspect of the supply chain that attracts high unit cost and that can lead to disruption and failure if it is not monitored diligently. The objective of supply chain visibility is perhaps the most prevalent in this area, due to the wide dispersion of shipping routes and modes. According to Giannakis *et al.* (2017:290) best performing supply chains interlink the entire logistics network into cloud-based platforms, to ensure continuous data generation and monitoring of effectiveness.

According to Jahn et al. (2018:702 - 703), Logistics 4.0 is characterised by:

- **Autonomous prediction** of logistics requirements and the scheduling of transportation events using mobile and cloud-based platforms.

- **Real-time traceability** of fleet and material locations across the globe.

- **Real-time visual condition monitoring** of vehicles, material and communication channels with the driving crew.

- **Continuous monitoring** of vehicle performance against predetermined performance requirements.

- Automation of **route optimisation** by means of predictive learning capabilities.

2.3.6.8 Marketing & Sales

Homburg *et al.* (2017:389) defines the role of marketing and sales (M&S) in the supply chain as the function that is responsible for enhancing brand equity through various targeted marketing strategies. M&S should establish long-lasting relationships with customers through a requirements collection process that is fed into the organisation as the foundation for supply chain design. M&S also regularly engages with customers by means of an account management process, for purposes of negotiating sales orders and determining whether the customer's unique needs are being addressed by the organisation.

Mussomeli *et al.* (2017:11) state that in addition to promoting the overall brand equity, M&S will need to build digital bridges between the organisation and its customers by means of sensor-driven replenishment pushes and segment marketing principles. Integration of smart sensors into the organisation's integrated systems will enable predictive demand fulfilment, which will create immense competitive advantage for the organisation.

2.3.6.9 Support services

Supply chain support services consist of accounting, governance, design & optimisation, risk, master data, projects, facilities and enablement. These services leverage economies of scale and skill, and can be utilised as a centralised service that operates across various supply chains.

According to Hald and Thrane (2014:3), in the supply chain management context, accounting services are responsible for both the payment and collection of financial transactions concluded as part of supply chain activities. The payment section of the supply chain ensures that vendors are paid on time and in full, so as to maintain enabling relationships between the organisation and its suppliers. From a collection point of view, it is responsible for the creditors function, which collects payments from customers for goods and services rendered. In addition to the inbound and outbound accounting roles fulfilled by accounting services, there is also a very important component to its portfolio of accountability. The function is responsible for inventory management practices, which include FIFO management, which ensures that inventory held is rotated timeously to prevent: the accumulation of working capital; and impact on sales margins due to aging stock impacting on cost of sales. A report issued by Chartered Accountants Worldwide (2017:1) stated that the future of accountancy resides with the implementation and application of block chain technology – as is the case with streamlining procurement processes using block chain technology. The report further states that block chains will become an industry necessity for accounting effectiveness, in order for organisations to compete in the technology disruptive age.

Dolci *et al.* (2014:2) state that there is a direct relationship between supply chain performance and the governance principles employed to control processes. There should

be a balance between the actual governance principles employed and the value this adds to the customer experience.

According to a report issued by Oracle (2017:16), organisations that fail in terms of master data excellence will not be able to effectively provide reliable accuracy and visibility across the various supply chains. The report further suggests that the lack of standardised and centralised master data accountability across the width of the supply chain impacts negatively on downstream processes - and ultimately on the customer experience.

2.3.7 Supply chain management evolution

Dachs and Derycke (2016:7) state that the supply chain of the future will be integrated, collaborative and oriented towards multi-channel partnerships, as well as providing real benefit to all stakeholders in the chain. Cecere and Mayer (2014:7) record that it is a continual tug-of-war to keep the supply chain in equilibrium as the size and complexity of the organisation increases. Hégelé *et al.* (2016:4) add that there are six digital supply chain capabilities that the chemical industry should master, in order to create sustainable competitive advantage, i.e.: demand sensing; integrated collaboration; dynamic inventory management; profit, sales and operations planning; supply chain resilience; and a supply chain control tower.

Siepen *et al.* (2018:9) state that the 4th Industrial Revolution enables consumers to rapidly adjust their personal preferences because of the unprecedented advances in technology. In order to adjust to rapidly changing consumer demands, organisations should transform their traditional forecasting methodologies into demand sensing platforms that can predict customer behaviour. Demand sensing requires short run forecasting that is based on historical sales data and market intelligence, and which utilises AI analytical platforms that continually analyse and predict demand volumes (Van Belle & Verbeke, 2017:4). In order to enable effective demand sensing, according to Ivanov *et al.* (2018:3362), organisations should digitalise all aspects of the supply chain to generate rich data sources in real time, which can be utilised as input for data mining during the forecasting runs.

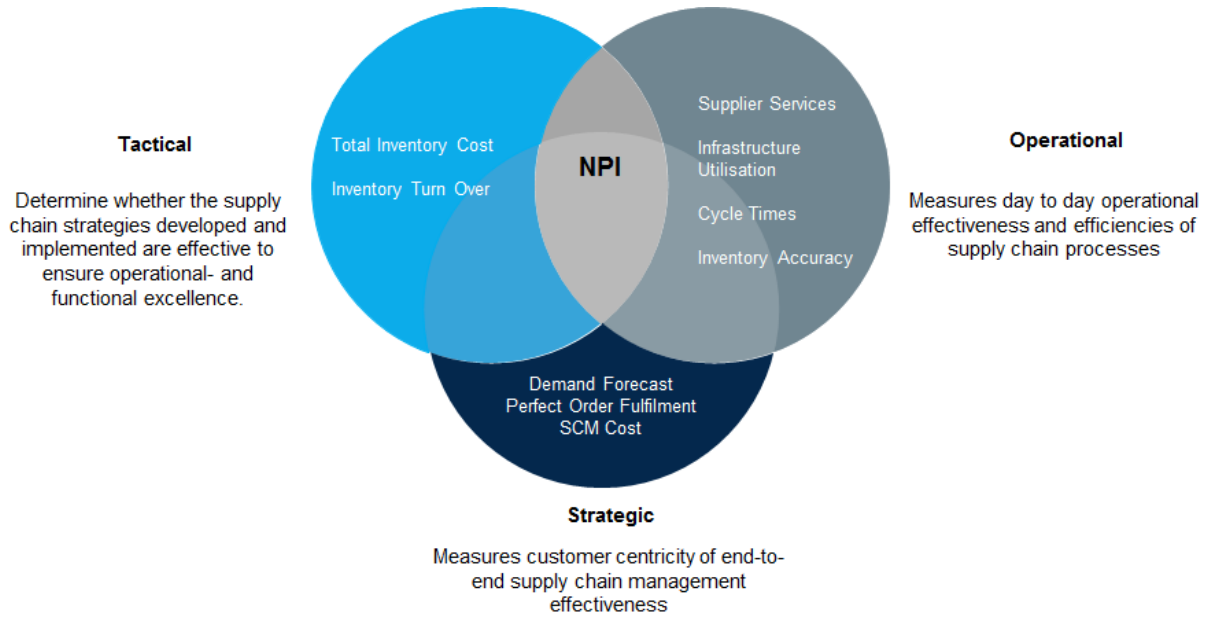
2.3.8 Supply chain key performance indicators

The key performance indicators utilised to determine supply chain performance should measure the end-to-end supply chain processes to ensure customer expectations are

achieved (Flegel & Wutzler, 2017:3). In addition, it will also be necessary to identify benchmark standards that will assist to derive an integrated and standardised methodology to determine whether a supply chain model is optimal and best of breed in the industry selected.

The Gartner supply chain hierarchy of metrics benchmarking for manufacturing is regarded as the best end-to-end database tool available to accurately measure and compare key performance indicators in supply chain management. Figure 2-4 provides an overview of cascading measures that can be used to benchmark supply chain performance. Supply chain metrics are divided into strategic, tactical, and operational measures that are intended to measure the end-to-end performance of the supply chain. Figure 2-4 provide examples of possible measures that can be used to measure the effectiveness of supply chain performance. Yu *et al.* (2017:11) and Ucenic and Ratiu (2017:3) offer complimentary views, stating that there is one core measurement that is not dictated by supply chain strategy, but by sheer disruptive forces driving supply chain strategy - and that is NPI.

Figure 2-4 Supply chain integrated performance measurements



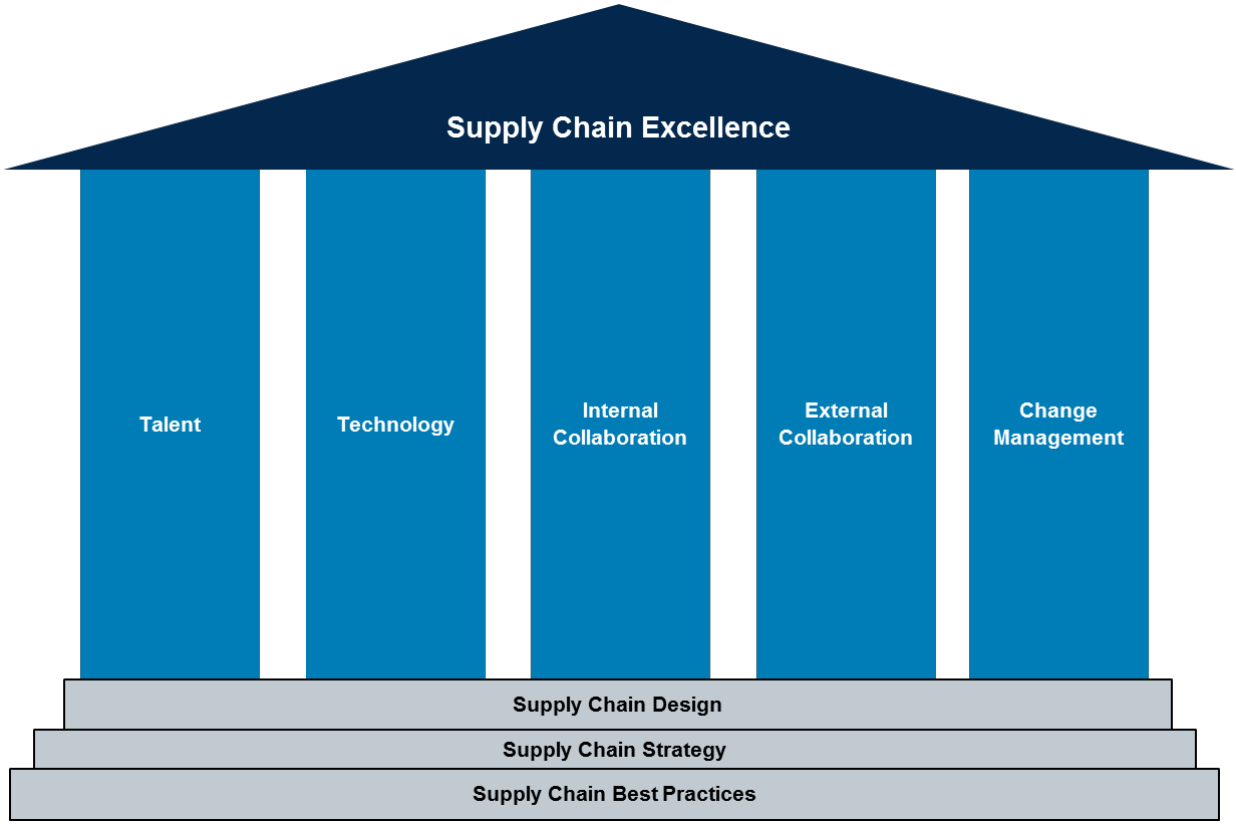
Adapted from Gartner (2017)

2.3.9 Supply chain management best practices

2.3.9.1 Supply chain excellence

Slone *et al.* (2010:52) state that supply chain excellence is based on a well-defined supply chain strategy that is supported by five fundamental pillars.

Figure 2-5 Supply chain excellence pillars



In their study on skills requirements in the supply chain industry in South Africa, Heyns and Luke (2012:120 -121) concluded that the critical skills required to ensure the success of any supply chain are: the ability to grasp business processes, creativity, multi-functional awareness, decision making, problem solving, and analytical and planning skills. In a study conducted by Marchese and Dollar (2015:9) on 500 executives from various global companies, the majority of the respondents indicated that the success of the supply chain in the next five years will depend on multi-disciplinary skills, rather than on speciality skills, as is the case today. Digitalisation of supply chain processes will require a complete review of the methodologies applied to identify, recruit and develop human capital with the necessary skills and abilities to deal with the pressures exerted on the organisation by the 4th Industrial Revolution.

According to Cutler and Lewis (2016:19) and corroborated by Khan and Forshaw (2017:4), organisations will need to cultivate and develop a number of new skills in employees, if they are to be effective in the digital age. The critical people capabilities that are required, include:

- **Cross functional adaptability:** Personnel will be required to work in multiple functions, where the organisation requires such expertise. There is a trend away from specialisation of supply chain role categories to generalizability of internal capabilities.

- **Vertical and horizontal knowledge:** Personnel will need to have the ability to quickly and comprehensively grasp cross-functional processes throughout the organisation and will have to be able to identify their impact on the greater success of supply chain management.

- **Inherent abilities:** Personnel will need to master cognitive, psychomotor- sensory and physical abilities to form and nurture close relationships between channel partners.

- **Personal growth mind-set:** Industry disruptions and the speed at which business processes and systems will change in the future, will require personnel to engage in a mind-set of lifelong learning, in order to stay abreast of developments in supply chain management.

- **Digital mastery:** Personnel will require the ability to operate various technology interfaces and will have to be skilled in data analytics and the interpretation of data.

According to Stewart *et al.* (2017:19), the training and development of supply chain personnel should transition past conventional classroom training interventions and online self-learning platforms to methodologies that harness the capability of technology to establish reflexive competence. Also referred to as practical competence, Alexander (2017:311) define reflexive competence as the highest desired level of personal competence, at which level a human being is able to integrate theoretical, practical and experiential knowledge when engaging in work activities. Rose (2014:2) is supported by

Letrud and Hernes (2018:14), when quoting research evidence that indicates that conventional training methods will not be effective in creating the necessary competency levels required by the digital supply chain. Classroom training methodologies contribute a mere 5% to knowledge absorption, while allowing the student to practice the outcome results in a knowledge absorption rate of more than 75%.

2.3.9.2 Lean supply chain management

According to Ugochukwu *et al.* (2012:87 - 96), lean operating principles have their origins from Toyota, as this organisation perfected the principles in response to strong competition in the car manufacturing industry. Toyota has proved that, through the implementation of lean principles in all aspects of its operations, a sustainable competitive advantage can be derived (Coetzee *et al.*, 2016:83). Lean principles are multi-functional and multi-disciplinary, which implies that they can be implemented in any process, whether production or service orientated organisations (Agrogiannis & Agrogiannis, 2015:105 - 106).

In a study performed by Professor Kovac (2013:3), it was discovered that lean SCM provides multiple benefits to an organisation, from a cost and waste reduction point of view. Lean supply chains have programs in place to continually identify activities, processes and systems that do not add value to the organisation (Fourie & Umeh, 2017:179). Continuous improvement and agility are at the heart of supply chain success in the 4th Industrial Revolution (Malmgren *et al.*, 2018:6).

Singh *et al.* (2013:85 - 96) state that there are four main categories of lean principles that underpin the successful implementation of lean methodologies in SCM. Firstly, there should be a continuous process in place to eliminate waste from all aspects of the supply chain. Secondly, improved quality practices should be a priority, as this will eliminate unnecessary waste in the chain. Thirdly, barriers to the effective and efficient flow of materials and information along the chain should be identified. Lastly, cost optimisation should be an imperative of all functions along the chain.

2.3.9.3 Agile supply chain management

Nel and Bdenhorst-Weis (2015:136 - 150) argue that agile SCM is perhaps the single most important evolution for supply chains wanting to compete in the 4th industrial

revolution. Gilaninia *et al.* (2011:46 - 55) state that a close relationship exists between agile and lean SCM, and that a combination of these methods will create sustainable competitive advantage. The main difference between the methodologies is that agile focuses on the exact requirements of the customer and then designs supply chain processes to meet these requirements (Koski, 2016:27). In addition, the level of agile capability in an organisation is derived from its ability to quickly and cost effectively adapt or change its operations in line with changing customer demands (Wu & Angelis, 2014:251). Supply chains with high agile capabilities will out-perform their competitors and increase their market share (Lenerius *et al.*, 2014:2). However, (Khastoo *et al.*, 2017:52) caution that the agile capability of an organisation is directly influenced by the complexity of its operations and supply chain.

2.3.9.4 Global best practices

Although the focus of this study is on SCM in the South African context, it is important to recognise international best practice. The reason for this is that most large companies have globalised their operations and international supply chain forces will inevitably impact on success in local supply chains. In a study performed by Stank *et al.* (2014:25 - 33), it was found that there are five best practices that best-in-class companies comply with, from an SCM perspective. These are:

- **Strategy driven -** These organisations have a clearly established strategic management landscape, which monitors threats and opportunities to the organisation at regular intervals. Strategies are then adopted or aligned in an agile and responsive manner.

- **Scalability -** There is in-depth understanding by the leaders of the organisation of the entire supply chain and how its success impacts on the organisation at large.

- **Analytical -** There are systems in place that collect, analyse and report on large data sets, which are obtained from each part of the supply chain in a proactive manner. This enables the organisation to quickly and effectively react to threats or opportunities in the business environment.

- **TCO -** The organisation understands its cost structures and the levers available to them to contain and optimise on spend.

- **Holistic -** Decision making processes are based on the availability of real time, reliable data. When decisions are made, the impact on the entire organisation is determined.

2.3.9.5 Characteristics of best practice supply chain management

Companies desiring to increase market share should focus on continually improving their supply chain system until it becomes best of breed (Wahdan & Emam, 2017:137). Companies that excel at this create competitive advantage over their competitors and tend to dominate the market in that specific industry (Bratic, 2016:2). The question is thus: What do best practice or best of breed supply chains entail? According to Cecere (2014), there are seven characteristics that distinguish a best in class supply chain, i.e.:

- There is targeted **leadership** with each element of the supply chain, which is empowered to make decisions in respect of the supply chain's success.

- Optimisation of the supply chain is executed using an **outside-in approach**. There are strong analytical systems that monitor and measure the macro environment of the organisation. Decision making to adapt to market forces is then institutionalised to adapt to market requirements, rather than to internal beliefs. The focus is thus to quickly and effectively identify changing market conditions and adapt to it in an agile way.

- The focus is on employing the **right people and resources**. These chains acknowledge that by employing people with a higher level of skill, a competitive advantage is achieved.

- **Supply chain design** is a core activity that contributes to the success of the supply chain. Therefore, organisations spend considerable resources and time on ensuring that the supply chain is sound, that it responds to customer demands, but that it is also cost competitive.

- Real time data availability and the analytics supporting this requirement is core to decision making processes. There is thus a greater focus on **planning** and responding to market requirements.

- The availability of real-time data enables management decision making systems through aligned and **integrated metrics**. The performance of the supply chain can be monitored continuously, which supports effective decision making.

2.3.10 Supply chain cost

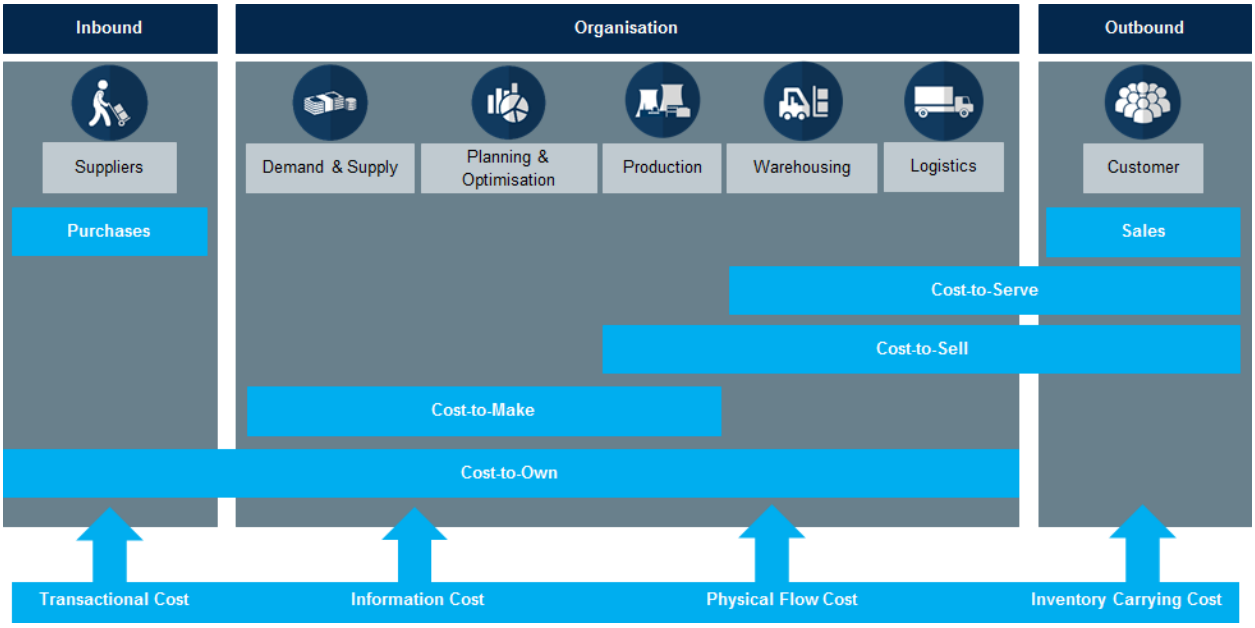
Trent and Monczka (2003:3) state that competing effectively in the market depends on the organisation's ability to implement programs and systems to identify, manage and reduce supply chain cost.

Cost optimisation in the organisation does not reside in individual activities or functions, but rather in the broader supply chain. This implies that when continuous improvement initiatives are implemented, the impact of these must be considered across the entire supply chain. Failure to do this will only result in shifting cost to the other elements of the supply chain. Organisations that want to reduce their supply chain costs should thus have a system in place to thoroughly test new initiatives across the entire supply chain. There is a cautionary message to be given with the implementation of new systems and processes, however: this does not necessarily result in value add in the supply chain.

Measuring supply chain costs accurately in a real-time context is extremely difficult and, to a large extent, impossible from a reliability perspective, without the adoption of technology-based platforms that have the ability to capture and analyse big data continuously throughout the various supply chain processes.

Supply chains attract four major types of cost, which translate into the total cost of ownership (TCO) of the chain. Figure 2-6 provides an overview of the leading and lagging costs within supply chain management, which should be monitored by sophisticated accounting and analytical systems.

Figure 2-6 Types of supply chain cost



Adapted from Christopher (2016:29 - 31)

2.3.11 Supply chain technology

According to Jadhav (2015:369 - 379), the role of technology in the wider supply chain context is to act as an enabler of greater effectiveness and efficiency. A report issued by DHL (2015:4) states that for organisations to stay relevant and competitive, they should adopt new technologies quickly and cost effectively. Schrauf and Berttram (2016b:6) state that digital supply chains have a number of core elements that enable the individual components of the digital platforms to integrate and collaborate with one another. There are various ways in which the implementation of technology or the digitalisation of the supply chain creates value for the organisation. However, DXC.Technologies (2017:3 - 6) group these value generators into five main categories, namely:

- Digital supply chains **improve revenue** owing to their ability to rapidly and accurately respond to changing demands.

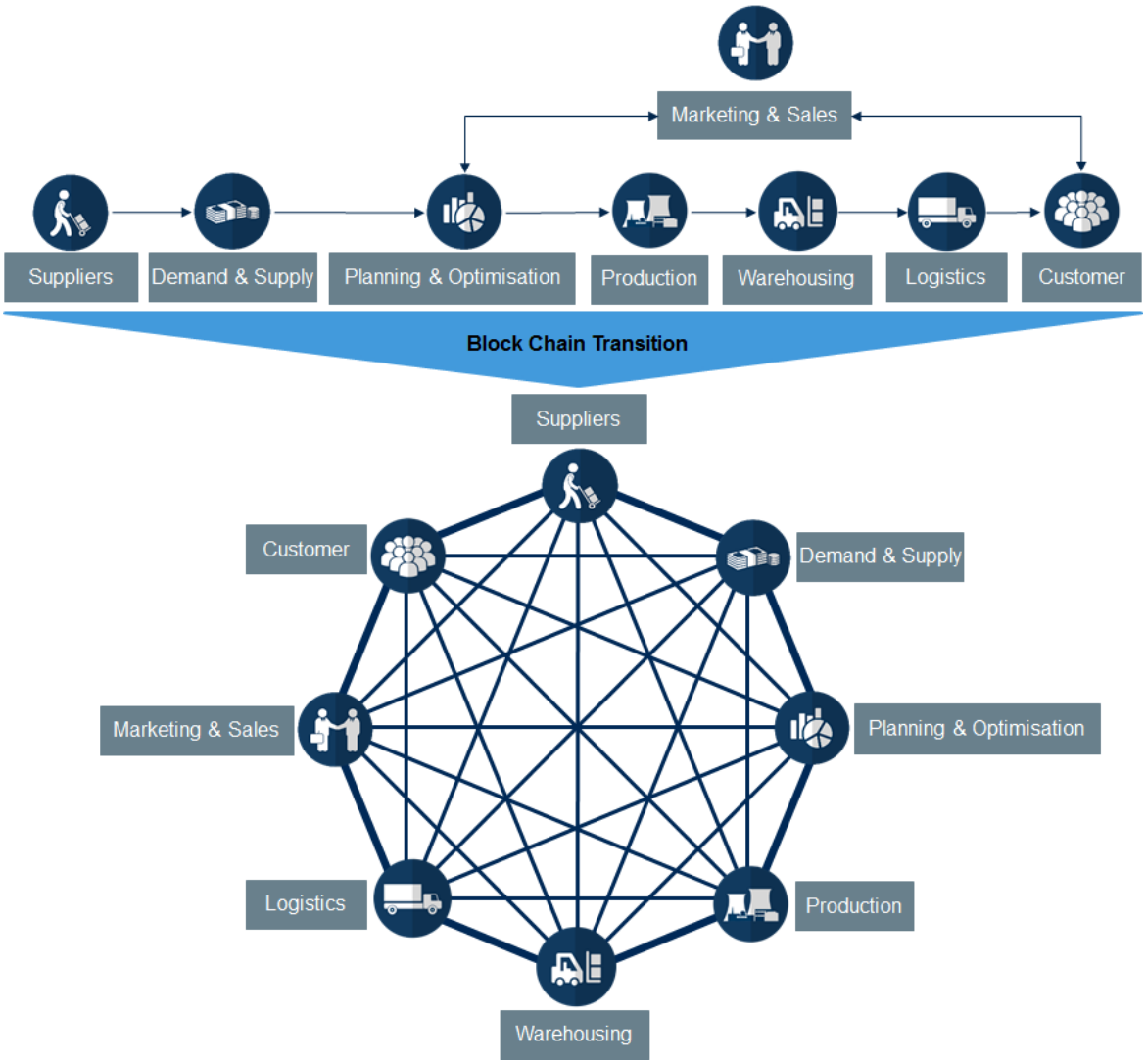
- Digitalisation creates **flexibility** due to end-to-end integration of processes.

- Clear audit trails of all activities exist, enabling **transparency** and **traceability** across the supply chain.

- Built in protocols, rules and procedures enable a higher degree of **security**.

Columbus (2017) found that supply chain technology can be layered within the organisation, with each layer fulfilling a unique purpose, but with all being dependent on one another to ensure the digital success of the supply chain. Figure 2-7 provides details on the different layers and the typical technology applications utilised in each layer. The use of block chain technology in SCM enhances SCM performance substantially, by leveraging the full capability of the supply chain network (Brody, 2017:4). Block chain technology will completely reshape and redefine the way in which processes and systems operate in the supply chain (Tipping & Kauschke, 2016:12). Figure 2-7 illustrates the evolution from a conventional supply chain model to a block chain-enabled supply chain.

Figure 2-7 Block chain transition model



Adapted from Kehoe *et al.* (2017c:6)

Through the implementation of block chain technology in the supply chain, the organisation can transition from a linear flow system to an integrated and collaborative supply chain flow system (Francisco & Swanson, 2018:4). Kewill (2014:4) cautions that the success of an integrated supply chain model is based on its ability to collaborate effectively and transparently. This can only be brought about by a strong technology-enabled ecosystem and interconnecting the individual pieces of technology by means of an Internet of Things (IoT) network (Laurent *et al.* (2017b:23). According to IBM (2017:2), there are two main benefits for organisations that implement block chain technology. Firstly, the technology is extremely trustworthy, as transaction decisions are decentralised. Secondly, it establishes a secure, integrated and continuous network of information sharing between the various partners in the supply chain.

In his report on the disruptive nature of block chain technology, Brody (2017:4 - 5) indicated that block chain-enabled supply chains provide a competitive advantage over their rivals. He further states that a block chain-enabled supply chain is able to address the following issues in the supply chain:

- It creates **more visibility** in the procurement process to negotiate better purchasing terms and to highlight areas of possible cost saving.

- **Data analytics** capability makes the business more responsive and proactive in reacting to changes in the procurement environment.

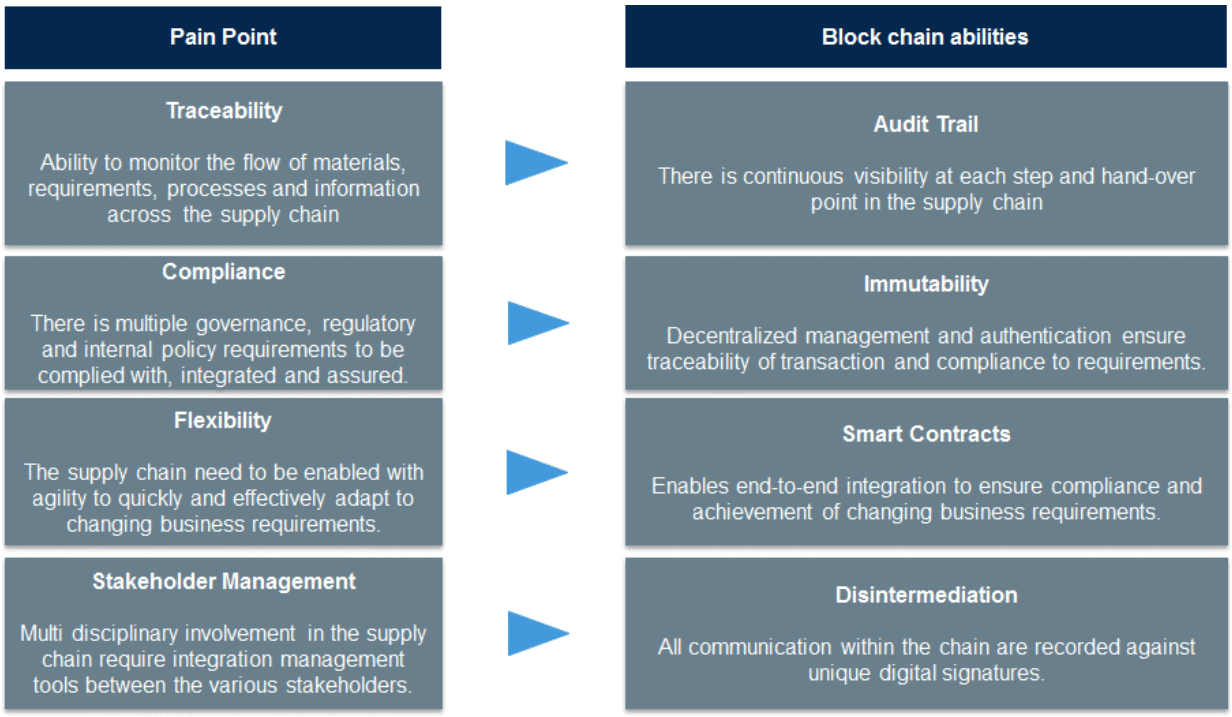
- It enables end-to-end **digitalisation** of contracts and payment of goods and services, which eliminates ambiguous, time-consuming and red-tape driven processes.

- The organisation can implement **smart contracts** that integrate the end-to-end procure-to-pay process. This means that supplier performance can be monitored and controlled more effectively.

- It largely eliminates the **risk** of fraud in the supply chain, due to its decentralised confirm-and-approve capability.

Kehoe *et al.* (2017b:2) states that some of the major pain points experienced in the global supply chain context can be addressed with the implementation of block chain technology. Figure 2-8 illustrates the transition from conventional ledger operations to block chain enabled networks.

Figure 2-8 Block Chain Abilities



Adapted from Kehoe *et al.* (2017d:3)

Technology in SCM is a key enabler of creating competitive advantage in a volatile business environment (Harnowo, 2015:16). Laurent *et al.* (2017a:6) argue that supply chain technology that is not digitally fused or interconnected will not yield the anticipated results. This implies that technology that is implemented in functional isolation will create issues for the supply chain, as opposed to solving the problems of the pain points identified.

Machado and Shah (2015:17) state that digital fusion can be facilitated by the implementation of IoT in the supply chain. According to Braun (2016:3), IoT is the integration of various systems, sensors and networks into a single eco system that receives, dissects, reports and make decisions on multiple aspects of the entire supply chain. Raj and Sharma (2014:2) state that transitioning SCM into a cloud-based operating system means taking a leap into new competitive advantage opportunities. In essence, a

cloud-based supply chain enables mobility of supply chain visibility on any device interconnected with the cloud.

Cloud computing is based on software as a service (SaaS) principles that act as an integrator between the various devices. According to De Mattos and Laurindo (2015:81), SaaS platforms transcend the meaning of supply chain integration, as channel partners can become cloud participants in free-sharing information and data in a real time context. De Donato *et al.* (2017:2) state that a lethal combination that will catapult SCM firmly into the 4th Industrial Revolution, is combining and integrating Saas and IoT.

Dhumale *et al.* (2017:787) define IoT as a collaborative and integrative system that interconnects signals and data from physical and information flow sources across the width and breadth of the supply chain. The pre-requisite for IoT success is the installation of smart sensors across the detailed processes of the supply chain (Fitzgerald *et al.*, 2018:4). IoT enables the various individual components to interact, influence and learn from each other, in order to ensure visibility and deliver reliable data that will drive supply chain optimisation (Alexander *et al.*, 2016:11).

The vast amount of data generated through the SaaS and IoT introduce a new type of complexity into the supply chain, as human beings will not be able to quickly and accurately analyse the various data points. Klumpp (2017:18) states that the introduction of analytical artificial intelligence (AI) systems will eliminate the problem of data interpretation complexity and will provide users with human-friendly data outputs that can be utilised for control and decision making. Nones *et al.* (2017:4) defines AI as an electronic system that mimics human capabilities and thought processes, as it is able to analyse data autonomously and make decisions about it. AI has the potential to analyse, compare and learn from data trends, which, in turn, enables predictive failure identification.

2.4 Types of supply chain management models

An SCM model is regarded as a management system that consists of various tools to integrate, optimise, coordinate and monitor the various parts of the supply chain in order to create value for the organisation and its stakeholders.

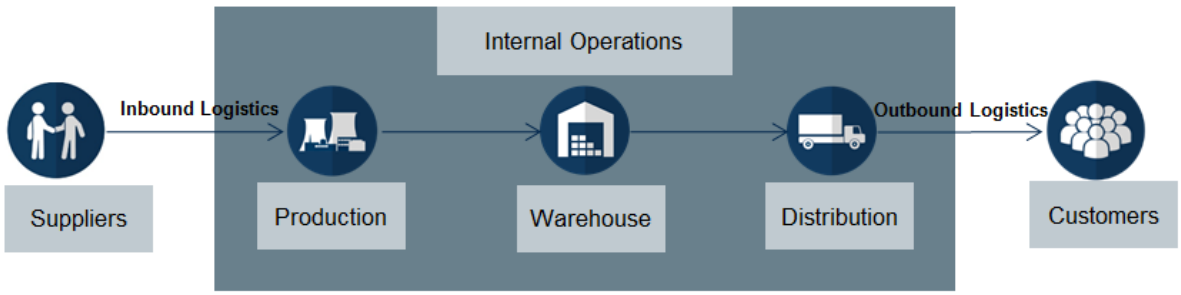
In the pursuit of developing a best practice supply chain model, it was necessary to understand the functioning and limitations of the various types of models available to industry. The following section will briefly identify and elaborate on the most popular models used.

2.4.1 Integrate make-to-stock model

The integrated make-to-stock model is a traditional type of supply chain model, the aim of which is to produce material to be put into storage based on forecast demand volumes for the product. These models are also referred to as “push” systems, as production pushes the product into the market, irrespective of whether there is a fixed and confirmed demand for the product.

There has, however, been significant improvement with this model, in that the integration of systems, processes and customer demand allows for more accurate planning and forecasting of production volumes, which results in lower inventory on hand (Network, 2016).

Figure 2-9 Integrated Make-to-Stock Model



Adapted from Subramaniam (2016)

The main benefits deduced from the make-to-stock model are that the organisation is directly enabled to determine the amount of stock to be kept in the W/H, irrespective of specific customer demand requirements. This enables the organisation to have sufficient stock to replenish most of its important orders.

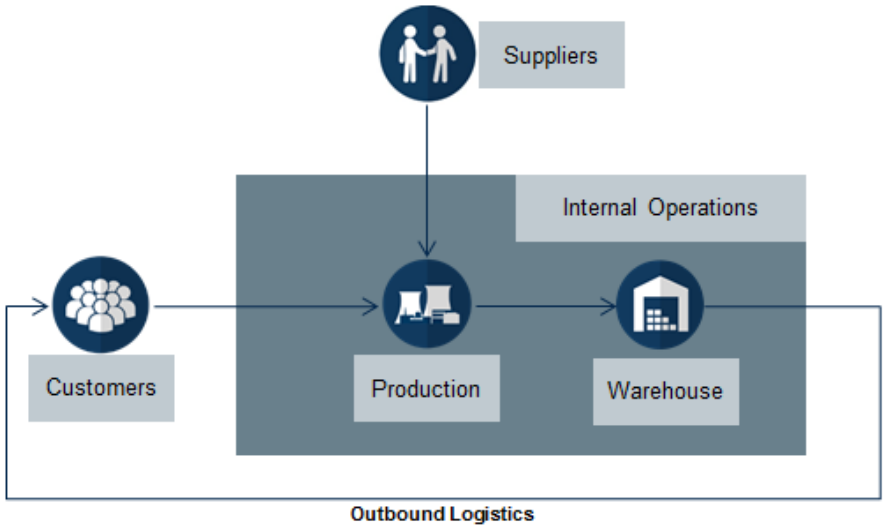
The downside to this, however, is that the working capital of the organisation increases sharply, due to inventory on hand that is not generating income for the organisation (Zuyderduyn, 2011).

2.4.2 Make-to-order model

As the name implies, with this model, products are not produced until a fixed and firm order for the product has been received from the customer. These types of models are efficiency driven, as lead time management is the imperative metrics for the determination of organisational performance.

The concept of Just-in-time (JIT) becomes a relevant aspect in ensuring OTIF is achieved with each order (Dillard, 2014). This type of supply chain model is also referred to as a "pull" model, in that production is dictated by demand requirements.

Figure 2-10 Make-to-order model



Adapted from Ptak and Schragenheim (2016:88)

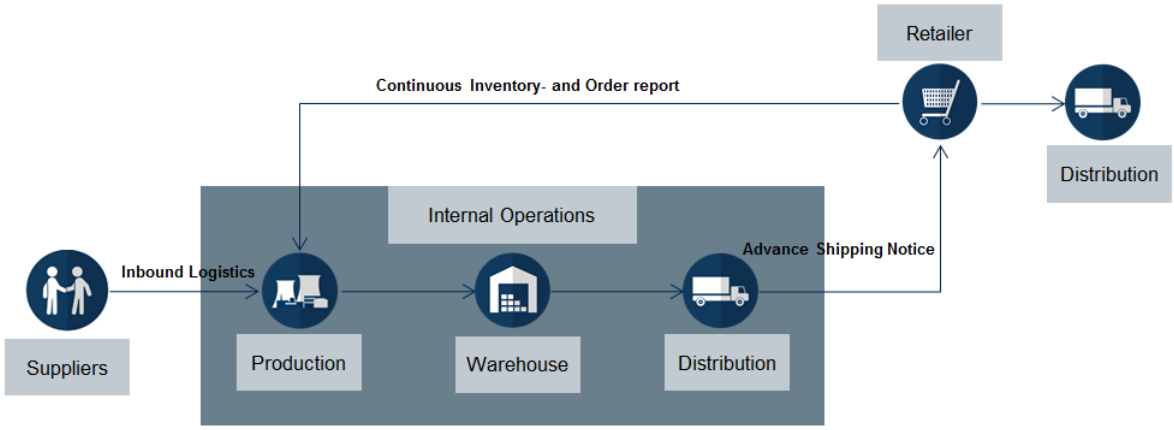
Bender (2015) states that the make-to-order supply chain model has two major benefits. Firstly, the quality of the product is substantially higher than with conventional supply chain models, as the product is customised to meet the customer's unique requirements. Secondly, the working capital of the organisation is conserved, as there is no need to hold surplus inventory.

She proceeds to caution that there are also risks with the implementation of this type of model, in that the organisation might not be able to deliver the ordered product on time, which will result in penalties or a loss of market share

2.4.3 Continuous replenishment model

One model is based on a continuous flow of information between the retailer or distribution centre (DC) and the production unit. The retailer or DC will inform the producer of actual sales made and the balance of inventory in its storage facility. The producer will respond by distributing the required material in the required volume to the retailer or distributer. This concept is based on lean principles, in that the material rarely requires extensive storage or handling interfaces (Imaoka, 2014).

Figure 2-11 Continuous Replenishment Model



Adapted from Gattorna (2015:24)

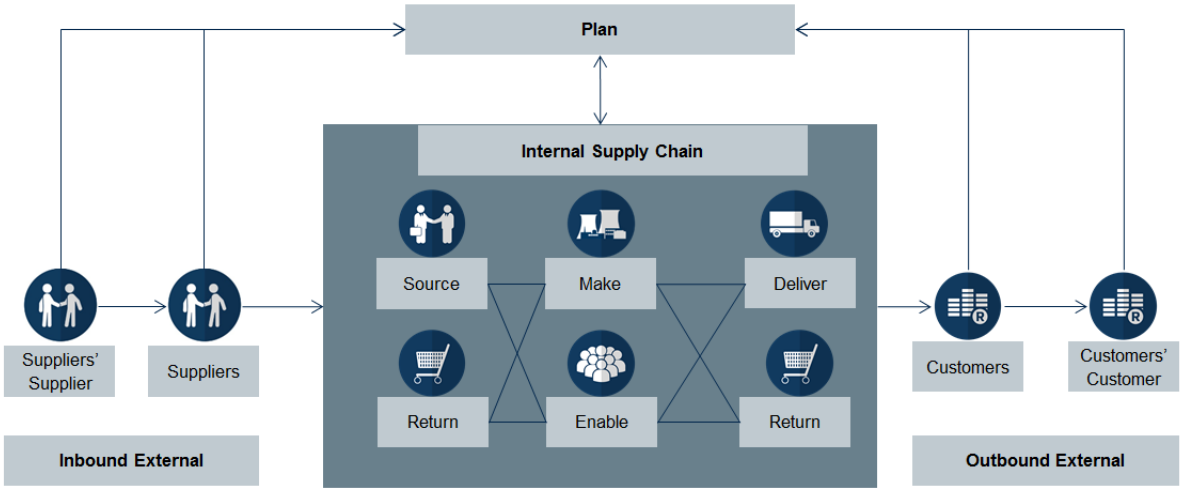
The Supply Chain & Operations Interest Group (2014) states that the main benefits of this model relate to: improved inventory flow, reduced inventory holding and improved customer service levels. However, the downside of the modelis its inability to effectively control logistics cost, due to the increased material delivery frequency.

2.4.4 SCOR model

The Supply Chain Operations Reference Model – SCOR – is a type of management system that is employed to control activities and communication within the supply chain. This model is different to the other models included here, in that it was developed for multi-industry implementation and the primary focus is on generating a deeper understanding of customer demands.

Figure 2-12 depicts the flow of processes and information in a SCOR supply chain system. From the diagram, it can be seen that SCOR is quite similar to the previous models explained. The main difference is that a lot of emphasis is placed on both supplier and customer relationships to ensure there is a reliable supply of inputs and of demand for products.

Figure 2-12 SCOR Model



Adapted from Palma-Mendoza (2014:636)

According to Lepori *et al.* (2013:424 - 429), implementation of the SCOR model in organisations results in both benefits and limitations for organisations, which should be properly understood prior to implementing the model. The major benefits and limitations of the model are depicted in the comparison table below

Table 2-1 Benefits and limitations of SCOR

Benefits	Limitations
Enables standardisation between SCM components.	Mapping of processes on level 3 might not be practically implementable. Lack of shop-floor capability.
Built-in provision for matrices of performance management.	Inability to change standardised process names in the model.

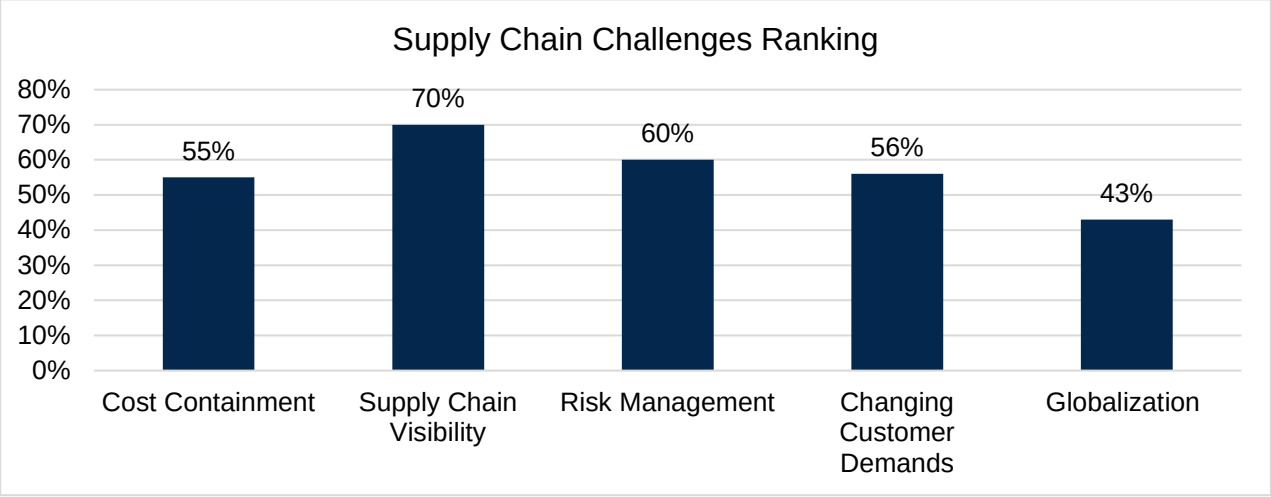
Establish a standardised methodology across the supply chain.	There is no template to map level 4 operational processes.
Assist with the modelling of work processes on multiple levels.	Most of the matrices might not be applicable to specific organisations.

Source: De Barros *et al.* (2015)

2.5 Supply chain management challenges

Due to its wide span of control, multi-disciplinary functions and impact across the entire spectrum of business operations, SCM is complex in nature, which makes it difficult to align actual operations with desired performance expectations. Supply chain strategies developed in isolation will result in the neglect of critical business constraints and will not be effective in addressing the strategic objectives identified. Supply chain design is perhaps one of the most difficult aspects of any business, in that it is impossible to predict with exact certainty whether the final design will achieve the objectives it was intended to achieve. The main reason for this is the various interactions and hand-over points in the supply chain. Uncertainty and risk is perhaps the leading cause of failure of supply chains. There are various types of risks that affect the supply chain and to control each of these with exact precision and certainty is an almost impossible task. There are several major challenges that impact on effective SCM. The model shown in Figure 2-14 illustrates these challenges and the significance of each on supply chains across the globe.

Figure 2-13 Major supply chain challenges



Source: Garcia and You (2015)

According to Figure 2-14, the two major challenges for organisations are visibility across the entire supply chain, followed by the management of risk. With specific reference to the chemical industry supply chain, Elwine (2016:1 - 13) indicates the following noteworthy challenges:

- The **external influences** on SCM will escalate with increasing pressure. Responsiveness to this influence in an agile manner will distinguish the best of breed supply chains from the failing supply chains.

- Increasing **upstream changes** will require organisations to become more flexible with their order-to-cash process management methodology.

- The **availability of critical feedstock** is becoming strained, due to competitive forces in the feedstock market. An example of this is the impact on low crude oil prices from the competitive strategy used by Saudi Arabia to ensure market dominance. The focus of the strategy will thus be on alternative types of feedstock and how to source these.

- The **globalisation** of most organisations' operations in the chemical industry requires that processes and procedures are re-evaluated and aligned to local operations, but using globalised thinking and operating methodologies.

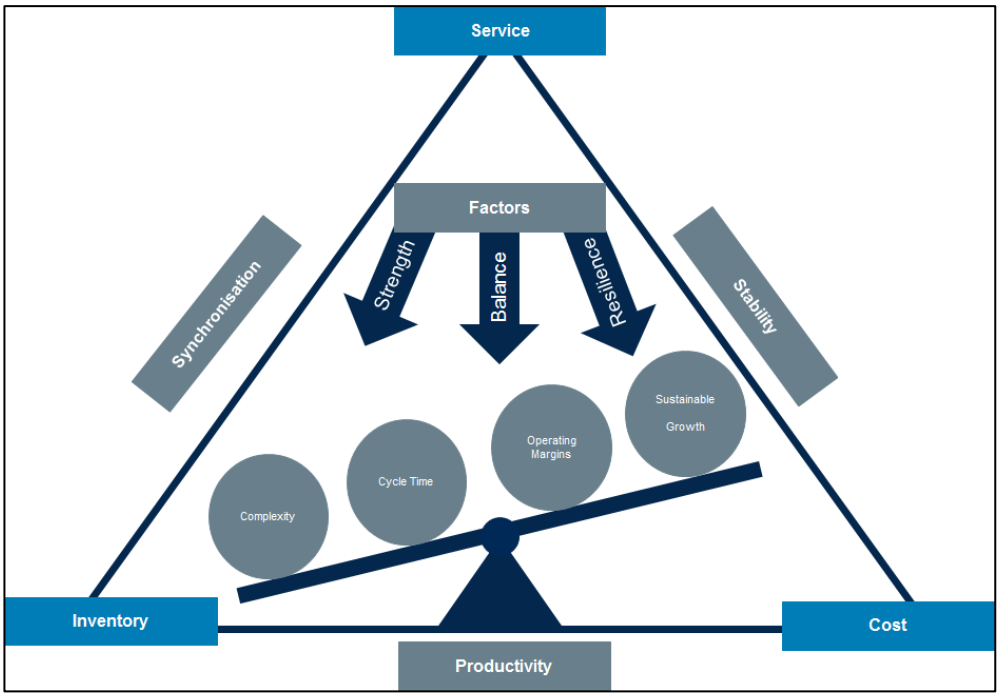
2.6 Supply chain management strategy

Hines (2014:3) states that the key to success of a supply chain strategy resides in its ability to improve visibility, velocity, variety and volume, whilst reducing variability at the same time. Veldhuijzen *et al.* (2012:13) stress the importance of supply chain visibility, because an effective supply chain requires constant balancing of the forces that continually threaten its equilibrium. In a study that included 623 professionals in 17 countries, it was found that end-to-end supply chain visibility was only present in 6% of the study results. Complexity in the make-up of SCM forces organisations to digitalise their supply chains as a foundational building block for transparent visibility across the chain (Handfield, 2016:9). Ahimbisibwe *et al.* (2016:43) states that supply chain velocity can only be increased through the alignment and integration of end-to-end processes.

Given its resources and capabilities, an organisation cannot be everything to everyone. The organisation should be able to clearly understand its resource constraints when deciding on product and services portfolios, before increasing the variety of product offerings to customers. According to Chavez *et al.* (2017:906) the main driver of product volumes to be produced and held by the organisation should be directed by customer-centric customer demand and the type of supply chain strategy that is suitable to serve the needs of each customer segment. The quickest way to introduce complexity and misalignment in a supply chain is through variability of systems, processes and people. Vanpoucke *et al.* (2017:260) suggest that effective supply chain management is based on its ability to reduce variability through standardisation, integration and collaboration between systems, processes and people.

There are three critical interrelated elements in SCM, namely, service, cost and inventory; when kept in balance, stakeholder value and sustainable growth is created. Figure 2-15 is an iteration between the supply chain triangle and the supply chain index; it can be utilised as a foundational directive model for selecting integrative and holistic supply chain strategies.

Figure 2-14 Supply Chain Triangle



Adapted from Cecere and Mayer (2014:7) and Klug (2013)

The effectiveness and efficiency of a supply chain is determined by the strategies developed and implemented for the purpose of continual optimisation of SCM practices. In order to ensure that the supply chain strategy selected is both relevant to the organisation and executable in terms of performance yield, it is important that the strategies encompass several critical elements that will ensure its success. The elements referred to are discussed in the following sections (Ideas, 2017).

The strength, balance and resilience of supply chain management is directly attributed to the maturity of the supply chain in comparison with credible benchmarks in similar industries. Mature supply chains result in reduced complexity, improved cycle times, increased operating margins and sustainable growth for the organisation and its stakeholders.

The effectiveness and efficiency of a supply chain is determined by the strategies that is developed and implemented for the purpose of continual optimisation of supply chain management practices. In order to ensure the supply chain strategy selected is both relevant to the organisation and executable in terms of performance yield, it is important that the strategies encompass several critical elements that will ensure its success. The elements referred to shall be discussed in the following sections (Ideas, 2017).

2.6.1 Leverage

Studies have shown that leveraging in SCM is not an appropriate strategy, in that it interferes with constructive supplier relationships. However, Ericksen (2015) (from Industry Week) contests this statement, by suggesting that leveraging does not always need to be a win or lose situation – it can be a mutually beneficial process that can advance the interests of both the organisation and its supplier base. The trade relationship can be beneficial through leveraging in two main ways. Firstly, leveraging can create economies for the supplier, resulting in lowering of the cost of goods manufactured. This results in a direct cost benefit to the organisation through order quantity discounts. Secondly, by classifying most supplier products as commodities, homogenous order buckets can be created, with supply and demand variables dictating the price, rather than normal trade principles.

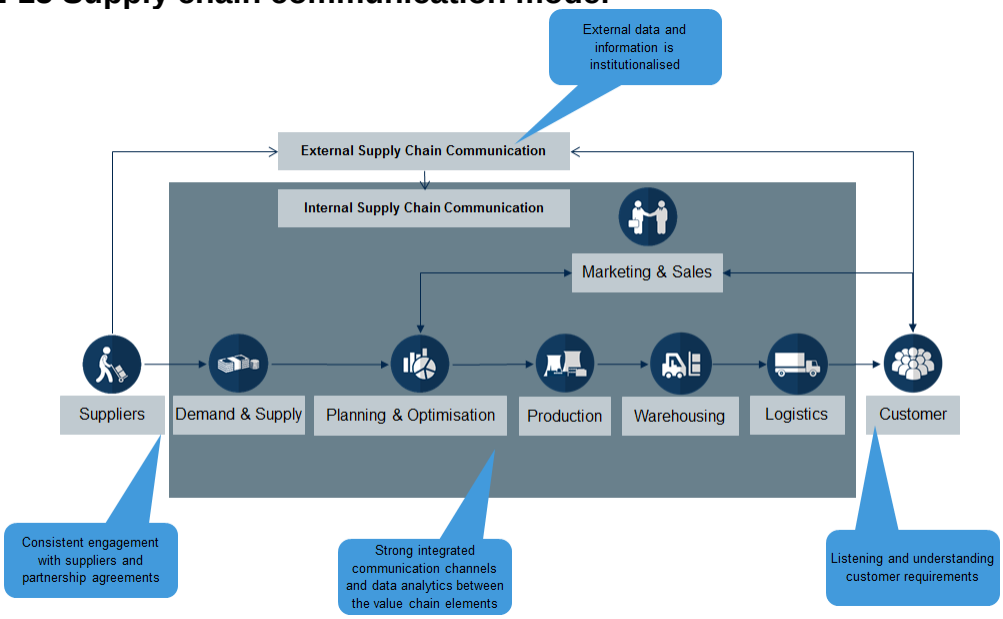
Effective leveraging is based on a negotiation process that is mutually beneficial to both the organisations and the supplier (Zimmermann *et al.*, 2015:2 - 3). Should the

organisation opt to implement a domination leverage strategy, in which suppliers are disadvantaged, the organisation will increase its operational risk because it does not have healthy relationships with its suppliers, which might affect the constant and reliable supply of critical raw materials required for the production process (Verweij & Peek, 2013:35).

2.6.2 Communication

The term 'supply chain' refers to a chain of interrelated components and elements that collectively ensure that the key objectives of the function are achieved (Jaradat *et al.*, 2017:5). A popular saying in society is, "*A chain is only as strong as its weakest link*" and this reveals a lot of truth, as well as the implications for supply chains. Should an issue or gap in the organisation's supply chain occur, it will result in operational inefficiencies and the inability of the supply chain to generate the value it was designed to provide to the organisation. According to the Oxford College of Procurement and Supply (2017), effective communication is critical to the success of a supply chain, in that it enables the integration of work processes and facilitates optimisation between the various links in the supply chain and its stakeholders. NRG Systems (2011) indicates that organisations that effectively create clear and conspicuous communication channels between the links in the supply chain and the external stakeholders are more likely to succeed and create value for the organisation. Figure 2-16 depicts a high-level communication channel between the various supply chain functions, which directs the flow of preferred information.

Figure 2-15 Supply chain communication model



Adapted from Khan *et al.* (2014:548)

2.6.3 Efficiency

Perez (2013) argues that the focus of efficiency in SCM is perhaps the most important strategy in which organisations should invest time, effort and resources. Efficiency in SCM results in reduced cost and improved work process flows, and, most importantly, it enables the organisation to react and adapt to competition in the market (Ivanovska & Kaleshovska, 2013:318). This can be brought about by focusing on the two main elements of efficiency. Firstly, the organisation should endeavour to utilise its asset and resource base optimally and effectively. The organisation should have programs in place to identify and monitor sources of waste and put pro-active control measures in place to prevent any impacts on the organisation as a whole. Secondly, there should be systems in place to continually analyse critical organisational information, so as to ensure increased demand and supply forecasting that will ensure that perfect order fulfilment (POF) is achieved.

2.6.4 Innovation

The manufacturing industry, in general, is plagued by constant competition for market dominance and market share. Thus, a prerequisite for supply chain success is that organisations invest in programs to continually innovate, in order to become more cost competitive and robust in their operations (Stank *et al.*, 2013:50 - 51). However, Rice (2016) caution organisations against using innovation as a main supply chain strategic driver.

Although innovation can provide a competitive advantage, it also increases risk in the organisation, as the innovation might fail, resulting in operational disruption and financial loss. Organisations should follow an aggressive approach with their innovation strategies; however, they should have a well-defined analytical capability, in order to determine the likelihood of implementation success and mitigate any risks that might arise from the proposed innovation. It is further proposed that innovation strategies should not be utilised in isolation, but rather in combination with other supply chain strategies.

2.6.5 Risk Management

SCM has a footprint in most of the organisation's processes, and undoubtable attracts risk to the organisation. According to Lawton (2016), there are five types of supply chain

risks to the organisation, as indicated in Table 2-2. The typical mitigating action that the organisation should consider to prevent any negative impact is also detailed.

Table 2-2 Types of supply chain risks

Type of Risk	Description	Typical mitigation actions
Strategy Risk	The incorrect strategy is utilised to optimise and grow the supply chain.	The organisation should have accurate market intelligence prior to formulating its objectives.
Market Risk	Incorrectly outsourcing to 3 or 4 PL providers might expose the organisation to unnecessary supply risk.	The most suitable operations strategy should be selected, in accordance with the organisation's market and the product that it sells.
Implementation Risk	Projects implemented might not yield satisfactory results, resulting in operational disruption and financial loss.	Models and programs should be in place to determine the feasibility and executability of projects.
Performance Risk	Suppliers to the organisation might not deliver critical input materials required for production.	The organisation should invest in SRM programs and have supply agreements in place with critical suppliers.
Demand Risk	The demand for the organisation's final products might decline.	Alternative product strategies should be developed and a program implemented to continually source new demand for the products.

Source: Brindley (2017:90)

Kilubi (2016:604 - 629) states that organisations that do not define strategies to mitigate supply chain risk are exposed to and at the mercy of market forces and competition - therefore, they are bound to fail.

2.6.6 Continuous Improvement

SCM is conventionally structured around work processes, with assets and resources being coordinated to progress from one step in the chain to the next. These work processes are plagued by continuous inefficiency issues and are at risk of becoming irrelevant as business imperatives and market situations change.

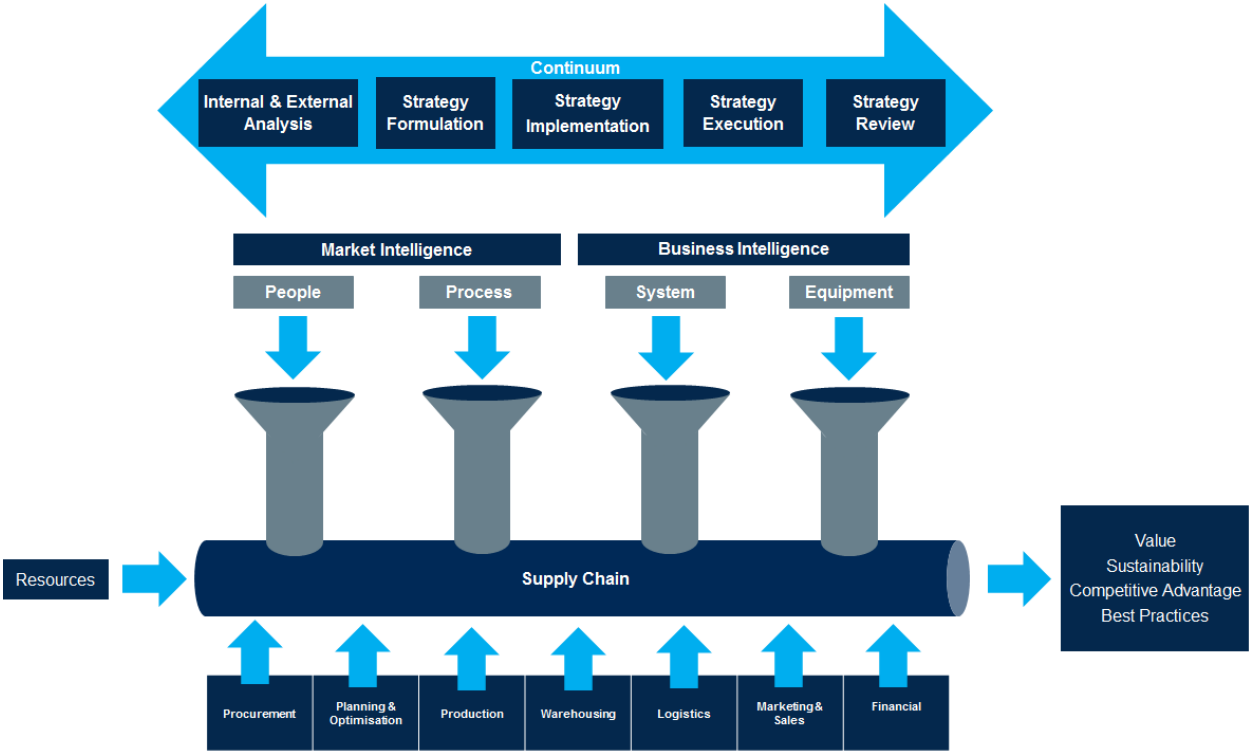
Prado (2009:301 - 309) observes that companies that invest in continuous improvement programs for their supply chains not only improve in terms of critical performance indicators, but also create sustainable competitive advantage. It is thus deduced that continuous improvement of work processes determines the success of the supply chain.

2.7 Supply chain strategy process

Supply chain strategy should be approached utilising a phased and structured approach, in order to ensure that front-end loading of selected strategies is executed holistically. Culey (2018:47) states that organisations regularly fail in their supply chain strategies for the simple reason that they do not understand or disseminate customer requirements and failure modes.

He further states that, prior to innovating a supply chain process, the organisation must be able to control failure modes effectively, which can only be achieved if the failure mode is properly understood. Figure 2-17 provides a graphic representation of a typical structured approach used in setting value-driven supply chain strategies.

Figure 2-16 Supply Chain Strategic Process



Adapted from Roh *et al.* (2014:201)

2.7.1 Types of supply chain strategy

According to Ambe and Badenhorst-Weiss (2012:13392), selection of an appropriate supply chain strategy is enabled by the organisation understanding customer demand signals and having the talent required to ensure the successful implementation and operation of such a strategy. Tarafdar and Qrunfleh (2017:2) indicate that there is no one-size-fits-all strategy that can be applied in the supply chain context: the strategy should be customised for each supply chain, in order to deliver the required service levels to the particular customer segment.

2.8 Supply chain design

Chung *et al.* (2018:13) state that supply chain design in the 4th Industrial Revolution should be dynamic, flexible and responsive to changing customer requirements. Stralin *et al.* (2016:15) indicate that supply chain design should steer away from using waterfall implementation processes, as the disruptive forces brought about by technology advancements require quick and agile solutions to deal with customer pain points. Gattorna (2015:24), supported by Cooper (2017:32), suggest utilising the integrated lean

service development processes as a feasible solution to align with customer requirements through supply chain design.

2.8.1 Supply chain configuration

Rabie (2014:23) states that supply chain configuration entails linking various components and parts of the chain into a continuous system of product and information flows, in an attempt to increase performance output and to meet customer expectations.

Masi *et al.* (2017:18) suggest that SCM performance is established using a closed loop configuration. Sundari and Vijayalakshmi (2016:2786) regard a closed loop supply chain configuration as a continuous circular network that facilitates uninterrupted flow of materials and information between channel partners in a seamless manner.

2.8.2 Integration

Gligor *et al.* (2015:72) indicate that integrated, agile supply chains should be developed as a best practice methodology to compete in the dynamic globalised market place. Supply chain integration should be considered during the design of supply chain processes, in order to narrow the collaborative gap created in the supply chain, brought about by traditional SCM structuring.

The term ‘integration’ is regularly de-emphasised and pitched as an element of supply chain optimisation; therefore, the true potential and real value of integration is largely neglected. The topic of integration is largely ignored, due to the seeming impossibility of implementation, which is brought about by supply chain complexity. The true potential of advanced supply chain integration has become a feasible reality brought as a result of rapid advancements in technology. Technology thus makes it possible to remove the linkages that have been identified throughout this study as the Achilles heel of SCM and which form a seamless interchange of products and services between the various supply chain partners.

2.8.3 Operating methodology

The methodology selected to execute the various supply chain operations can deliver major benefits to organisation. The type and configuration of the operating methodology will largely depend on the type of organisation, the variety of products and the location of the organisation in line with its suppliers and customers. Organisations should be

cognisant of the fact that intense analysis of the organisational supply chain is required, prior to making an operating methodology decision.

Supply chain managers are faced with continual challenges in determining the most effective operating methodology to apply in the supply chain and its individual components. Organisations need to select between in-house, offshore, outsourced or hybrid operating models to ensure optimal operations within the supply chain. The operating methodology will be dictated by the most appropriate measures to serve the customer in a cost-effective manner.

2.8.4 Optimisation

Wight (2013:2) states that continual focus on supply chain optimisation results in increased service levels, reduced cost and competitive advantage. Supply chain optimisation can be vastly improved through fostering a corporate entrepreneurship focus in the organisation.

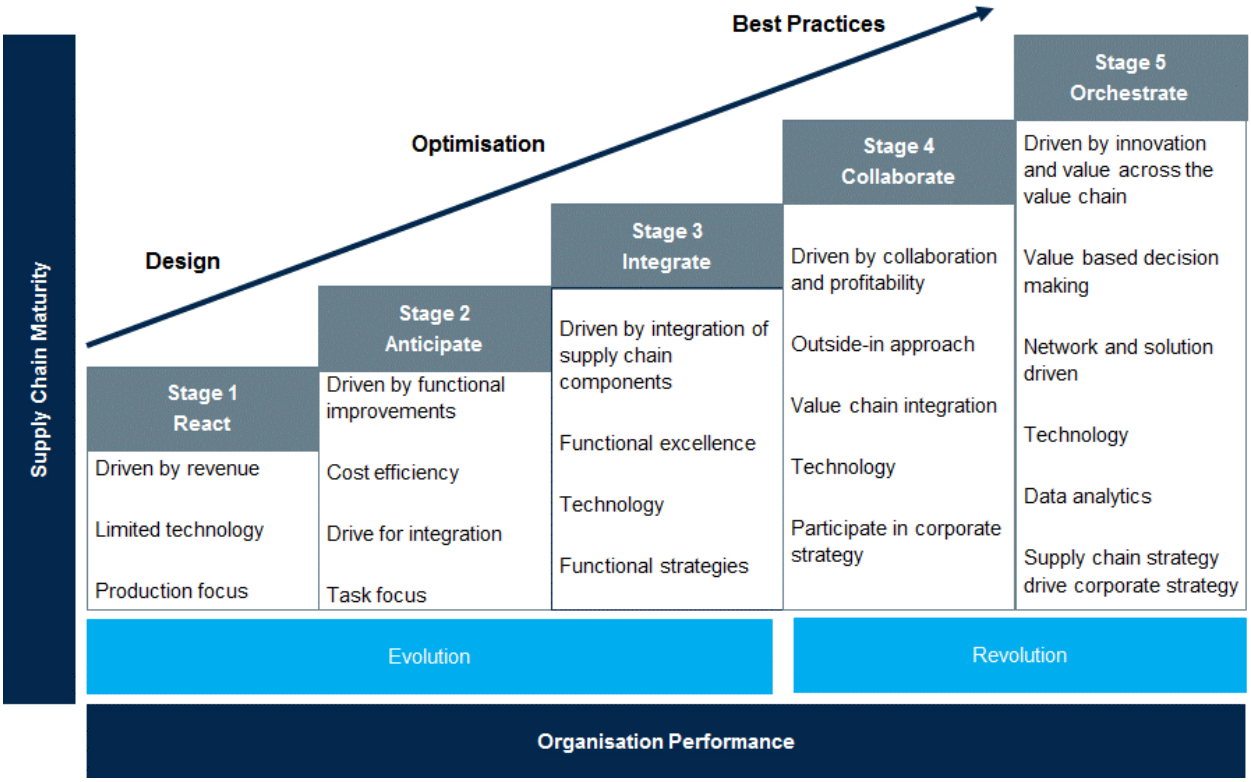
According to (Sakhdari, 2016:8), corporate entrepreneurship can harness the power of entrepreneurial thinking in a business context as an enabling factor to continuous improvement. Batovrina (2017:25) states entrepreneurial thinking is grounded in creativity, innovativeness, direct communication and customer centricity. Hoglund (2015:10) indicate that bureaucratic governance processes and rules will counter the success of corporate entrepreneurial thinking.

2.8.5 Maturity

Rudnicka (2017:203) suggests that supply chain maturity relates to the level of integration and collaboration between the various parts of the supply chain. Organisational growth and performance is directly linked to the maturity of the organisation’s supply chain operations.

According to Suleski and Griswold (2017) (at Gartner), supply chain maturity can be plotted in one of five stages. The model used to do this and the various stages and key focus areas in each of the five stages is depicted in Figure 2-18.

Figure 2-17 - Supply Chain Maturity



Adapted from Suleski and Griswold (2017)

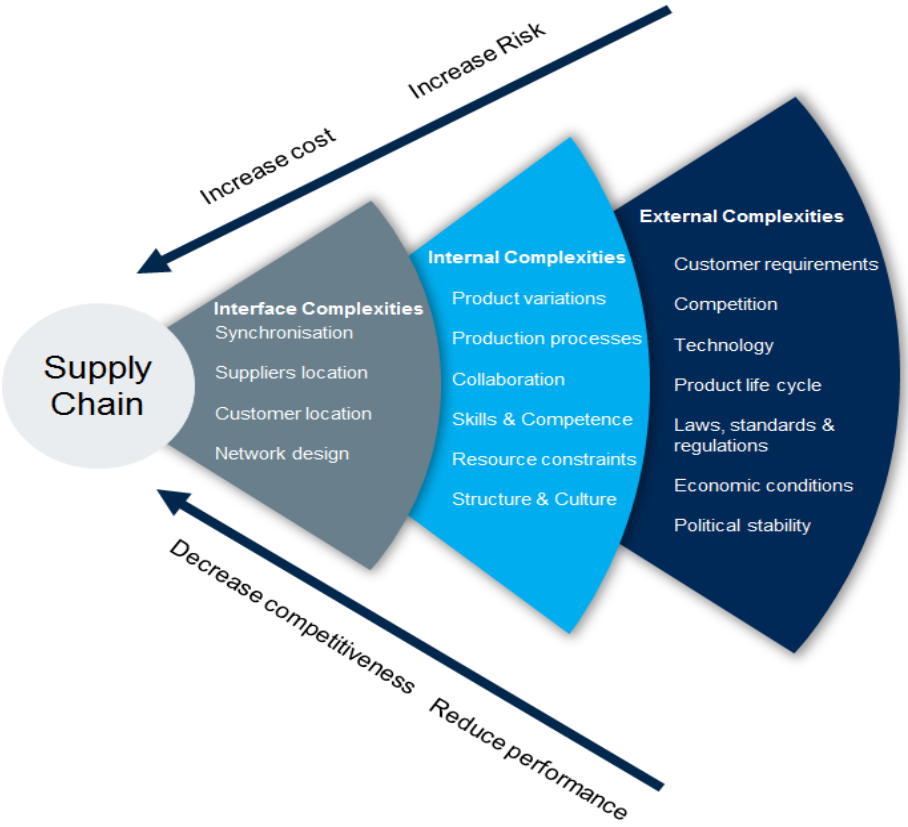
2.8.6 Complexity

Irrespective of the industry, supply chains are complex in nature and this complexity increases as the size and global expansion of the organisation increases. Donofrio and Francis (2016:2) indicate that the main reason for this complexity is that there are various parts, material flows and interactions between the various components of the chain. Piya *et al.* (2017:47 - 49) further established that there are three major complexity drivers in a supply chain. Figure 2-19 depicts each complexity driver and its individual components. Halim (2015:171 - 173) states that inherent supply chain complexities can have a severe negative impact on the success of an organisation, if control measures are not introduced to manage these complexities.

Uncontrolled supply chain complexities lead to: increased cost; elevated risk levels within the organisation; a decrease in the ability of the organisation to compete in the market; and reduced overall performance outputs of the organisation (Kavilal *et al.*, 2014:2 - 3). Filiz (2011:422) argues that supply chain complexity cannot be eliminated, but it can be reduced and controlled to the extent that the systems of the organisation respond to the

complexity - as opposed to using human intervention. Therefore, organisations should peruse strategies to reduce the level of complexity in the organisation.

Figure 2-18 Levels of supply chain complexity



Adapted from Bode and Wagner (2015:216)

2.9 Summary

The literature review has confirmed that multiple reliable and reputable sources exist to provide a value-adding and meaningful conclusion to this study. From the literature review conducted, the following conclusions were reached in relation to the proposed study:

- SCM, as a concept, has evolved substantially over the years and the future success of SCM is entrenched in the use of futuristic technology.

- The characteristics of best practice supply chain models are well defined and researched in the market.

- Well defined best practice benchmark statistics are available for comparable analysis.

- Various supply chain models have been defined, each with their own benefits and limitations.

- The specific supply chain challenges in the chemical manufacturing industry have been identified.

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction

The core focus of this chapter is to elaborate on the empirical research process adopted for this research study. The chapter is sub-divided into four main sections, in order to unpack the empirical journey undertaken comprehensively. The research design was the precursor to conducting the empirical research and acted as a planning blueprint that directed the data collection and analysis processes. The qualitative research methodology was utilised exclusively for the collection of data, using a semi-structured interview process.

Interview data was regarded as the primary data source and was supplemented by various secondary data sources, in order to enhance the depth of the study. The constructivist grounded theory model and ATLAS.ti were applied as directing principles, so as to keep the study grounded during the data analysis and interpretation phases. Lastly, research ethics were adhered to diligently during the research process, in order to ensure that participants were shielded from any negative impact caused by their participation in this research study.

3.2 Research Design

Qualitative research was used as the foundational methodology for this research project. Qualitative research is rooted in ontological and epistemological assumptions that collect and explore various positions and knowledge held within society (Young & Hren, 2017:9). The selection of this research methodology was motivated by the requirement to explore various perspectives of SCM that could support the development of an optimal supply chain ecosystem framework.

A deductive approach was followed during the research process, which allowed for the integration of literature review and empirical sources and so derive a supply chain framework that will add value to the chemical manufacturing industry. The diagram in Annexure A reflects the research design blueprint used as foundational directive in approaching the research study.

3.2.1 Study Population

As indicated in the research topic, the study population was large chemical manufacturing companies in South Africa.

3.2.2 Research Setting

The research setting for this study was Sasol Limited and its group of companies. Primary and secondary research data was collected primarily from the Sasolburg operational site and the Sandton headquarters of the organisation. Scheduled interviews were conducted in the natural work-setting of the participants.

3.2.3 Piloting

A number of test interviews were conducted with randomly individuals employed by Sasol Limited. The aim of the test was to check that participants understood the questions posed, that they could respond in a structured and detailed manner, and to check that the questions posed to respondents would yield the necessary data to allow for meaningful research results to be derived.

3.2.4 Sampling Strategy

The sampling strategy applied in this study was non-probability sampling, using the expert purposive sampling technique (Saunder, 2012). Etikan *et al.* (2016:3) state that expert purposive sampling is a technique used to identify and select participants based on their specific knowledge and expertise of the research topic. SCM is complex in nature and the contribution of this study to the body of knowledge required that participants with the necessary knowledge and experience in this field of study be approached.

Identified subject matter experts were clustered into two categories, namely: discipline-specific participants who are involved in a singular functional role in the supply chain; and cross-discipline candidates, who are involved in the overall design and management of the supply chain.

Purposive sampling required that a set of criteria be developed for use in selecting participants. The criteria identified were that the participant:

- Should be actively involved in the design, operation or management of supply chains;

- Must be in possession of a post-school qualification in the supply chain field of study;

- Should have noticeable experience working directly in SCM functions;

- Have an education background that is relevant to SCM concepts.

Demographic-related questions, testing and ensuring that the criteria listed above was included in the interview schedule and is discussed at a later stage.

3.2.5 Geographics

The units of analysis were situated in the private institution domain. The three main regions of the Sasol Limited operational footprint in South Africa, namely Sasolburg, Secunda and Johannesburg, were included in the frame of this research as possible locations for data gathering.

3.2.6 Unit of analysis

In this study, both a primary and secondary unit of analysis were utilised to enrich the value of the research results. The primary unit of analysis was human participants, who were interviewed utilising semi-structured interview questions. The secondary unit of analysis was documents that were used as a supplementary data source.

3.3 Data collection

3.3.1 Nature of data

The primary source of the data that was collected was one-on-one interviews (face-to-face and electronic conference) conducted with the sample population, who possess the necessary skills, competence and knowledge to contribute meaningful responses to the research questions posed. A two-fold strategy was applied to determine the questions that were to be posed to the participants, in the attempt to achieve the primary research objective. Firstly, a set of questions was designed to determine whether the participant possessed the necessary experience and competence to contribute value to the research

study. Secondly, unstructured, open-ended questions were compiled to dissect and understand the research topic from an expertise point of view. An interview schedule was compiled to elaborate on the questions that were posed to participants during the interview process - see Annexure B. All interviews were voice-recorded and transcribed in English, to allow for data analysis to take place.

To comprehensively explore the research topic selected, secondary research data was collected to supplement the data collected from the various interviews conducted. This included:

- Various reports based on supply chain models, frameworks and characteristics published by reputable sources.

- Previous studies and benchmark assessments done on SCM best practices.

- Statistics based on supply chain indicators of performance.

3.3.2 Data collection process

In terms of the primary interview data, the following collection process was followed to obtain valid and reliable data:

- After obtaining approval to conduct the study, a document of support was sourced from Senior Management and used to secure participants.

- An initial engagement session was conducted with each randomly selected participant, to explain the research being conducted and to provide the context for the interviews to be conducted.

- An interview meeting was scheduled with each participant using Microsoft Outlook and a date and time suitable to the participant confirmed.

- One-on-one interviews were conducted at a time convenient to each participant.

- During the interview, written notes were taken of the responses provided by the participants. In addition, all interviews were voice recorded and transcribed, so as to ensure accuracy and data reliability during the data analysis phase.

- All interview records were stored in both hard and soft copy format.

The secondary data sources were collected by making use of both printed and electronic sources.

3.3.3 Interviews

As the primary method of data collection, interviews were conducted to obtain the research data. Semi-structured qualitative studies (SSQS) involve the completion of interviews in a structured and theoretical manner, while allowing participants to elaborate on their knowledge and experience of the subject and theories, as they are guided by a set of open-ended questions (Zahirovic *et al.*, 2014:2).

Prior to the commencement of data collection through semi-structured interviews, participants were presented with an informed consent form (Annexure C) and were requested to complete and sign the document. The informed consent form was discussed in detail with each participant, to provide the context of the research study and to inform them of their role and responsibilities during the interview process. The input received from participants was recorded for audit trail purposes.

During the interview process, both recorded and written field notes were taken to ensure that all input and discussions were captured accurately and comprehensively. Upon completion of the interview plan, recordings were placed in the ATLAS.ti briefcase, as part of the formal research audit trail. The recordings were transcribed into text documents by a reputable transcription provider. In order to ensure the accuracy and quality of transcription, audio to text verification was performed by the researcher.

A total of 22 interviews were conducted with supply chain managers and specialists. This yielded 621:31:00 minutes of expert data related to SCM gathered for analysis.

3.4 Data analysis

The data that was collected from the interview process was coded, in order to interpret the data in a holistic and reliable manner (research, 2012). To ensure the essence of the data was extracted, so as to allow a reliable opinion to be formed, a phased approached was followed. The data analysis phases that were used were: examination of the data collected; categorising the data into a meaningful bucket system aligned to the research topic; tabulation of the categorised data; and interpretation of the data, in order to reach a study conclusion. The most appropriate qualitative analytics methodology for this research was the grounded theory methodology, as the data that was collected from the various participants was utilised exclusively to identify trends and similarities between the various data sets, so that the data will "speak for itself" (Need, 2017). Each of these phases are elaborated on below, to provide details regarding the research analysis methodology that was applied.

The transcribed records of the interviews conducted were studied to identify patterns in feedback from the participants. Due to the sample size selected and the complexity of the data that was obtained, the use of qualitative data analysis software was required. The use of this software ensured that the essence of grounded theory was maintained, as the software identified patterns in feedback, which were used for coding purposes.

The various software applications available for qualitative data analysis were reviewed, and it was determined that ATLAS.ti would be the most effective and user-friendly solution. The data obtained from the interviews was recorded in the ATLAS.ti database and a trend analysis initiated to identify the data to be categorised. The categories obtained from ATLAS.ti were regarded as raw and unworked data and were further refined by establishing patterns between the categories obtained. The final data categories were placed in buckets to segregate the data in each category from that in other categories. The individual data obtained from the interviews was added to the relevant bucket, in tabulation form, in an attempt to compare the input received from each participant with that received from the others. The final table of information was interpreted and referenced in the final dissertation after reaching conclusions and making recommendations.

The other data sources (i.e. reports, studies, etc.) were collated into bundles that showed similar characteristics. An interpretation of the researched information was captured directly in the dissertation and the credible sources were referenced.

3.4.1 Grounded Theory

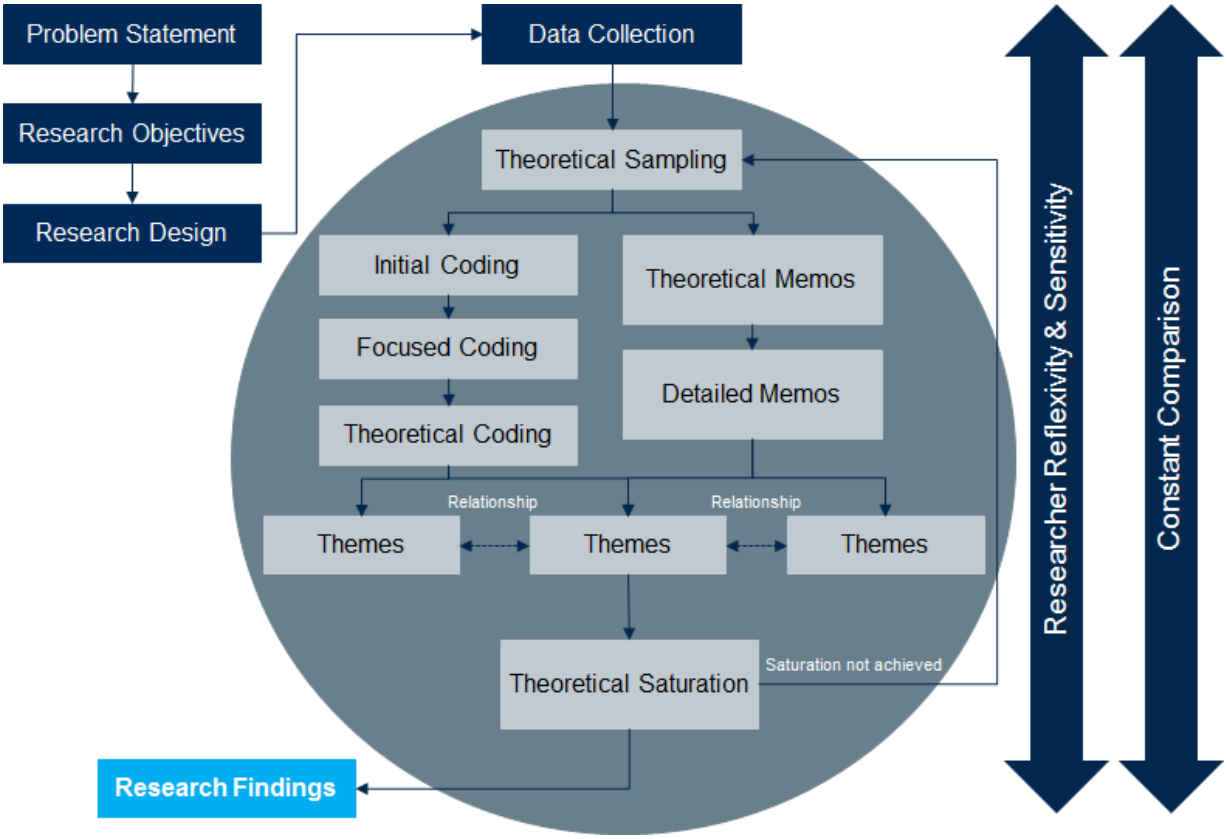
Grounded theory was developed by Glaser and Strauss in the 1960's. It is a qualitative data analysis methodology that utilises systematic and structured methods of linking primary and secondary research data, in order to develop inductive theories from the data (Evans, 2013:37).

In a recorded lecture, Moerman (2016) cautioned about the application of grounded theory. According to Moerman (2016), there are various versions of grounded theory that researchers should be cognisant of prior to selecting the applicable methodology, as there are three main versions of grounded theory, namely: Glaserian grounded theory; Straussian grounded theory; and Constructivist grounded theory. There is a notable difference between the Glaserian and Straussian grounded theories and these theories contradict each other in terms of method and rigor of application and they disregard the researcher as a central and important part of the research analysis process.

Straussian grounded theory follows a structured approach of continual comparison of data sets with one another, with limited allowance for deviation from the set procedure. Glaserian grounded theory suggests an unstructured approach to data analysis and regards all data sources as relevant and applicable. Constructivist grounded theory, on the other hand, proposes a combination of the Straussian and Glaserian grounded theory, but introduces the concept of researcher co-creation during the data analysis process. It also suggests the possibility of generating multiple theories from the data analysis process if it is viewed from multiple angles.

The multi-vocal views of the constructivist theory will ensure that data analysis is approached from multiple viewpoints, where the research focus on stated and implied messages gathered from the primary and secondary research data. Constructivist grounded theory was selected as the primary grounded theory methodology for the research study. The process flow diagram in Figure 3-1 depicts the constructivist grounded theory, which was applied during the data analysis process Kenny and Fourie (2015:19).

Figure 3-1 Constructivist Grounded Theory Process



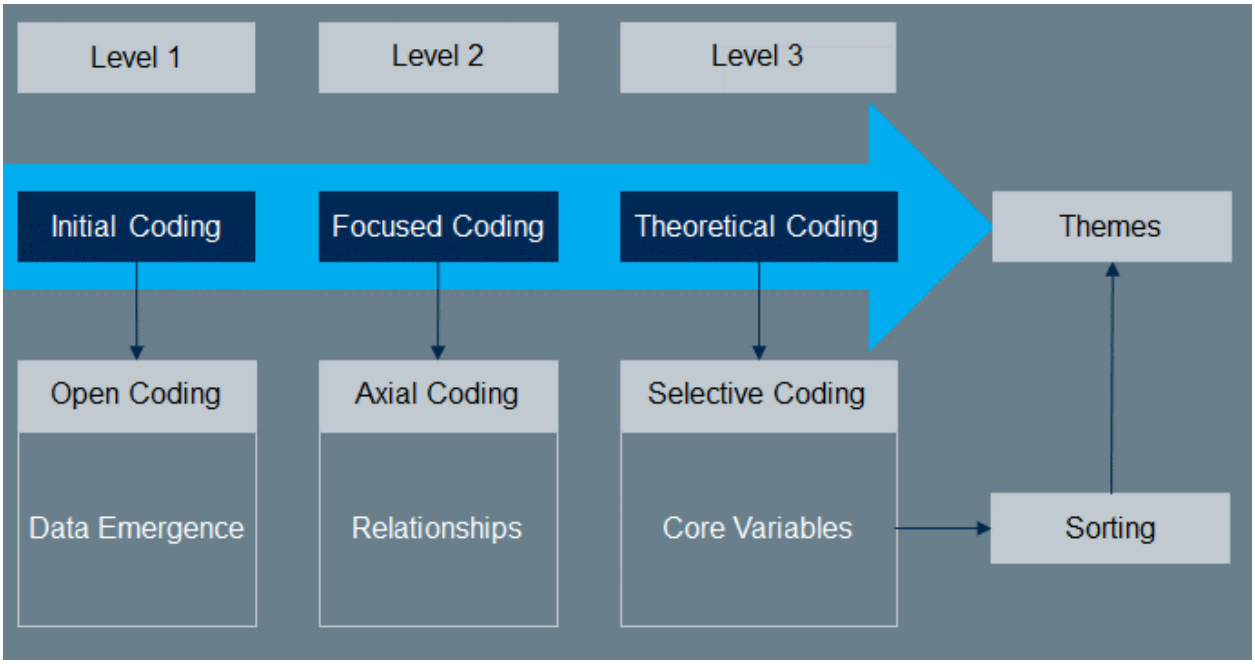
Adapted from Mitchell (2014:7) and Lee *et al.* (2018:3)

3.4.2 Qualitative Coding

Blair (2015:16) states that the effective analysis of qualitative data is dependent on the coding or labelling of important sections in the data set. These sections can be combined into themes that will support effective and reliable interpretation of the data. A combination of free coding, open coding, and in-Vivo coding methodologies were applied to effectively extract and label data relevant to the research study (Archer *et al.*, 2017:25). The input provided by the participants was grouped into separate work sheets, and each work sheet was linked to the various interview questions posed. The data set was then scrutinised by the researcher on a line-by-line basis and codes were assigned to important and relevant aspects of the research study.

In order to derive saturation and value from the primary data obtained, multiple coding methodologies were utilised in a phased approach. Aligning with the principles and requirements of grounded theory, qualitative coding was approached in a phased manner, in order to derive accurate research findings. Figure 3–2 is a graphic display of the coding phases used in this research study.

Figure 3-2 Coding Phases



Adapted from Silver and Lewins (2014:52)

Table 3-1 acts as a summary of the number of codes generated throughout the various coding phases.

Table 3-1 Qualitative coding summary

Question	Open Coding	Axial Coding	Theoretical Coding
1	312	16	1
2	70	12	1
3	386	17	1
4	131	3	1
5	107	12	1
Total	**1 006**	**60**	**5**

Source: Du Plessis (2018)

3.4.3 Memos

During the structured interview process, detailed field notes were compiled and data considered critical to the achievement of the research objectives was indicated as important on the notes made. Parallel to the coding process, this important information was transferred into analytical memos. Dr Friese (2009:1) promotes the use of memos in qualitative research, in order to ensure that proper reflexivity occurs during the detailed

data analysis process. Dr Friese (2017:44) further suggests that memos assist the researcher to analyse and note important matters that are to be included in the research findings when analysing the detail of the data sets.

Sixty-eight theoretical memos were developed and the interview field notes compiled. This was refined into five detailed memos covering each of the code themes identified. In support of the research objectives, memos were utilised in the following context:

- During the interview process, constant comparison and reflexivity was applied by the researcher to identify important integration points with the literature review conducted.

- Important comments made by participants, which supported the research objectives, were noted and prioritised for inclusion in this research study.

- Gaps in terms of industry norms and deviation from conventional processes were recorded, to ensure a deeper understanding was formed of the unique supply chain challenges in the chemical manufacturing industry.

3.4.4 Theoretical Sampling

Gentles *et al.* (2015:1786) that, unlike with quantitative research, where saturation is achieved at a given numerical point, qualitative research poses a challenge with selecting the optimal sample size. Theoretical sampling is based on the emergence of theory and the saturation thereof.

The sampling size for this study was based on a representative sample of individuals with permanent employment status at Sasol Limited. The initial interview plan identified 40 individuals who possess the necessary skills, experience and competence in the field of SCM. Saturation was continuously measured and ultimately dictated the actual sample size selected during the data collection and analysis phases.

3.4.5 Constant Comparison

Urquhart and Fernandez (2016:3) state that the combination of the constant comparative methodology and theoretical sampling for the foundation of qualitative data analysis techniques in grounded theory. Constant comparison required the researcher to

simultaneously analyse the data whilst coding is taking place, in order to generate integrated and clear findings that are core to the data analysed (Kolb, 2012:83). During the analysis phase of the study, the data was categorised into themes, through the development and integration of core concepts by means of notes and memos in ATLAS.ti.

3.4.6 Theoretical Saturation

A core element of grounded theory is that theoretical saturation is achieved when the addition of new data - in the case of this study, the structured interviews - provide no new data that can be used to achieve the research objectives. Aldiabat and Le Navenec (2018:248) elaborate on two main types of qualitative data saturation, namely code and meaning saturation. Hennink *et al.* (2016:14) attempted to decipher the elusive point at which saturation is achieved in qualitative research and which ensures that rigour and validity of the outcomes. According to their research, data saturation is achieved at nine data sets (in this study, the structured interviews) and meaning saturation is achieved at 16 to 24 data sets. These recommendations are not an exact indication of saturation; however, they do provide the necessary basis to ensure that reliable saturation levels were achieved in this study.

The complexity of the study, its range and scope, the sampling strategy employed, and the type of participants should be considered in providing evidence of saturation. In order to provide compelling evidence that saturation was achieved in this study, a two-fold confirmation approach was followed. Firstly, the number of structured interviews was compared with the literature related to data and meaning saturation, which was reviewed. During the data collection process, 22 structured interviews were conducted. The number of interviews conducted is comparable with the saturation range proposed by Hennink *et al.* (2016). Secondly, the data analysis revealed that significant saturation was achieved for the themes and categories discussed in this study.

3.4.7 Document Analysis

In addition to the primary source of data for empirical analysis, i.e. structured interviews, additional documents were sourced from credible resources to support the research study and are regarded as secondary data sets. According to Johnston (2017:620), Grounded Theory recognises various credible data sources that are relevant to the research study as reliable and allowable inputs from which to derive research findings. The secondary

data documents included in the research were identified and networked to codes, memos and themes identified during the primary data analysis process. These secondary sources acted as a catalyst to enrich and provide additional insight into the research. In support of the primary data analysed, additional secondary documentation was analysed from the target population to enhance and support the findings generated during the initial coding phase.

The following aspects and documents were included in the data analysis:

- Operating model
- Supply Chain Policy
- Supply Chain Governance Framework
- Supply Chain Delivery models
- Supply Chain Excellence Approach
- Supply Chain Management of Change Procedure
- Digital strategy
- Digital Program Management
- Customer Pain Points Analysis
- Agile methodology

3.4.8 Theoretical Sensitivity

Chametzky (2016:170) states that theoretical sensitivity is based on the premise that qualitative data analysis should be approached in isolation from the literature on the topic discussed. This means that the researcher should not incorporate literature and be influenced by such literature when engaging in coding practises, and especially when developing theoretical codes. It is evident from Chapter 4 of this report that the voices of the participants have been aired clearly and in a manner that integrates the viewpoints of the participants in this study. It is only in Chapter 5, where literature and empirical was infused, in order to effectively derive research recommendations.

3.4.9 Qualitative Reflexivity

Palaganas *et al.* (2017:427) indicate that qualitative reflexivity is a widely neglected aspect of qualitative research, which is critical to the delivery of accurate and reliable results. Reflexivity relates to the conscious and subjective involvement of the researcher in the data analysis and interpretation process. It requires the researcher to be cognisant

of his values, beliefs, norms and cultural background and how these might influence the interpretation of the research data. In this study, a continuous reflective and inductive approach was followed in a phased and structured way.

3.4.10 Assessing and demonstrating the quality and rigour of the research design

3.4.10.1 Qualitative Validity

Validity of qualitative research refers to the extent to which the research achieves the objectives it is set out to achieve (Research, 2017). According to Mohajan (2017:14), research validity is based on the fundamental principles of internal credibility and external transferability. Internal credibility relates to the objective trustworthiness of the data utilised and the methodology of analysis. Transferability assesses the ability of the research findings to be replicated in other environments and situations (Barnes *et al.*, 2018:8) The validity of this study and its instruments was tested against these principles, with the following outcomes being obtained:

- A pilot run was conducted utilising the designed data collection instruments, in order to determine whether the interview questions composed would yield the necessary data from which to derive research findings.

- Data analysis was approached through the use of a reputable qualitative data analysis software platform, and coding was conducted on the raw data obtained.

- An ATLAS.ti briefcase was developed, which contained the relevant primary and secondary data sources used to derive the research findings. The briefcase also contained the necessary audit trail for the research findings.

- A detailed context for the study was provided in this document and can be utilised for purposes of transferability to other environments.

3.4.10.2 Qualitative Reliability

Research is regarded as reliable when the data collected is dependable and when the same outcome is reached using the same at any given stage (Shuttleworth, 2017). To

ensure the reliability of the data obtained, two main approaches were utilised. Firstly, multiple sources were presented with similar questions and data was collected until the point of data saturation was achieved. Secondly, a reputable qualitative research analysis program was utilised for purposes of analysis of the data collected.

3.4.10.3 Qualitative Generalizability

Generalizability in research refers to the ability of the research to transfer the conclusions and recommendations applicable to the sample selected to be representative of the entire target population (Association, 2017). According to qualitative research principles, there is no specific sample size that is required; however, the researcher should be able to prove that a sufficient sample size was selected to reflect the target population effectively. It was determined that the sample size selected in this study is larger than what was required for the purpose of ensuring that the point of saturation was achieved with the data collection process. It is suggested, therefore, that the sample data can be able generalised to the target population.

3.5 Research ethics

The main ethical considerations that have be applied and monitored during the execution of the research conducted is as follows (University, 2013):

- Participants have been allocated a unique identifier code and have been assured that their privacy, anonymity and confidentiality was maintained throughout the data collection and analysis phases of the study.
- The research shall aim to ensure that the participants benefit from the process of providing information that will assist in ensuring a successful study.
- The research process shall prevent personal, physical or reputational harm to the participants and the larger sample audience that might be negatively affected by the study or the results that are transcribed.

Prior to interviewing participants, written permission was requested from each participant to ensure that the participants understood the context of the study to be performed, participant rights during the data collection phase, and how privacy and confidentiality would be assured during the data collection and analysis phase. This was achieved by providing each participant with the Informed Consent Form that is attached as Annexure

C. A pre-requisite requirement to commence with research under the ambient of the NWU, the research proposal should be subjected to a rigorous ethical clearance process. This is achieved by submitting the completed research proposal with the ethical clearance form to the Faculty of Commerce and Administration Research Ethics Committee. Approval to commence with the study and ethical clearance was obtained from the NWU's Ethics Committee. The ethical clearance certificate applicable to this research study has been included for review - see Annexure D.

3.6 Summary

This chapter aimed to communicate and elaborate on the process followed to conduct the empirical research portion of this study.

In summary, the following aspects was confirmed in this chapter:

- A formalised process of research design was followed prior to engaging in the research.

- Comprehensive effort was applied to ensure the core principles of constructivist grounded theory was maintained during the execution of the empirical research.

- A total of 22 semi-structured interviews were conducted, which served as the primary data source for input into the empirical process. A number of secondary data sources in the form of policies, procedures and manuals supplemented the primary data collected.

- A total of 1006 open codes was identified during the initial line-by-line coding phase of the primary data obtained. The codes was further refined through reflexivity and constant comparison into 60 axial codes which was defined as categories during the presentation of key findings. Five core themes (otherwise known as theoretical codes) were developed as the main focus areas for the discussion of the findings.

- Both data and meaning saturation was achieved during the primary data analysis phase.

- A rigorous process of ethics management was followed during all phases of the empirical research processes. An ethical clearance certificate was issued by the Ethics Committee of the NWU in support of the ethical standards maintained during this study.

CHAPTER 4 DATA ANALYSIS AND FINDINGS

4.1 Introduction

The purpose of this chapter was to present the findings of the empirical study conducted. ATLAS.ti was utilised as exclusive program to analyse and interpret the primary data obtained through semi-structured interviews. The analysis database consisted of 5 primary documents and 10 secondary documents that were applied unilaterally to derive research findings.

The chapter comprises two main sections. Firstly, the applicable biographical information of participants was discussed, in order to identify the skills and competency profiles of the sample pollution. Secondly, the findings of the data analysis were discussed, with the voices of the participants being incorporated. The presentation of the research findings was structured around each question used during the semi-structured interview process. A combination of reflexive views, direct quotations of participants and ATLAS.ti relationship diagrams were utilised to detail the findings in a comprehensive and holistic manner.

4.2 Demographic information

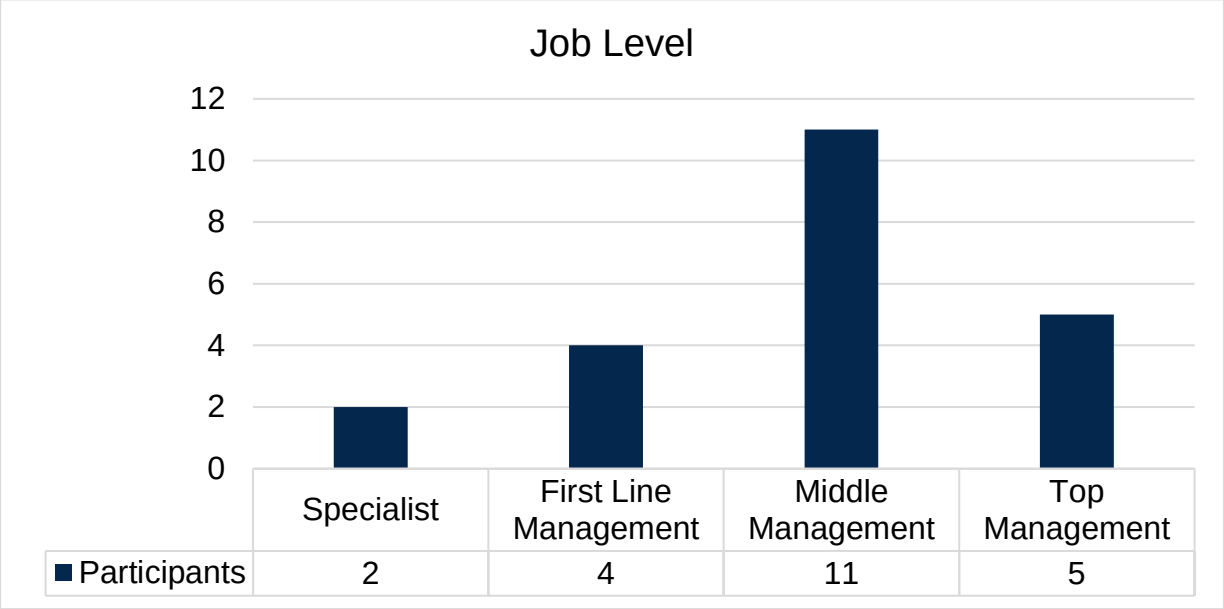
In order to ensure the validity of the research study and facilitate accurate and reliable results, strategic biographical data was collected from the participants who were key to achieving the research objectives.

The biographical data collected included constructs such as job level, highest qualifications, supply chain specific qualification and years of experience working in the supply chain. The biographical data collected revealed the following important information:

4.2.1 Job level

Of the participants, 73% were at top or middle management level, and were actively involved in matters related to strategic SCM. A further 27% of the interviewees were involved in supply chain design, implementation and operations aspects.

Figure 4-1 Job level



Source: Du Plessis (2018)

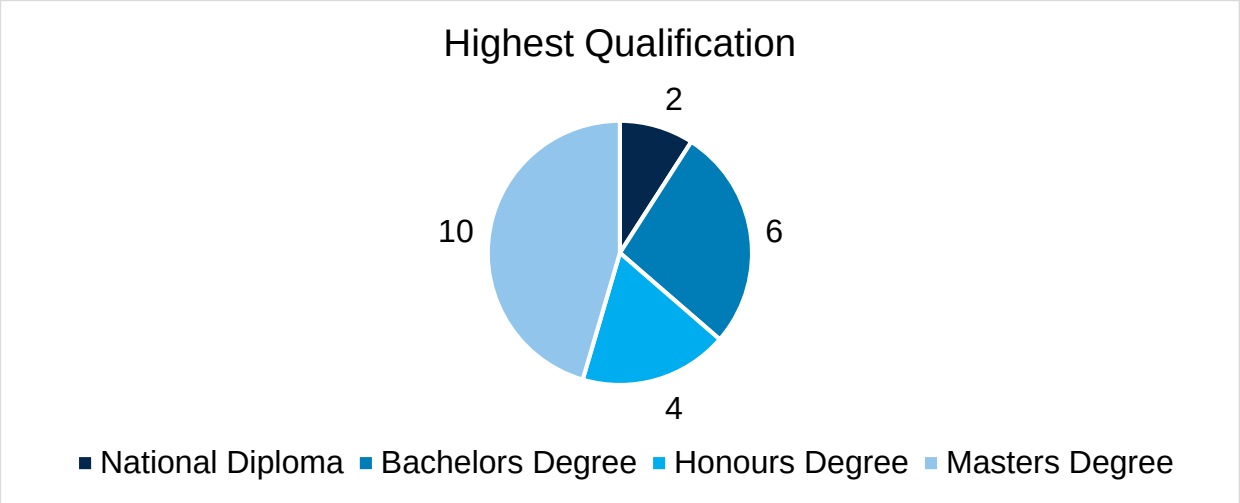
4.2.2 Highest qualification

All participants in the research had formal post school training, and:

- 64% of the interviewees had a post graduate qualification- predominately Honours and Master's degrees in business management, engineering and psychology.

- 36% of the respondents was in possession of a first level degree in similar disciplines.

Figure 4-2 Highest qualification



Source: Du Plessis (2018)

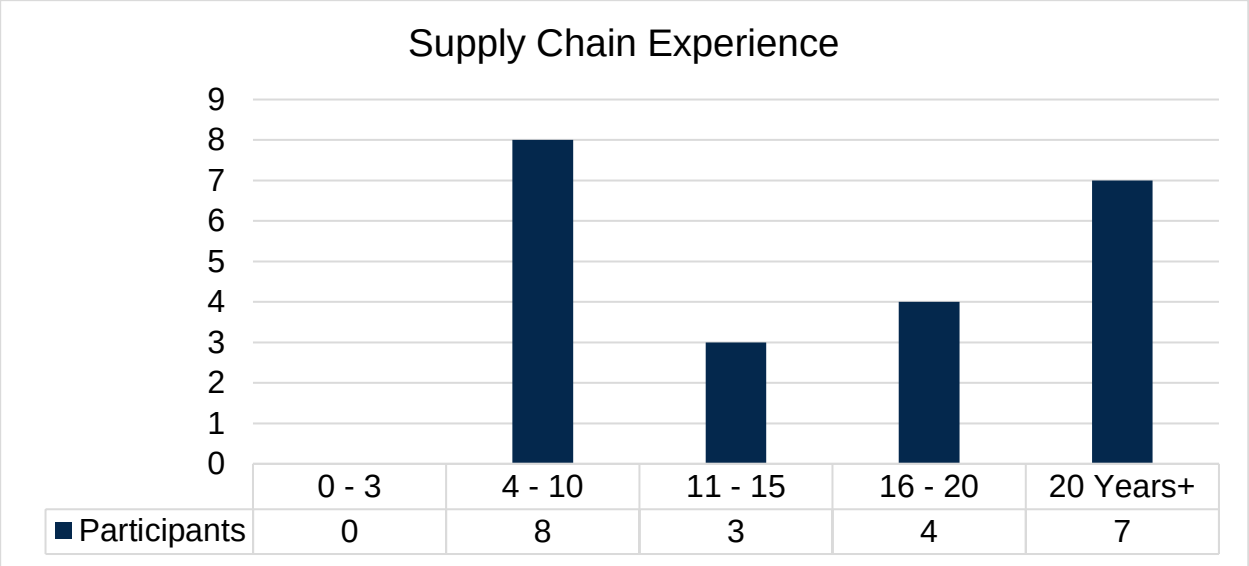
4.2.3 Supply chain qualification

It was discovered that 18% of the participants have a formal qualification and/or a professional certification in SCM.

4.2.4 Work experience

It was established that the participant population had an average of 16 years work experience working in or with supply chains. The lowest level of experience was identified as 4 years and the largest was stated at 37 years. Cumulatively, the participants had a combined 284 years of relevant experience working in supply chains.

Figure 4-3 Supply chain experience



Source: Du Plessis (2018)

4.2.5 Participant profile

The main purpose of collecting the aforementioned data was to ensure that participants in the research study had the necessary skills and knowledge to provide in-depth information into the challenges faced by supply chains and how to best address these challenges. In conclusion, it can be confirmed from the biographical data, the participants selected conformed to these factors.

Table 4-1 provides the profiles of the participants who participated in the interview processes.

Table 4-1 Participant profile

Participant	Job Level	Highest Qualification	SC Qualification	Experience
MBAICD001	Top Management	Masters Degree in Industrial Engineering MBA	No	16
MBAICD002	Top Management	MBA	No	21
MBAICD002	Top Management	Masters in Engineering Management	Bachelor of Commerce Degree in Supply Chain Management	6
MBAICD004	Middle Management	BCom Honours BEng Degree	No	20
MBAICD006	Specialist	BCom Degree in Logistics Management	Certified Supply Chain Professional	11
MBAICD010	Middle Management	BCom Honours Accountancy Chartered Accountant	No	7
MBAICD011	Specialist	Cost and Management Accounting Degree	No	22
MBAICD013	Middle Management	Masters in Industrial Psychology	No	23
MBAICD014	Top Management	MBA	No	31
MBAICD014	Top Management	Masters in Financial Analysis Chartered Accountant	No	15
MBAIDS001	Middle Management	Masters in Chemical Engineering MBA	No	7
MBAIDS002	Middle Management	National Diploma in Purchasing	National Diploma in Purchasing	37
MBAIDS006	Middle Management	Masters in Business Administration	No	25

MBAIDS007	Middle Management	Industrial Mechanical Engineering Degree	No	19
MBAIDS008	First Line Management	BCom Economics, Money and Banking	No	20
MBAIDS010	Middle Management	Chartered Accountant CA SA	No	6
MBAIDS014	Middle Management	BCom Honours in Marketing Management	No	15
MBAIDS015	Middle Management	BCom Degree	No	8
MBAIDS016	First Line Management	National Diploma in Logistics Management	National Diploma in Logistics Management	4
MBAIDS023	First Line Management	BCompt in Accounting and Business Management	No	10
MBAIDS024	Middle Management	PGD Business Administration	No	9
MBAIDS025	Middle Management	Master Diploma Mechanical Engineering	No	23

Source: Du Plessis (2018)

The demographic profile of participants is particularly important to display the essence of non-probability sampling using the expert purposive sampling technique. Table 4-1 confirms that the input obtained from participants can be regarded as expert opinion, based on their competencies and experience related to supply chain management in the chemical manufacturing industry.

4.3 Results, Findings and Discussion

4.3.1 Theme 1: Supply chain management challenges in the chemical manufacturing industry

The first interview question was intended to help understand the unique challenges faced within the SCM structures of chemical manufacturers. The analysis of the data revealed sixteen categories of challenges that impede the effectiveness and efficiency of the supply chain.

4.3.1.1 Category 1: Transparency of supply chain cost structures

MBAICD013 (2018) stated, "*It's just: how do we cut costs and it becomes all about cutting costs.*" This might be the singular biggest issue with SCM in the chemical manufacturing industry, in that supply chain is regarded as a cost-cutting function, as opposed to a driver of organisational and customer value. This does not imply that spend conservation should be ignored, but rather that the type of supply chain strategy, which is optimal for delivery of customer requirements, needs to dictate the optimal supply chain cost structures. MBAIDS014 (2018) confirmed this finding, saying: *"Because the business strategy is X, the cost of supply chain is not always to have the cheapest supply chain, it's to have the most suitable supply chain to support the business strategy.*"

MBAICD010 (2018) indicated: "*It is a major challenge to understand the costs in the different brackets to determine a true reflection of the cost of your supply chain in the supply chain process.*" Without end-to-end integration and real time monitoring of activities throughout the supply chain, it will be impossible for organisations to optimise costs within the supply chain. This is evident during restructuring programs, where the aim is to cut costs throughout the organisation, however only seeing these cost re-occurring after a couple of months. Effective supply chain cost optimisation can thus only be successful if aligned with a sound customer centric strategic and continual transparent monitoring of activities that generate cost in the chain. In this regard, MBAIDS014 (2018) stated that *"I think supply chain there's a lot of opportunity to save costs and it's to make sure that cost is measured on the overall basis and total cost of ownership of a process of the supply chain, and that's not located in the silo, individual basis which sometimes often happens."*

The number of hand-over points created by functional structuring of the supply chain (silo) is another source that prevent the transparent monitoring of cost throughout the supply chain. As already established, future competitive forces will be directed towards supply chains that are unable to satisfy customer requirements and that are unable to compete on cost competitiveness. Cost competitiveness does not imply a cheap supply chain, but rather one that can convert an investments into tangible returns of value for all stakeholders who engage with the supply chain.

4.3.1.2 Category 2: Strategic importance of supply chain management

Generally, the participants indicated that SCM is not receiving the necessary executive recognition as a strategic driver for sustainable value creation. SCM is also not regarded as core to business success, which is a clear indication of industrialist management views, meaning that intense focus is placed on the product; however, the customer is largely neglected as a driver of business decision making processes. MBAIDS025 (2018) stated: *"The first challenge with sub-results is the fact that supply chain is not necessarily seen as the full integrated part of the business as such."* Participants stated that supply chain leadership are positioned to low in the organisational structure to direct effective supply chain strategy. This is echoed by MBAICD013 (2018) who stated, *"You also find that unless supply chain is taken incredibly seriously by CEOs, we are invisible."*

The data analysis also revealed that the real value of SCM in the chemical industry supply chain is largely under estimated and not well defined. According to MBAICD006 (2018) *"Supply chain is one of the cogs in the machine, one of the very important cogs because it links your buyers and your sellers from the inbound and outbound environment and if you can't look at it from a total supply chain perspective and see supply chain interfacing with other areas, that's a big gap and a challenge."* According to MBAICD006 (2018), effective supply chain strategies are seen as, *"Marketing proactively in support of demand forecasting is actually to position your product and then once you have product positioning you need to also assess via marketing intelligence/ business intelligence what are new product opportunities."* Market and business intelligence gathering can only be effectively facilitated by the availability of reliable data that is exposed to rigorous analytical systems that can support strategic reaction on market forces in an agile way.

4.3.1.3 Category 3: Reliability of product and service supply

The majority of participants referred to the supply component of the inbound supply chain as crucial to the effectiveness of the downstream processes. Aligned to the literature review conducted, it was confirmed that if the front-end loading within all supply chain processes is not reliable and accurate from inception, the ripple effect of failure will be felt throughout the downstream processes. This confirms that there is a great deal of interdependency between the various processes and steps in the chain. According to MBAICD002 (2018) *"Supply chain has a number of challenges facing them; but the biggest one is deriving contracts that are fit for purpose and the implementation of them."* Throughout the data gathering phase, it was evident that there are a substantial gap between what the user requires and what is delivered by strategic sourcing. This disconnect is mainly attributed to unclear and undefined scope of work processes and the over-governance of procurement processes that result from long lead times involved in finalising a contract. This impedes the supply chain from being effective, as the foundation for strategic supply assurance is based on red tape, rather than deriving value. *"From the inbound side of the supply chain, you are expecting your suppliers to be as efficient as you are, and if there's any disconnect in that, if there are delays, it affects your processes going forward* (MBAIDS016, 2018)*."*

Participants believe that the standards set for vendors in the chemical industry far exceeds the actual required level of service delivery. This is mainly brought about by over-governance of processes, due to unclear root causes of process failure. This situation places the onus on the organisation to develop its supplier base, due to the excessively high standards set by the organisation. As stated by MBAICD010 (2018), *"I think it's just our duty to develop suppliers; and we need to do that. And it's not only to give work to a supplier, but to ensure the supplier can actually deliver on the requirement."* However, it is imperative to secure sustainable and reliable supplies of strategic inbound materials. MBAICD010 (2018) adds, *"We have shut-down periods - and you have a vendor that says, 'You don't pay us; we wait for our money', and then we need to source from other areas."* The failure to pay vendors on time is a major sources of increased supply chain risk. The challenges is mainly brought about by rigorous governance processes, lack of integration between the contracting and payment systems and the general lack of the required depth of process automation.

4.3.1.4 Category 4: Supply Chain risk management effectiveness

The various moving parts and processes in a supply chain is a source of continual risk, "*So you have to manage the risk at all times (MBAIDS002, 2018)*." MBAIDS014 (2018) stated, *"I think risk management is one, managing all the risks, it's costs and efficiency."* Risk management should enable a process of continually being able to leverage on opportunities and protect the organisation against possible failures. The current supply chain structure does not enable continuous visibility of critical risk data and the work teams are to laborious to focus on detailed risk management processes. *"It is to identify the risks sufficiently, with also a view of being able to do something about them, to manage them effectively because often the risks are not directly under your control and to make sure that those people or departments or places where the risk can be controlled takes the full accountability and takes it seriously to do so (MBAIDS014, 2018)."*

4.3.1.5 Category 5: Maintaining value adding governance processes

The implementation of governance processes and systems are both a regulatory requirement and business imperative; however, when applied excessively without deriving the necessary value for the customer can be destructive to the effectiveness and efficiency of SCM. MBAIDS008 (2018) stated, *"I think that the governance of processes and of financial transactions that need to happen in the supply chain is of utmost importance because the ease of fraud being committed or materials or money being stolen is one of the biggest issues that you need to cover."* Although governance has a strategic role to play in SCM, it has driven supply chains to become large bulky structures that are unable to align effectively to customer requirements.

MBAICD002 (2018) indicated, *"So there was these eras, I think we are now in the time within the supply chain environment where the key focus today first of all on compliance and governance."* The view of establishing governance management as a supply chain priority is contradictory to the factors of survival in the 4th Industrial Revolution, as this means that if a supply chain cannot adapt quickly and effectively to its continually changing customer requirements, it will quickly become irrelevant in the age of persistent disruption. This concern was supported by MBAIDS008 (2018) who stated: *"I wouldn't say there's a big lag in it, but I think the process and the red tape and the approval process to get technology approved is a big concern."* With the rapid and disruptive pace of

technology enhancements across the globe, supply chains that are unable to keep up with the required pace of new technology absorption will also lose their competitive advantage. Introduction of additional governance processes is contradicting to the factors that will generate growth and sustainability in the 4th Industrial Revolution.

4.3.1.6 Category 6: Maintaining accurate and reliable master data

The data utilised as input sources to the supply chain and those received from internal and external sources and the effective use of this to create visibility throughout the various supply chains was the dominant cause of concerns for participants. Participants stated that most of the failures in the supply chain could be attributed to the availability and reliability of data in enablement of pro-active decision making processes and identification of failure modes. MBAICD011 (2018) confirmed this concern, by stating: *"The biggest challenges I think are master data, that is your statistical master data as well as your analytical master data."* MBAIDS007 (2018) added, *"Now the challenge we have is although we have these wonderful tools, personally I think the importance here is still to ensure that your data integrity, that you input into the tools still aids your business decision making, and I think that's where we perhaps still have a gap to fill."*

The data that is available for analysis is disintegrated and ineffectively applied for the benefit of the organisation. MBAICD006 (2018) confirmed this by stating, *"We don't use the benefit of the data that it has, to improve our supply chains."* The level of data maturity thus dictates the success of both supply chain processes and the effective enablement of these processes. MBAIDS015 (2018) believes, *"If you look at an aspect of the latest technology that is proposed to be used, the company is, specifically in supply chain, not necessarily prepared from a data steward basis to have readiness for the new technologies."*

4.3.1.7 Category 7: Visibility across the supply chain

MBAICD001 (2018) mentioned, *"The other big challenge that also goes along with that is the ability of organisations to have visibility and the unified approach or platform to support their management of these respective supply chains."* Centralisation or decentralisation of SCM does not yield the required output results. This is evident in the amount of restructuring projects applied in most chemical supply chains. Trends show that these projects normal come in waves of five to ten years where the supply chain is moved

between centralisation and decentralisation structures. The reason for this is that the real dilemma with of SCM is not addressed. This dilemma resides in the term utilised to describe the process, referring to “Supply Chain”. Popular analogies refer to a chain being as strong as its weakest link. So if a supply chain is structured by means of link, functions or department, the natural result is a silo work mentality, diminishing of end-to-end accountability and a loss of complete visibility across the end-to-end processes. MBAICD014 (2018) added, *“In the technology space, our challenges are too many diverse systems that are not integrated and that do not speak to each other and do not leverage any information from each other resulting in double capture and lack of visibility across the supply chain.”* Although the use and integration of technology will improve SCM visibility, the results will be short lived, as the structure and composition of the supply chain will diminish the capability of the technology.

4.3.1.8 Category 8: Customer centric supply chain design

Most participants referred to the customer and meeting their requirements; however, there was a general lack of acknowledging the customer as the central strategic focus point, which alone directs supply chain design and optimisation initiatives. This is another indication of industrialist thinking culture that directs all its attention to the products and services of the organisation, as opposed to recognising that the customer as the product or service. It should be repeated that SCM success in the 4th Industrial Revolution is not supported by conventional business management processes. MBAIDS016 (2018) said, *“The other challenges are in terms of what our customers, customers in any organisation, what they are doing and what they expect.”* The challenge resides in the ability of the supply chain to gather and analyse important business and market intelligence in enablement of strategic decisions aimed at creating customer and organisation value. *“I think the second is just making sure that our systems keep up with the challenges that exist again both within the context of the globalisation of the chemical industry and within the expectations of our customer* (MBAICD014, 2018)*.*”

Organisations should be able to customise supply chains within the larger supply chain context and enable it with the necessary technology to monitor and predict customer demand based on the unique requirements for each market segment. MBAIDS016 (2018) suggested: *“Because if there is a disconnect there a likely potential customer would insist on being partners or doing business with a company that is within more or*

less the same capability technology wise, employee wise, understanding wise, process wise with their own company." One of the main determining factors of success the 4th Industrial Revolution is the relative ease of exchanging products and doing business. Participants indicated that it is currently extremely difficult for customers to do business with chemical manufacturing companies, due to the lack of integration between systems and the lack of availability of such systems. The level of governance and compliance focus has increased to such an extent that it is having a negative impact on customer purchases and long-term relationship building. Another critical challenge is the ability of the organisation to effectively forecast demand signals by means of data analytics. MBAIDS006 (2018) stated: *"I think demand management should be understood as more specifically demand forecasting, not only looking at existing products and existing product grades, but also looking into new customers, new markets, new product."* Demand predictability can become a major competitive advantage for chemical manufactures when applying the concepts and principals required by the next disruptive business age.

Supply chain effectiveness and efficiency is, however, based on the end-to-end customer experience. It does not matter how well an organisation can predict customer demand, if it cannot deliver such demand on-time, in-full and while exceeding the customer expectations. MBAIDS001 (2018) reiterated the challenge of delivering products and services based on expectations: *"In the outbound area - meeting the requirements of your customer, making sure that you can deliver the products that they are procuring from you on time, in full and at the appropriate cost."*

4.3.1.9 Category 9: Supply Chain skills and competence requirements

Participants agreed that there is a general lack of end-to-end supply chain knowledge that impedes on the effectiveness of the overall chain. Knowledge and experience are directed towards functional components of the supply chain, as opposed to cross-pollination of skills and abilities. Participants further stated that stakeholders outside of the supply chain are fairly unskilled at process knowledge. MBAIDS014 (2018) suggested: *"A lot of people are involved in the supply chain process and they are forming part of the supply chain process and doing some activities in that; but they often may not understand the supply chain process, how it fits into the overall picture and how their compliance to or their support and their execution actually contributes to improving the supply chain effectiveness."*

Participants believe that the current level of technology literacy within the supply chain is not to the required standard and MBAIDS015 (2018) corroborated this by stating, *"You can see it as a challenge, but it is also an advantage to us going forward, is that typically you can see that in the era we are moving into is that much more automation of processes and transactions are visualised and our workforce is not necessarily matured yet to support the initiatives."*

The challenge for chemical manufacturing supply chain going forward is to develop or source the skills it requires to be successful in the 4th Industrial Revolution. According to MBAICD014 (2018), *"I think some of that, and this is a personal perspective, supply chain isn't necessarily looked at as the sexy area to work in, and so attracting the highly qualified individuals to come into supply chain and remain there for a career standpoint is a challenge."* MBAIDS010 (2018) added: *"Lastly, I think on our side is also a true skill set or if I look in the US at the moment, I'm busy with adding some people, the talent pool that you have to choose from, of skilled supply chain professionals who know the industry, have got experience with managing big contracts or service providers with size or complicated operations."* Acknowledging the requirement for integration, standardisation and visibility of processes along the supply chain, there will be increasing requirements to develop cross-functional or cross-process competence on a higher level than is currently available in the chemical manufacturing supply chain.

According to MBAICD013 (2018), *"We don't have the training – what we've got is great, but we've still got a lot of people who don't really know what's expected of them in their jobs, and who have moved typically from other functions or from operations or production, etc., into supply chain - and they don't actually realise that supply chain is a very specialised function, which requires very specific knowledge. And that knowledge is only in a few people's heads and then it's gone."* There is a challenge with the current methodology used to train supply chain employees, in that the focus is on classroom and online training programs, which the literature has shown is ineffective in ensuring maximum knowledge absorption. The challenge is further intensified by the need to establish cross-functional competence, as opposed to up-skilling staff in a certain area of the supply chain.

4.3.1.10 Category 10: Supply chain integration

Followed by the accuracy of supply chain data, participants stated that the integration of processes, systems and people across the supply chain cause increased complexity and is a major obstacle to establish best practice eco systems. MBAICD014 (2018) said: *"So we have multiple systems, multiple practices and multiple processes that we follow."* The most profound source of complexity in a supply chain is brought about by the structure of the chain. Commonly, whether centralised or decentralised, supply chains are grouped into functions or department, each responsible for departmental KPI's. MBAIDS007 (2018) emphasised the irrelevance of the supply chain model applied, saying, *"I think the old supply chain integration cross-functional integration silo management – that is still fairly visible and will always remain a challenge, regardless of whether you have an integration business model, people still tend to focus in a silo environment."* The mere fact that there is an interruption in the seamless flow of materials, processes and information along the chain causes a breakdown in communication and a misalignment of objectives, which further deepens supply chain complexity. The result is a supply chain that does not serve the customer, but rather focuses on individual successes that are driven by and dictated by governance requirements.

MBAIDS016 (2018) indicated, *"The hand-over point typically between a production facility or production department flowing over to marketing, flowing over to warehousing, flowing over to transportation – that can be a bit lacklustre. It's not as efficient as it would be if the entire supply chain moves and improves together as a whole."* Furthermore, there is an inclination to adopt a silo mentality when end-to-end accountability is institutionalised towards individual functions. MBAICD004 (2018) stated that hand-over points provide an opportunity for failure between functions: *"And the 'happy flow' takes into account I've done my bit correctly and I hand over to the next person and they do their bit correctly; but that's not how the real world works."* There is a major challenge in creating a unified, integrated and standardised supply chain that seamlessly establishes an uninterrupted flow of value for the customer.

The design of processes, enablement systems and structures should thus be dictated by a deep understanding of the customer's requirements. The simplification of processes is further diminished by the application legacy type processes in an age dominated by technology to establish sustainable competitive advantage. MBAICD011 (2018) stated,

"The problem that we have with a paper system is that you will not get system triggers like re-order points and things that you need to react on urgently … You will always be fighting fires in a situation like that." This confirm the fact that supply chains that ignore the call for the digitalisation and integration of processes will not survive in the era of continual disruption and change in customer demands.

4.3.1.11 Category 11: Technology enablement of supply chain processes

Organisations that are laggards in terms of implementation and absorption of technology will find it increasingly difficult to effectively compete and retain customers in the future. MBAIDS001 (2018) cautioned: *"Another challenge is your digitisation, or in other words disruptive technologies where you have to make sure that you are in line with best practices because if you are not then your competitors will do it for you and put you out of business."* Participants stated that there is a general lack of innovative thinking when it comes to the implementation and automation of supply chain processes in the chemical industry supply chain. The literature confirmed that business-to-business-to-market competition strategies will be thought out by optimised, integrated and responsive supply chains, and this will become the new industry norm for establishing competitive advantage. MBAIDS008 (2018) stated, *"I think the process and the red tape and the approval process to get technology approved is a big concern."*

Agility and technology adoption are synonymous terms and cannot be divorced from one another. Due to the rapid and disruptive speed at which technology changes, organisations cannot follow conventional project management methodologies: these normally require months of implementation and it is later realised that the technology provides no benefit to operations. There is still significant reliance on people to drive processes, rather than automating processes - from both a physical material handling and a transaction viewpoint. MBAICD014 (2018) stated: *"It's moving away from being data capturers, but actually interpreting the data and making decisions and then executing based on those decisions, which comes from the data."* The pre-requisite of data analysis is the availability of technology that can analytically unpack big data in order to provide information of value.

4.3.1.12 Category 12: Adequate infrastructure to enable supply chain processes

MBAIDS010 (2018) stated, *"I think the other challenges that I see particularly in the South African context is the macro-economic environment, so it's aging infrastructure."* MBAIDS008 (2018) added, *"In all honesty I would say South Africa's infrastructure and roads."* Participants state that the condition of road, rail and port operations in South Africa is deterring the supply chain from optimal customer service delivery standards.

4.3.1.13 Category 13: Collaboration between stakeholders

Participants indicated that there is a general lack of clear and concise collaboration between the various channel partners in the supply chain. MBAIDS016 (2018) states, *"It is the overall cohesiveness of different departments or units within the supply chain fraternity and their ability to work efficiently together."* There is a general lack of persistent and targeted communication between the supply chain functions, brought about by excessive hand-over points and silo mentality. MBAIDS025 (2018) indicated that the absence of the communication, negatively impact supply chain performance, stating: *"I would, which is also still supply, supporting these processes or a lack of them, would just each of these processes would be a very clear communication throughout this whole supply chain/ supply chain."* Another challenge relates to effective collaboration within the supply chain is people's understanding of processes and failures. MBAIDS023 (2018) corroborates this being a challenge: *"So, to clarify that, if everybody doesn't understand the processes well we will find that we would have time delays in terms of execution or orders or also time delays in getting information to the relevant parties to make the correct decisions."*

4.3.1.14 Category 14: Economic transformation targets

MBAIDS015 (2018) stated, *"In the era of doing business these days with the transformation in our country one of the biggest challenges is surely to have competent BBEEE suppliers to support the business."* These companies do not possess the necessary business and technical expertise to deliver products and services to the standard required by the supply chain; however, legislation dictates that the supply chain must make use of these services providers. Another challenge is to ensure compliance to transformational targets and requirements. MBAIDS001 (2018) suggested: *"In the South African context, obviously economic transformation, to make sure that you meet*

the organisational objectives, more specifically in terms of spend, in terms of your black spend, as well as social responsibility."

4.3.1.15 Category 15: Regulatory compliance

In the chemical industry, there a numerous legislation, regulations and standards that influence the supply chain. MBAICD002 (2018) stated *"There's a huge increase in the legislation globally that focuses on compliance and focuses on bribery and corruption and so forth."* The challenge is the supply chain context is thus to adhere to all the regulation in a manner that does not influence the customer experience. MBAIDS008 (2018) also cautioned that regulatory compliance increase supply chain cost: *"The amount of work that goes into the governance and safety aspects of supply chain is immense."*

4.3.1.16 Category 16: Alignment to global business processes

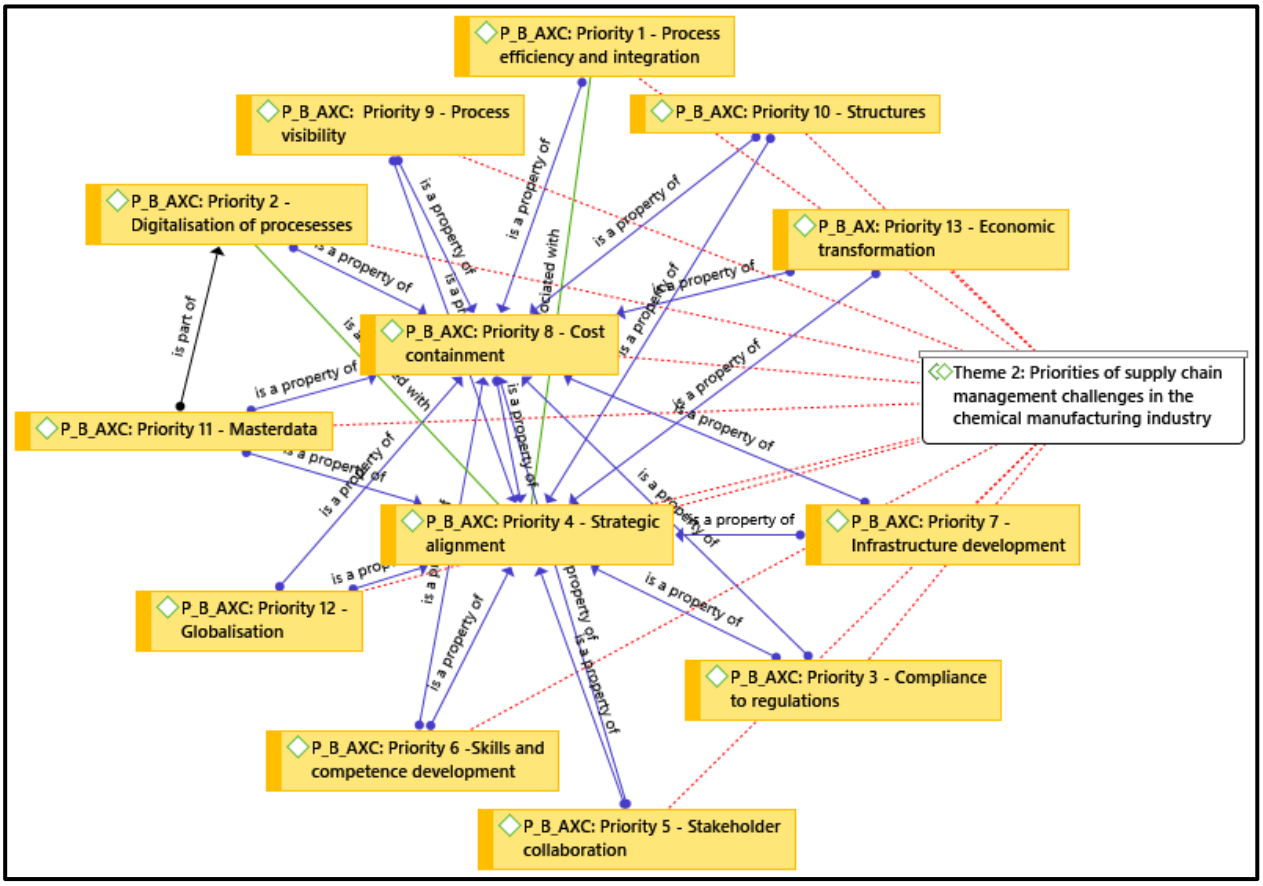
Globalisation of the chemical industry has largely eliminated the one-size-fits-all approach and the challenge for supply chains is to adapt to the customs, cultures, risks and resources of the specific operating environment in which they function. MBAICD014 (2018) stated: *"I think, today, the biggest challenge is the globalisation of business. If I think specifically of the chemical industry, we have plants in South Africa, Europe. If I think about PC, we have plants in the US, and with a significant expansion there. And in all cases we supply not only to the domestic market, but across the globe to all regions. And getting product there, number one, in a reliable fashion is extremely important, as well as the flexibility and versatility to ship product between regions, as we work to optimise margins and net backs and take advantage of arbitrage windows that may open and close with fairly short notice."*

4.3.2 Theme 2: Priorities of supply chain management challenges in the chemical manufacturing industry

Participants was requested to prioritise the importance of the various supply chain challenges identified. The data was analysed to identify the challenges that will have the highest impact of supply chain performance and sustainability when addressed.

Figure 4-4 provide a graphical representation of the ranked supply chain challenges.

Figure 4-4 Prioritisation of supply chain challenges



Source: Du Plessis (2018)

The data analysis revealed that prioritisation of supply chain challenges by individuals is not a reliable framework for the improvement of end-to-end supply chain processes. MBAIDS006 (2018) cautioned regarding prioritisation of challenges: *"It is not one size fits all, it depends on where your specific supply chain, your specific company finds itself. What are the current threats and realities for your specific business."* This finding is based on two predominant factors. Firstly, the participants are subjective in their rating of the unique challenges, which is based on previous experience and influences. Secondly, the various challenges are interlinked with one another and changing one element will have an impact on another. Although rated as fairly unimportant, two dominant supply chain challenges has been identified, which have an interdependent relationship with the other priorities. Strategic alignment is the first dominant factor. Without a solid foundation of strategic alignment throughout the organisation, addressing other impacts will have little impact on overall supply chain improvement. The second factor, cost containment is prevalent in all of the priorities identified: changing any of the other priorities will have a direct influence on cost and vice versa.

The literature indicates that customer requirements should be central to supply chain strategy and design; however, participants did not explicitly mention or prioritise the importance of alignment with customer requirements.

4.3.3 Theme 3: Solution for supply chain management challenges in the chemical manufacturing industry

Based on their knowledge and experience in SCM, participants was requested to provide solutions to the various SCM challenges experienced in the chemical manufacturing industry. It was required from participants to not only mention short-term mitigating solutions, but to also mention best practice solutions that could sustainably address the challenges identified and create competitive advantage. A wealth of feasible solutions was obtained from the participants, which will later form the foundation of the proposed best practice SCM framework for the chemical manufacturing industry. The initial line-by-line analysis of the data obtained from participants, 386 open codes was identified. The codes were scrutinised for similarity from which 17 axial codes were developed which acts as solution categories to improve on the identified supply chain challenges. In order of highest saturation and density, the categories identified are unpacked individually in the following sections.

4.3.3.1 Category 1: Supply chain strategy

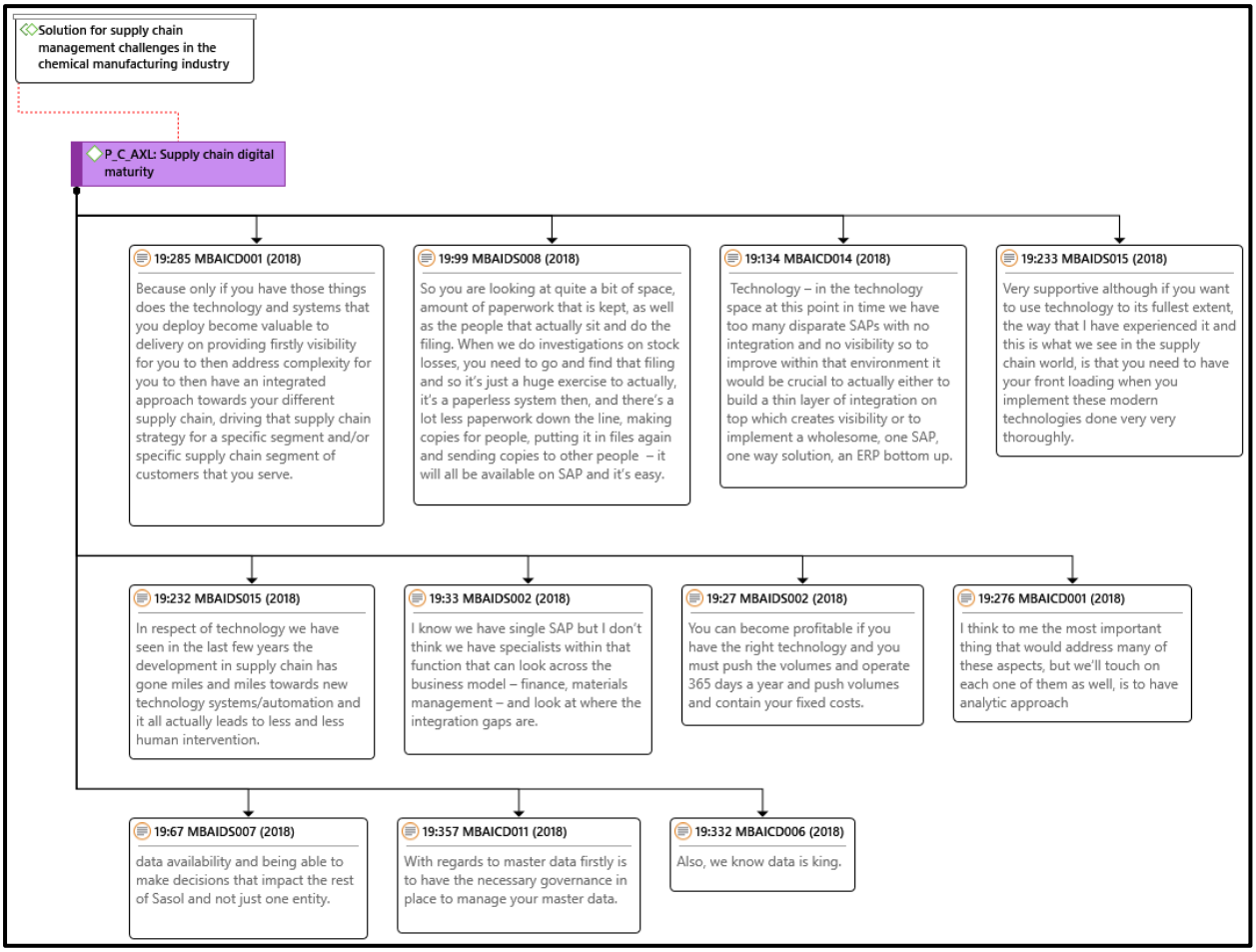
Participants stated that the supply chain strategy should be influenced and directed by customer requirements. Figure 4-5 indicates the direct input received from participants during the interviews conducted. Participants feel that SCM should be regarded as the core business and thus it should be represented on the board. This will enable the full integration of business wide supply chain strategies and will allow SCM to direct and influence all processes in the organisation.

Participants also stated that supply chain strategy should focus on creating sustainable competitive advantage, which means competing utilising supply chain capability, rather than product and service offering alone. This can only be achieved if there is constant targeted investment in supply chain capability. Participants also direct that supply chain strategy should be developed based on accurate, reliable and real-time business and market intelligence capabilities.

Figure 4-5 Supply chain strategy quotations

4.3.3.2 Category 2: Supply chain digital maturity

Figure 4-6 Supply chain digital maturity quotations



Source: Du Plessis (2018)

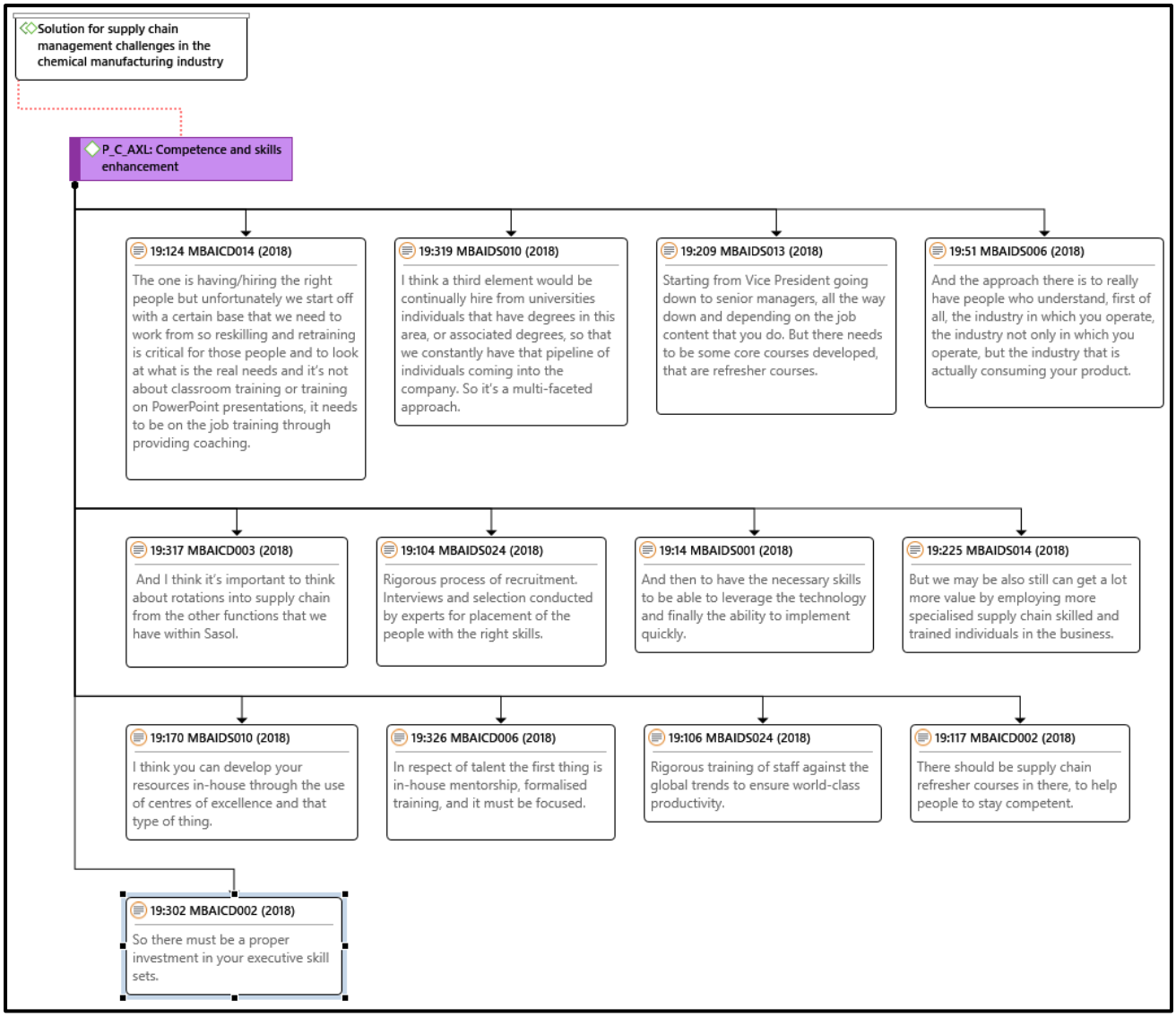
Predominately, participants stated that the sustainable solution for supply chain challenges and the creating of competitive advantage reside in the level of digital maturity of the organisation. Participant believe that the current laggard approach of supply chain technology advancements will soon create serious financial and competitive difficulties to organisations following this approach. There is a clear need to transition into a technology innovation mind-set. Figure 4-6 display the opinions of participants in relation to technology implementation in the supply chain. Participants state that end-to-end supply chain processes should be paperless. According to the participants, paper-based processes prevent the collection of accurate and reliable data and prevent visibility across the supply chain. Through the digitalisation of the supply chain, organisations will create real time visibility of the holistic supply chain which will transition the supply chain from a reactive response function into a proactive decision making and alignment ecosystem. A

clear strategy should be developed and implemented, which directs the full integration of all systems and processes into a single unified global supply chain operating system. Analytical capability should be harnessed that monitors, tracks, analyses and learns from multiple streams of organisational data in order to shorten planning cycles and the enablement of accurate and reliable predictive supply chain strategies. There is thus a requirement to increase the focus on master data management processes in the organisation.

4.3.3.3 Category 3: Competence and skills enhancement

Participants state that not enough focus is placed on enhancing the skills and competence of the supply chain function. The interview data revealed that the general skills and competency requirements in SCM is evolving in line with the pressures brought about by the 4th Industrial Revolution. Figure 4-7 indicates the views of participants regarding competency and skills required in the supply chain. The rigour and methodology utilised to recruit supply chain employees need to be enhanced substantially. To a large extent, there are low literacy and educational requirements for working in the supply chain. The evolution of SCM will require specialised skilled employees that have the ability to operate cross-functionally in the supply chain. SCM should partner with universities to develop specialised SCM degrees that can assist with closing the gap in terms of the required skills and competencies. Centres of excellence should be developed within the organisation to develop the supply chain skills and competencies of employees. The methodology of conventional class room training should be relooked as this type of training is largely ineffective to transfer knowledge effectively. Training and development should be focused as compulsory modules at all levels and functions in the organisation and should focus on end-to-end supply chain knowledge.

Figure 4-7 Competence and skills enhancement



Source: Du Plessis (2018)

4.3.3.4 Category 4: Process optimisation and integration

Supply chain complexity is created by business processes that is misaligned and lacks standardisation across the supply chains. Functional structuring of SCM results in a silo implementation approach and changes to business processes, which delivers a misaligned supply chain that is unable to collaborate effectively. Participants believe that the simplification and integration of processes is critical to eliminate a majority of supply chain failures identified. This will mean that SCM will need to be viewed and structured from a holistic point of view when designing processes. MBAIDS006 (2018)stressed the necessity of supply chain integration: *"I believe addressing these challenges will be best through an integrated business and management process which provides, first of all, line*

of sight, a clear line of sight." The transition of SCM from a chain link concept to a seamless continuum of material, service and information flows will require advance adoption of technology throughout the supply chain. MBAICD010 (2018) said, *"I think, from my perspective, from where I stand, we live in a new era of digitalisation; and one of the things we need to do is automate processes".* MBAIDS001 (2018) further stated that SCM should clearly understand the causes of failures prior to the implementation of business processes changes, stating: *"So it's not transactionally focus, but it's the ability to look at the supply chain, look at the … let's call it the causes of issues … and the ability then to leverage technology to address those."*

4.3.3.5 Category 5: Customer centric focus

Participants strongly suggest that the chemical industry should move away from the traditional product-focused supply chain approach and transition into a customer-centric supply chain that is designed to meet the specific requirements of the customer. *"In respect of meeting of customer requirements firstly you need to understand and it must be very clear what your customer wants and what they are willing to pay for it* (MBAIDS001, 2018)*."* MBAIDS016 (2018) indicated that in order to understand customer requirement, there should be active and persistent engagement with the various customers, *"Think in that regard, the supply chain would need to communicate and actively engage with the customer on what their strategies are, what their risks and typical changes over the next few years, or currently, that they are experiencing, and the organisational supply chain would need to take that into account and adapt to a customer or perhaps advise or assist within the supply chain to assist a customer."* It also requires that extensive investment are made into the strategic leg of SCM to gather necessary business and market intelligence of its customer base. MBAIDS006 (2018) cautioned: *"Currently, companies only bank on their marketing information about existing customers and then they derive their production plans based on demand planning/ forecasting; but it should actually feed from the business intelligence to set up your production plans."* The data accumulated through business and market intelligence interventions is worthless if there is no integrated methodology to analyse and internalise the data to the benefit of the organisation. MBAICD001 (2018) stated: "*The question to what extent we are utilising data to help us predict and understand and utilise that data to be more be more proactive in dealing and providing customers with their requirements on time, that's where the value*

would lie." MBAICD006 (2018) indicated that supply chain design strategies should be centralised around customer requirements, *"So that they can understand if I design my supply chain a specific way I need to take into consideration what my market wants, what my supply chain strategy is supposed to be."*

4.3.3.6 Category 6: Upstream value proposition

According to the participants, the inbound supply chain component is perhaps the most important in the holistic supply chain context, in that it acts as an enabler for effectiveness in downstream processes. If front-end loading is not executed in accordance with standards and an agile methodology, the entire supply chain is effected, due to the domino effect. It is for this reason that emphasis should be placed on identifying and sourcing competent and experienced suppliers that can deliver material according to specification.

Participants state that systems should be implemented to actively manage supplier relationships. These systems should large automate the procurement processes to enable quick turnaround and availability of fit for purpose contracts. The enabling variable for reduced complexity contracting processes is the availability of a clear scope of work. Participant believe that the methodology of work scoping should be digitally standardised throughout the supply chain. MBAICD002 (2018) stated that a clear scope of work was required: *"Then from the sourcing plan enables a supply chain to go and test the market and come up with fit-for-purpose contracts."* Suppliers should be fully integrated as a channel partner into the supply chain processes. MBAIDS025 (2018) alluded to the importance of integrated collaboration in the supply processes when stating, *"Communication between nodes – that I believe is the typical old - not having necessarily formal SLAs, but a very clear regular communication/interface process, where there is either meetings at certain levels or be it daily business results orientation: having a look at what was planned, what was conducted, etc."* The hand-over points should be limited in the organisation supplier relationship to ensure visibility, track and trace capability and compliance to contractual requirements. MBAIDS015 (2018) stated: *"Often you will find that your suppliers cannot supply, due to not having a product or not necessarily having the service that are not compliant to the systems and the specific grading - if I can call it that - we prescribed."* There should be systems in place that compare service provider

outputs with required delivery standards in order to identify the reliability and supply riskiness of the vendor.

4.3.3.7 Category 7: Value driven governance

Participants believe that governance should be implemented from a perspective of adding value, rather than simply adding more and more controls just because the root cause of failure is not well understood and unpacked. MBAICD002 (2018) stated *"You can only ensure proper governance and compliance if you understand the working of the business processes."* Governance practices and rules should be hard-coded into SCM systems, in order to automate compliance with governance rules. MBAIDS008 (2018) stated that there should be a holistic understanding and acknowledgement of the impact of governance rules on the supply chain, saying: *"There should be from a governance perspective there should be a process governance which is almost a company-wide governance that needs to be implemented as well as a department level of governance, which is not necessarily the same."*

4.3.3.8 Category 8: Stakeholder integration

Participants state that there should be a clear mind-set change from an operations focus to a supply chain focus. MBAIDS023 (2018) stated that there should be a clear line of sight by SCM in all aspects of the business: *"Also, supply chain needs to work with various other functions such as planning and optimisation, operations, site services and it's important for supply chain to be in the loop of business plans as they evolve on a month-by-month or week-by-week basis."* MBAIDS025 (2018) focused on the level of stakeholder integration, by stating: *"I believe there should be a strategy which is developed right from the top where the production and the final despatching of the product out the gate, there should be a very clear methodology whereby these are integrated with the critical performance indicators between the various controls, hand-over points, should actually be assisting each other and not necessarily always be conflicting with each other."* In order to facilitate effective and transparent collaboration between the various stakeholders in the supply chain, participants propose a two folded strategy. Firstly, the number of hand-over points in the supply chain should reduce significantly to prevent a silo mentality from impacting on supply chain performance. Secondly, technology should be applied to its fullest capability to enable real time collaboration between stakeholders

based in different geographic regions. MBAIDS024 (2018) supports the use of technology to enable collaborative processes when suggesting, *"More usage of technology to create synergies, i.e. online collaborations and hand-overs on one platform."* Leadership should be in the position to monitor the effectiveness of supply chain collaboration utilising technology. MBAICD013 (2018) stated, *"I would like stakeholder engagement to be completely automated so that the SVP can go on to his/her phone, for example, and look at the state of stakeholder engagement in the business and go actually you know what, base chemicals and energy have got the same problem with a particular service provider and me as SVP it looks like I'll be best placed to sort that problem out and then I've got two birds killed with one stone."*

4.3.3.9 Category 9: Supply chain responsiveness

Participants stated that conventional methodologies used to implement supply chain changes using comprehensive project management methodologies will become irrelevant and ineffective in the 4th Industrial Revolution. MBAICD002 (2018) argued against conventional project management methodologies, by stating: *"If you only focus on where you will find the biggest impact you will most probably do nothing."* Focus should be placed on processes that yield small by continuous value for the supply chain. MBAIDS006 (2018)proposed a solution to the project management dilemma, i.e. *"So we need to be able to react much faster to challenges and opportunities in the market, especially again in the chemical commodity markets."* More than ever, there is a need for SCM to evolve into responsive and flexible structures that are able to quickly and effectively adapt to market forces and changing customer requirements. MBAICD014 (2018) proposed the utilisation of Agile methodologies which are based on the premise of MVP: *"One of the things that, within the digital space, we're focusing on is this Agile methodology, which is a little bit foreign for Sasol. But it's basically learning how to sprint, fail fast where we realise we are not going in the right direction, recalibrate, spring again – always with the view with where we ultimately want to get to, but use this methodology versus the traditional project plan approach where it may be a year plus until you get to an end result, only to find out you've missed the mark."*

4.3.3.10 Category 10: Supply chain cost optimisation

Participants state that supply chain cost initiative should focus on cost optimisation, rather than on cost saving. The cost of the supply chain should be determined by the type of supply chain strategy employed and what is required to effectively and efficiently serve the customer. In order to optimise on supply chain cost, there should be a deep understanding of cost drivers and TOC. Cost information should be visible and transparent across the supply chain in enable cost optimisation leverage. MBAIDS001 (2018) stated, *"And finally, I would say your cost at which you do it should also be competitive and you should have a very good understanding of your cost drivers, so that you don't make commitments, for example to deliver faster, but then, from a cost perspective, it doesn't make business sense anymore."* Participants stated that reliable cost data should be analysed on continuous intervals and compared with similar supply chains in the market. Benchmarking of supply chain cost can be a major driver for supply chain optimisation and alignment with international best practice benchmarks. MBAIDS014 (2018) suggested: *"With cost - it's easy to say something about it – you must come up with a plan! I am wondering whether the companies, and if we are, good positioned to actually compare the cost of supply chains and supply chain processes on an almost individual basis, that you have a certain supply chain and you achieve something and that you are actually able to compare the cost of those supply chains with one another over time."*

4.3.3.11 Category 11: Roles and responsibility transparency

Functional segregation of teams within SCM results in faded roles and responsibilities brought about by excessive hand-over points. MBAIDS010 (2018) stated, *"With respect to fragmentation organisations needs to create single and clear accountability."* MBAIDS010 (2018) added, *"And for me STI is a powerful metric in terms of short-term incentives to drive behaviour, but it has a lot of unintended consequences when you directly draw people's remuneration and their functional remuneration to specific KPIs."* Participants felt strongly that functional KPIs are destructive in terms of supply chain success. There should be a single accountability point per supply chain which culminates success through customer experiences. Accountability and ownership is brought about by a clear understanding of processes, people and equipment requirements and how these ensure the end-to-end success of the supply chain. MBAIDS007 (2018) stated,

"So I think improving their understanding of the business model, understanding of roles and responsibilities, understanding the business process execution, I think all of those elements will definitely help in terms of fulfilling the integration picture."

4.3.3.12 Category 12: Supply chain planning optimisation

Participants indicated that supply chain planning cannot be executed in pockets of upstream and downstream focusing on different directives and variables, e.g., *"So it has to be that holistic approach* (MBAICD014, 2018)*."* There should be systems in place to provide real time visibility of supply and demand variables throughout the chain. Holistic supply chain planning should be executed by a core team responsible for the end-to-end planning process. This challenges the concept of conventional supply chain structuring which separate upstream and downstream processes from one another and cluster planning functions into disintegrated teams. Holistic planning and real-time visibility will enable shorter forecasting and execution cycles with more control of demand and supply variables. MBAIDS008 (2018) stated, *"So the planning function actually, and there's no alert system to warn if materials aren't being delivered on time."* Effective planning and the control thereof is based on the ability of the supply chain to identify failure before it occurs and to put preventative measures in place to deal with the anticipated disruptions. Participants also believe that not enough time are spent on proper planning processes. The main focus is to go into execution mode, which regularly result in crisis management. MBAIDS010 (2018) believes the solution is: *"Ultimately, the time probably takes much the same, but the journey is a lot smoother when you have actually thought things through and planned and realised the consequences of your actions, prior to just jumping into execution mode."*

4.3.3.13 Category 13: Leadership competency

As already identified, a supply chain is only as strong as its weakest link; however, it is the glue that keeps the chain together. It is relatively easy to simplify processes, improve on system failures and implement solutions to customer pinpoints. However, if leadership competence in the supply chain is not at the required standard, the supply chain will attract complexity, and deliver failure or poor performance. MBAIDS007 (2018) said, *"I think, probably the first thing, is to just have that mind-set change."* Leadership competencies that worked effectively in the industrialist age will become redundant in the

4th Industrial Revolution. Leaders will thus require a completely new skill set to navigate the disruption brought about by market forces and will have to change the culture of the organisation to cope with these pressures. The culture exhibited in the chemical industry should be reinvented and the supply chain leader should be accountable for bringing about this culture shift. MBAICD013 (2018) indicated that it is important to screen and appoint the right leaders, who are capable of leading in a digital age: *"Whatever that SVP wants to do, their thinking, their pet projects, their passions, their preferences becomes our work instructions. So, if you make the wrong decision we are totally derailed."* Supply chain leaders will need to work tirelessly on changing the old culture or old way of working, as it will be difficult to change old habits and behaviours that have been imprinted over many years of operations. MBAICD006 (2018) alluded to this challenge when saying, *"So, changing the people's mind-set – we have this whole thing of moving on a continuous improvement drive – but getting people to understand what it means and how to apply those kind of principles ..."*

4.3.3.14 Category 14: Leverage industry best practices

MBAICD014 (2018) indicated: *"There has to be the balance between utilising internal resources to manage cost, but at the same time using external resources - so call those consultants - to take advantage of industry best practices, especially given how quickly things are developing in this area."* An analysis should be conducted on identify gaps in SCM skills and capabilities. Industry knowledge and expertise should be strategically sourced to enhance the capability of the supply chain. This strategy should be applied in a manner where knowledge transfer is facilitated in as short period as possible. The aim of leveraging on industry expertise is to derive substantial and immediate value to SCM.

4.3.3.15 Category 15: Optimised supply chain structures

MBAICD011 (2018) believes, *"… in terms of structures, we need to simplify our structures as far as we possibly can."* This aspect links with the integration and optimisation of processes, which indicate that hand-over points and a silo mentality should be eliminated as far as is reasonably possible, in order to ensure seamless supply chain processes. In order to ensure enablement of seamless processes, the supply chain structure employed should fully integrate and support the SCM processes and systems.

4.3.3.16 Category 16: Corporate intrapreneurship

Participants believe that corporate intrapreneurship is a major contributor to SCM success, in that it allows employees to come up with new ideas and it provides them with the autonomy to implement these ideas. MBAICD013 (2018) stated, *"So, it's about thinking of yourself as an entrepreneur and I have in my PVPs with the people who report to me, I encourage them to start their own little side business, obviously with governance attached to it."* Entrepreneurial thinking and action will foster dual organisational ownership cultures, which will benefit the supply chain in its attempt to align with customer expectations. In a volatile and disruptive business environment, continuous improvement of systems, processes and people are of critical importance. MBAICD006 (2018) indicated: *"We need to change that culture within our teams and we also need to get them to understand listen what is continuous improvement: it's not just another cost saving initiative, it's a way of life."* According to MBAICD001 (2018), the chemical industry should implement protective measures to protect the organisation from disruptions through the use of innovative business models. The participant stated: *"I see a future, if I may, where if chemical companies are not careful, they will become more or less similar to what suppliers to the fast moving consumer goods industries like grocery outlets where they are squeezed for margins, paid on long lead time, or long payment terms, have no leverage while these online or portals or people that are able to extract value by understanding customers would be able to shop around from different chemical industry players to provide the best possible solutions and/or products to their customers."*

4.3.3.17 Category 17: Operations excellence

Participants indicated that sound maintenance strategies should be implemented on physical infrastructure that can impact the customer experience negatively. MBAIDS002 (2018) stated, *"If equipment is in good standard and you have a good maintenance strategy you will be able to maintain your throughput on volume."* MBAIDS008 (2018) mentioned the importance of thorough and continuous infrastructure preventative maintenance, stating, *"First of all you need to ensure that you have a full-time maintenance planning team."*

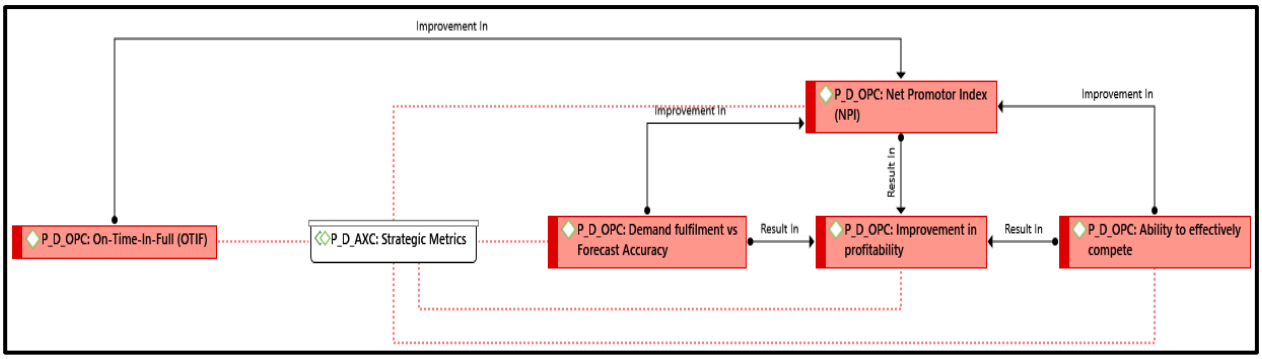
4.3.4 Theme 4: Measurement of the success of supply chain management in the chemical manufacturing industry

Participants provided different views on how the overall success of SCM should be measured. A number of 131 line codes were refined into 23 open codes; these were categorised into three main categories, namely strategic, tactical and operational metrics, so as to derive the optimal value based methodologies to measure SCM effectiveness.

4.3.4.1 Category 1: Strategic Metrics

According to MBAIDS010 (2018), *"For me, again my definition of a supply chain is really the end-to-end process. So, I think that's sometimes where we forget, I mentioned it earlier around the customer purpose, but we've got things like now we're tracking net promoter index – which is an NPI score for customer retention, what is the likelihood of them reordering from you their happiness and their experience."* The Net Promoter Index (NPI) was identified by participants as the most important strategic measurement to determine supply chain performance. MBAIDS010 (2018) further stated, *"So for me, if we are getting repeat customers who are buying from us day in and day out, they are paying us on time, their complaints are limited - there's just generally a positive feedback. There's not, every time you want to change the price, that there's massive push-back."* Positive experience and the ability of the organisation to exceed the expectations of customers is confirmed as the single most important measurement to determine customer centric SCM. Analysis of participant data revealed that improvement in profitability is another dominant measurement of supply chain performance and that it is influenced by the other identified strategic metrics.

Figure 4-8 Strategic metrics relationships



Source: Du Plessis (2018)

In order to increase the NPI, participants indicated that real time visibility of On-Time-In-Full (OTIF) deliveries are monitored. OTIF is an important measurement of supply chain performance in that it establish whether the customer requirements have been met, considering time, scope and money. MBAIDS008 (2018) elaborated on the importance of measuring OTIF, stating: *"If all of your materials are delivered, the right material, at the right price, on the requirement date, of the right quality, when the end user requires it for production, or the customer receives it who ordered it. Then you know you've arrived and you are doing it right."* Profit margins are negatively influenced by imbalance between actual supply and demand forecasting.

MBAIDS006 (2018) stated, *"A very important aspect is to look at production versus market versus sales relevancy."* Participants mentioned that these imbalances normally result in lower margins, as disposal sales strategies are implemented to effectively cover the cost of sales of over-production. The integrated end-to-end measurement of product-to-sales effectiveness is thus a critical measurement in supply chain effectiveness.

It has been established that the 4th Industrial Revolution will intensify competitive forces within the business world, due to the introduction of innovative and disruptive business models. For this reason, it is crucial that organisations track its continuous improvement initiative. *"Continuous improvement, now whether that is technology and digitalisation driven and whether that's just improving your business processes, as long as you continuously improve what you do today and stay competitive in the market* (MBAIDS007, 2018)*."*

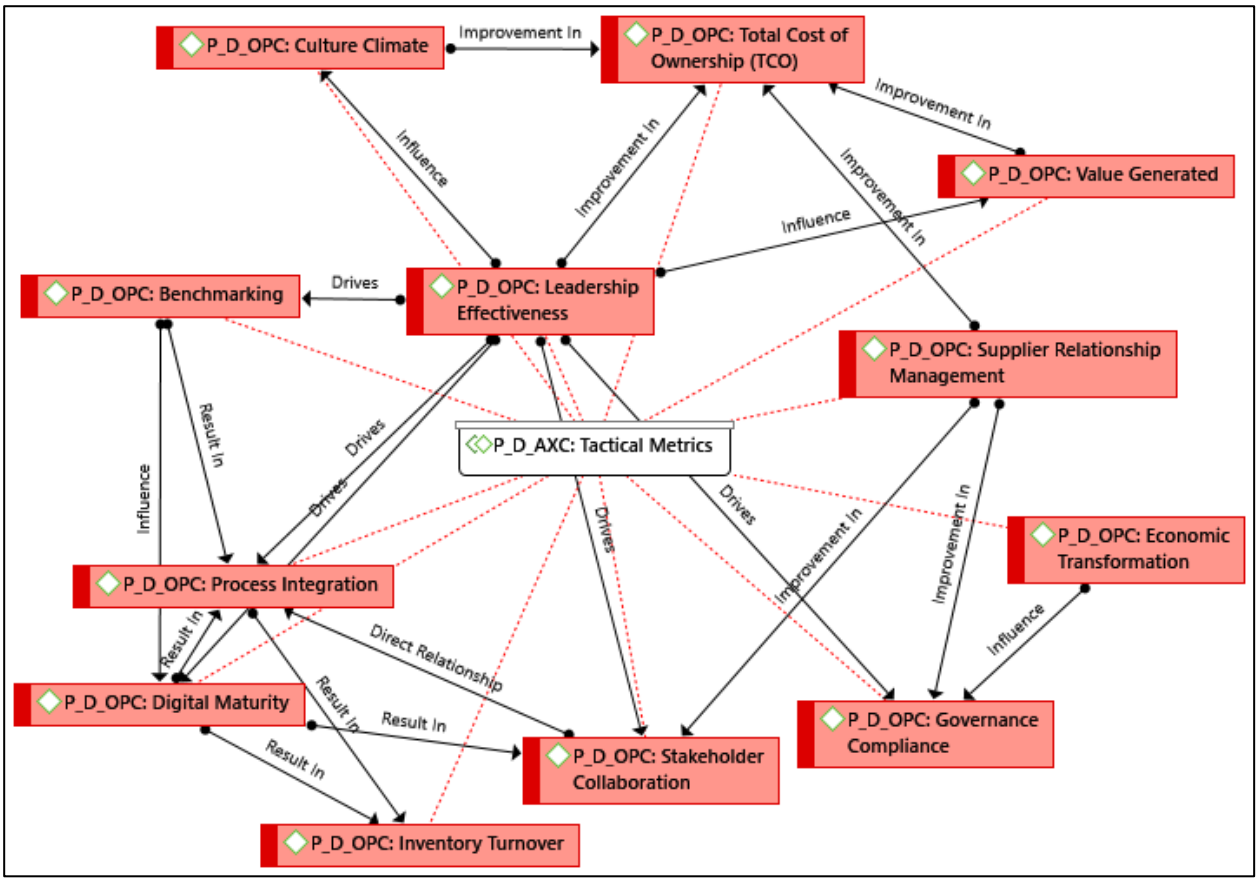
4.3.4.2 Category 2: Tactical Metrics

MBAIDS006 (2018) indicated: *"And it's coming back to the proposal of any integrated business process and management approach."* Participants regard the measurement of process integration and the seamless flow of goods and services along the supply chain as the dominant tactical metrics approach, due to its ability to positively influence the other identified measures.

MBAIDS016 (2018) confirmed the measurement of process integrations, when stating, *"I think another form to indicate if a supply chain is more or less healthy is that communication is flowing and information is flowing in a positive, correct and efficient*

manner between each and every supply chain." Cost saving is not a major objective for SCM, but rather the optimisation of cost while improving the customer value proposition.

Figure 4-9 Tactical metrics relationships



Source: Du Plessis (2018)

Participants believe that there should be systems in place to transparent visibility of the TCO in each individual supply chain in order to identify cost optimisation opportunities. Participants believe that SCM is more about "ticking the boxes" or "executing process steps" than about generating tangible and intangible value to the organisation. *"So it should be really on value add by the supply chain* (MBAIDS006, 2018)*."* Participants believed that measurements of cultural climate within SCM is largely neglected as a measurement of SCM success. According to MBAICD013 (2018) *"You get absolutely no discretionary effort from people who are leaderless and when the culture is full of threat and fear and confusion."* Metrics should be developed to measure the supply chain against international benchmark best practices.

Benchmarking cannot be seen as a once-off initiative, given the rapid changes occurring in the business environment globally. Participants highlighted the impact of leadership effectiveness within SCM. As indicated in the literature, a new leadership mind-set is required to survive the onslaught of the 4th Industrial Revolution. MBAIDS016 (2018) stated*, "I think the feedback of the leaders in the organisation within the supply chain, if they are able to give good feedback and can positively speak about their output per region, per supply chain."* MBAIDS015 (2018) *"Another big point is you must ensure that there's a working relationship between your supplier and your end user."* SRM measurement is important to ensure that front-end loading of materials and processes is executed accurately, on time and to standard, so as to prevent failure in the downstream processes. Participants stated that the measurement of digital maturity is both relevant and of strategic importance in order to ensure long-term supply chain success. Another important measure that participants revealed was inventory turnover.

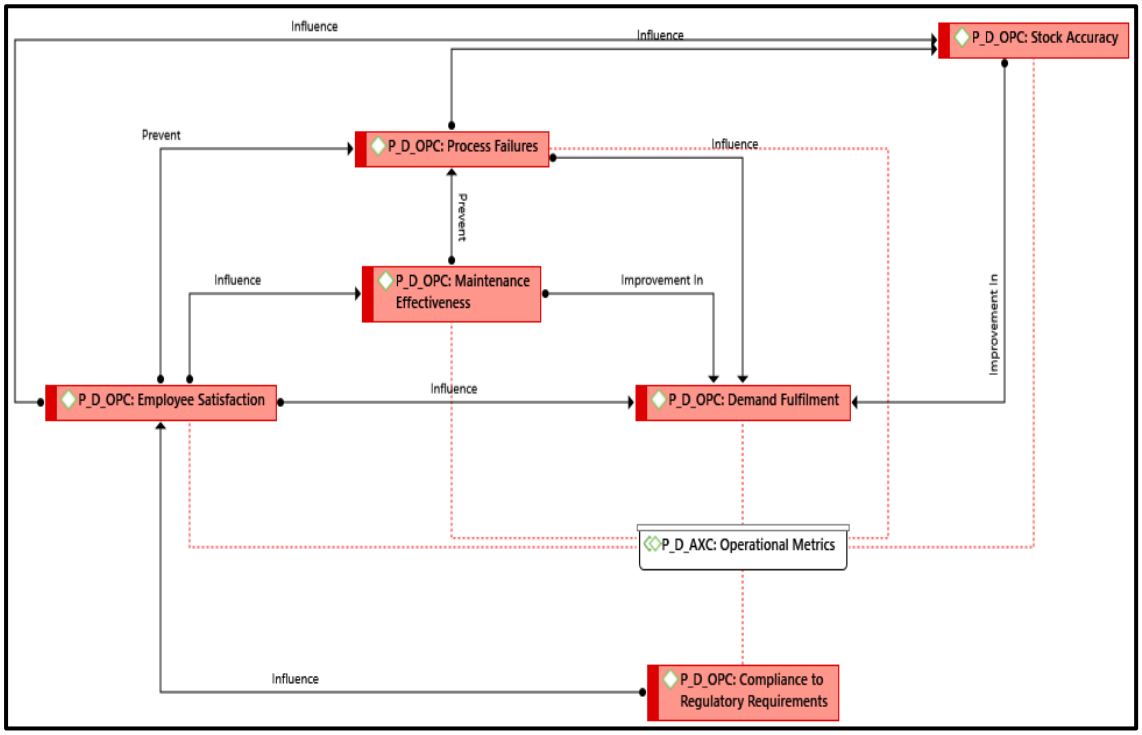
MBAIDS006 (2018) supported this point when stating: *"And then also looking at do you have aging stock, stock that doesn't sell off which is basically depleting your working capital or can be regarded as a working capital loss."* Participants stated that principles of JIT should be measured to ensure optimal working capital structures are maintained when holding inventory. Stakeholder collaboration was mentioned by the participants as a key aspect for measuring SCM success, as seamless communication between channel partner's results in improvement in multiple supply chain processes. *"And then again in the South African context your economic transformation, your spend and upliftment, those are also critical measures* (MBAIDS001, 2018)*."*

Economic transformation as a legal agenda should be measured to both align with legal requirements and to maintain the license to operate. Lastly, and for a very specific reason, compliance with governance requirements should be monitored. MBAICD004 (2018)stated, *"You need to look at your governance and compliance KPIs.*" Governance compliance does not necessarily ensure supply chain success; however, it does steer the organisation on the pathway of integrity, fairness and equitable business processes whilst it is executing the supply chain strategies.

4.3.4.3 Category 3: Operational Metrics

Participants regarded demand fulfilment as the most important operations metrics to measure supply chain success. MBAIDS006 (2018)stated: “Meaning did we produce what we have marketed … *We are so prone in the production environment to look at tonnage produced. Reaching design capacity, output capacity of a specific production plant. That is not relevant - at least, not in these days, it’s not relevant. But we should rather focus on actual demand fulfilment and that is where the company starts to focus on total contribution towards bottom line earnings.”*

Figure 4-10 Operational metrics relationships



Source: Du Plessis (2018)

Participants regarded employee satisfaction as the second most important operations measurement, mainly due to its ability to impact end-to-end supply chain processes. MBAIDS010 (2018) confirmed the importance of employee satisfaction: “*And so that understanding where the people are in the supply chain, what their level of work or stress or where they are is generally for me a key indicator, because they feel it much earlier than others.”* As with governance compliance measures, compliance to regulatory requirements does not ensure the success of SCM; however, it does contribute to sustaining the license to operate.

The maintenance effectiveness directed towards ensuring sustainable and reliable infrastructure is critical to enable the success of reliable material flows throughout the supply chain. MBAIDS008 (2018) added, *"I would say if your maintenance plan, if what you have budgeted and executed has gone correctly, and then also if there's an expansion in the amount of new facilities or replacement of, say like asbestos has been done according to your environmental plan because that also is a government regulation on when that needs to be disposed of and worked out of the system and reduced."* Participants stated that the measurement of process failures is a direct input into the supply chain strategic management process in that it enables stakeholders to clearly understand failure modes prior to implementing mitigating controls. MBAIDS008 (2018) confirm that stock accuracy is an important enabler of supply chain success: *"I would say stock accuracy, because if you receive the stock correctly, you process it correctly, it's binned correctly, it's picked correctly, then you know that you are managing it properly."* Stock accuracy is a direct input factor to OTIF measurements and, ultimately, to improved customer experience.

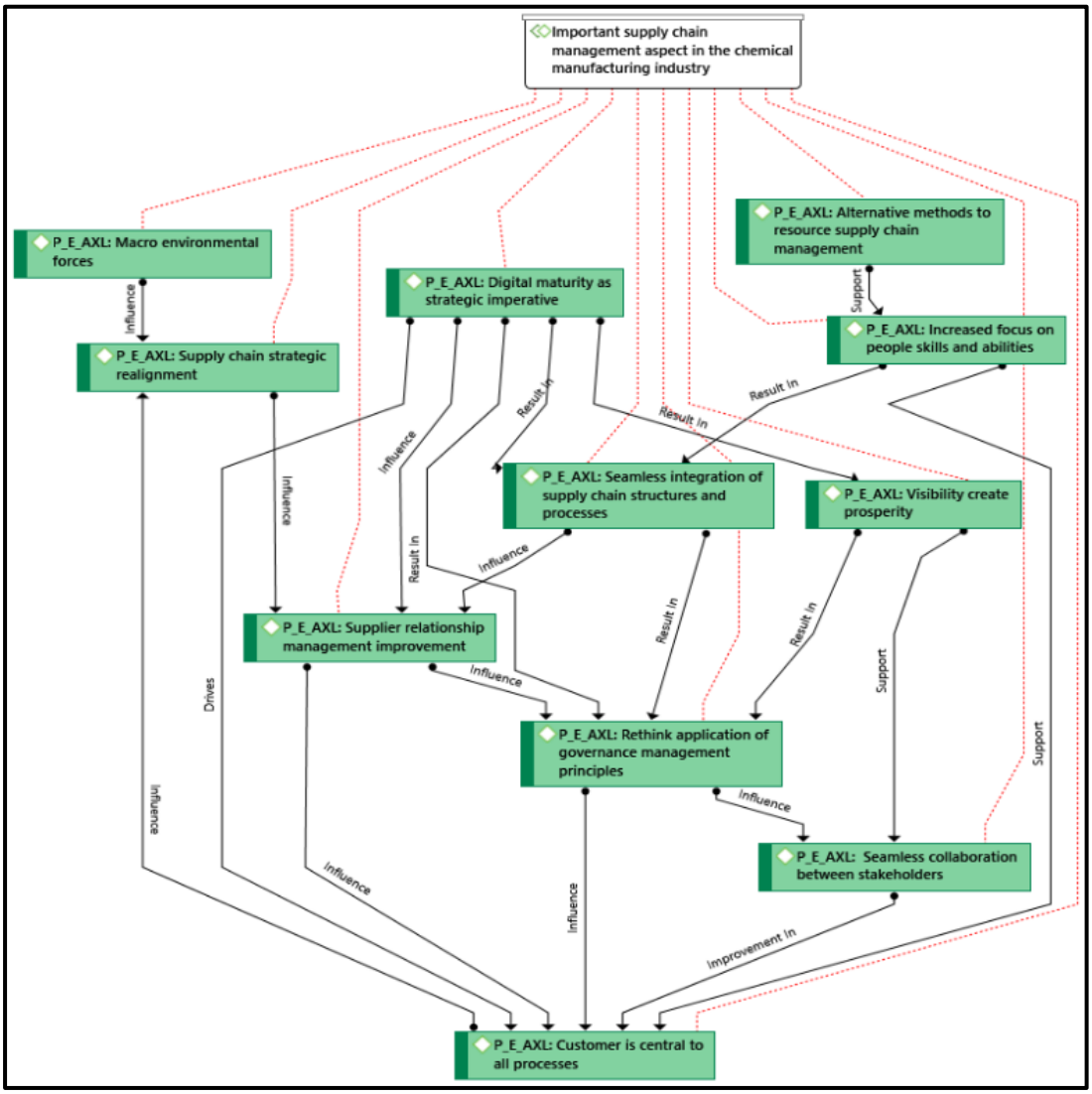
4.3.5 Theme 5: Important supply chain management aspect in the chemical manufacturing industry

The final question of the interview schedule was designed to allow participants to openly and freely share any important aspect they felt was relevant, important and can support the outcome of the research study. This question was strategically added to ensure the maximum application depth of knowledge and experience were achieved. A total of 107 open codes was developed from the line-by-line data analysis.

Through reflexivity and constant comparison, the additional data inputs from participants was scrutinised and combined from a similarity point of view. The data was categorised into 12 axial codes. This data analysis serves the purpose to enhance the research findings identified during theme one to four.

Figure 4-11 depicts the various categories of additional SCM best practice that were analysed and the interrelationships between each of the categories.

Figure 4-11 Important supply chain management aspects in the chemical manufacturing industry



Source: Du Plessis (2018)

Participants cautioned against the continued stance of digital aversion and bureaucracy regarding innovation. The types of technology used and the way in which technology is absorbed into the supply chain require urgent and serious alignment with industry trends, if they are to remain relevant and competitive in the chemical industry. MBAICD002 (2018) stated, *"So I believe the digital era actually brings a lot of opportunity for supply chain to step to a different level of performance."* MBAIDS008 (2018) believes that in the current disruptive era, "How we look at structures, or organisational structures, will need to be amended." MBAIDS025 (2018) added, *"In my viewpoint, if I look at operations and I use that as an analogy there is a very clear structure and there are very clear acceptable knowledge bases expected at various levels which I'm of the opinion that the supply chain*

environment is not necessarily there." The participants agreed that supply chain is not seen as a strategic driver for business success and that it should be of core importance to organisations, in order for organisations to achieve supply chain excellence. The data collected revealed that there is still a strong focus on products and the production processes involved, as opposed to customer centric alignment. This is again a typical example of industrialist thinking that is not supported by the 4th Industrial Revolution. Participants stated that an extensive re-alignment is required in the way supply chain strategies are institutionalised.

Participants emphasised the importance of comprehensive supply chain integration through the elimination of silo mentality and functional structuring of the supply chain. The participants explicitly pointed towards a supply chain that has few to no hand-over points, which facilitates the seamless flow of materials, services and information from upstream to downstream and vice versa. Table 4-2 reveals the voices of the participants in relation to supply chain integration.

Table 4-2 Participants views on supply chain integration

MBAICD001	*"Hence, from my view, the way that we structure organisations going forward in support of serving the customer better by means of supply chains, needs to be, well we need to rethink how that is put together."*
MBAICD002	*"If disintegrated you end up working in different directions. Integrated approach you have one common vision, one strategy that you all work towards."*
MBAIDS010	*"So, we need to get the healthy balance of managing the end-to-end process, but also allowing different people who are experts in that field."*
MBAICD014	*"So, each area is trying to be functionally excellent, but not looking across the supply chain and delivering what actually is needed for the customer."*

Source: Du Plessis (2018)

Participants stated that the importance of supply chain visibility as a core component to responsive and agile decision making, influenced by internal and external forces.

Participants mentioned that macro environmental forces impacting on the supply chain should be clearly understood, internalised and partnerships established to limited the impact of these forces on the organisation. MBAIDS006 (2018) elaborated on the sources of these impacts, saying *"I think relevant in the context of South Africa is negative impacts, for example, port operations specifically looking at export opportunities that we have and the effective of support, or rather lack thereof, at the point of export."* MBAIDS010 (2018) contributed to the list of sources when saying, "*And I think in the South African context we are under pressure from a Black Economic Empowerment point of view."* Participants feel that large organisations should form partnership agreements to dialogue the impact of these forces on the effectiveness of the supply chain. Collaboration between channel partners was again emphasised by participants as a core focus point of supply chain strategic management processes.

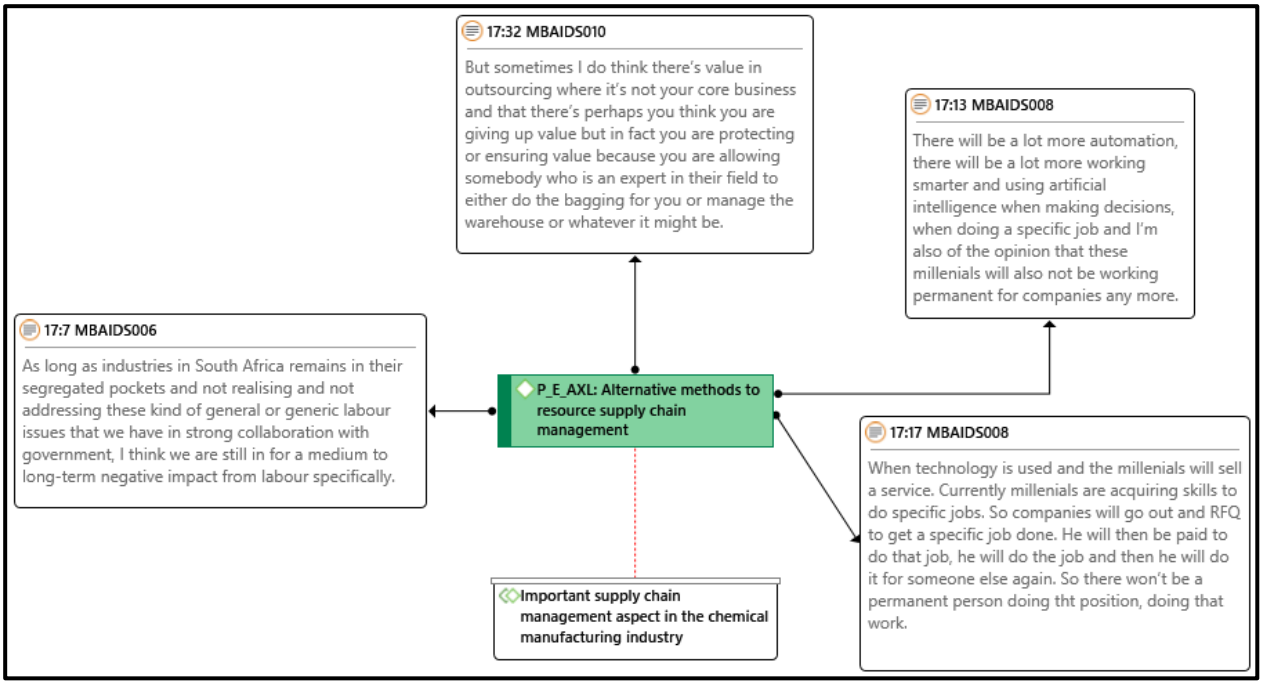
MBAICD014 (2018) stated: *"That we have good collaboration and making sure, both from a culture/behaviour perspective and in terms of our internal processes that we have that holistic view that takes into account all the various stakeholders, or customers if you will, of the supply chain."* Participants feel that there is not enough focus on upstream processes, especially focusing on supplier relationships. There should be processes in place to seamlessly integrate with suppliers to ensure uninterrupted and reliable flow of materials and services into the supply chain. A similar approach should be followed as with customers, to really understand the needs and constraints of suppliers to delivery materials and services on the required standard. Participants further elaborate that the current supplier relationship landscape is strained by complexity and over-governance. Participants stressed the importance to rethink the application of governance management principles in the supply chain.

The current governance landscape is destructive in aligning with customer requirements and prevent tangible value adding activities in the supply chain. Excessive governance prevents innovative and integrative methods of work, which ultimately impact negatively on the customer experience. MBAIDS008 (2018) *"In my opinion I think that within the next ten years, if I look at the advancement in artificial intelligence, in technology, and our millenials that are actually going to, are taking up arms in the workplace, there's going to be a big change in the way we do things."* There will be increased pressure on the supply chain from a human resource point of view. In order to survive the 4th Industrial

Revolution, a complete shift in mind-set and culture, as well as new skills is required. This will require a complete relook of how SCM is resourced and the types of skills and expertise that will be required to effectively execute according to customer expectations.

MBAICD006 (2018) also suggested that supply chain employees will have to be managed using different management principles to those currently applied, i.e. *"But it's also … we need to figure out from an organisation perspective, how to motivate our people and change the thinking of our people."* Given the increased pressure to seamlessly integrate supply chain processes and to enhance collaboration between partners, MBAICD001 (2018) suggested: *"The other skill that I think is of critical importance is being able to manage relationships well and engage with different stakeholders."* Various participants believe that these changing requirements in supply chain skills and abilities, require that organisations look at alternative methodologies to obtain skills and expertise. Noteworthy comments made by participants is displayed in Figure 4-12.

Figure 4-12 Supply chain resourcing quotations



Source: Du Plessis (2018)

There is a strong indication that supply chains will transition into non-permanent labour structures that provide a service on a contract basis and that are paid for that service in accordance with actual output. According to the participants, this type of labour structuring will improve productivity, capitalise on skills and experience from various

industries and will make work more flexible and motivating for people. Participants is of the strong opinion that governance and compliance measurements enjoy more priority than measuring customer experience as corroborated by MBAIDS010 (2018) *"In terms of the customer satisfaction measure as opposed to a BEE measure."*

4.4 Summary

The chapter focused on the profile of participants and the presentation of research findings identified during the data analysis process.

In summary the following important consideration from this chapter is noteworthy:

- Participants in the semi-structured interview process had a cast amount of skills, competencies and experience related to SCM in the chemical manufacturing industry.

- Unique challenges impacting on the effectiveness of SCM in the chemical manufacturing industry context was identified and disseminated.

- The challenges identified was prioritised in accordance with relative impact and prevalence in SCM.

- Participants provided proposed solutions to the various challenges identified through referencing their wealth of industry knowledge and experience.

- Attempts were made to identify supply chain performance metrics that can provide clarity on end-to-end supply chain performance management.

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Research suggests that the chemical manufacturing industry is at the brink of a revolution that will challenge the principles, operating methodologies and cultures constructed and perfected during the period of operating in the industrial age – and it will do so to such an extent that its relevance and presence in the market will be determined by its ability and willingness to adopt new work processes and methodologies. The revolution is largely being brought about by the unprecedented speed at which technology is developed and adopted in all industries. Experts are of the opinion that it is only a matter of time before chemical manufacturing giants are directly exposed to threats brought about by innovative business models that aim to increase competition and level the competitive playing field. Therefore, chemical manufacturers cannot rely on old tactics of dominating the market by means of sheer size, presence and capital intensity. It is thus a strategic imperative for basic survival that the organisation's supply chain management processes, systems and people are aligned to credible and visible market trends.

The primary objective of this study was to develop a supply chain management best practice framework that can be utilised by the chemical manufacturing industry to align processes, systems and people with the requirements and principles of the 4th Industrial Revolution. The primary objective was supported by a number of secondary objectives to construct the most effective, efficient and reliable SCM best practice framework.

The aim of this chapter is to synthesise the findings obtained from the literature and empirical studies undertaken. Synthesising the data will provide a solid scientific foundation for the development of recommendations that will assist the chemical manufacturing industry to substantially improve its SCM standards and operating methodologies. The recommendations provided will focus on two contributions to the body of knowledge. Firstly, based on the literature review and empirical study, recommendations will be made to chemical manufacturing organisations on how their supply chains can be transitioned in line with trends and pressure from the 4th Industrial Revolution. Secondly, during the research project, multiple opportunities for further studies were identified and these will be recommended in this chapter.

5.2 Conclusions

5.2.1 Nature and scope of the study

The nature and scope of the study provided the required context for the background and purpose for undertaking the study. In section 1.2 it was established that organisational competitiveness is determined by the capability of the supply chain management system. Furthermore, it was found that there is a requirement for a complete mind-shift - from conventional operating systems towards digitalisation of end-to-end processes. The significance and the contribution of the study is in its positioning of supply chain management in the chemical manufacturing industry to respond to the trends and principles brought about by the 4th Industrial Revolution.

In order to unpack the probable solutions to the problem statement, both literature and empirical studies was undertaken. The size and complexity of the study necessitated ring-fencing of empirical reviews on the South African chemical manufacturing industry, with a focus on the strategic SCM level of large chemical manufacturers. The literature reviewed was based on international sources and best practices that enabled this study to be scaled towards smaller chemical manufacturers and the international community.

5.2.2 Literature review

A literature review was conducted, focusing on unpacking the context of the South African chemical manufacturing industry, and the role played by supply chain management within this industry. Various findings and conclusions were derived from the literature, through the application of reflexivity, which was done to identify contributing factors that support the primary and secondary research objectives.

When focusing on the South African chemical manufacturing industry, various notable conclusions were deduced from the literature, which provided clarity on the dynamics of the industry and how it impacts and influences supply chain management.

There are multiple, large chemical manufacturers based in South Africa, however, the largest, in terms footprint, output and financial capability, was identified as Sasol. Section 2.2.6 states that there is a notable trend in the chemical manufacturing industry to capture value over volume, increase investment in technology advancements and create systems of predictable demand.

From a supply chain management perspective, there are various critical considerations that were identified that support the credibility of the outcomes reached in this study. Supply chain management was unpacked in sections 2.3.1 – 2.3.2, in order to define the scope, objectives and benefits of supply chain management. Section 2.3.4 confirms that supply chain management must be based on best practice principles that direct thought and decision processes across the organisation. Early on in the literature study, there was a clear indication of the importance of measuring and optimising supply chain cost as a primary determinant of supply chain excellence. Figure 2-3 is an important reflection of supply chain management functions that were used extensively in this study to develop a best practice supply chain management framework for the chemical manufacturing industry.

There are various measures that can be used to measure supply chain performance, i.e. strategic, tactical and operational. However, Section 2.3.8 concludes that the measurement of customer-centricity should be an integrated performance requirement throughout the supply chain.

A well-defined supply chain strategy is the basis for supply chain excellence. One such strategy is to align personnel competence with key trends brought about by supply chain digitalisation. Personnel will require higher skills and cognitive abilities as they relate to technology and data analytics. It has been found that continuous improvement and agile methodologies will be regarded as pre-requisites to supply chain success. Waterfall project management methodology will be ineffective in the future, due to its inability to deliver responsive value to the organisation. As stated in section 2.3.9.4, best practice supply chain management is strategy driven, scalable to requirements, has an optimised cost structure and applies a holistic approach to supply chain management.

In section 2.3.11, the adoption of a multi-layered and advanced technology ecosystem was suggested as being the singular most important transition that supply chain management should undergo, in order to remain competitive. The literature review has suggested multiple supply chain models that can be implemented by organisations.

It has been discovered that, to a large extent, the models are a major contributor to the supply chain's inability to reach levels of functional excellence. The models explained in sections 2.4.1 to 2.4.4 claim that certain benefits are derived from implementation of these

one-size-fits-all models; however, the research strongly opposes the use of an off-the-shelf supply chain solution. Instead, the research suggests that supply chains should be based on customer-centric value creation principles.

Figure 2-14 shows the major challenges for supply chain management, as indicated in the literature perspective. It has been found that the lack of visibility across the supply chain was a major cause of concern and inefficiency. The supply chain strategy should thus be directed towards enhancing visibility, velocity, variety and volume throughout the supply chain; but it should also aim to reduce variability in the processes and systems.

Figure 2-15 depicts the importance of maintaining a balance between service, cost and inventory, through fit-for-purpose and customer-centric strategies.

Figure 2-17 is a further important contributor to the outcomes of this study, as it suggests that the supply chain strategy should be fluent and persistent in its drive to deliver value. Supply chain design should thus be approached from a holistic perspective, in order to deliver value to the customer - as opposed to responding to internal organisational pressures.

Section 2.7.1 highlights an important consideration for supply chain excellence, i.e. that there should be an uninterrupted and continuous physical and information flow throughout the supply chain. This provides literature evidence that the word “chain” in supply chain management is a direct contributor to supply chain management ineffectiveness, as it promotes a disjointed process that is characterised by hand-over points and silo thinking. Section 2.7.2 provides further evidence of the disjointed result of conventional supply chain management methodologies and structures and suggests end-to-end integration of supply chain processes and systems.

Increased complexity is a major source of risk to supply chain performance, which requires a dedicated reduction focus to be applied through strategic decisions.

5.2.3 Research methodology

A rigorous and detailed approach was followed in enabling the empirical research process through the application of acknowledged research methodologies. A deductive approach was followed in the study, which means that the outcomes were deduced from a synthesis of the literature and empirical findings. A qualitative methodology was applied during the

research study, which used semi-structured interviews as the primary data collection mechanism. The study population was identified and defined as large chemical manufacturing organisations situated in South Africa. The size and scope of the industry did not permit an industry-wide empirical review and the research setting was decided upon due to the presence and industry dominance of Sasol Limited and its subsidiary companies. Non-probability sampling was used, with the expert purposive technique being applied during the empirical research process.

Participation in the empirical research was dictated by the participants' experience, skills and education related to supply chain management in the chemical manufacturing industry. A total of 40 interviews were initially planned, through the application of theoretical sampling techniques. In the end, 22 interviews were conducted, which yielded over 600 minutes of rich, primary data extracted from expert opinion. The qualitative data analysis software, ATLAS.ti was utilised during analysis of the primary and secondary data obtained from the target sample population.

Constructivist grounded theory was used as the theoretical model to ensure the validity, reliability and generalizability of the research outcome. Figure 3-1 illustrates the grounded theory process that was applied during the empirical study, in the quest to derive findings from the primary and secondary data collected. Various layers of qualitative coding were deduced, with Table 3-1 showing that 1006 open codes, 60 axial codes and 6 theoretical codes was developed during the data analysis phase of the empirical study.

A total of 68 theoretical memos were developed through the application of reflexivity principals; these were further refined and consolidated into five detailed memos. Data and meaning saturation was achieved at 22 interviews and this was established through the application of theoretical saturation tests and principles. Ethical considerations were consistently observed and ensured throughout the empirical study and were supported by formal ethical clearance being provided by the educational institution, after a rigorous assurance process was followed.

5.2.4 Data analysis and findings

Feedback from the data analysis process was approached by categorising the findings into themes that were consistent with the questions posed to participants during the

interview process. Demographic information was collected, in the interests ensuring that the sampling strategy had been consistently applied, in the attempt to generate valuable and expert findings regarding supply chain management. Table 4-1 confirms that participants possessed the required skills and competencies to participate in the study.

The first theme that was discussed was based on the specific and unique challenges faced by the chemical industry supply chain.

In sections 4.3.1.1 to 4.3.1.16, a total of 16 categories of challenges were identified and discussed, alongside the direct input of the participants. The section below highlights the main challenges to supply chain management in the chemical manufacturing industry that were identified:

- The lack of transparency of cost throughout the supply chain is heavily influenced by the absence of clear and reliable visibility of supply chain processes and activities.

- Supply chain management are not regarded as a core strategic focus in the chemical manufacturing industry: it is seen as a support function for manufacturing.

- Supplier reliability is erratic and influences the performance of supply chain management.

- Risk management is not holistically applied in a manner that can effectively mitigate the risks. The premise is that organisations do not invest adequate resources to comprehensively understand the unique challenges faced by supply chain management prior to the implementation of governance control measures.

- Governance management is not applied in a value-adding manner and it has been identified as a major contributor to supply chain management inefficiencies and a lack of customer-centricity in approach.

- Master data management is approached utilising conventional supply chain principles, which are not regarded as an excellence approach for establishing reliable and accurate master data in the digital age.

- The organisation tends to focus its attention on its portfolio of products, rather than adopting and approach that focuses on customer-centric customisation of supply chain processes.

- The customary skills and competency requirements in supply chain management is insufficient for effective functioning in a digitally-driven supply chain context.

- There is an indication that the rate of technology adoption by supply chain management in the chemical industry is lagging critically behind world trends. There seems to be a sense of sceptical rejection regarding new and innovative technology.

- The South African public distribution networks are not sufficient to support advanced supply chain management.

- Silos created by traditional supply chain structures drastically decrease the effectiveness of collaboration between channel partners.

- There is a direct impact on supply chain performance brought about by BBBEE vendors not possessing the required abilities and resources to reduce supply risk for the organisation.

- Compliance with regulations is a complex task, due to the excessive number of industry codes and practices imposed on the chemical manufacturing supply chain.

- Responsive adaptability and customisation of processes to meet the customer's changing needs is lagging in rigidity.

The second theme aimed to prioritise the identified challenges according to relative impact and value when addressed by the organisation. Figure 4-4 maps the priorities, based on the analysis of the primary research data. The top three priorities identified by participants, which deserve priority focus by the chemical industry, are: end-to-end integration of processes and systems; aggressive adoption of technology from a vertical and horizontal perspective within the supply chain; and compliance with regulatory requirements.

The third theme aimed to explore the various options to mitigate the supply chain management challenges identified in the chemical manufacturing industry. The data analysis revealed 17 main categories of solutions, which are discussed in sections 4.3.3.1 to 4.3.3.17. The solutions preferred by participants were:

- Supply chain management should transition from product orientated business processes to customer-centric hubs of value, which determine and direct strategies.

- There should be a dedicated strategic focus to rapidly enhance digital maturity within supply chain management.

- Personnel competencies and skills should be enhanced, in order to effectively adapt to changing business eco systems.

- Chemical supply chains should transition away from conventional functional structuring of supply chain departments.

- An upstream value proposition should be developed that enhances the responsiveness of souring and contracting processes.

- Systems should be deployed that narrow the gap between stakeholders and foster advance levels of consistent and reliable collaboration.

- Chemical manufacturing supply chains should enhance the responsiveness and agility through which processes and systems are improved to meet customer expectations.

- Attention should be given to clarifying the roles and responsibilities in supply chain management for purposes of transparency and to prevent ambiguity from influencing performance.

- A structure should be deployed that enhances the capability of the supply chain to effectively execute planning across all systems and processes.

- There will be pressure to enhance leadership capability to drive digitalisation of supply chain processes.

- Supply chain best practices are rooted in the comparison of a supply chain to targeted benchmarking standards.

- Supply chain excellence should be based on a strong culture of corporate intrapreneurship that promotes and rewards innovative thinking.

Theme four explored the various metrics that can be utilised to measure the performance of supply chain management in the chemical manufacturing industry. Three major categories of supply chain metrics were discussed in sections 4.3.4.1 to 4.3.4.2. The first category identified was strategic measurements, with the data revealing that NPI and OTIF are the most important measures for supply chain excellence. Secondly, operational metrics priorities were established as the level of supply chain integration and the optimisation of TCO. Thirdly, demand fulfilment and employee satisfaction was identified as important supply chain operational measures.

Theme 5 focused on the collection of additional data from participants, which could support the development of a best practice supply chain management framework. The data analysis revealed that there is a lack of concise and targeted adoption of technology in the chemical industry. There was also a suggestion that supply chain should be elevated to board level through the establishment of a CSCO position.

The data suggested that best practice supply chain management entails the elimination of hand-over points as far as possible.

5.3 Recommendations

The synthesis of the literature review and empirical study findings allowed for the development of a recommended supply chain management framework ecosystem that could help the chemical manufacturing industry to align its current supply chain methodologies to industry best practices derived from credible trends.

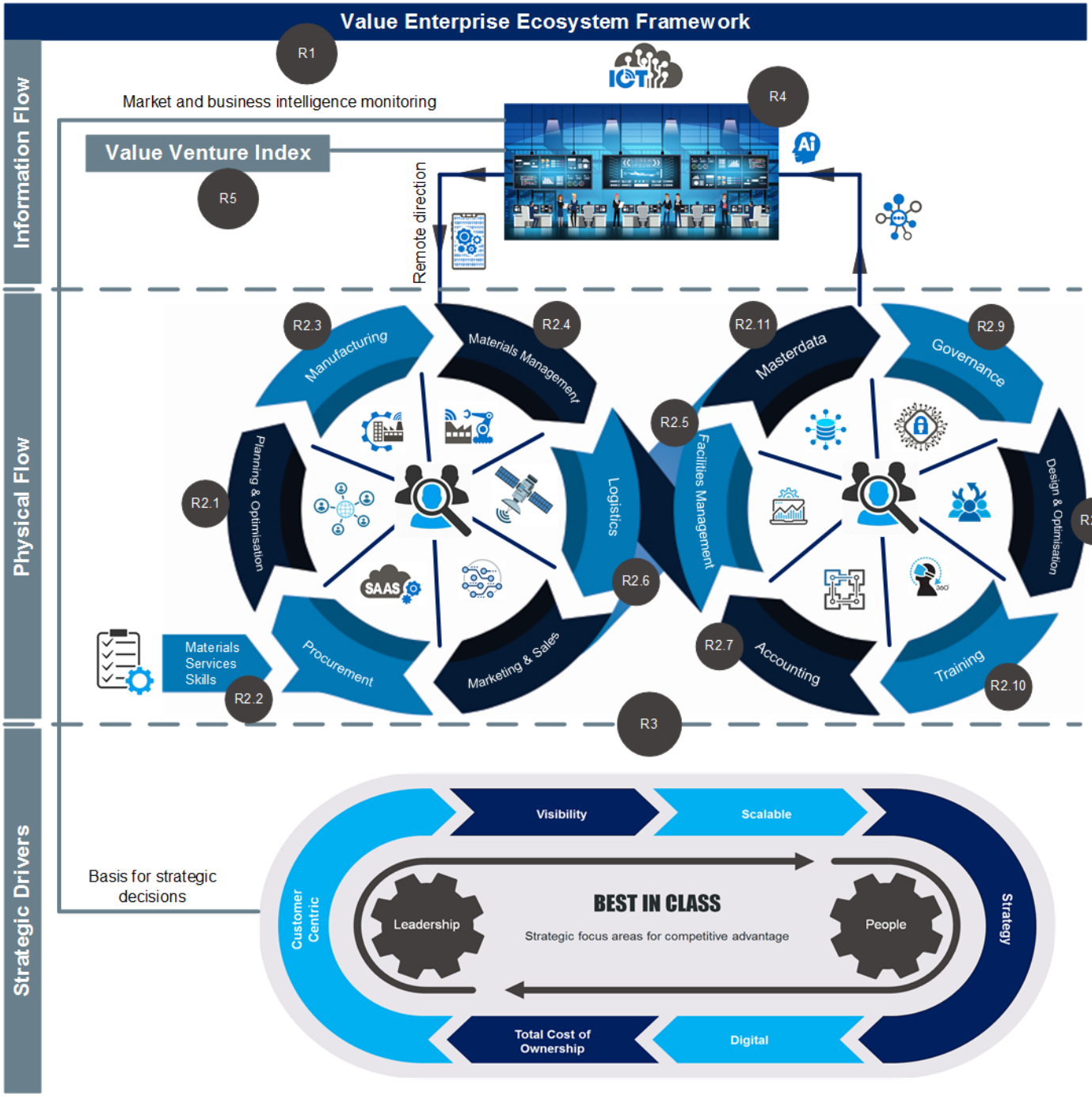
Figure 5-1 is a consolidated depiction of the proposed best practice supply chain framework for the chemical manufacturing industry. The framework is followed by specific recommendations derived from the various investigations performed in this study.

The essence of the framework is captured in the continuity of processes and systems through the concept named the Value Enterprise. In order to establish seamless processes characterised by uninterrupted flows of information and materials through the various value streams, the framework has been divided into two main sections. Firstly, it is proposed that the organisation standardise and centralise its information flows across the various Value Venture. This will enable continuous collaboration between the various channel partners. Secondly, there should not be a distinction between the various value streams when executing physical flows throughout the continuum. This will ensure end to end accountability of process, people and equipment.

The foundation of the framework focus on institutionalising the characteristics of best practice supply chain management confirmed during the literature review conducted.

The corresponding number of the specific recommendations has been applied to Figure 5-1 in order to enable cross referencing.

Figure 5-1 Supply chain management framework ecosystem



5.3.1 Recommendation 1: Transition away from conventional supply chain terminology

The terminology used to describe the process of creating customer and organisational value is distorted and destructive towards reaching value excellence. The term 'Chain' used in supply chain suggest an interrupted flow of physical and information processes brought about by the compartmentalisation of roles and responsibilities resulting in silo mentality being generated.

It is proposed that the chemical industry transition well past popular supply chain management and value chain terminology to Value Enterprise. This term will create a whole new mind-set and direct strategic thought towards seamless processes defined by the absence of handover points and diluted accountability.

5.3.2 Recommendation 2: Advanced digitalisation of value stream processes

Both the literature and empirical studies conducted has cautioned on the effects of not introducing advanced and sophisticated technology across the chemical manufacturing supply chain. By making use of the digital maturity assessment methodology, it is proposed that organisations in the chemical manufacturing industry assess its current level of digital maturity compared to industry benchmarks and trends. The outcomes of the assessment should direct the level of investment and strategic priority required to align the organisation with the aspirational digital maturity level. A holistic approach to design and implementation of advance technology systems should be taken into account to assure the integration and collaboration of individual technologies by means of IoT.

There is specific digitalisation recommendations directed towards the individual value streams to effectively enable recommendation 4.

5.3.2.1 Recommendation 2.1: Establishment of interconnect and holistic planning processes

The planning and optimisation value stream should be established in both the command centre and Value Enterprise to enable interconnectivity with all processes and systems.

5.3.2.2 Recommendation 2.2: Advancement in responsiveness of procurement processes and systems

The organisation and it supplier base must be interconnected by means of digital technology in order to remove the complexity from the demand and supply relationship. The procurement channel must be enabled with systems that continually monitor both market and business signals to enable the generation of real time, reliable intelligence that supports optimal strategic sourcing strategies. It is also recommended that the procurement value stream transition away from bureaucratic contracting processes to smart contracts that can be initiated and deployed using digital capabilities.

5.3.2.3 Recommendation 2.3: Continual monitoring of manufacturing processes

It is proposed that smart sensors be installed, measuring and monitoring the end-to-end manufacturing process. These sensors should be interconnected to the IoT cloud that enables continuous visibility of all operational processes from a regional and central command centre perspective.

5.3.2.4 Recommendation 2.4: Establishment of smart materials management facilities that enables leveraging of economies of scale and skill

Research clearly suggest that there are an unprecedented migration from conventional warehouse methodologies to smart warehouses. Seeing that warehousing is a major source of cost and complexity, it will be unwise for chemical manufacturing organisation to invest in conventional warehouse operating models. Conventional warehouse operating models are characterised by its inability to automate and integrate end-to-end processes. The literature study has proposed that the automation of warehousing facilities will create sustainable competitive advantage for the organisation.

It is proposed that the boundary between inbound and outbound warehousing be diminished and be regarded as an integrated warehousing eco system driven by variety of products and services rendered. The organisation should invest in a centralised warehouse facility that strategically service the needs of value stream partners in a large geographical region. The proposed warehouse facility should be fully automated in nature and material handling activities should be autonomous as far as reasonably

practicable. The information generated by the facility should be paperless and systems should be employed that connect the facility to the IoT cloud.

5.3.2.5 Recommendation 2.5: Establishment of predictive failure monitoring in order to enhance maintenance effectiveness

The various smart sensors employed in the operational processes must be connected to a system that enable predictive failure monitoring in order to apply maintenance prior to the actual failure occurring.

5.3.2.6 Recommendation 2.6: Real-time traceability and condition monitoring of logistics networks

Irrespective of the mode of transport utilised, it is proposed that the vehicles be fitted with smart sensors that is interconnected by means of a satellite to the Value Enterprise command centre in enablement of real time tracking and condition monitoring.

5.3.2.7 Recommendation 2.7: Implementation of block chain technology as advancement for accounting effectiveness

It is recommended that a block chain be established to control payment and receipt processes through the Value Enterprise.

5.3.2.8 Recommendation 2.8: Establishment of agile design and optimisation value streams

There should be a mass migration away from waterfall project management methodologies throughout the organisation. Supply chain design should be approached following agile and lean principles.

5.3.2.9 Recommendation 2.9: Introduction of value based governance design

Governance rules and regulations should be approached from a customer centricity point of view. Systems should be put in place to monitor the impact of governance rules on the customer experience. It is also recommended that the organisation transition away from conventional documented operating procedures that is difficult to recall. The organisation should rather institutionalise procedures by means of technology and training interventions.

5.3.2.10 Recommendation 2.10: Develop state of the art training and development centres in enablement of centralised and decentralised skills development

A two folded strategy is recommended to develop employee skills and competence towards the requirements of operating in the digital age. Firstly, class room training and e-learning platforms should be discontinued due to its proven inability to create meaningful knowledge absorption. Secondly, regional training centres should be established that is equipped with technology advance training equipment to facilitate reflexive competence. Simulator cubicles should be equipped with virtual reality glasses that immerse the trainee into the training material. Investment in a mobile training unit, equipped with similar technology should be perused to target outlying areas.

5.3.2.11 Recommendation 2.11: Masterdata excellence through big data analytics processes

The organisation should steer away from disintegrated master data management methodologies. Artificial intelligence systems should be applied to monitor masterdata efficiency and make adjustments based on programmed business rules.

5.3.3 Recommendation 3: Seamless structuring of the Value Enterprise into an infinity continuum revolving around customer segments

It is proposed that the conventional naming of supply chain departments be maintained however that these departments be structured into the physical flow component of the Value Enterprise. The conventional departments should be referred to as streams in the proposed framework (i.e. procurement stream).

The framework depicted in figure 5-1, customise the Value Enterprise per customer segment however the functional streams is continuous across the segments in order to provide singular accountability, visibility and integration across all of the Value Enterprise. These streams will be created where there is a requirement for a physical activity to take place in order to create value for the organisation and the customer.

5.3.4 Recommendation 4: Establish a globalised Value Enterprise command centre to monitor and direct value stream activities

It is proposed that the organisation establish a centralised Value Enterprise command centre, which monitors and directs global Value Enterprise operations. This command centre will mainly be responsible for the analysis, integration and management of information flows across the various Value Enterprise streams.

It is envisaged that the command centre should be based in a signal geographical region and building. There should be a single rounded room, equipped with state of the art technology systems that connect all the Value Enterprises to the command centre by means of IoT. The walls of the command centre must be constructed of high resolution frameless screens which visualise the entire Value Enterprise in real time across all geographic. In the centre of the command centre, there should be working pods fitted with technology devices to enable control of the Value Enterprise. These working pods will be operated by groups of analysts interacting with one another and with other pods whilst interpreting the big data received from the various value streams.

In an article by Stack (2016), Jeff Bezos, the revolutionary founder of Amazon state "*If you can't feed a team with two pizzas, it's to large*". The important message to all large organisations from this statement is that, if teams are to large, the connections between the individuals become so complex that it eliminates communication and meaningful interaction between the group members.

It is proposed that pods of 6 individuals be established within the command centre in order to facilitate continuous and autonomous interdependent relationships between the team members. The grouping of teams into small pods of interrelated groups will enhance corporate entrepreneurship within the organisations. It is also proposed that the roles and responsibilities of the working pods be fluent and flexible in nature, meaning that teams rotate on daily intervals. The rotation of pods will enable the establishment of cross process skills and competence development.

A single integrated cloud based ERP system should be customised and standardised across the various Value Enterprises. The big data generated by the Value Enterprise and value streams will require sophisticate artificial intelligence systems to be integrated with the cloud based ERP solution.

5.3.5 Recommendation 5: Development of an integrative value based performance monitoring system

It is proposed that the organisation transition to a singular measurement to establish Value Venture performance. The organisation should refrain from creating value stream KPI's that is utilised as performance management of such stream. Individual KPI's create silo mentality and prevent customer centric focus.

By no means does this recommendation suggest the elimination of well-known metrics to measure the operational performance of the Value Venture however these measures should be applied to determine the real time effectiveness of the value stream at a particular point of the time. The formula below is a recommendation of singular measurement of end-to-end effectiveness and efficiency.

$$Value\ Venture\ Index = \frac{7Rs}{Total\ number\ of\ deliveries} + \frac{Promotors - Dectractors}{Total\ Customers}$$

The first portion of the formula intends measuring compliance to the value proposition communicated to the customer by ensuring the right product, was delivered in the right quantity, in the right condition, to the right place, at the right time, with the right price to the right customer.

The second portion of the formula intends to measure the value creation experienced by the customer by comparing brand promoters with detractors.

The formula thus measures the capability of the Value Venture to create sustainable value to the stakeholders of the organisation.

5.4 Achievement of the objectives of the study

Table 5-1 has been constructed as a guidance roadmap to illustrate the achievement of primary and secondary research objectives in this study.

Table 5-1 Achievement of objectives

Objective Type	Objective	Literatur	Empiric	Chapter Reference	Section Reference
Primary	Develop a strategic supply chain management ecosystem framework that assimilate industry best practices and principles at each phase of the supply chain life cycle within the chemical manufacturing industry	X	X	2 4 5	2.2, 2.3 ,2.4, 2.5, 2.6, 2.7, 2.8 4.2, 4.3 5.3
Secondary	Understand and disseminate the unique supply chain challenges encountered by the chemical manufacturing industry.	X	X	2 4	2.5 4.3.1, 4.3.5
Secondary	Identify the relevance and importance of individual challenges in order to prioritise the impact of recommendations.		X	4	4.3.2
Secondary	Discover feasible solutions that can create sustainable competitive advantage for supply chain management in the chemical manufacturing industry.	X	X	2 4	2.3.6, 2.3.9, 2.3.11, 2.6, 2.7 4.3.3, 4.3.5
Secondary	Establish integrative performance metrics for the holistic determination of supply chain management effectiveness and efficiency.	X	X	2 4	2.3.8 4.3.4

5.4.1 Primary Objective: Develop a strategic supply chain management ecosystem framework that assimilate industry best practices and principles at each phase of the supply chain life cycle within the chemical manufacturing industry

The primary objective of this study was to develop a framework for best practice supply chain management in the chemical manufacturing industry. The successful achievement of this objective was orchestrated by means of a comprehensive literature review that dissected the dynamics of the chemical manufacturing industry in South Africa, followed by a review of the global supply chain management situation from the perspective of tried and tested industry benchmarks. The literature review was supported by an empirical study of aspects unique to the chemical manufacturing industry. The synthesis of the reviews allowed for the generation of a best practice framework, which is displayed in section 5.3.1.

5.4.2 Secondary Objective 1: Understand and disseminate the unique supply chain challenges encountered by the chemical manufacturing industry.

This objective was developed to establish an in-depth understanding of the unique challenges faced by the supply chain of the chemical manufacturing industry. The absence of a clear understanding of the unique challenges faced by the industry would also result in a supply chain framework that did not focus on supply chain management holistically. The objective was achieved through both literature and empirical studies that focused on industry-wide challenges, and this was further refined into the challenges that are unique to chemical industry supply chains.

5.4.3 Secondary Objective 2: Identify the relevance and importance of individual challenges in order to prioritise the impact of recommendations.

The prioritisation of supply chain management challenges was achieved through the empirical study performed.

5.4.4 Secondary Objective 3: Discover feasible solutions that can create sustainable competitive advantage for supply chain management in the chemical manufacturing industry.

Solutions to the challenges identified in the empirical study were compared with solutions and best practices supported in the literature.

5.4.5 Secondary Objective 4: Establish integrative performance metrics for the holistic determination of supply chain management effectiveness and efficiency.

The supply chain management metrics identified in the empirical study were tested against benchmark metrics identified in the literature review.

5.5 Recommendations for future research

The literature review and empirical study has revealed a number of challenges within the chemical manufacturing industry and supply chain management which require targeted research in contribution to the body of knowledge. It is recommended that detailed research be conducted on the following topics, revolving around the research topic:

- The impact of chemical packing methodologies on the effectiveness of supply chain management.
- The extent to which industrialist methodologies are impacting the chemical industry negatively in the 4th Industrial Revolution.
- A development of a blueprint for the digitalisation of supply chain management.
- The design of an integrative block chain on end-to-end supply chain processes.
- Supply chain leadership development and measurement in the 4th industrial revolution.

5.6 Summary

Chapter 5 presented the conclusions derived from the literature review and empirical study performed. These conclusions was provided as sound foundation to derive reliable and credible recommendations that can be applied by the chemical manufacturing industry for the establishment of a best practice supply chain framework. Chapter 5 also

aimed to assess the achievement of the research objectives developed in Chapter 1. The analysis in table 5-1 provide satisfactory assurance that the primary and secondary objective of this research study has been achieved through literature reviews, empirical study and the synthesis of scientific data.

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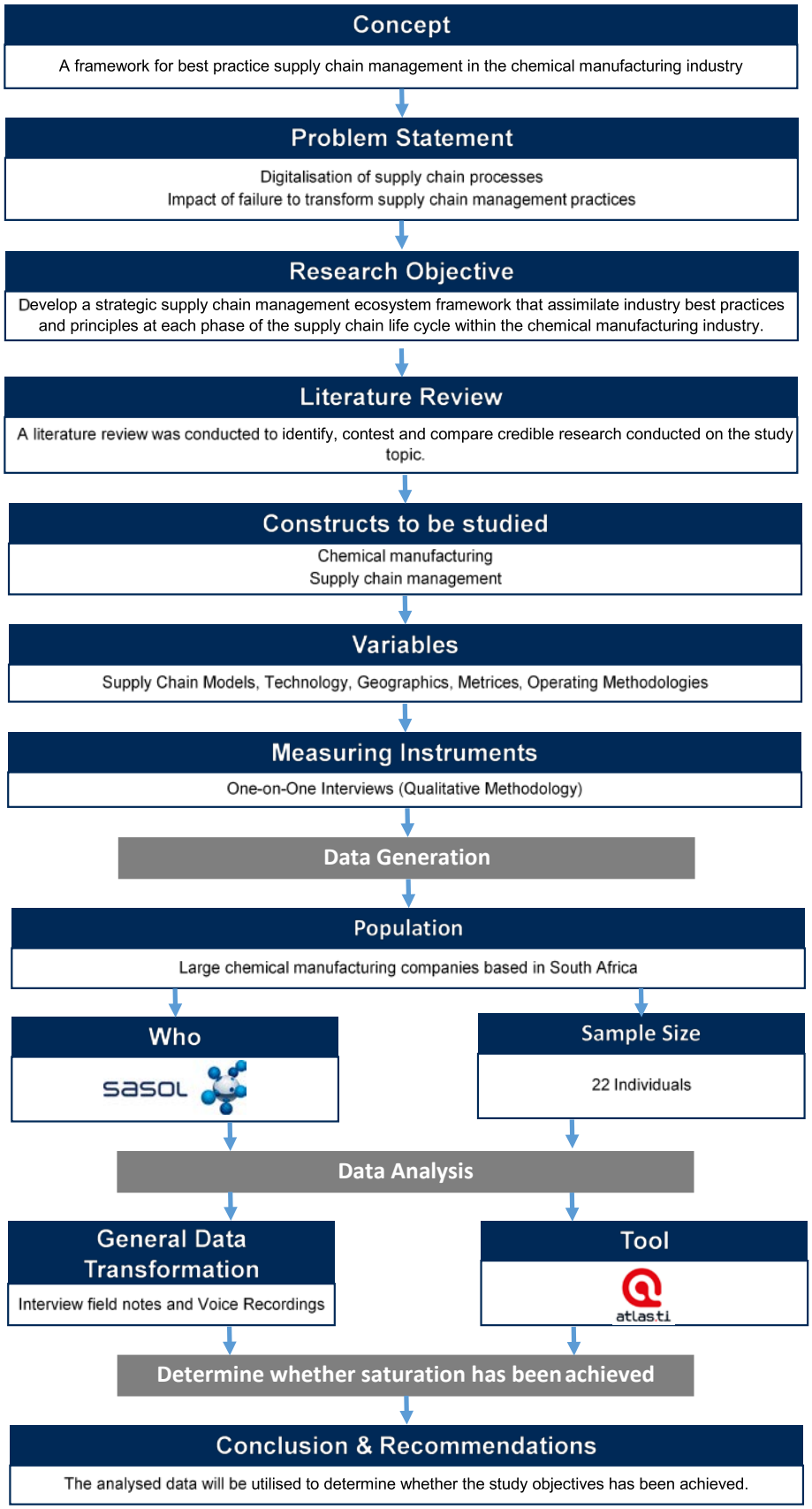
ANNEXURE A: RESEARCH DESIGN



ANNEXURE B: INTERVIEW SCHEDULE

MBA Research Interview Schedule

1. Opening Statement

1.1. Introduction

Thank you for the opportunity and willingness to meet with me. My name is Werner du Plessis and I am currently completing my Master in Business Administration degree (MBA) at the North West University. As partial fulfilment of the requirements of the degree, we are required to conduct and report on targeted business research. I would like to ask you a set of targeted questions related to best practices within supply chain management.

1.2. Research Topic

A framework for best practice supply chain in the chemical manufacturing industry

1.3. Purpose

The purpose of this interview will be to gather relevant information that can assist/support the development of a framework for best practice supply chain management in the chemical manufacturing industry.

1.4. Motivation

The information that you supply, combined with various literature reviews conducted on the research topic will be instrumental to develop and propose best practice supply chain management practices.

1.5. Confidentiality

Your participation and responses in this interview process will be regarded as confidential and will not be shared with any other person not directly involved in this research study. Whilst compiling the mini-dissertation, all efforts shall be made not to identify you as a respondent.

1.6. Timeline

The interview will take approximately one (1) hour to complete.

1.7. Approval

In alignment with the requirements of the Sasol procedure on the minimum standard for study aid (Reference: HR GP POE 101) section 8e, sub section iii. Written approval was obtained from authorised personnel to conduct research within the Sasol group of companies. The written approval to conduct research has been attached to this interview schedule for your review.

1.8. Pre-Interview Checklist

Before we commence with the interview, there is important information that I need to convey to you. Can you please verbally respond to the following questions:

1.8.1. The interview will be conducted in English, are you able to respond to all questions in English?
1.8.2. Are you willing to participate in the interview?
1.8.3. Have you read and signed the informed consent form prior to the interview?
1.8.4. Are you aware that you may stop the interview at any stage without explanation?
1.8.5. Are you satisfied that proper controls are in place to ensure confidentiality during the interview process?
1.8.6. Both written- and recorded field notes will be taken during the interview process, may I record the conversation for transcription?
1.8.7. Is the facility in which the interview is taking place sufficient and comfortable?
1.8.8. Should any interruptions occur during the interview process, the exact time will be noted and the recording will be stopped. When the interview reconvene, the recording will be started and the exact time noted. Do you have any objections with this protocol?
1.8.9. If the interview is not completed in full for whatever reason, all recording will be destroyed and the obtained inputs will not be considered during the research process. Do you understand this protocol?
1.8.10. No incentives, reimbursements or payments towards participation in the research study will be made. Do you accept this?
1.8.11. One question shall be asked at a time and I (as interviewer) will verify and clarify any unclear responses. Do you agree with this process?
1.8.12. Do you have any further questions that need clarification prior to commencement of the interview?

2. Interview

2.1. Biographical Information

Before we commence with the interview, there is a couple of biographical data I need to collect from you in the interest of deriving accurate and reliable research results

2.1.1. What is your unique identifier code that was provided to you prior to the interview?
2.1.2. What is your current job title?
2.1.3. What is your highest educational qualification?
2.1.4. Do you have supply chain specific qualifications?
2.1.5. How many years of experience do you have working in supply chain?

2.2. Interview

The following questions are directly related to the research being conducted. Please provide detailed information on each of the questions posed to you:

2.2.1. What do you believe is the biggest challenges in Supply Chain Management?
2.2.2. How do you believe should organisations address these challenges?
2.2.3. How will you prioritise the importance of these challenges?
2.2.4. How should organisations measure the success of its supply chain management?
2.2.5. Is there any other issue/s you regard as relevant and important, that you would like to discuss?
2.2.6. Is there any other individual you propose I should interview?

3. Closing Statement

I would like to take the opportunity to thank you for the valuable information you have provided in clarifying the research topic.

ANNEXURE C: INFORMED CONSENT

MBA Research Informed Consent

The part below provides you as participant in the project with more information, so that you can make an informed decision about your voluntary participation or not.

Title of the project

A framework for best practice supply chain in the chemical manufacturing industry

Institution / School / Subject group / Institute

North West University, School of Business and Governance

Ethics Reference Number

NWU-00548-18-S4

Names and contact details of project staff

	Supervisor	Researcher
Title, name & surname	Mr Johan Jordaan	Mr Werner du Plessis
Full Names	Johan Jordaan	Werner Rudolph Du Plessis
Function in Project	Research Supervisor	Researcher
Qualifications	Higher Education Diploma Bsc in Natural Sciences: Mathematics, Physics and Chemistry Bcom in Business Management Masters of Business Administration	National Diploma in Safety Management Bcom in Business Management Post Graduate Diploma in Management
Telephone (work)	[redacted]	[redacted]
Cellphone	[redacted]	[redacted]
Postal address	[redacted]	[redacted]

You are being invited to take part in a **research study** that forms part of my Master of Business Administration (MBA) degree. Please take some time to read the information presented here, which will explain the details of this study. Please ask the researcher or

person explaining the research to you any questions about any part of this study that you do not fully understand. It is very important that you are fully satisfied that you clearly understand what this research is about and how you might be involved. Also, your participation is **entirely voluntary** and you are free to say no to participate. If you say no, this will not affect you negatively in any way whatsoever. You are also free to withdraw from the study at any point, even if you do agree to take part now.

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

What is this research study all about?

The study is aimed at developing a framework for best practice supply chain management in the large chemical manufacturing industry.

Why have you been invited to participate?

You have been invited to participate in this research study due to your level of specific knowledge and experience in the field of supply chain management.

What will be expected of you?

You will be expected to provide specific information related to the research topic in a one-on-one interview process.

Will you gain anything from taking part in this research?

No monetary reward shall be made available for participation in the study. You will however be furnish with a final report on the outcomes of the study that you can utilise to improve the supply chain models within your department and/or organisation.

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

Participation in this study does not create any physical risk to you as the study does not involve any physical activities or experiments. It is however envisaged that reputational or occupational damage can be incurred by yourself should inaccurate transcribes of your responses be made public. We however have identified certain ethical principles that shall be maintained at all time to prevent such damages to you. The focus of these

principals will be to protect your dignity and keep all records provided private and confidential.

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

Data collected shall be regarded as confidential and will not be shared with any 3rd party that is not directly involved in the research process. Personal details of respondents and their direct input to the research study shall not be made public. All records of the research shall be kept for a retention period and destroyed in an appropriate means. The findings of the study will be made public however will not contain any raw data that might incriminate certain individuals.

What will happen with the findings or samples?

The findings concluded in the study will be for academic purposes and will only be utilised to add to the current body of available knowledge.

How will you know about the results of this research?

Respondents to the study will be made aware of the results of the research by means of electronic mail. The electronic final version of the dissertation will be used as the official communication tool.

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

Participation in this study will not yield monetary value to you. There is no cost envisaged to you except the time that you spend to participate in this study.

Declaration

Declaration by participant

By signing below, I [ ] agree to take part in the research study titled: **A framework for a best practice supply chain model in the South African large chemical manufacturing industry**

I declare that:

- I have read this information/it was explained to me by a trusted person in a language with which I am fluent and comfortable in.
- The research was clearly explained to me.
- I have had a chance to ask questions to both the person getting the consent from me, as well as the researcher and all my questions have been answered.

- I understand that taking part in this study is **voluntary** and I have not been pressurised to take part.
- I may choose to leave the study at any time and will not be handled in a negative way if I do so.
- I may be asked to leave the study before it has finished, if the researcher feels it is in the best interest, or if I do not follow the study plan, as agreed to.

Signed at (Place)		**On (Date)**		**20**	

Signature of participant	**Signature of witness**

Declaration by researcher

I ***Werner du Plessis*** declare that:

- I explained the information in this document to
- I did/did not use an interpreter
- I encouraged him/her to ask questions and took adequate time to answer them or I was available should he/she want to ask any further questions.
- The informed consent was obtained by an independent person.
- I am satisfied that he/she adequately understands all aspects of the research, as described above.
- I am satisfied that he/she had time to discuss it with others if he/she wished to do so.

Signed at (Place)		**On (Date)**		**20**	

Signature of researcher	**Signature of witness**

ANNEXURE D: ETHICAL CLEARANCE CERTIFICATE

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

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Economic and Management Sciences Research
Ethics Committee (EMS-REC)
Tel: 018 299-1427
Email: Bennie.Linde@nwu.ac.za

3 September 2018

Mr WR Du Plessis
Per e-mail

Dear Mr WR Du Plessis

FEEDBACK – ETHICS APPLICATION: W DU PLESSIS (13086707)

Your application for ethical clearance – A framework for best practice supply chain management in the chemical manufacturing industry – has been evaluated on the 2nd of August 2018.

Outcome:

The application is approved as a low risk study.

Ethics number: NWU-00548-18-S4

The prerequisite is that no raw data be made available to SBU management, since this will increase the research ethics risk level. The findings of the study may be shared with the SBU management.

Yours sincerely,

Prof B Linde
Chairperson: Economic and Management Sciences Research Ethics Committee (EMS-REC)

Original details: (11153431) C:\Fakulteit\Bestuur\Kwaliteitsbestuur\Etiek\August 2018\W du Plessis\ August 2018

File reference: 9.1.5.3

ANNEXURE E: DOCUMENT EDITING CERTIFICATE

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17 November 2018

To whom it may concern

DOCUMENT EDITING

This serves to confirm that an academic research report was submitted for the substantive English language editing service, as follows:

- Editing date: 12-17 November 2018
- Title: A framework for best practice supply chain management in the chemical manufacturing industry
- Length: 235 pages; 43437 words
- Author: Mr Werner du Plessis
- Number of revisions: 8724

Gillies

Member: J C Gillies BA (Eng, Comm, Psych), Postgrad Dip. (Marketing), BA Hons (English)