A Demand Driven Supply Chain Management Maturity Model for the Public Healthcare Sector

By

Munyaradzi Bvuchete

Dissertation presented for the degree of
Doctor of Philosophy in Industrial Engineering in the
Faculty of Engineering at
Stellenbosch University

Supervisor: Prof. Sara Susanna Grobbelaar
Co-supervisor: Dr. Joubert van Eeden

March 2020

Declaration

By submitting this dissertation electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third-party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

March 2020

Abstract

To cope with low forecast accuracy and high demand variability in complex public healthcare supply chains, many supply chain nodes are trying to move from a pure Push strategy, to a Pull strategy, driven by actual customer demand. However, there are a few methodologies through which an analyst can impartially measure and support implementation of Demand Driven Supply Chain Management (DDSCM) practices in public healthcare Supply Chain Networks (SCNs). Therefore, the research aim of this study was to develop a network-maturity mapping tool that support the design, implementation and assessment of DDSCM performance for unique supply chain nodes in the public healthcare SCN as well as to provide guidance on how the unique supply chain nodes in the SCN can progress towards advanced DDSCM maturity stages.

This study used a systems engineering research design and provides a systematic literature review to establish the main dimensions[1] and their associated capabilities[2] in the DDSCM network maturity-mapping tool such as visibility, technology, collaboration, human resources, organisational alignment, performance management and distribution management. The tool was validated through twenty-three (23) subject matter experts to assert its completeness, credibility and usefulness in public healthcare SCN. Moreover, to test for applicability and validity of the tool, it was applied in twelve (12) SCN case studies, which included pharmaceutical manufacturing companies, Central Medicines Stores (pharmaceutical distributors), primary healthcare facilities and hospitals. All these supply chain nodes in the public healthcare SCN acknowledged that the network maturity-mapping tool was clear, structured logically and allows for comprehensive assessment.

Key findings from the case studies show that, for those DDSCM capabilities that require higher effort to implement/sustain, it is common for the DDSCM capabilities to be less mature. Moreover, case study outcomes suggest that, the higher the impact of the DDSCM capabilities, the more mature the capabilities. Findings also reveal that most mature supply chain nodes are at the manufacturing end of the SCN. In contrary, healthcare facilities are the least mature.

The study contributes to the limited literature on DDSCM in the public healthcare sector in developing countries. Moreover, the main contribution is the network maturity mapping tool to assess both where the public healthcare SCN is today on the maturity scale and how it can progress to more

[1] Dimensions represent a category of capabilities that enable Demand Driven Supply Chain Management.

[2] Capabilities are key success factors for Demand Driven Supply Chain Management.

advanced maturity levels of DDSCM. This allows for a systematic and methodological planning of interventions for improvement.

Lastly, to make DDSCM sustainable, supply chain nodes have to adopt a continuous improvement commitment that focuses on enhancing the supply chain processes, supporting the people, and fixing the data issues. This implies that supply chain nodes need to develop strategically aligned capabilities, not only at the supply chain node itself, but also among the other supply chain nodes that are part of the value-adding networks.

By adopting this DDSCM orientation, supply chain nodes will attain tremendous benefits, which include improved delivery performance, reduced inventories and supply chain costs. Another benefit is that downstream supply chain nodes will be able to scale up and implement the Visibility Analytics Network (VAN) model developed by the National Department of Health (NDoH) to improve the availability of medicines at primary healthcare facilities, since informed planners will have total visibility of inventory levels and consumption patterns of primary healthcare facilities. Consequently, orders will be generated based on this quality data.

Opsomming

Om lae vooruitskattingsakkuraatheid en groot variasie in die vraag in komplekse openbare verskaffingskettings vir openbare gesondheidsorg te hanteer, probeer baie voorsieningskettingnodes om van 'n suiwer Stoot-strategie na 'n Trek-strategie te beweeg, aangedryf deur die werklike vraag van die kliënt. Daar is egter enkele metodologieë wat analiste in staat stel om die implementering van vraaggedrewevoorsieningskettingbestuur-praktyke in openbare gesondheidsorgverskaffingnetwerke onpartydig te meet en ondersteun. Daarom was die navorsingsdoel van hierdie studie om 'n netwerk-volwassenheid kartering instrument te ontwikkel wat die ontwerp, implementering en assessering van vraaggedrewevoorsieningskettingbestuur-prestasie vir unieke voorsieningskettingnodes in die verskaffingnetwerke vir openbare gesondheidsorg ondersteun, asook om leiding te gee oor hoe die unieke voorsieningskettingnodes in die verskaffingnetwerke kan vorder na gevorderde stadiums van vraaggedrewevoorsieningskettingbestuur-volwassenheid.

Hierdie studie het gebruik gemaak van 'n navorsingsontwerp vir stelselingenieurswese en bied 'n sistematiese literatuuroorsig om die belangrikste dimensies en die gepaardgaande vermoëns daarvan te bepaal in die vraaggedrewevoorsieningskettingbestuur-netwerk vir volwassenheidskartering soos sigbaarheid, tegnologie, samewerking, menslike hulpbronne, organisasiebelyning, prestasiebestuur en verspreidingsbestuur. Die instrument is deur drie en twintig (23) vakkundiges bekragtig om die volledigheid, geloofwaardigheid en bruikbaarheid daarvan in die verskaffingnetwerke vir openbare gesondheidsorg te bevestig. Om die toepaslikheid en geldigheid van die werktuig te toets, is dit ook toegepas in twaalf (12) gevallestudies van verskaffingnetwerke, wat farmaseutiese vervaardigingsondernemings, sentrale pakstore (farmaseutiese verspreiders), primêre gesondheidsorgfasiliteite en hospitale insluit. Al hierdie nodes in die openbare gesondheidsorg verskaffingnetwerke het erken dat die instrument vir die volwassenheid van kartering van netwerke duidelik is, logies gestruktureer is en omvattende assessering moontlik maak.

Belangrike bevindings uit die gevallestudies toon dat dit vir die vraaggedrewevoorsieningskettingbestuur-vermoëns wat groter inspanning benodig om te implementeer / te onderhou, algemeen voorkom dat die vraaggedrewevoorsieningskettingbestuur-vermoëns minder volwasse is. Uit gevallestudie-uitkomste word voorgestel dat, hoe groter die impak van die vraaggedrewevoorsieningskettingbestuur-vermoëns is, hoe meer volwasse is die vermoëns. Uit die bevindinge blyk dit ook dat die meeste volwasse voorsieningskettingnodes aan die einde van die vervaardiging van die SCN is. Daarteenoor, is gesondheidsorgfasiliteite die minste volwasse.

Die studie dra by tot die beperkte literatuur oor vraaggedrewevoorsieningskettingbestuur in die openbare gesondheidsorgsektor in ontwikkelende lande. Verder is die belangrikste bydrae die instrument vir die kartering van netwerk-volwassenheid om te bepaal waar die verskaffingnetwerke vir openbare gesondheidsorg vandag op die volwassenheidskaal is en hoe dit kan vorder tot meer gevorderde volwassenheidsvlakke van vraaggedrewevoorsieningskettingbestuur. Dit laat 'n sistematiese en metodologiese beplanning van intervensies vir verbetering toe.

Laastens, om vraaggedrewevoorsieningskettingbestuur volhoubaar te maak, moet die voorsieningskettingnodes 'n voortdurende verbintenis tot verbetering aanneem wat fokus op die verbetering van die voorsieningskettingprosesse, die ondersteuning van die mense en die oplossing van die datakwessies. Dit impliseer dat voorsieningskettingnodusse strategies, in lyn met die nodige nodusse moet ontwikkel, nie net by die verskaffingskettingknoop self nie, maar ook by die ander voorsieningskettingknope wat deel uitmaak van die waardetoevoegende netwerke.

Deur hierdie vraaggedrewevoorsieningskettingbestuur-oriëntasie aan te neem, sal die voorsieningskettingnodusse geweldige voordele hê, wat verbeterde leweringsprestasie, verlaagde voorraad en koste van die voorsieningsketting insluit. 'n Verdere voordeel is dat nodusse van stroomafleweringskettings die Sigbaarheid Analitiese Netwerkmodel wat deur die Nasionale Departement van Gesondheid ontwikkel is, kan opskaal en implementeer om die beskikbaarheid van medisyne by primêre gesondheidsorgfasiliteite te verbeter, aangesien ingeligte beplanners totale sigbaarheid van voorraadvlakke en verbruikspatrone van primêre gesondheidsorgfasiliteite sal hê. Gevolglik sal bestellings gegenereer word op grond van hierdie kwaliteit data.

Acknowledgements

Hebrews 11:30 *"By faith the walls of Jericho fell down after they were encircled for seven days"*

I have been undeservedly lucky throughout my life to work and associate with people who are more talented than I am, and got an opportunity to draw insights from their pools of wisdom.

My greatest gratitude goes to my family, my father, Francis, my mother, Margie, my sister, Esther, and brother, Zvidzai. They are the reason why I am an explorer in this journey of unlimited opportunities.

Moreover, I am forever indebted to my supervisors, Saartjie (Prof. Grobbelaar) and Joubert (Dr. van Eeden). I am not only thankful for their support and mentorship during this research journey but most importantly for the opportunity they gave me to learn to "*THINK*" even in the presence of "*NOISE*"

I strongly acknowledge and appreciate the substantial input from subject matter experts (manufacturers, Cape Medical Depot, hospitals, clinics, consultants) and academic supply chain experts. Their inputs and opinions contributed immensely to the development and the refinement of the model. Special mention to Martin Ellis and Donna Samuels, you guys *"ROCK*".

The financial assistance of GlaxoSmithKline pharmaceuticals towards this research is acknowledged. Opinions expressed and conclusions arrived at, are those of the student and are not necessarily to be attributed to Glaxo Smith Kline pharmaceuticals.

Above all, I would like to thank God, for the life that He has granted me so far at no cost, and I am forever hopeful for more years of success and significant social, economic and political impact.

"The object of education is not to fill a man's mind with facts; it is to teach him how to use his mind in thinking"

~ Henry Ford ~

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Glossary

GSCF	Global Supply Chain Forum
DDSCM	Demand Driven Supply Chain Management
SCM	Supply Chain Management
SCN	Supply Chain Network
SCP	Supply Chain Planning
SCE	Supply Chain Execution
NDoH	National Department of Health
SCOR	Supply Chain Operations Reference
SVS	Stock Visibility System
VAN	Visibility Analytics Networks
QR	Quick Response
USA	United States of America
GDP	Gross Domestic Product
CMS	Central Medicines Stores
IT	Information Technology
MCC	Medicines Control Council
ERP	Enterprise Resource Planning
MRP II	Manufacturing Resource Planning
3PL	Third Party Logistics
SP	Supply Planning
CPFR	Collaborative Planning Forecasting and Replenishment
VMI	Vendor Managed Inventory
PM	Performance Management
SCI	Supply Chain Integration
SCC	Supply Chain Collaboration
CMM	Capability Maturity Model
CRM	Customer Relationship Management
CSM	Customer Service Management
DM	Demand Management
DiM	Distribution Management
DiP	Distribution Planning
SDG	Sustainable Development Goal
SC	Supply Chain
CSCM	Construction Supply Chain Management
MOQ	Minimum Order Quantity
EBQ	Economic Batch Quantity
GAVI	Global Alliance for Vaccines & Immunization

Chapter 1: Introduction and Background

1.1. Introduction

This chapter describes the research background, rationale of the research and outlines the research gap that this study intends to fill. Moreover, research objectives and research contributions of the study are also described.

1.2. Research background

In South Africa, the gross domestic product expenditure (GDP) on healthcare is 8.5%, but the country still has poor healthcare outcomes in comparison to other middle income countries with lower levels of healthcare expenditure (National Department of Health South Africa, 2010). With 25% - 30% (Mustaffa and Potter, 2009) of healthcare costs emanating from the supply chain, and 80% of the SA population that is dependent on public healthcare (Foreword *et al.*, 1995), this highlights significant potential for more effective management and improved access.

Healthcare Supply Chain Management (SCM) involves the management, planning and control of four flows; medical products, information, finance and services from suppliers to patients. The concept further includes the coordination of supply chain partners (Ridwan and Norzamani, 2014). Challenges such as unexpected spikes and drops in demand can cause devastating effects on the ability of a healthcare supply chain to provide the right products and services to the right patient at the right time.

Emulating the proven private sector operating models such as the Proctor and Gamble (PG) control tower, the National Department of Health (NDoH) of South Africa developed a Visibility and Analytics Network (VAN) blueprint in 2015 (Llewellyn, 2016). The VAN aims to improve the availability of medicines at public healthcare facilities. Figure 1.1 shows the proposed transformational stages of the public healthcare supply chain. These stages outline healthcare supply chain processes and capabilities for improvements.

The name that is given to *Stage 1* is Uninformed Push. It represents a generic approach whereby the upstream supply chain partners, with no training in SCM, send stock to health facilities based on assumptions and rough calculations. *Stage 2* is an Uninformed Pull. It represents an approach whereby trained “demanders” make orders for their health facilities but are not fully utilising the available data. *Stage 3*, Informed Push/or Advised Pull, is a stage in which trained and informed planners have total visibility of inventory levels and consumption patterns of health facilities and they recommend orders based on this data. *Stage 4*, Informed Pull, utilises an automated ordering system that recommends orders to demanders and the demanders only authorise spending (Llewellyn, 2016).

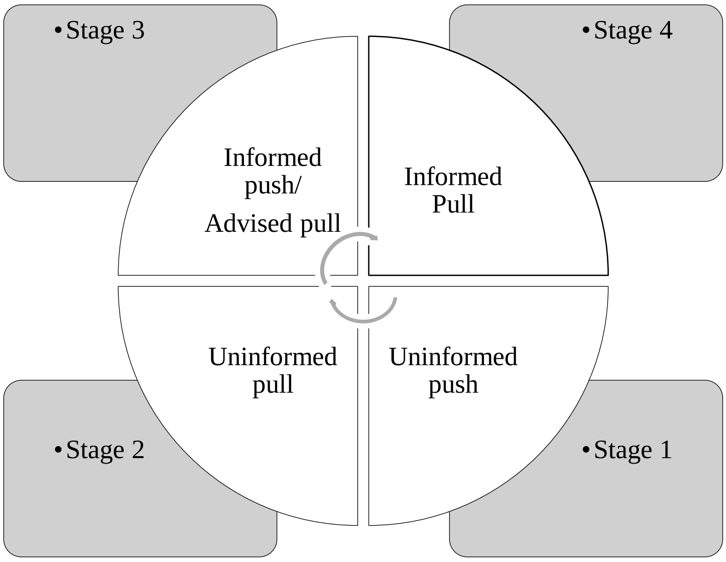


Figure 1.1: Visibility Analytics Network model

Source: [Llewellyn, 2016]

The transformation of public healthcare supply chains from one stage to a higher stage under the VAN blueprint is guided by four factors. These factors include Technology, People, Process, and Policy. These factors are interdependent and cannot exist in isolation from one another. The Technology factor is inclusive of the custom-built mobile application called Stock Visibility System (SVS), which provides real-time visibility of drug stocks at primary healthcare facilities (Mezzanine Health Solutions, 2017). The SVS coupled with other multiple data systems can enhance the generation of alerts and actionable insights across the entire supply chain. This facilitates end-to-end healthcare supply chain visibility (Llewellyn, 2016; Mezzanine Health Solutions, 2017).

Secondly, the People factor consists of adequately skilled staff with a proactive approach to evidence-based quality improvements. Next, the Process factor includes data-driven processes that utilize analytics for planning and proactive responses. The final factor is the Policy aspect which consists of government framework explicitly outlining clear responsibilities and accountabilities of empowered decision-makers across the supply chain (Llewellyn, 2016).

1.3. The rationale of the research

The healthcare expenditure as a percentage of GDP in South Africa equates almost to 8.5% as shown in Figure 1.2. Despite this, South Africa is still experiencing poor healthcare outcomes such as high infant mortality and low life expectancy relative to other middle-income countries such as Indonesia, and China (Vargas Bustamante and Shimoga, 2017), (Bidzha, Greyling and Mahabir, 2017) as shown in Figure 1.3.

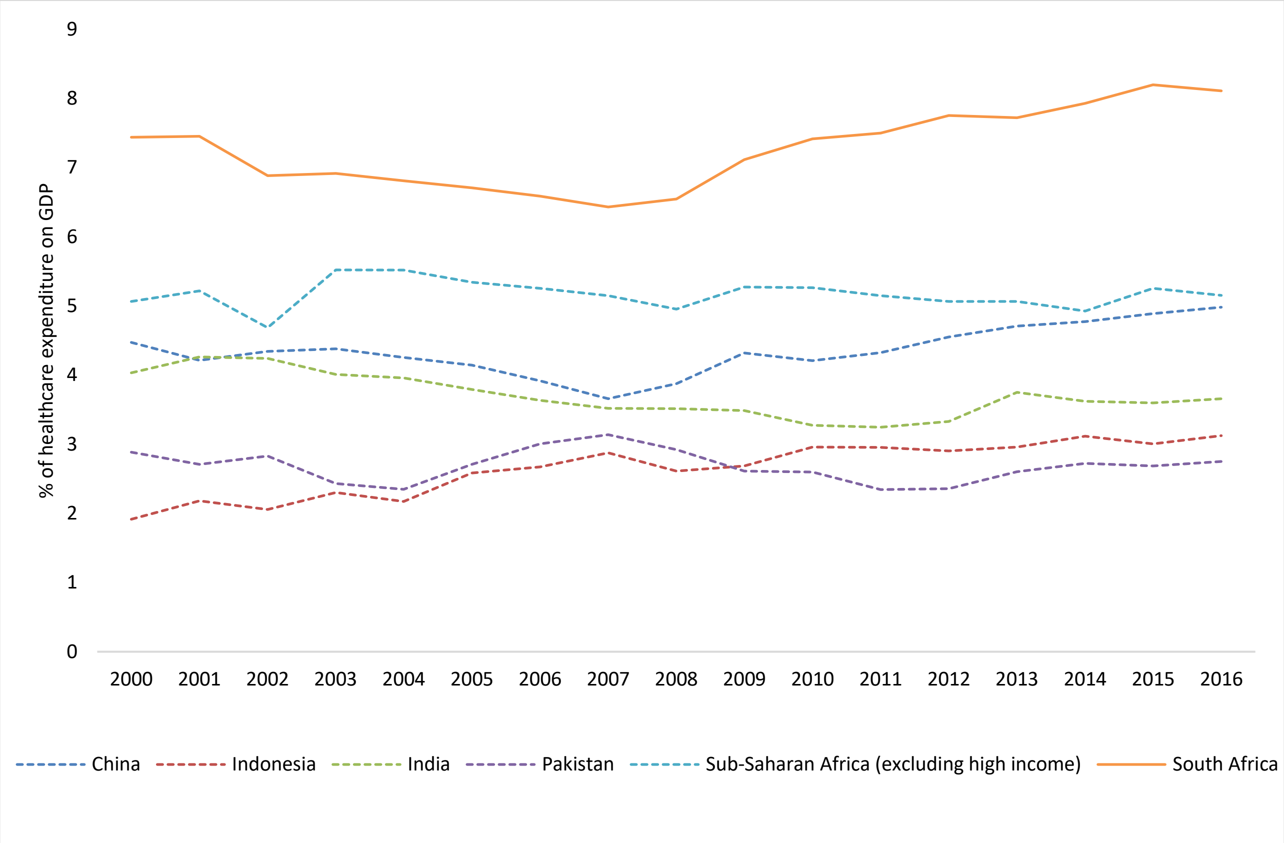


Figure 1.2: Healthcare expenditure as a percentage of GDP for middle-income economies (2000 - 2016)

Source: (WHO, 2018)

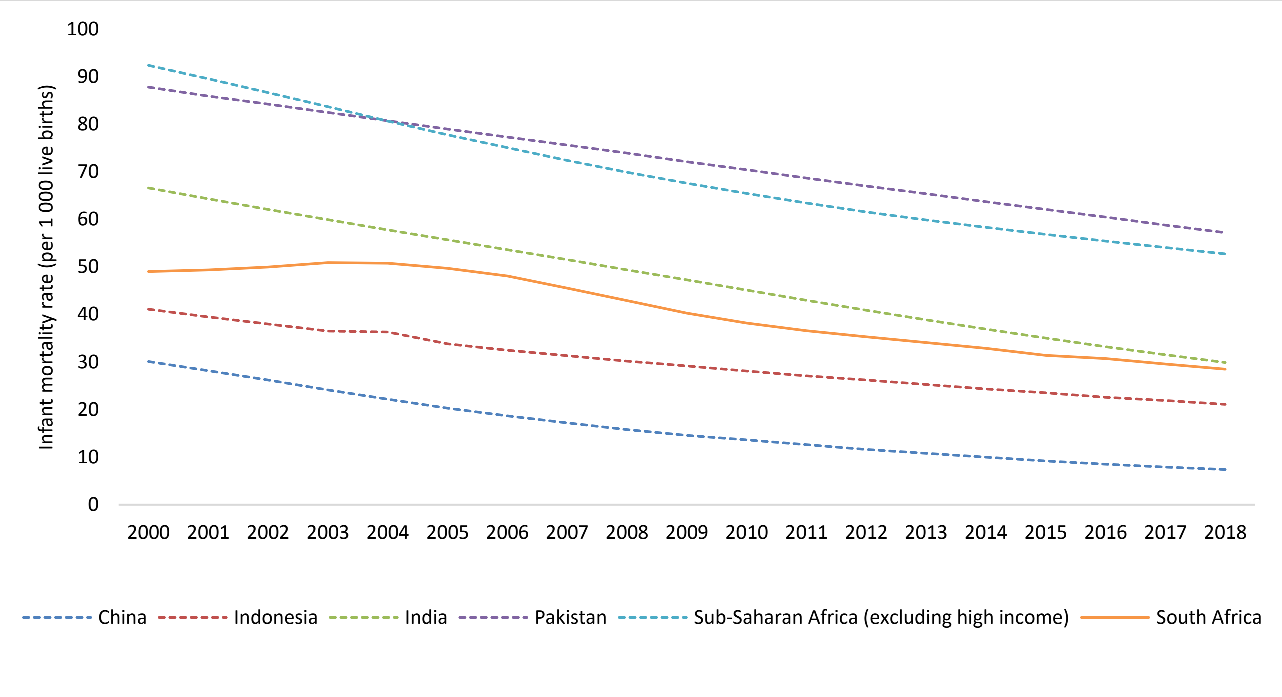


Figure 1.3: Infant mortality (per 1000 births)

Source: (WHO, 2018)

Global Alliance for Vaccines and Immunizations (GAVI), (2008), observed that:

"Much of the world's burden of disease could be prevented or cured. The problem is getting those drugs, vaccines and other forms of prevention, care or treatment to those who need them on time, reliably, in sufficient quantity and at a reasonable cost."

Research has also shown that people living with the Human Immunodeficiency Virus (HIV) and Acquired Immunodeficiency Syndrome (AIDS) can lead normal and healthy lives on the condition that they receive their antiretroviral (ARV) medication on a continuous, uninterrupted basis. The treatment of HIV and AIDS is life-long, and once initiated, patients must obtain an uninterrupted supply of their ARVs from health facilities. When the use of the ARVs is interrupted, there is a potential risk of virus reactivation.

The number of people living with HIV in South Africa is steadily increasing and an estimated 7.06 million people need ARV medications as shown in Figure 1.4. This accounts for 12.57 percent of the South African population (Statistics South Africa, 2017).

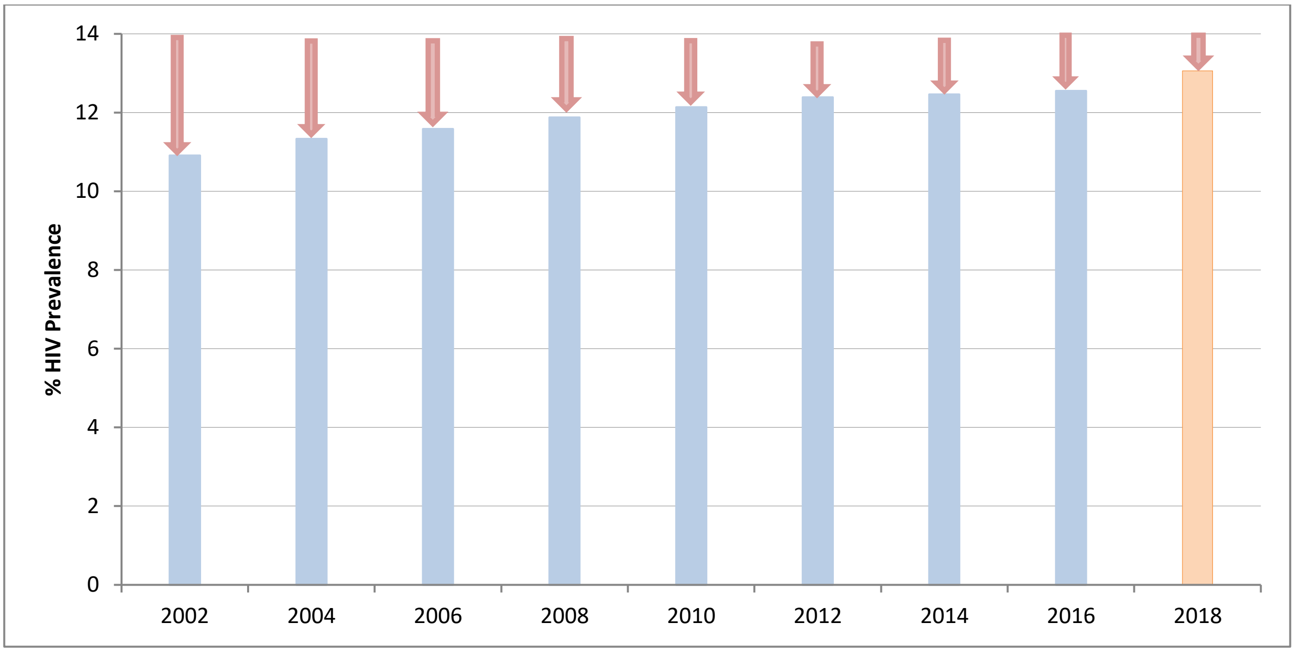


Figure 1.4: Estimates of people living with HIV in South Africa (2002-2018)

Source: (Statistics South Africa, 2017)

Furthermore, South Africa is one of the countries with the highest burden of TB in the world as illustrated in Figure 1.5. There were an estimated 567-incidence cases of active TB per 100 000 people in 2017. This compares with an estimated incidence of 922 in 2011 (World Health Organisation, 2018).

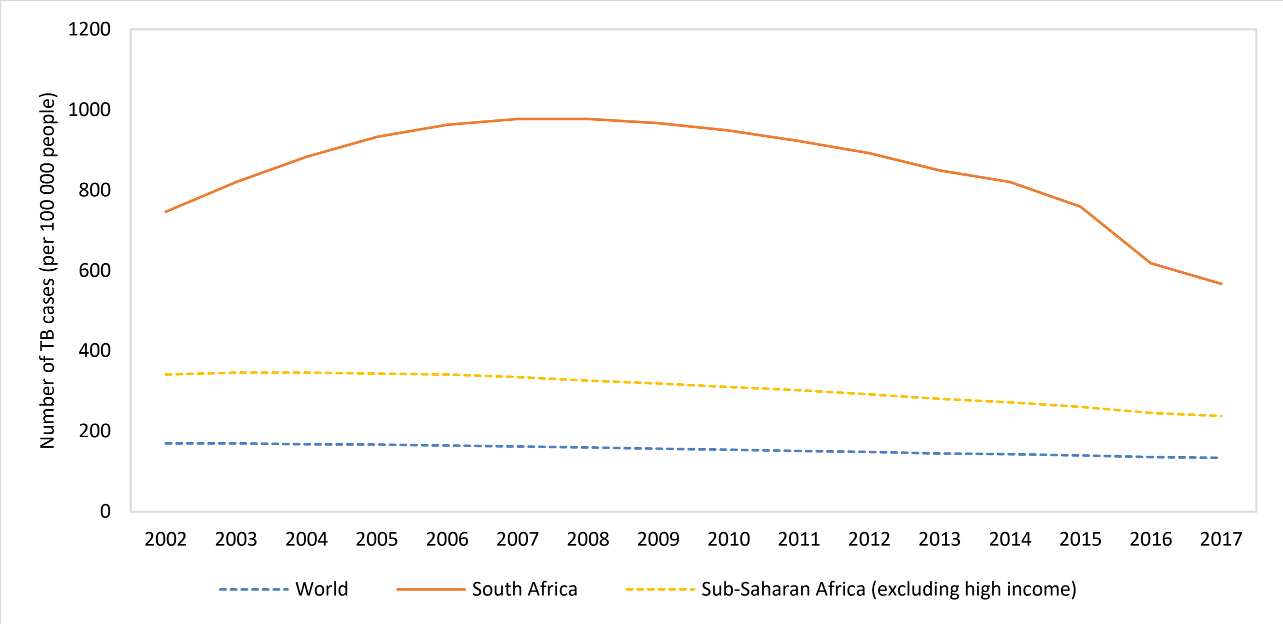


Figure 1.5: TB incidence (per 100 000 people)

Source: (WHO, 2018)

Both the HIV prevalence and incidence cases of active TB illustrate that stock-outs of drugs will have severe impacts on the affected population. Drug stock-outs thereby increase the risk of emergence of drug-resistant strains on the health delivery system and also results in high levels of morbidity and mortality (Mokheseng, Horn and Klopper, 2016). Hence, the need to develop agile and efficient healthcare supply chain systems is inevitable (Kokilam, Joshi and Kamath, 2016).

However, due to ineffective procurement and supply chain systems in the public healthcare sector, the supply of medicines to health facilities is often interrupted resulting in frequent stock-outs of essential medicines and other healthcare products (USAID, 2010). To illustrate this, evidence of ARVs and Tuberculosis (TB) drug stock-outs by province in South Africa is shown in Figure 1.6.

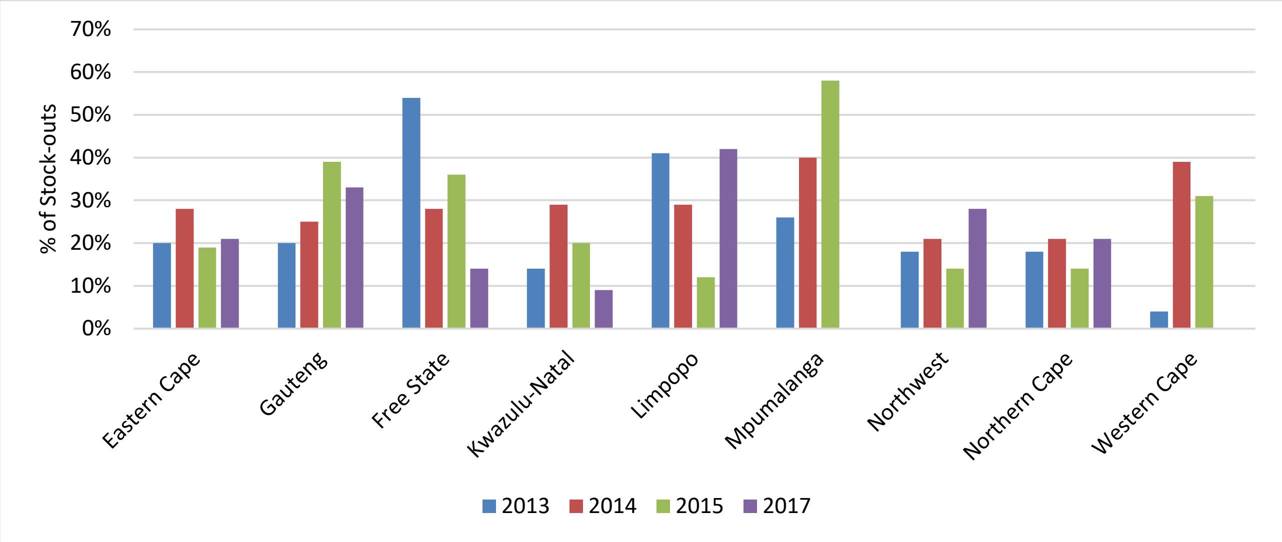


Figure 1.6: Percentage of ARV/TB stock-outs (3-month stock out) by province in South Africa

Source: (Medicines Sans Frontiers et al., 2017)

1.4. Research gap

A healthcare supply chain is an ecosystem consisting of a combination of organisations, people, technology, activities, information and resources that facilitate the delivery of healthcare products, vaccines and other medicines from the manufacturer to the end-patient in a cost-effective way. (Yadav, 2015). The prime purpose of public healthcare supply chains is to ensure agile healthcare delivery systems to the citizen of a country, regardless of geographic locations and in response to diversified patient needs (Serbout, Berrado and Benabbou, 2016). Consequently, a strong healthcare delivery system cannot function without a well-designed, well-operated and well-maintained Supply Chain Management (SCM) system - one that can ensure an adequate supply of essential healthcare products to the patients who need them (JSI, 2017). However, public healthcare supply chains are not only growing in size, but they are becoming more complex as there are more interconnected parts and feedback loops within the system. (USAID, 2010).

With low forecast accuracy and high demand variability, organisations[3] usually have to increase safety stock levels or move products from one location to another, on an expedited basis. However, these initiatives hurt operational efficiency and increase supply chain costs. To cope with this scenario, many organisations are trying to move from a pure Push system, which is only driven by forecast, to a Pull system, which is driven by actual customer demand. This system ensures a better

[3] The word "organisation" is used interchangeably with Supply Chain Node in this dissertation.

balance between supply and customer demand, thereby delivering expected customer service levels, and supply chain efficiency Mendes et al., (2016).

Current management systems and practices in public healthcare supply chains are less and less able to cope with the growing complexities of low forecast accuracy and demand variability, thereby resulting in medicines stock-outs, poor healthcare outcomes, high supply chain costs and operational inefficiencies (USAID, 2010). Other studies in literature support this notion of a Pull-based supply chain strategy and suggest that healthcare supply chains need to move towards an integrated "demand pull" model (Demand Driven Supply Chain Management (DDSCM)) that enables medicine manufacturers' to have visibility on actual consumption of medicines (Byrnes, 2004).

Although this Pull system has been established in industries such as computer, fruit, flower, telecommunications, transport, beef and fashion (Christopher and Towill, 2001; Canever, Trijp and Beers, 2008; Caro and Gallien, 2010) to manage supply chain complexity, demand volatility and uncertainty (Mendes et al.,2016), previous work has not comprehensively considered this system in the public healthcare SCN. Hence, the focus that is required is to ensure that supply chains are engineered to match demand requirements (Childerhouse, Aitken and Towill, 2002) in public healthcare sector.

However, there are a few methodologies or well-defined processes through which an analyst can impartially measure and support implementation of DDSCM practices in public healthcare Supply Chain Networks (SCNs). This becomes a challenge for organisations that want to adopt DDSCM practices in public healthcare SCNs. Nevertheless, other industries have focused on improving and expanding individual performance evaluation of organisations' suppliers, distributors and customers but there exists no supply chain maturity model that is able to manage properly the typical complexities in management of Supply Chain Networks (SCNs) (Lahti, Shamsuzzoha and Helo, 2009).

In particular, network level studies of the healthcare sector are still scarce (Marques et al., 2019) and current studies on DDSCM in other industries only focus on a single supply chain node. This study reinforces the need to take a network-level analysis when addressing DDSCM in public healthcare sector. A network perspective improves and facilitates the understanding of the complexities of interconnected supply chain nodes and feedback loops within public healthcare SCNs. It also helps in comprehending the interactions between the supply chain nodes in the public healthcare SCN.

Problem statement

An opportunity exists to adopt a network lens in the development of a tool that impartially supports the design, implementation, and assessment of both where a supply chain node is today along the DDSCM maturity scale as well as providing guidance on how the supply chain node can progress to more advanced maturity levels. This is achieved through planned interventions for improvement of the individual supply chain nodes in the public healthcare SCN.

1.4.1. Primary research question

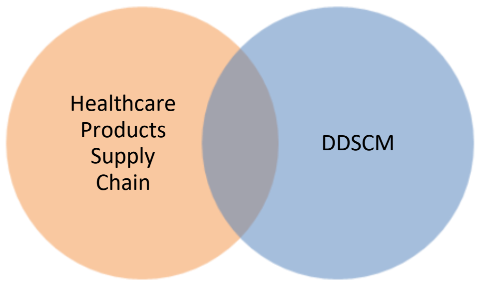
The primary research question for this study was:

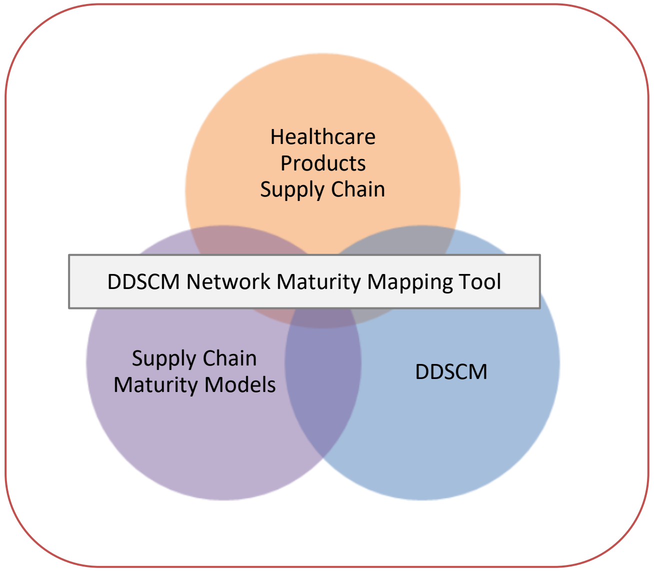
How can unique supply chain nodes in public healthcare Supply Chain Networks become more responsive and be guided towards advanced DDSCM stages?

1.4.2. Secondary research questions

The primary research question was broken down into secondary research questions to identify the research domains that could support the fulfilment of the research aim as shown in Table 1.1.

Table 1.1: Research domain development

<table>
<tr><th>Primary research question</th><th>Research domain development</th><th>Secondary research questions</th><th>Reference Chapter</th></tr>
<tr><td rowspan="4">How can unique supply chain nodes in public healthcare Supply Chain Networks become more responsive and be guided towards advanced DDSCM stages?</td><td></td><td>What does the structure of public healthcare products supply chain network look like?</td><td>Chapter 4</td></tr>
<tr><td rowspan="3"></td><td>What is DDSCM?</td><td rowspan="3">Chapter 5</td></tr>
<tr><td>What are the key success factors for DDSCM?</td></tr>
<tr><td>Why do we need a paradigm shift from classical supply push model to Demand-Driven Healthcare SCM?</td></tr>
</table>

Primary research question	Research domain development	Secondary research questions	Reference Chapter
		What design requirements should a maturity model satisfy so that it can be used as an assessment tool and guide the development of roadmaps for performance improvement?	Chapter 6
		What traits should a maturity model possess?	
		What is the difference between mature and immature Demand –Driven Healthcare supply chains?	Chapter 7
		How does the DDSCM Network-Maturity mapping tool function?	Chapter 9 Chapter 10

1.5. Research aim

Therefore, the research aim of this study is to develop a network-maturity mapping tool that supports the design, implementation and assessment of DDSCM performance for unique supply chain nodes in the public healthcare Supply Chain Network (SCN) as well as provide guidance on how the unique supply chain nodes in the SCN can progress towards advanced DDSCM maturity stages.

1.5.1. Research objectives

To answer the research questions set in section 1.4.2, and 1.4.3 the following objectives are set:

1. To understand the concept of DDSCM.
2. To investigate the key success factors for DDSCM.
3. To investigate the benefits of transforming healthcare supply chains from classical Supply Push model into Demand-Driven Healthcare supply chains.
4. To understand the distinction between mature and immature Demand-Driven Healthcare supply chains.
5. To develop a maturity model to assess the current state "*AS-IS*" of DDSCM in public healthcare supply chains
6. To validate the DDSCM maturity model with subject matter experts.
7. To develop a network maturity-mapping tool that supports network analysis and maturation of DDSCM from both an organisational and systems view perspective.

1.6. Research contributions of this study

The primary research question for this study was to investigate how unique supply chain nodes in public healthcare SCN can become responsive and be guided to progress towards advanced DDSCM stages so that the public healthcare SCN can deliver the right product, at the right place, and at the right time.

Firstly, a new comprehensive DDSCM framework for understanding and implementing DDSCM in complex end-to-end public healthcare supply chains (systems orientation) was developed. Secondly, a maturity model to measure and track the progress of DDSCM for organisations in public healthcare supply chains was also developed. Thirdly, a network maturity-mapping tool for public healthcare Supply Chain Networks (SCNs) was developed to support management at national, provincial, district and even at facility level to perform public healthcare SCN analysis and strategic decision-making. This addresses the limitation that is associated with most maturity models that focus only on evaluating individual performance of organisations such as suppliers, distributors and customers without addressing the typical complexities in the management of the entire supply chain networks. Fourthly, the network maturity-mapping tool was also emperically validated through 12 extensive case studies, therefore, this study makes some strides towards addressing the limitation associated with most of the supply chain maturity models, which are theoretical constructs. Fifthly, another interesting contribution from this research is that the 12 case studies demonstrated the tremendous impact that DDSCM concepts have on an organisation's performance. The effort to implement/or sustain these DDSCM concepts was also illustrated. The sixth and last contribution of the study relates to the identified benefits that unique organisations in the public healthcare SCNs can reap from the implementation of DDSCM within their organisations and subsequently across entire networks.

1.7. Research outputs

Five research publications resulted from this study. Table 1.2 outlines the type of publications, reference chapters in this research as well as the research objective that was addressed.

Table 1.2: Publications

	Research Objective	Reference Chapter	Publication
RO1	To understand the concept of DDSCM	Chapter 5	Bvuchete, M., Grobbelaar, S., van Eeden, J., (2018). Best practices for Demand Driven Supply Chain Management: A Systematic Literature Review. Accepted for publication in the Southern African Journal of Industrial Engineering
RO2	To investigate the key success factors for DDSCM		
RO3	To investigate the benefits of transforming healthcare supply chains into Demand-Driven Healthcare supply chains.		Bvuchete, M., Grobbelaar, S., van Eeden, J., (2017). Big Data and Demand Driven Supply Chain Management: Potential benefits for Healthcare Supply Chain Management in South Africa. Full paper published in the SAIIE28 Conference Proceedings, 25-27 October 2017, Riverside Sun, Vanderbijlpark.
RO4	To develop a maturity model to assess the current state "AS-IS" of DDSCM in public healthcare supply chains	Chapter 6	Bvuchete, M., Grobbelaar, S., van Eeden, J., (2018). A Comparative analysis of existing supply chain maturity models: Full paper published in the Proceedings of the International Conference on Industrial Engineering and Operations Management Pretoria / Johannesburg, South Africa, October 29 – November 1, 2018
RO5	To understand the distinction between mature and immature Demand-Driven Healthcare supply chains.	Chapter 7	Bvuchete, M., Grobbelaar, S., van Eeden, J., (2018). A Conceptual Demand Driven Supply Chain Management Maturity Model for Public Healthcare Sector in South Africa. Full paper published in proceedings of IAMOT 2018 conference in Birmingham, United Kingdom
		Chapter 4	Bvuchete, M., Grobbelaar, S., van Eeden, J., (2018). A Case for Healthcare Supply Chain Visibility in South Africa. Full paper published in the 3rd Biomedical Engineering Conference Proceedings, 4-6 April 2018, Spier, Stellenbosch. DOI: 10.1109/SAIBMEC.2018.8363179

1.8. Thesis Structure

The thesis consists of eleven (11) chapters and the contents of these chapters are described in Table 1.3. The chapters are ordered such that they reflect the logical sequence of this study. Each chapter has an introductory paragraph and is concluded with a concise summary.

Table 1.3: Thesis structure

Chapter	Chapter Description
1	Introductory chapter outlining the problem statements, research rationale, research questions and research objectives.
2	Research methodology chapter that gives an overview of the research philosophy, research approaches, research strategies, methods and techniques followed in this thesis.
3	A literature review on the supply chain concept discussing degrees of supply chain complexity, supply chain processes, supply chain decision making processes, supply chain planning, demand driven material requirements planning and supply chain metrics.
4	Literature review on the healthcare products supply chains focusing on the structure of healthcare products supply chain, healthcare SCM framework, healthcare supply chain processes, stakeholders in the public healthcare supply chain in SA, healthcare supply chain visibility, and the integrated public healthcare supply chain.
5	A systematic literature review on the DDSCM approach, its benefits, and the development of a DDSCM Framework.
6	A comparative review of existing supply chain maturity models including healthcare supply chain maturity models.
7	Conceptual maturity model development.
8	Validation of the conceptual maturity model.
9	Development of the network maturity-mapping tool (matching capabilities to unique supply chain nodes).
10	Testing the applicability of the network maturity-mapping tool through multiple case studies.
11	Conclusions, unique contributions and recommendations.

1.9. Ethical considerations

Maree (2011) argues that, it is important to obtain clearance from ethics committee when human (or animal) subjects are involved in any kind of research of an empirical nature. Furthermore, participants need to be aware of general agreements of the research.

This research was conducted according to ethical guidelines. This study obtained ethical clearance from both the Stellenbosch University Research Ethics Committee (*ethics code ING-2018-6963*) and the Department of Health Ethics Committee (*ethics code WC_201902_18*). Verbal and written informed consent from participants was obtained before semi-structured interviews and questionnaire administration. The participants were reminded also that they could withdraw from the study at any time, if they wish to. The ethical clearance form is shown in Appendix 1.

1.10. Chapter summary

Public healthcare supply chains are not only growing in size, they are becoming more complex. Current management systems and practices are less and less able to cope with the growing complexities, thereby resulting in medicines stock-outs, poor healthcare outcomes, high supply chain costs and operational inefficiencies. However, other studies in literature support the notion of a pull-based supply chain strategy and suggest that healthcare supply chains need to move towards an integrated "demand pull" model. In particular, healthcare supply chains need to become demand-driven as opposed to the current supply push system. The concept of DDSCM that has been applied in other industries to manage this complexity, demand volatility and uncertainty is a potential promise for public healthcare supply chains.

Therefore, the research aim of this study is to develop a network-maturity mapping tool that supports the design, implementation and assessment of DDSCM performance for unique supply chain nodes in the public healthcare Supply Chain Network (SCN) as well as provide guidance on how the unique supply chain nodes in the SCN can progress towards advanced DDSCM maturity stages.

This chapter has provided the background and context of the research. Research objectives have been set in this chapter. The next chapter provides a research methodology that outlines how the research was designed and conducted.

Chapter 2 Research Methodology

2.1. Introduction

A research methodology is a philosophical framework within which research is conducted or the foundation upon which the research is based or undertaken (Saunders, Lewis and Thornhill, 2007). It describes the research methods, approaches and designs in detail highlighting those used throughout the study, justifying the choices selected, taking into account their practical applicability to the study (Dudovskiy, 2018). This chapter provides an overview of the research design for this study that was adapted from Saunders et al., (2007). The research onion that was developed by Saunders et al., (2007), (Figure 2.1) outlines the research philosophies, research approaches, research strategies, research time horizons and research techniques and procedures that can be incorporated in a research design.

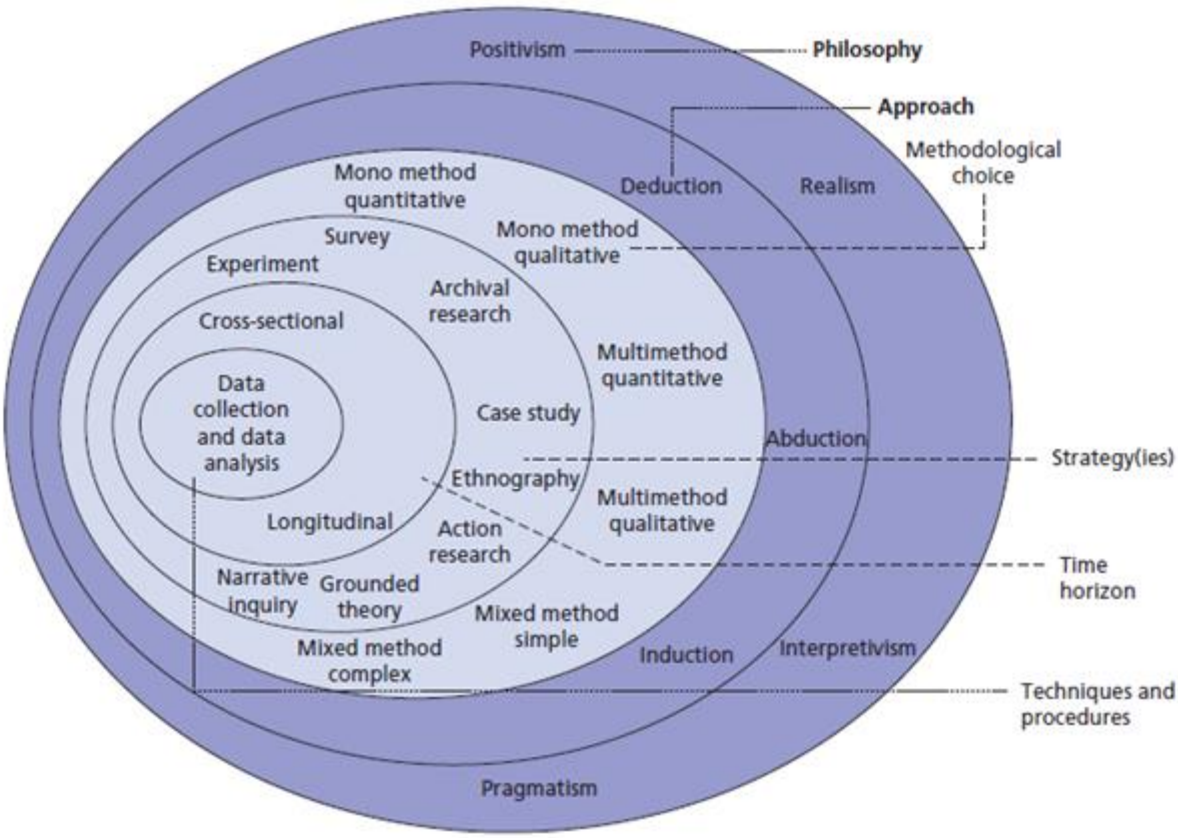


Figure 2.1: Research Onion

Source: (Saunders, Lewis and Thornhill, 2012)

2.2. Research Philosophy, Epistemology and Ontology

Research philosophy deals with the source, nature and development of knowledge (Bajpai, 2011). Saunders et al., (2007), argues that the research philosophy that is adopted for a study contains important assumptions about the way in which the researcher views the world. These assumptions will underpin the research strategy and the methods used as part of that strategy. In particular, it outlines the relationship between knowledge and the process by which it is developed. Stated differently, a research philosophy is a belief about the ways in which data about a phenomenon should be collected, analysed and used. Assumptions should be stated clearly (Dudovskiy, 2018).

As shown in Figure 2.1, the identification of the research philosophy is positioned at the outer layer of the "research onion" (Saunders, Lewis and Thornhill, 2012). This is important since it reflects the stages of the research process based on assumptions about sources and the nature of knowledge. There are many branches in research philosophy that are associated with a wide range of disciplines. However, three main research philosophies emerge (Dudovskiy, 2018) as shown in Table 2.1:

- Pragmatism
- Positivism
- Interpretivism

Table 2.1: Epistemology and Ontology (Dudovskiy, 2018; Bryman et al., 2014)

	Pragmatism	**Positivism**	**Interpretivism**
Principal orientation	Pragmatics recognise that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture and that there may be multiple realities. The research question is the most important determinant of the research philosophy.	Epistemological approach that advocates applying natural science methods to study and understand social reality. Only phenomena that can be observed by senses can be verified as objects and sources of knowledge. Only scientific statements are the true domain of the scientist.	Access to reality (given or socially constructed) is only through social constructions such as language, consciousness, shared meanings, and instruments. Therefore, this approach requires the researcher to grasp the subjective meaning of social action.
Research approach	Deductive/Inductive	*Deductive* (the purpose of theory is to generate hypotheses that can be tested, so that the validity of propositions can be assessed through deduction) *Inductive* (Knowledge is arrived at through gathering facts that provide the basis for universal propositions through induction)	Inductive
Research strategy	Qualitative and/or quantitative	Quantitative analysis and mathematical methods	Qualitative
Ontology	Objective or subjective/constructionism	*Objective/realism* (the world exists and can be studied as it is)	*Subjective/constructionism/idealism* (the world exists, but is studied differently by different people)
Axiology	Value-free/biased	*Value-free* (science must (and presumably can) be conducted in a way that is value free (objective))	Biased (since data is heavily impacted by personal view point and values (subjective))

This study adopts pragmatism as a research philosophy. As illustrated in Table 2.1, unlike the positivism and interpretivism research philosophies, pragmatism research philosophy can integrate more than one research approach and research strategy within the same study since both positivism and interpretivism are two extreme mutually exclusive paradigms and sources of knowledge (Dudovskiy, 2018). Pragmatism research philosophy can integrate the use of multiple research methods such as qualitative, quantitative and action research methods (Saunders, Lewis and Thornhill, 2012; Dudovskiy, 2018). From a pragmatic viewpoint, the study's research questions are of primary importance (Vos, Strydom and Delport, 2012). This is the motivation for choosing pragmatism as a research philosophy in this study since it can advance a specific research in the best possible manner and guiding the answering of the research questions (Wilson, 2010).

2.3. Research Approach

Research approach is another important element of research methodology that directly affects the choice of specific research methods. The most common research approaches that are utilised in many studies include deductive and inductive (Saunders, Lewis and Thornhill, 2007). A deductive approach is used when the researcher wants to develop hypothesis (or hypotheses) based on existing theory, and then designing a research strategy to test the hypothesis (or hypotheses) (Wilson, 2010). The hypothesis (or hypotheses) must then be subjected to empirical scrutiny (Bryman et al., 2014). A deductive approach also test whether the causal relationship or link between theory and data is true (Gulati, 2009).

In the inductive approach, the researcher would collect data, analyse data, and develop theory. This implies that, theories are proposed at the end of the research process as a result of observations (Goddard and Melville, 2004). In most instances, the inductive approach is associated with qualitative methods of data collection and data analysis, whereas deductive approach is perceived to be related to quantitative methods (Saunders, Lewis and Thornhill, 2007). In a nutshell, deduction begins with an expected pattern "that is tested against observations, while induction begins with observations and seek to find a pattern within them" (Babbie, 2010).

Stated differently, a deductive approach takes a "top-down" direction while an inductive approach takes a "bottom-up" direction (Alexandiris, 2006). Deductive approach is an empirical testing of theory while inductive approach is generation of theory from data (Bryman et al., 2014). Finally, the deductive approach tests the validity of assumptions (or theories/hypotheses) at hand, whereas inductive approach contributes to the emergency of new theories and generalizations (Dudovskiy, 2018).

In this study, an inductive research approach is adopted since the study seeks to explore ways to improve the public healthcare supply chain using DDSCM principles, identify themes and patterns on DDSCM literature and create a conceptual framework that is used as a baseline for the development of the maturity model and the network maturity-mapping tool.

2.4. Research Strategy

Multiple research strategies exist that a researcher can employ. Each strategy can be used for exploratory, descriptive and explanatory research (Yin, 2009). The choice of research strategy will be guided by one's research question(s) and objectives, the extent of existing knowledge, the amount of time and other resources you have available, as well as your own philosophical underpinnings (Saunders, Lewis and Thornhill, 2007). Table 2.2 shows the different research strategies which include qualitative research, quantitative research and mixed-methods research (Bryman et al., 2014).

Table 2.2: Research strategies (Dudovskiy, 2018; Bryman et al., 2014; Vos, Strydom and Delport, 2012)

Research strategy	Principal orientation	Advantages/disadvantages
Qualitative research	Words and description	-Flexible investigation -Researcher involved with participants -Rich, deep, thick data -Outlines the participants' view points -Understanding of the context
Quantitative research	Numbers and measurement	-Structured data collection -Researcher detached from subjects -Hard, reliable data -Outlines the researcher's view point -Generalisation of the population
Mixed methods research	Combination or integration of qualitative and quantitative research methods within a single study	- Using both quantitative and qualitative research strategies may allow the researcher to capitalise on the strengths and offset the weaknesses of each method -Mixed methods enables the researcher to simultaneously address a range of confirmatory and exploratory questions with both the qualitative and quantitative approaches therefore verify and generate theory in the same study -It provides strengths that offset the weaknesses of both quantitative and qualitative research, and therefore has potential to provide better (stronger) inferences -Mixed methods research encourages the use of multiple world views or paradigms rather than the typical association of certain paradigms for quantitative researchers and others for qualitative researchers

Quantitative research is concerned about concepts and their measurements and most of qualitative research focuses on concepts rather than developing measures. A quantitative approach is usually associated with finding evidence to either support or reject hypotheses while the qualitative approach refers to non-numeric information that can be collected through interviews, video recordings, images and text documents (Dudovskiy, 2018). In other words, a qualitative study is concerned with non-statistical methods, small samples that are often purposively selected while a quantitative study is based on testing a theory composed of variables, measured with numbers and analysed with statistical procedures in order to determine whether the predictive generalisation of theory hold true (Vos, Strydom and Delport, 2012).

Qualitative research is sometimes criticised for being too subjective, difficult to replicate and lacks transparency because it is unstructured and rely too much on the researcher's views about what is significant and important and upon the close personal relationships that the researcher frequently strikes up with the people studied. It is sometimes difficult to establish what the qualitative researcher actually did, how people were chosen for observation or interview, how qualitative data was actually analysed and how the researcher arrived at the study conclusions.

On the other hand, quantitative research processes possess an artificial and false sense of precision and accuracy. This is because they are based on the assumption that all respondents interpret the key terms similarly when they answer a question in a questionnaire. In reality however, not all respondents interpret such terms similarly. Another critic of quantitative research lies on the reliance on instruments and procedures. How do we know if a respondent has the requisite knowledge to answer a question? One may also ask whether their answers to questions relate to their actual behaviour or practice (Bryman et al., 2014). However, it is noted that both qualitative studies and quantitative studies are not mutually exclusive but at one point in research, researchers often need to combine both approaches in what they call a mixed research approach (Vos, Strydom and Delport, 2012).

Based on this argument, mixed methods research strategy is used in this research since it utilises both quantitative and qualitative research strategies. This allowed the researcher to capitalise on the strengths and offset the weaknesses of each individual method. Mixed methods strategy involves collecting and analysing quantitative and qualitative data to give a more complete picture of the problem (Vos, Strydom and Delport, 2012).

2.5. Research methods

Research methods are techniques and procedures used to obtain and analyse data (Saunders, Lewis and Thornhill, 2007). The research methods consist of three main data collection and analysis techniques (Dudovskiy, 2018), which are mono-method, mixed method and multi-method. A mono-method is when a researcher uses a single data collection technique and corresponding analysis procedures. When the researcher uses more than one data collection technique and analysis procedures to answer the research question, it is now called multi-methods approach while in a mixed method approach, both quantitative and qualitative data collection techniques and analysis procedure are used (Saunders, Lewis and Thornhill, 2007). In this research, we have used mixed method approach. These methods include interviews, questionnaires, case studies and survey. For qualitative data analysis, Qualitative Content Analysis (QCA), Grounded Theory (GT) and Conceptual Framework Analysis (CFA) were used. Table 2.3 discusses some of the research methods.

Table 2.3: Research methods

Research method	Description
Experiment	Study causal links; whether a change in one independent variable produces a change in another dependent variable (Saunders, Lewis and Thornhill, 2007). The ability to infer causality and test causal relationships is a strength for this method while, small samples make generalisability risky and also errors which also limit validity of findings (Mouton, 2012).
Survey	Used to answer who, what, where, “how much” and “how many” questions. It therefore, used for exploratory and descriptive research. Surveys are popular as they allow the collection of a large amount of data using a questionnaire, from a sizeable population in a highly economical way (Saunders, Lewis and Thornhill, 2007). Surveys ensure high measurement reliability if proper questionnaire construction and high construct validity has been considered. Survey data is usually context specific and lacks depth (Mouton, 2012).
Case Study	The case study strategy is most often used in explanatory and exploratory research. It involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence. Case study approach allows the investigators to retain the holistic and meaningful characteristics of real life events such as organisational processes and group behaviour (Yin, 2009).
Interviews	A conversation in which an interviewer asks participants questions to gather data about their opinions, beliefs, views and ideas. Interviews can be open-ended, semi-structured or structured (Maree, 2012). During interviews, rich descriptive data can be collected that can help the interviewer to understand the participant’s knowledge and social reality (Bryman et al., 2014).

Research method	Description
Grounded Theory	It is inductive and involves qualitative theory building through the discovery of relationships between concepts (Strauss and Corbin, 1994; Charmaz, 1996). This is important for the purpose of grounding the research in empirical data (Martin and Turner, 1986). This data is systematically collected and inductively analysed (Charmaz, 1996).
Content analysis	Process of categorising verbal, behavioural data to classify, summarise and tabulate data (Dudovskiy, 2018). Qualitative content analysis is particularly useful for research involving large volumes. The limitation lies in authenticity of data sources and overall external validity of the findings (Mouton, 2012).
Ethnography	Rooted firmly in the inductive approach. It describes and explains the social world in the way in which the research subjects would describe and explain it (Saunders, Lewis and Thornhill, 2007). Ethnographic studies have high construct validity, give in-depth insights and allow the establishment of rapport with research subjects. The limitations include, lack of generalisation of results, non-standardisation of measurement, data collection and analysis can be very time consuming (Mouton, 2012).
Framework Analysis	Consist of familiarization, identifying a thematic framework, coding, charting, mapping and interpretation (Dudovskiy, 2018). Also involves the analysis of concepts through clarification and elaboration of the different dimensions of meaning. This brings conceptual clarity, explicates theoretical linkages and reveals the conceptual implications of different viewpoints. However, poor conceptual analysis leads to conceptual confusion, theoretical ambiguities and fallacious reasoning (Mouton, 2012).

2.5.1. Data collection and analysis

Since data collection process involves the collection of information from all relevant sources to answer the research question and evaluate the outcomes (Dudovskiy, 2018), this study utilised both the primary data collection methods and secondary data collection methods. The primary data collection methods included a survey as a quantitative data collection method and qualitative data collection methods such as interviews, questionnaires and case studies were used.

Purposive sampling was used in selecting participants for case studies, interviews and the survey because the research needed to be validated by people with knowledge and experience. Purposive sampling is a non-probability sampling method that is most relevant when one needs to collect practical data on a certain domain from knowledgeable experts (Tongco, 2007).

2.5.2. Systematic literature review

The secondary data collection methods included literature reviews and systematic literature review on journal articles, books, reports and conference articles. The motivation for using the Systematic

Literature Review (SLR) method is that, it is an evidence-based process intended to evaluate all published and unpublished literature on the topic. It is highly replicable (Bryman et al., 2014) and transparent, thereby minimizing bias (Jackson, 2004; Petticrew et al., 2006; Keele and Staffs, 2007)**.** Moreover, it is a systematic way of collecting, critically evaluating, integrating, and presenting findings from across multiple research studies on a research question or topic of interest. The framework for SLR that is used to ensure methodological rigor and quality is called Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA). This methodology addresses quality issues, such as bias, replicability and credibility. It offers a broader and more accurate level of understanding than a traditional literature review. Another motivation of using a SLR is that a SLR adheres to standardized methodologies in systematic searching, filtering, reviewing, critiquing, interpreting, synthesizing, and reporting of findings from multiple publications on a topic of interest (Debajyoti et al., 2018). The actual SLR proceeds systematically through various sequential steps including question formulation, identification of search domains and publication sources, systematic search, systematic critical analysis, systematic interpretation, and systematic reporting as shown in Table 2.4 and Figure 2.2.

One of the limitations of systematic literature reviews stems from situations where research questions cannot be defined in terms of the effect of a particular variable, or when the subject boundaries are more fluid and open or subject to change. Hence the systematic approach requires articles to be evaluated in terms of clear methodological criteria (Bryman et al., 2014).

Table 2.4: Steps in Systematic Literature Review

Reference	**Proposed stages of Conducting a Systematic Literature**	**Objectives**
Bryman et al., (2014)	Planning the review	Specifying the research question (s)
	Conducting the review	Key words and search terms
		Data analysis of what is known about the subject
	Reporting and dissemination	Identify contributors to the main research
		Where are the contributors based
		When was the main research activity conducted
		Define criteria for reporting study accessibility and readability
Debajyoti et al., (2018)	Planning the review	Develop your study question

	Data collection	Identify concepts to be included in your search
		Select databases relevant to your topic area to conduct your research
		Key words to be used for the search
	Data selection	Decide the inclusion and exclusion criteria (PRISMA flow chart)
		You can also use snowballing
	Data analysis	Critical review of full articles

Therefore, the methodology for performing the systematic literature review is shown in Figure 2.2.

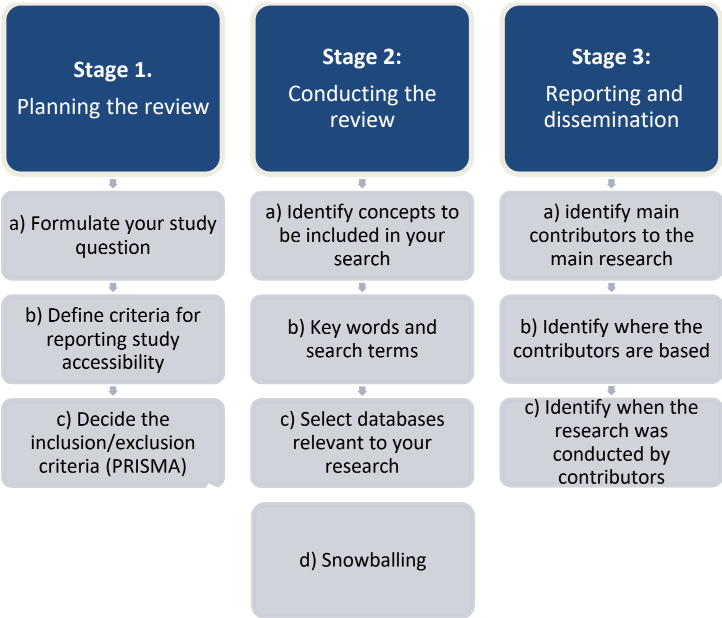


Figure 2.2: Methodology for conducting systematic literature review

The research question for this study was,

"How can unique supply chain nodes in public healthcare Supply Chain Networks become more responsive and be guided towards advanced DDSCM stages?"

PRISMA (Debajyoti et al., 2018) was used to determine the inclusion/exclusion criteria for systematic review. Moreover, the search was restricted to scientific journals, conference proceedings, technical reports, and textbooks. Table 2.5 shows the search terms that were used. Three data sources were searched which include Scopus, Web of Science and Science Direct.

Table 2.5: Search terms used

	Search Terms	Scopus	Web of science	Science Direct
#1	((demand driven) AND (supply chain) AND ((visibility) OR (information sharing)))	64	52	178
#2	((customer driven) AND (supply chain) AND ((visibility) OR (information sharing)))	46	34	165
#3	((pull) AND (supply chain) AND ((visibility) OR (information sharing)))	34	24	1169

After the initial search from the three databases, studies were included for review based on the relevance of topic. Secondly, based on convenience and accessibility of the papers. Thirdly, the inclusion of papers for the SLR was based on the language used in the paper and lastly the relevance of the abstracts. Furthermore, after reading the abstracts of these papers, snowball strategy was used to identify more papers to add to the total number of papers for the SLR. The result was a final dataset that was analysed using Qualitative Content Analysis (QCA) to extract themes and concepts. Figure 2.3 describes the PRISMA flow diagram for our study.

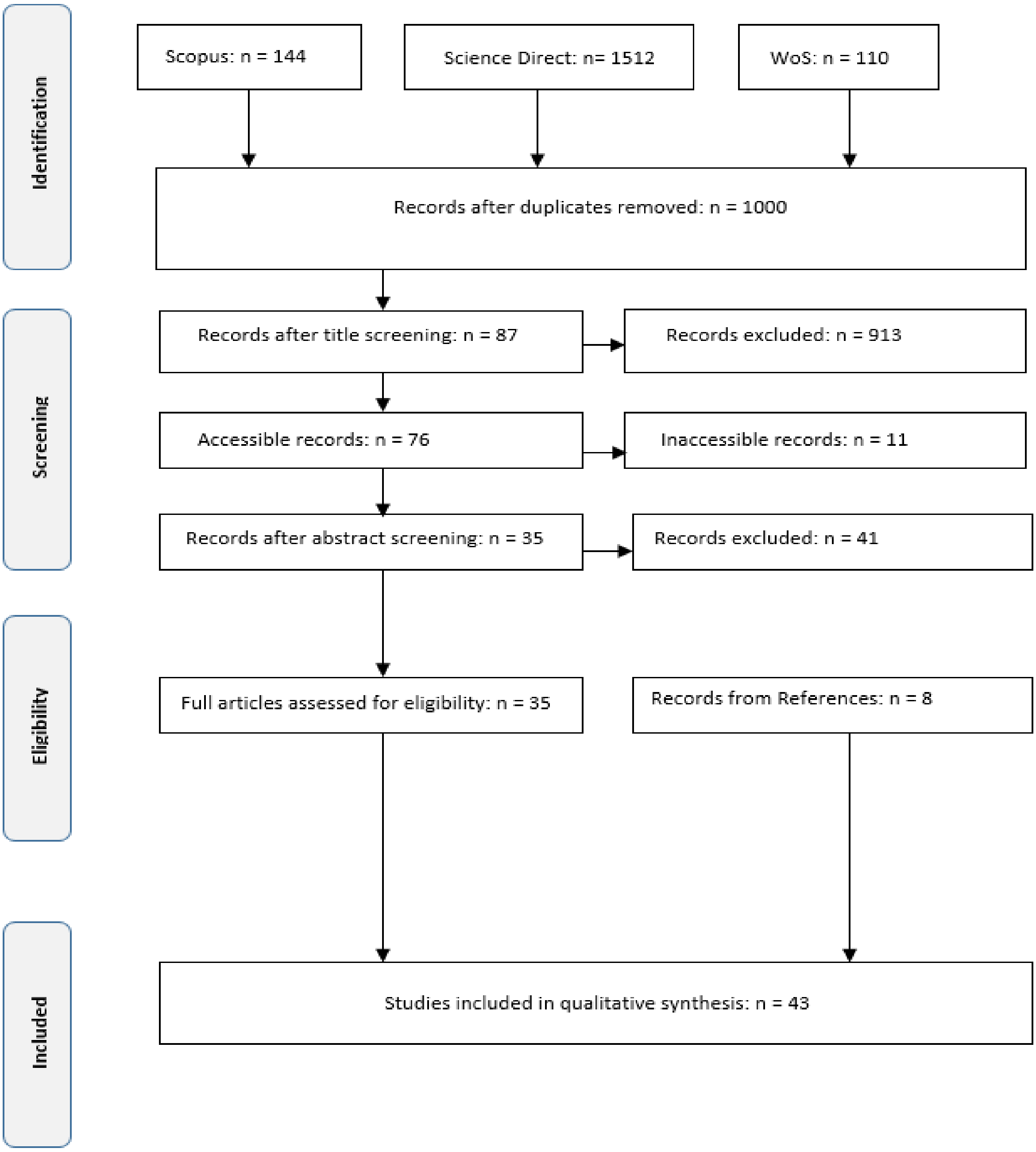


Figure 2.3 : Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram

2.5.3. Conceptual framework analysis

The integration of the qualitative data collected was guided by the Conceptual Framework Analysis (CFA) method by Jabareen (2009). CFA consist of eight phases and Table 2.6 gives a detailed description of the phases. The CFA phases form part of the foundation for the research design canvas for this study.

Table 2.6: Conceptual Framework Analysis, (Jabareen, 2009)

Phases	Descriptions	Objectives
Phase 1	Mapping the selected data sources	-Identify sources of data -Define search terms -Systematic data collection
Phase 2	Extensive reading and categorizing of the selected data	-Extensive reading of selected data -Categorization of the data by discipline and by scale of importance
Phase 3	Identifying and naming concepts	-Discover all concepts from the literature
Phase 4	Deconstructing and categorising concepts	-Deconstruct each concept -Identify each concept main attributes and characteristics -Categorize concepts according to their features
Phase 5	Integrating concepts	-Integrate and group concepts that have similarities to one new concept
Phase 6	Synthesis of concepts into a framework	-Iteratively develop a conceptual framework
Phase 7	Validating the conceptual framework	-Validate the conceptual framework to find out whether the proposed framework and its concepts can make sense to academia and industry
Phase 8	Rethinking the conceptual framework	-Refine the framework using inputs from the validation process

2.6. Research design

Despite different conceptualisations of research design, this research defines a research design as a general plan that provides a detailed guideline to answering the research question. Important elements of research design should include research strategies and methods related to data collection and analysis (Dudovskiy, 2018).

This study combines qualitative data from literature and semi-structured interviews to construct a DDSCM framework with associated relationships among the success factors for DDSCM. To add on, the relationships are quantified using a survey (quantitative research).

Vos et al., (2012) supports this notion by arguing that two characteristics are common to most research designs. One research design can merge the quantitative and qualitative data in a parallel or concurrently. The other one utilises qualitative data or quantitative data to extend the other type in a sequential way (Vos, Strydom and Delport, 2012).

The research design in this study takes an exploratory direction as it seeks to explore aspects in DDSCM that can be utilised within the context of public healthcare supply chains. The exploratory mixed methods design is used when a researcher first needs to explore a phenomena using qualitative data before attempting to measure or test it quantitatively (Vos, Strydom and Delport, 2012). The illustration of this exploratory research design is shown in Figure 2.4.

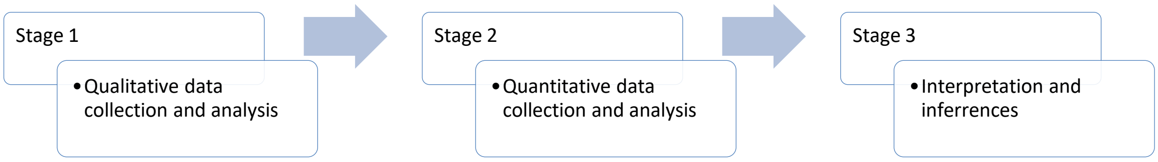


Figure 2.4: Exploratory mixed methods research design

Source: (Vos, Strydom and Delport, 2012)

The research design for this study consists of the constructive phase that builds the artefact and a testing phase that evaluates the designed artefact. This was characterised by collecting qualitative data first, then quantitative data, followed by integrating the two data collection methods during the interpretation phase.

This research design, illustrated in Figure 2.4, enables the researcher to use results from the qualitative approach to sequentially establish and explain results of the quantitative approach (Maree, 2011). This study collected qualitative data by means of literature reviews, semi-structured interviews and multiple case studies in the public healthcare supply chain context in South Africa and Kenya. Thereafter, quantitative data was collected by means of a survey design in the form of a standardised questionnaire (Maree, 2011).

It is imperative to recognise that other studies in literature, apply a conclusive research design that describes specific elements, causes or phenomena using only quantitative methods (Saunders, Lewis and Thornhill, 2012). Figure 2.5 outlines the research design canvas for this study and it was built upon the foundations of the research onion (Saunders, Lewis and Thornhill, 2007), CFA process (Jabareen, 2009) and maturity model development process (Becker, Knackstedt and Pöppelbuß, 2009). For the purpose of this study, the sequential exploratory mixed methods design is regarded as the most appropriate (Maree, 2011; Vos, Strydom and Delport, 2012).

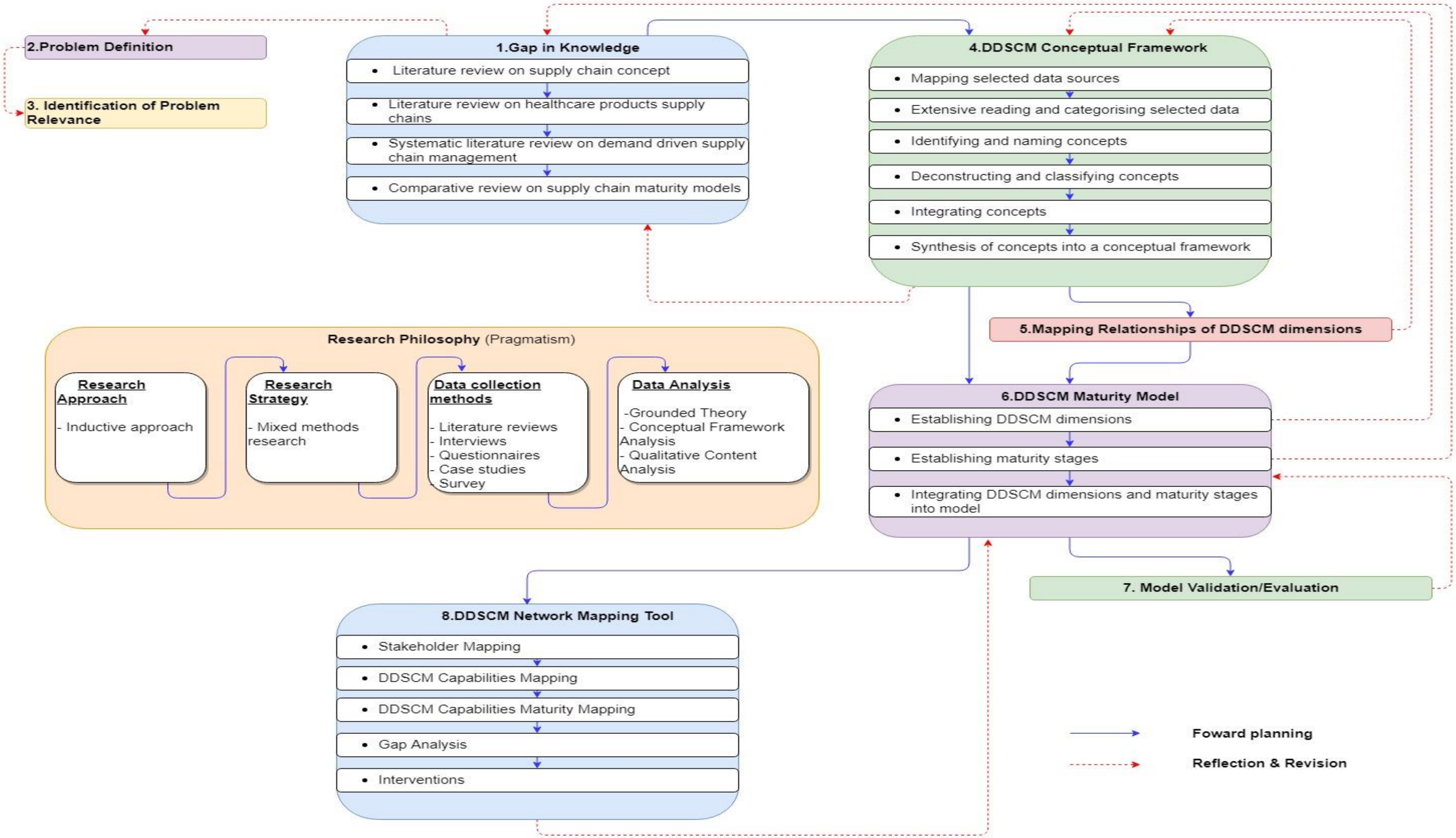


Figure 2.5 : Research Design Canvas

The problem statements led to the development of a primary research question and secondary research questions. The research aim and objectives were also established. The conceptual framework was developed by the integration of relevant concepts from literature on supply chains, literature review on healthcare product supply chain, SLR on DDSCM and comparative literature review on supply chain maturity models. The conceptual framework outlines the relationships between the DDSCM concepts.

Furthermore, the DDSCM maturity model was developed by coupling the conceptual framework concepts and maturity stages adopted from Paulk *et al.*, (1993) capability maturity model. Lastly, through capabilities mapping at each unique node of the public healthcare supply chain, a network-mapping tool was developed that guides in the capabilities maturity mapping and gap analysis.

2.7. Evaluation process

Table 2.7 and Figure 2.6; provide a detailed illustration on the validation process that was followed in this study. Firstly, validation through semi-structured interviews to ascertain the credibility and completeness of the conceptual maturity model. This stage was conducted with fourteen (14) participants and these participants were selected using purposive sampling. These participants have knowledge and experience of DDSCM.

The output of this stage was an enhanced maturity model, which was empirically tested through maturity model ranking interviews to ascertain the reliability, relevance and usefulness of the maturity model within the context of public healthcare supply chains. Nine (9) participants were interviewed at this stage.

Next, relationship mapping among DDSCM dimensions was conducted through a survey of seventy-eight (78) people. This was to ascertain how the DDSCM dimensions interlock and amplify each other. This guides the process of prioritising interventions on immature DDSCM dimensions. While the mappings represents ideal DDSCM interrelationships derived from literature and validated by subject matter experts in the supply chain field, there is need to explore more the practical application, analysis and validation of the DDSCM interrelationships within the context of public healthcare Supply Chain Network (SCN). However, these interrelationships derived from literature and validated by subject matter experts in the supply chain field remain suggestive and hypothetical within the context of public healthcare SCN. The bias for this approach is on the assumption that all respondents interpret key terms similarly when they answer a question in a questionnaire.

Through capabilities mapping interviews at unique supply chain nodes, the generic DDSCM maturity model was transformed into a network maturity-mapping tool that was used as a reference for case studies.

To finalise the validation process, twelve (12) case studies were conducted to establish the applicability and validity of the tool to unique supply chain nodes within the context of public healthcare supply chains.

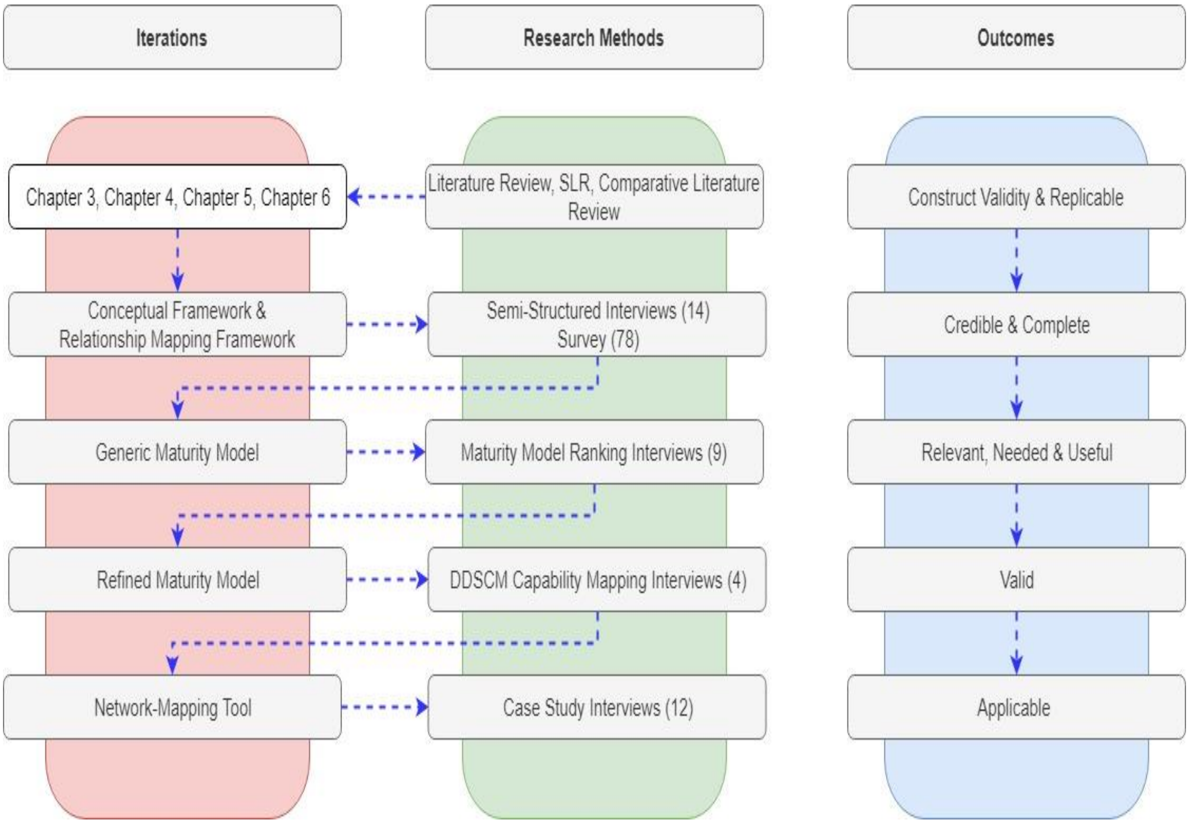


Figure 2.6: Research Evaluation Methodology

Table 2.7: Model validation outcomes (Marais, 2018)

Validation stage	Outcome	Overview	Methods
Stage 1	Credible	The model needs to be developed on credible concepts and should be complete	-Semi-structured interviews -Skype interviews
	Complete		
Stage 2	Reliable	The model needs to be based on empirical foundation. It should be needed, reliable, relevant and useful	-Model ranking interviews
	Needed		
	Relevant		
	Useful		
Stage 3	Applicable	Empirical testing of model on an organisation processes to assess validity and applicability of model	-Case study interviews -Questionnaires
	Valid		

2.8. Chapter summary

This chapter provided an overview of the research methodology. A research design canvas was discussed, which is the guide to the development of the final DDSCM network maturity-mapping tool. It outlines the research problem, the purpose of the research, the literature review approach, and the developmental stages of both the DDSCM conceptual framework and the maturity model. The research onion was adopted for reference on the choice of research philosophy, research strategies, research approaches and the choice of methods. Finally, the research evaluation methodology was outlined. The next chapter provides a foundation on which the concept of DDSCM is built. It outlines the concept of supply chains.

Chapter 3 : A Literature Review on the Supply Chain Concept

3.1. Introduction

This chapter provides an overview of supply chain concepts. It serves as a foundation to build the DDSCM concept. To that end, it answers the following questions:

<u>Chapter 3</u>

- What are the components that make up SCM?
- How is supply chain visibility defined?
- What are the components in the Demand Driven Materials Planning (DDMRP) model?

3.2. Defining the supply chain concept

A supply chain is made up of multiple organisations that directly facilitate the flow of goods, services, information and finances (Mentzer et al., 2001). This definition outline three degrees of supply chain complexity: direct supply chain, extended supply chain and ultimate supply chain.

A direct supply chain consists of a company, supplier and customer as shown in Figure 3.1 (Mentzer et al., 2001).

Figure 3.1: Direct supply chain

Source: (Mentzer et al., 2001)

An extended supply chain involves suppliers of the immediate supplier and customers of the immediate customer as shown in Figure 3.2 (Mentzer et al., 2001).

Figure 3.2: Extended supply chain

Source: (Mentzer et al., 2001)

An ultimate supply chain consist of all companies involved in facilitating the flow of materials, information, and finances in the supply chain (Mentzer et al., 2001). Figure 3.3 depicts an ultimate supply chain.

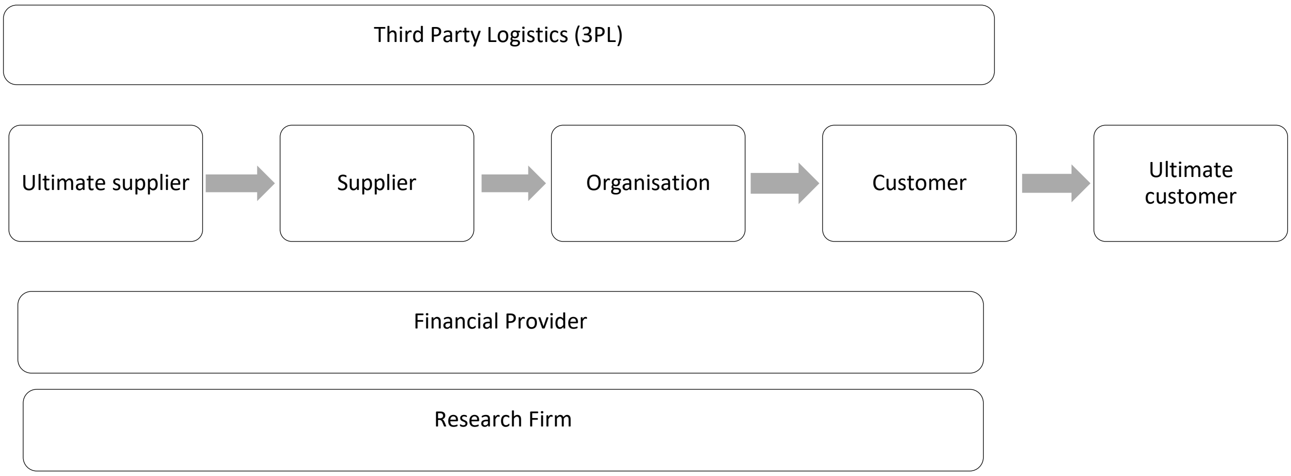


Figure 3.3: Ultimate supply chain

Source: (Mentzer et al., 2001)

Furthermore, four supply chain strategies are identified in the literature. The selection of a supply chain strategy can be influenced by lead-time, lead-time gap, product type and the availability of information (Payne and Peters, 2004). However, Yadav (2015) argues that the choice of a push or pull supply chain strategy is largely dependent on the capacity to conduct stock planning and forecasting as well as the availability of local information to relevant supply chain partners in the public healthcare supply chain. The four supply chain strategies are *Push supply chain*, *Pull supply chain*, *Mixed Push–Pull supply chain and Mixed Pull–Push supply chain*.

In a *Push supply chain*, products are pushed from upstream to downstream without considering the actual demand. Each supply chain partner in the network does order planning for the succeeding node (Ashayeri and Kampstra, 2005). This implies that both the supply chain information and products flow in one direction, that is from upstream to downstream (Bonney *et al.*, 1999). *Push supply chains* are more appropriate for products associated with low demand uncertainty and low cost (Mendes, Leal and Thome, 2016). From a manufacturing perspective, a *Push based supply chain* takes a long time to react to demand volatility and this compromise its ability to meet the changing demand patterns resulting in stock-outs or over-stocking of inventories (Janvier-James, 2011). In healthcare supply chains, the Central Medicines Stores (CMS) or the distribution stores determine the amount of medicines that are supposed to be delivered to a healthcare facility at a particular time. This allocation is based on rules that take into consideration the population, disease and epidemiology trends in a certain area. This approach is called *a Push system approach*. This system is designed to work in instances where there are weak ordering and inventory management capabilities at the lowest level of the distribution system (Yadav, 2015).

In a *Pull supply chain*, the downstream supply chain partners place orders and upstream supply chain partners in turn produce and deliver (Ashayeri and Kampstra, 2005). Information among supply chain partners flows in both ways while products flow from the upstream supply chain partners to the downstream supply chain partners (Bonney *et al.*, 1999b). This *Pull supply chain* is more appropriate for products with high uncertainty and that are very costly (Mendes, Leal and Thome, 2016). In manufacturing and distribution, a *Pull based supply chain* minimizes inventories, reduces costs and enhances the ability of organizations to manage resources effectively. However, it is difficult to implement a *Pull based supply chain* approach when lead-times are long making the response to demand information practically impossible (Janvier-James, 2011). A *Pull system* in a healthcare supply chain context is when each health facility performs requisitions on the amount of medicines it needs based on its past consumption and status of stock. This is only possible through the use of local information about consumption and demand , which may not reach CMS or higher levels (Yadav, 2015).

To curb the deficiencies evidenced in both the *Push* and *Pull systems*, organizations often take benefits of both *Push* and *Pull systems* and develop a *Mixed Push-Pull system* (Janvier-James, 2011). The downstream partners place an order for products and the upstream partners replenish from the stock that is rebuilt after every fixed period (Ashayeri and Kampstra, 2005).

In a *Mixed Pull-Push supply chain*, downstream supply chain partners trigger an order for products and upstream supply chain partners replenish from the stock that is rebuild immediately (Ashayeri and Kampstra, 2005). This strategy is appropriate for products with high demand uncertainty but economies of scale in production and distribution are important (Mendes, Leal and Thome, 2016).

3.3. Generic supply chain models and types

Given the nature of demand and supply uncertainties of different product types, different supply chain models are needed for different products (Fisher, 1997; Lee, 2002; Christopher, Gattorna and Christopher, 2005; Pérez-arroyave and Rodríguez-ramírez, 2013; Mapowo, Kock and Eeden, 2018).

Christopher et al., (2005), extended this view to include the alignment of supply chain types to customer segment types. Table 3.1 outlines the common supply chain models.

Table 3.1: Supply chain models (Lee, 2002; Christopher, Gattorna and Christopher, 2005; Pérez-arroyave and Rodríguez-ramírez, 2013)

Model type	Description
Efficient supply chain	-A supply chain aimed at creating the highest cost efficiencies by reducing non-value added activities and maximizing economies of scale and best capacity utilisation techniques in production, distribution and information linkages. Used for functional and commoditised products such as cement and steel.
	-Useful when used as a backbone for supporting mixed strategies.
	-Efficiency is supported by a high asset-utilisation rate based on “make to forecast” model in order to maintain continuous production and ensure an optimal production sequence, thereby reducing setup time.
Continuous flow	-A supply chain focused on building synergies supported by collaborative relationships.
	-Focus on developing loyal customer relationships with trusty and reliable service.
	-Low working capital for customers is the main deliverable.
	-Workload is smoothed by customer’s demand.
	-Order penetration point is “make to stock” to ensure medium-high utilization rates with a high level of perfect orders.
	-Production is driven by market demand, and production is executed to replenish predefined inventory levels.
Fast supply chain	-The fast supply chain is best for companies that produce trendy and functional products with a short lifecycle.
	-Production should be scheduled in a single batch per SKU, with its size defined by sales expectations for the sales season (or collection, in the fashion industry), using a model based on a "make to forecast" decoupling point.
Flexible supply chain	-A supply chain suited for companies that must meet unexpected demand and therefore are faced with high demand peaks and long periods of low workload
	-This supply chain model is characterized by adaptability, which is the capability to reconfigure internal processes in order to meet a customer's specific need or solve a customer's problem.
	-This model typically is used by service companies that focus on handling unexpected situations, perhaps even including emergencies
	-Due to the nature of such events, customers appreciate not only the speed of a supplier's response, but also its ability to tailor solutions to their needs.
	-Consequently, the price becomes largely irrelevant to the customer.

Model type	Description
Agile supply chain	-This supply chain is useful for companies that manufacture products under unique specifications for each customer.
	-Focus on responding rapidly and commercially to unpredictable supply/demand conditions.
	-This is typically seen in industries that are characterized by unpredictable demand
	They use a "make to order" decoupling point, producing the item after receiving the customer's purchase order to avoid manufacturing products that have no certainty of future sales.
Custom-configured supply chain	-This supply chain is characterized by a high degree of relevance of the cost of assets to the total cost, and multiple (potentially unlimited) configurations of the finished product on a unique platform
	-Competitive positioning is founded on offering a unique configuration of the finished product according to the end consumer's needs
	-In this supply chain, the product is configurable within a limited combination of product specifications, usually by combining parts into a set or assembly.
Lean	-Focus on economies of scale, synergies and low cost production and delivery.
Risk-hedging supply chain	-A supply chain that utilises strategies aimed at pooling and sharing resources in the supply chain so that the risks in supply distribution can also be shared. Some of these risks can be shared by transparency in information sharing on inventory.

3.4. Managing the supply chain

The SCM concept first gained attention in the mid-1980's (Cooper, Lambert and Pagh, 1997). It is defined as the planning and control of procurement, manufacturing and logistics activities, and the collaboration and coordination of supply chain partners (CSCMP, 2013). It appears that this definition emphasise the management of supply chain relationships between the suppliers and the customers (Meng, Sun and Jones, 2011). Furthermore, SCM link intra-and inter-business functions and processes (Lambert and Cooper, 2000). This represents the concept of internal and external integration of business processes from end user to suppliers (Cooper, Lambert and Pagh, 1997).The purpose of SCM, therefore, is to enhance supply chain effectiveness, quality and customer service through collaboration and transformation of the way operations meet the needs of customers (Du Toit and Vlok, 2014). This study adopts the definition of SCM proposed by Mentzer et al., (2001): "the systemic and strategic coordination of the traditional business functions and the tactics across these business functions within a particular organisation and across organisations within the supply chain, for the purposes of improving the long-term performance of the individual organisations and the supply chain as a whole." This concept of SCM is illustrated in Figure 3.4.

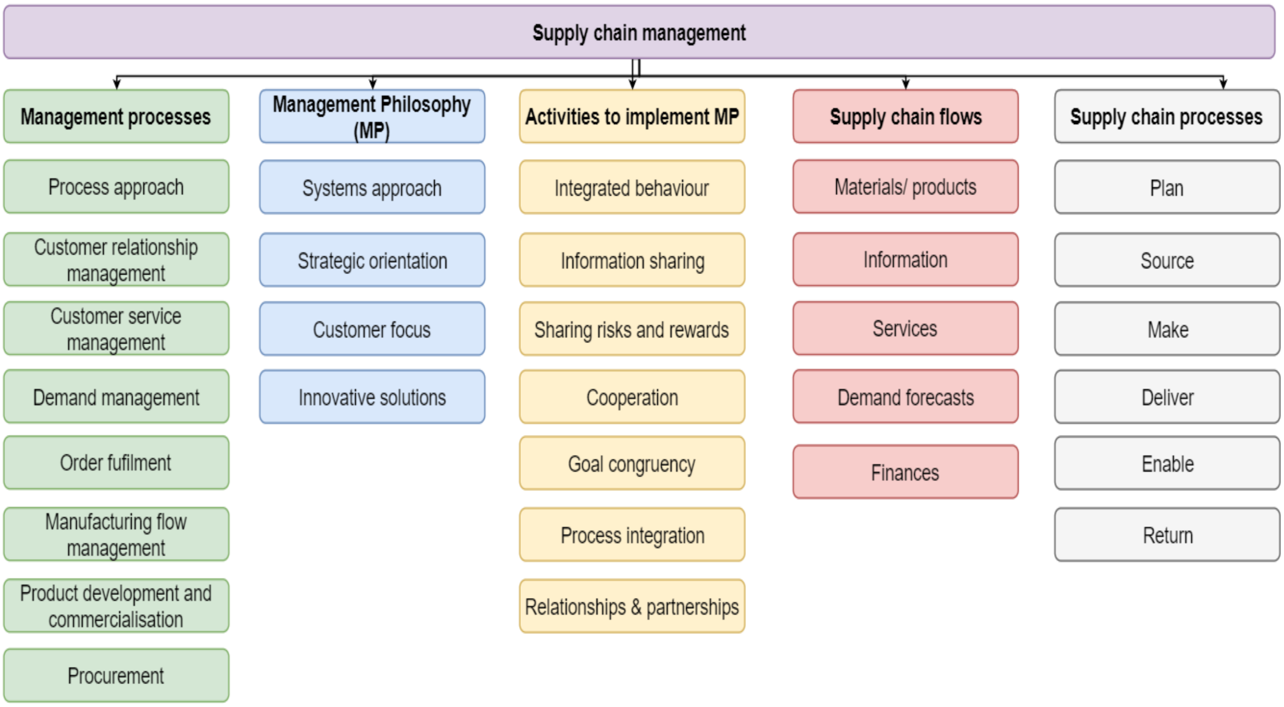


Figure 3.4: Supply chain management concept

Source: (Mentzer et al., 2001; Cooper et al., 1997; APICS, 2017)

The management philosophy explains the concept of SCM from the systematic, strategic and customer orientation perspectives. It recognises that the supply chain is a single entity with all supply chain components totally connected rather than fragmented. This is an attempt to satisfy customer demand with innovative solutions. The implementation of the management philosophy is supported by several activities such as external integration between the organisation with its customers and suppliers, and information exchange on strategies that facilitates planning and monitoring of supply chain processes. Other activities involved in SCM include mutually sharing risks and rewards, process integration, partnerships, goals alignment, and cooperation (Mentzer et al., 2001). In addition, the supply chain processes also include customer relationship management, procurement, demand management, manufacturing flow management, product development, and customer service management (Cooper, Lambert and Pagh, 1997).

Furthermore, Frazelle (2002) indicates that there is a lot of confusion surrounding the terms logistics and SCM. Logistics activities (customer response, inventory management, transportation, supply, and warehouses) connect and activate the objects in the supply chain as shown in the logistics framework of activities (Figure 3.5).

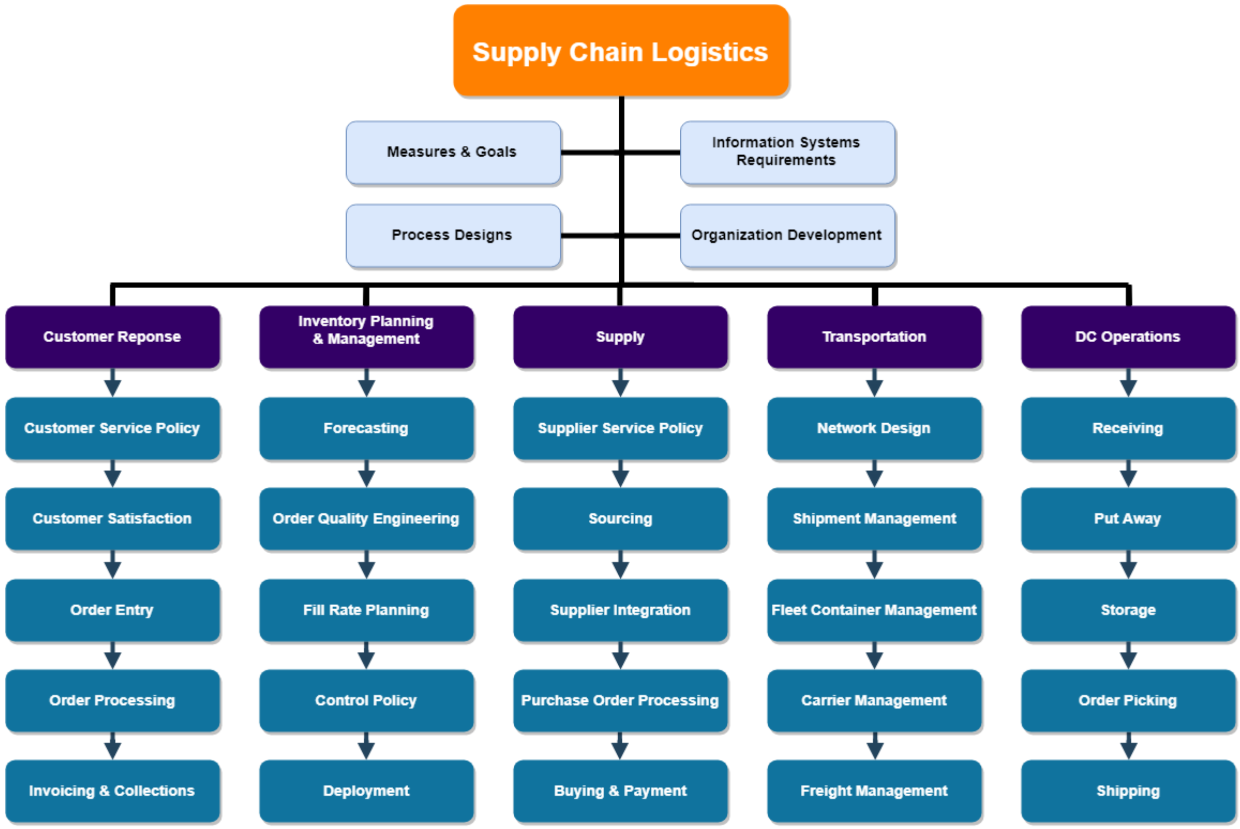


Figure 3.5: Logistics framework of activities

Source:(Frazelle, 2002)

3.4.1. Supply chain visibility

In supply chains, information sharing involves the dissemination of relevant information to different organisational departments, systems and supply chain partners (Lotfi et al., 2013). The information captures all activities and dynamics in the supply chain including internal and external uncertainties (Zhou and Benton, 2007). Importantly, the information collection process requires the integration of intra-business functions and inter-business processes, and, information systems and decision systems to facilitate business operations (Hsu et al., 2008). In the same vein, information sharing can also be conceptualised as the organisational capability to utilize technology to capture, analyse, and transmit data across the supply chain nodes to support supply chain decision making (Fawcett et al., 2009).

Barratt & Oke (2007) demonstrated that information sharing is merely an activity and the outcome is visibility. This visibility leads to decision-making and enhanced supply chain performance. Previous studies have shown that supply chain visibility (SCV) has different perspectives and that it has different meanings to different supply chain members (Christopher and Lee, 2004; Kaipia and Hartiala, 2006; Barratt and Oke, 2007; Bartlett, Julien and Baines, 2007; Wei and Wang, 2007; Zhang, He and Lee, 2008; Francis, 2008; Goh et al., 2009; Mahadevan, 2010; Caridi, 2013; Caridi et al., 2014; Papert, Rimpler and Pflaum, 2016).

Barratt & Oke (2007) suggests that SCV can be achieved by sharing quality information that is accurate, trusted, timely, useful, and in a readily usable format. This implies that SCV relies on both information sharing and information quality. This concept of SCV is elaborated in Table 3.2.

Table 3.2: Supply chain visibility

Author (s)	Supply Chain Visibility Definition
Christopher (2004)	Accessibility of both inventory level status and flow information by both upstream and downstream supply chain partners as it progresses through the chain.
Kaipia & Hartiala (2006)	Sharing of relevant and meaningful information with important supply chain actors.
Wei & Wang (2007)	It is the degree to which supply chain partners have on hand information related to demand and supply for planning and management control.
Barratt & Oke (2007)	The extent to which actors within a supply chain have access to or share information, which they consider as key or useful to their operations and which they consider, will be of mutual benefit.
Francis (2008)	SCV is the identity, location and status of entities transiting the supply chain, captured in timely messages about events, along with the planned and actual dates/times for these events.
Zhang & Lee (2008)	SCV is the ability to provide the latest relevant information/knowledge to all supply chain partners for collaborative decision making.
Goh et al., (2009)	It is the capability of a supply chain actor to have access to or to provide the required timely information /knowledge about the entities involved in the supply chain from/to relevant supply chain partners for better decision support.
Khan et al., (2012)	SCV enables comprehensive monitoring and management of the supply chain operations, real time collaboration and synchronisation of supply and demand.
Caridi (2013)	SCV is measured on the amount and quality (i.e. freshness, accuracy) of the information, that the focal company possesses, compared to the total information that could be exchanged.
Caridi et al., (2014)	SCV relates to the ability of the supply chain leader to access and share reliable and meaningful information related to the supply chain strategy and the operations of supply chain partners
Papert, Rimpler and Pflaum (2016)	SCV may be seen as the result of information gathering and sharing valuable information and from applying an appropriate Auto-Identification Technology.

Table 3.2 supports the argument that SCV has different definitions in different contexts. However, for the purposes of this study, SCV can be conceptualised as real-time gathering of relevant and meaningful inventory and demand information using various technologies, analysis of the information and subsequently transmitting this information to relevant supply chain actors to facilitate collaborative planning and joint decision-making.

Despite investing in information technologies, most organisations in a supply chain still lack integration mechanisms and information exchange strategies (Khan et al., 2012). SCV, from an Information Technology (IT) perspective, is defined as the ability to collect and analyse data, generate specific recommendations and match insights with strategies (Zhang, He and Lee, 2008). The data collected can be on the status of orders, inventory , identity and location of products in the supply chain (Francis, 2008). Informed decision-making is supported by SCV which includes collaborative decisions such as procurement, supplier selection, production capacities and, distribution decisions (Zhang, He and Lee, 2008). In addition, it is suggested that the key element in any strategy designed to mitigate supply chain risk is enhanced end-to-end visibility (Christopher and Lee, 2004).

3.5. Supply chain processes

Louw (2006) categorised supply chain processes into five classes, as indicated in Figure 3.6:

- Supply chain planning (SCP)
- Supply chain execution (SCE)
- Supply chain event management(SCEM)
- Supply chain performance management(SCPM)
- Reverse logistics/returns management

SCP comprises of demand planning and forecasting, network planning, production planning, distribution planning, and transportation planning, while SCE comprises of order management, warehouse management and international trade. SCEM involves monitoring, notifications, simulations, control and measurement. SCPM comprises of key performance indicators (KPIs) (Louw, 2006).

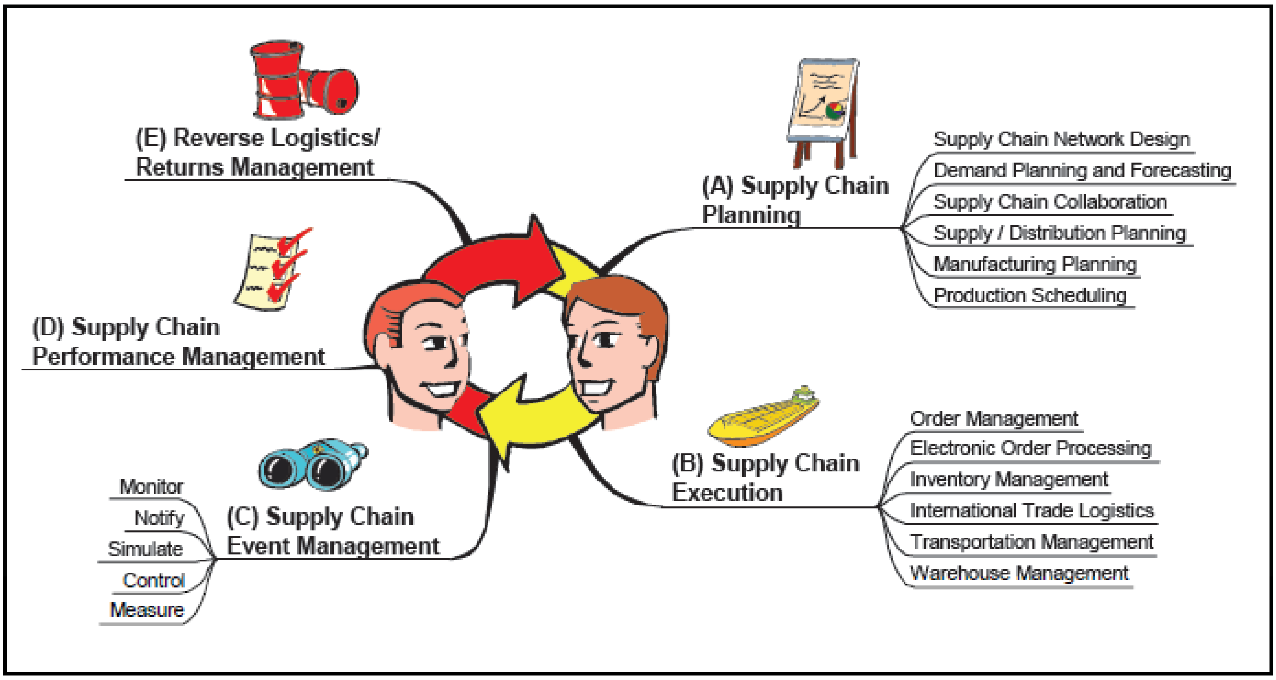


Figure 3.6 : Supply chain processes

Source: (Louw, 2006)

Supply Chain Council (SCC) developed a Supply Chain Operation Reference (SCOR) model, which is a guideline in explaining and analysing supply chain processes and practices. The SCOR framework comprise four components: processes, performance metrics, practices and people (APICS, 2017) as shown in Figure 3.7.

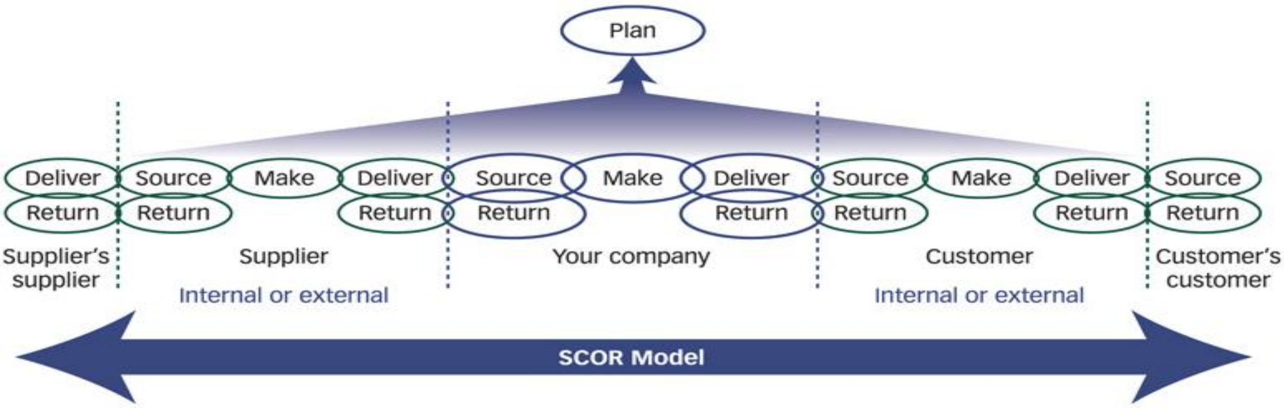


Figure 3.7: SCOR Model

Source: (Stewart, 1997)

The supply chain processes in the SCOR model are:

i. Plan:

It involves demand and supply planning, inventory planning, production capacity planning and the aggregation of demand and supply plans (Stewart, 1997). It also encompasses the collection of information on available resources and requirements (Lambert and Enz, 2017).

ii. Source:

Includes activities related to procurement of goods to meet planned and actual demand (Stewart, 1997). It also includes activities such as generating purchase orders, accepting invoices from suppliers, deliveries scheduling, goods receiving, verification and storage of the goods (Lambert and Enz, 2017).

iii. Make:

It describes the processes related to the conversion of materials into a finished state so as to meet planned or actual demand (Stewart, 1997).

iv. Deliver:

Describes the process of fulfilling customer orders, demand management, warehouse management and transport management (Stewart, 1997). Also includes scheduling order delivery and shipment plans (Lambert and Enz, 2017).

v. Return:

This deals with the identification of a need to return goods (Lambert and Enz, 2017) and subsequently with decision making regarding receiving returned goods and extends into post-delivery customer support (Stewart, 1997). Finally, it addresses the activities such as scheduling of the goods to be returned and the receipt of the returned goods.

vi. Enable:

Describes activities associated with performance management, contract management, managing regulatory compliance, risk management, data management, resource management and, facilities management (Lambert and Enz, 2017).

Furthermore, Lambert and Cooper (2000) outlines the SCM framework, which consist of key supply chain processes as shown in Figure 3.8.

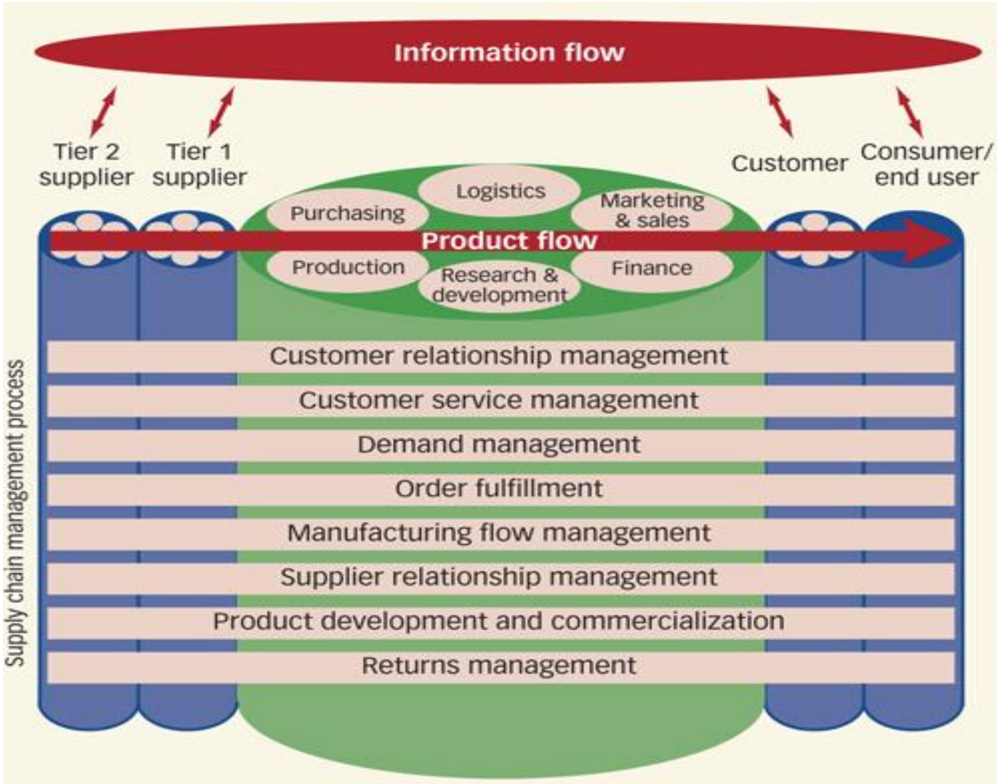


Figure 3.8: Supply chain processes

Source: (Lambert and Cooper, 2000)

The supply chain processes are described in detail in Table 3.3. The success of SCM is rooted in the change management - transitioning from managing individual functions to integrating activities into key supply chain processes (Lambert and Cooper, 2000).

Table 3.3: Supply Chain Management Framework

Key supply chain processes	Description
Customer Relationship Management (CRM)	Identify key customers that the organisation targets. Make product and service agreements specifying the levels of performance with the customers.
Customer Service Management (CSM)	This provides the customer information and provides the customer with real time information on promised shipping dates and product availability through interfaces with the organisation's production and distribution operations. In addition, it can assist the customer with product applications.
Demand Management (DM)	The demand management process tries to balance the customer demand with the organisation's supply capabilities. Coordinating market requirements and production. This can be done by trying to determine what products customers purchase and when they purchase them. This can be made possible by technologies such as Point Of Sale (POS), Vendor Managed Inventory (VMI), Collaborative Planning and Forecasting Replenishment (CPFR).
Customer Order Fulfilment	Fulfilling customer needs within agreed periods. This requires the integration of production, distribution and transportation plans and alliances to be developed with supply chain partners.
Manufacturing flow management	Flexible manufacturing processes that are able to respond to market changes. In manufacturing flow, the production priorities are driven by required delivery dates.
Procurement	Strategic plans are jointly developed with suppliers to support the manufacturing flow management process and new products development. Also involves categorising of suppliers based on either their contribution or capabilities. In addition, it involves the development of supplier relationship management. The procurement function also utilises technologies such as Electronic Data Interchange (EDI) and internet as communication mechanisms.
Product development and commercialisation	Customers and suppliers integrated in product development process.
Returns process	Effective management of returns to identify opportunities for improvements

3.6. Supply chain decision making processes

Decision making in SCM can be classified into three levels namely Tactical level, Operational level and Strategic level (Thierry, Bel and Thomas, 2010). Figure 3.9 provides a detailed overview of the different levels of decision making in a supply chain.

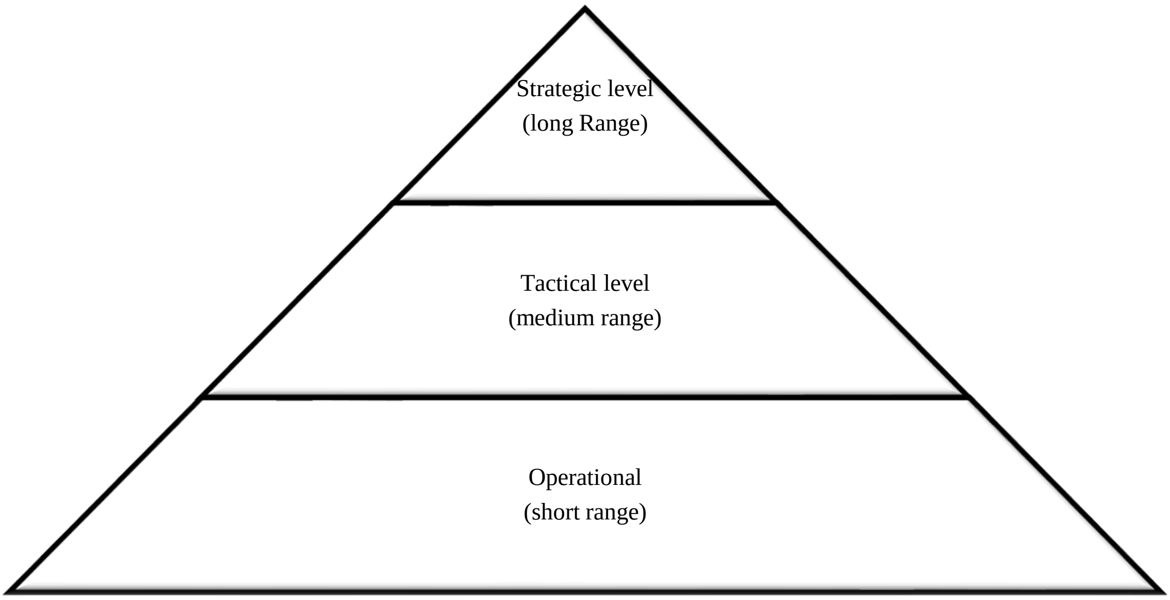


Figure 3.9: Decision making levels in a supply chain

Source : (Thierry, Bel and Thomas, 2010)

3.6.1. Strategic level

Strategic decision making in a supply chain involves long-range (strategic) decisions. The top management and directors are the actors in this level. The decisions made at this level are concerned with supply chain configuration, supply network design, distribution network design, number and location of suppliers, distribution centres, warehouses, customers and the definition of supply chain metrics (Thierry, Bel and Thomas, 2010). The measures at this level include levels of product quality, lead time, and cost (Gunasekaran, Patel and McGaughey, 2004).

3.6.2. Tactical level

Tactical decision making in a supply chain involves medium range (tactical) decisions. The middle level managers are the actors in this level. The decisions made at this level are concerned with planning processes, inventory management, contracts and procurement management (Thierry, Bel and Thomas, 2010). The measures at this level include purchase order cycle time efficiency, purchasing quantities, capacity flexibility and quality assurance methodology (Gunasekaran, Patel and McGaughey, 2004). The Tactical level decision making level support the strategic decision-making level.

3.6.3. Operational level

Operational decision making in a supply chain involves short-range day-to-day decisions. The supervisors are responsible for the daily operations. The decisions made at this level are concerned with daily adherence to schedules and the ability to avoid defect deliveries. This level is the technical implementation of the tactical level decisions (Gunasekaran, Patel and McGaughey, 2004). Another operation at this level is daily or weekly forecasting of demand. This information is transferred to a much higher level, for example the tactical level, enhancing planning processes and inventory management (Thierry, Bel and Thomas, 2010). In its simplest form this level of decision making in supply chain is about demand fulfilment and warehouse replenishment (Thierry, Bel and Thomas, 2010).

3.7. Supply chain planning

Supply chain planning is used as a generic term to describe the whole range of decisions on the design of the supply chain, on the midterm coordination and on short term scheduling of processes in the supply chain (Fleischmann and Meyr, 2003).The supply chain matrix integrates generic organisational processes and the range of decisions. The supply chain matrix is shown in Figure 3.10. The main function of a supply chain planning matrix is to support the flow of materials across a supply chain and related business operations: procurement, production, transport and distribution as well as sales (Stadtler, 2005).

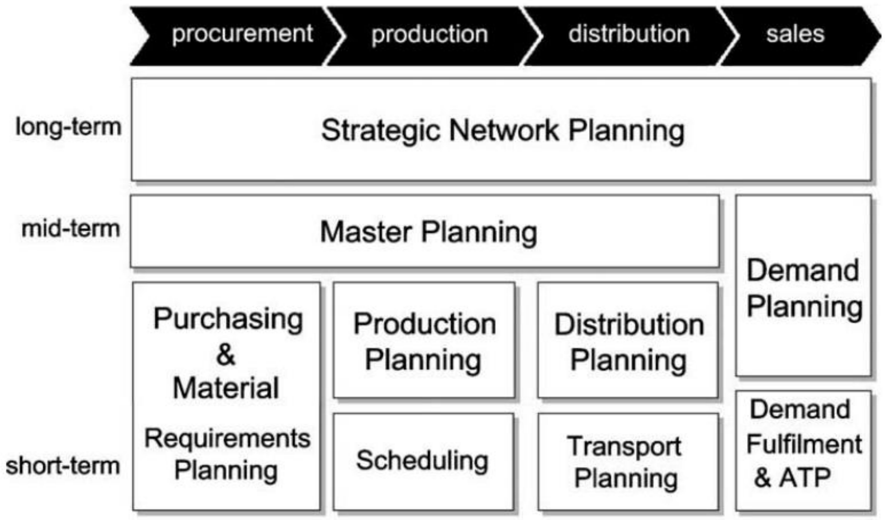


Figure 3.10: Supply chain planning matrix

Source: (Stadtler, 2005)

- **Strategic Network Planning** covers the long term planning involving the design of the physical structure of supply chain. Questions on the location of production sites, warehouse sites, choice of distribution and the capacities of these facilities as well as transportation needs are answered (Fleischmann and Meyr, 2003; Stadtler, 2005).
- **Demand Planning** involves forecasting future demand on both midterm aggregate and short term detailed basis (Fleischmann and Meyr, 2003). It also takes into consideration exceptional influences expected to happen in the future and their impact (Stadtler, 2005).
- **Master Planning** coordinates the flow of materials in the supply chain as a whole for mid-term planning horizon. It looks for the most efficient way to fulfil demand forecasts over a medium-term planning interval by balancing the demand forecasts with available capacities. It also deals with seasonal stock levels at different stocking points in the supply chain (Stadtler, 2005).
- **Production Planning and Scheduling** deals with machine assignment, scheduling, lot-sizing and it is within the short term planning cycle to satisfy customer needs. The same is true for **Distribution** and **Transportation Planning** (Fleischmann and Meyr, 2003). **Distribution Planning** looks at regular transport links, and delivery areas of warehouses while **Transportation Planning** deals with short term dispatching of the shipments in the distribution (Hübner *et al.*, 2014). It also deals with the sequencing of customer locations on a vehicle's trip accomplished in (models of) vehicle routing as well as a special purpose planning software (Stadtler, 2005).
- **Demand fulfilment and Available to Promise (ATP)** involves the balance between customer order management and checking the availability of materials, due date setting, and of measures in case of shortage. It also involves tracking customer orders from order entry, via order execution to order delivery (Stadtler, 2005)
- **Purchasing and material requirements planning** comprises of the Bill of Materials (BOM) explosion that outline the required quantities of procured items. Master planning as well as short term production planning provide directives for calculating procurement quantities (Stadtler, 2005).

3.8. Demand driven material requirements planning

Material Requirements Planning (MRP) is defined as the set of techniques that use BOM data, inventory data and Master Production Schedule (MPS) to calculate requirements for materials. It makes recommendations to release replenishment orders for materials. However, the current volatile and variable manufacturing environment where complex planning scenarios exist, a demand-driven production strategy is required. This strategy emphasises on centralising demand instead of inventory so that organisations are able to sense and adapt to market changes thus becoming agile (Kortabarria *et al.*, 2018).

Therefore, Demand Driven Material Requirements Planning (DDMRP) is an integral element of a manufacturing strategy that focuses on lead-time compression and alignment of efforts to respond to market need. It is the careful synchronisation of planning, scheduling and execution with actual consumption (Miclo *et al.*, 2019). It is a multi-echelon demand and supply planning and execution methodology that integrates multi-tiers in order to provide end-to-end integrated planning and execution visibility. The purpose of the DDMRP is to mitigate the effects of variability and volatility on manufacturing operations and supply chains to promote visibility and velocity (Ptak and Smith, 2011). The DDMRP principle focuses on pulling replenishments between strategic buffers. These buffers control supply, operational, demand and management variability (Miclo *et al.*, 2016).

3.8.1. Systems in DDMRP

DDMRP is a hybrid system that takes best practices from four systems: MRP, Lean, Six sigma and Theory of Constraints (TOC) (Miclo *et al.*, 2019). These four systems are shown in figure 3.11.

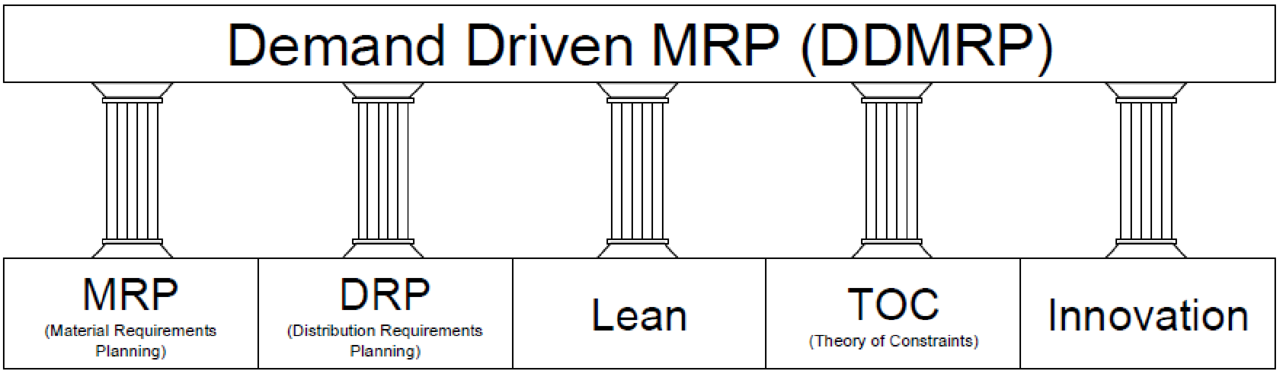


Figure 3.11: Systems in DDMRP

Source : (Ptak and Smith, 2011)

From MRP, DDMRP takes the demand, product explosion and time phasing. The concepts of waste and variance and the pull flow are adapted from Lean Logic; from Six Sigma, it takes adaptive adjustments possible from outlier variance analysis. Finally, from TOC, it takes the concepts focusing on bottlenecks, acceptance of inventory and the strategic placement of inventory (Miclo *et al.*, 2019).

3.8.2. Components of DDMRP

DDMRP comprises of five sequential components as shown in Figure 3.12. The first three components essentially define the initial and evolving configuration of a demand driven material requirements planning model. The final two elements define the day-to-day operation of the method. DDMRP is most common the start of an organization's transformation to a Demand Driven Adaptive Enterprise (Ptak and Smith, 2019).

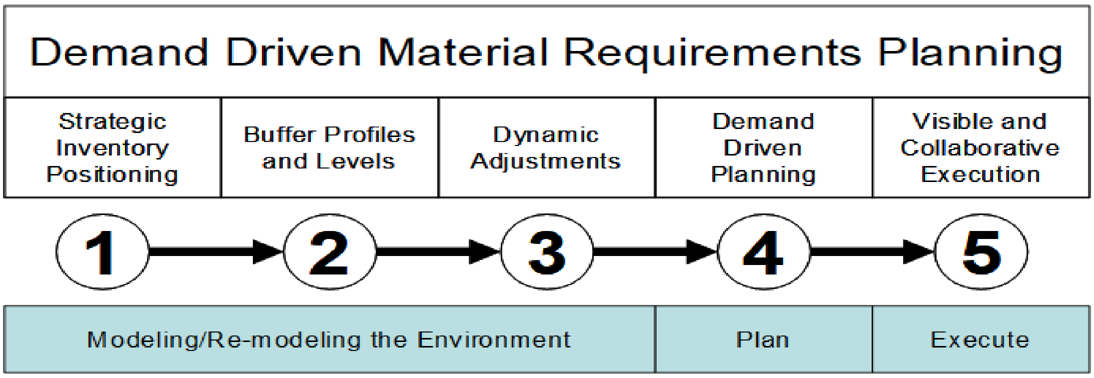


Figure 3.12: Components of DDMRP

Source: (Ptak and Smith, 2019)

- **Strategic inventory positioning** determines where to place the decoupling points.
- **Buffer profiles and levels** will determine the amount of protection needed at the strategically positioned decoupling points.
- **Dynamic adjustments** define how the level of protection at the decoupling points flexes up or down based on market changes and planned or known future events.
- **Demand driven planning** is the process by which supply orders (purchase orders, manufacturing orders and stock transfer orders) are generated.
- **Visible and collaborative execution** is the process by which a DDMRP system manages open supply orders.

3.9. Concept of Demand

The alignment of supply and demand is a fundamental issue for any organization that provides goods and/or services to a base of customers. The mantra “right product, right place, right time, every time,” which is often recited in supply chain discussions, goes to the heart of this alignment (SAS, 2014). Demand-side research looks downstream from focal firm, towards product markets and consumers, in order to explain and predict those managerial decisions that increase value creation within a value system. Recent demand-side research has examined consumer-focused strategies for value creation (determined by consumer's perceptions of utility from an offering) and recognise that consumer preferences change dynamically and sometimes are latent (Priem and Swink, 2012). Demand reflects what and how much customers want, therefore demand drives supply and subsequent production plans (Min, 2015).

3.9.1. Characteristics of customer demand patterns

Inventory control systems must cope with a variety of different customer demand patterns. In practice, it is assumed that the following demand patterns exist (Lewis, 1997):

i. Stationery demand

This type of demand pattern assumes that although customer demand per unit time fluctuates, there is no apparent long-term underlying growth or seasonal trend. Although within a stationary demand pattern no growth or seasonality is assumed to exist, it should be accepted that occasionally fundamental changes in demand patterns may occur, but these are presumed to be short-term in nature, such as impulses and step changes exist (Lewis, 1997).

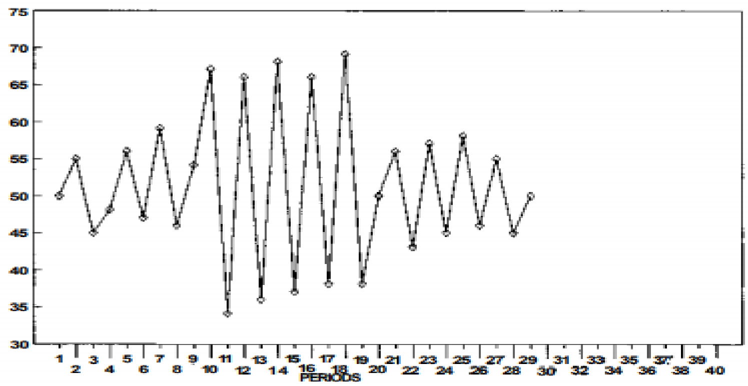


Figure 3.13: Stationery demand data with no long term growth or seasonality but with considerable variability of demand

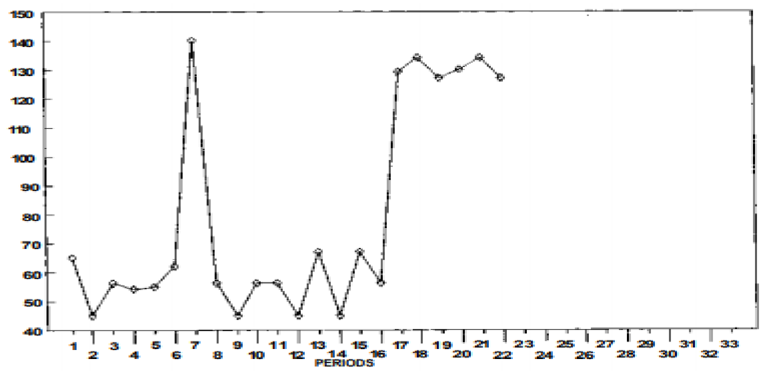


Figure 3.14: Stationery demand pattern where an impulse is followed by a change step

ii. Demand with growth characteristics

This describes a situation where a demand pattern exhibits a growth characteristic over the longer term. Systematic increase of demand exist (Lewis, 1997).

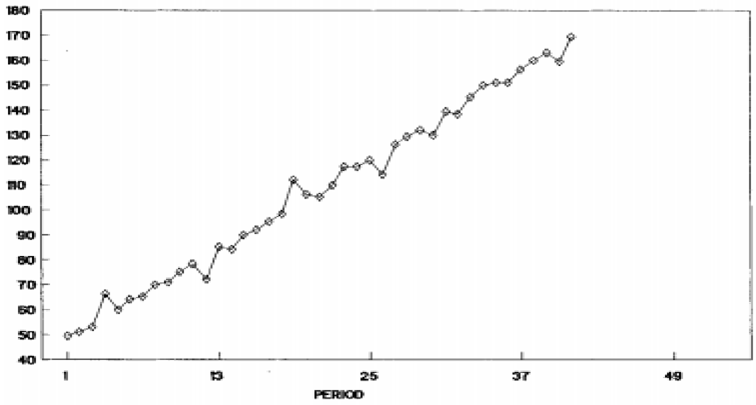


Figure 3.15: A demand pattern characterised by long-term growth

iii. Demand with seasonal characteristics

Many demand series are influenced by the seasons of the year and by other events, which occur annually. In such situations it is possible to establish the degree to which demand in any particular period of the year (i.e. month, quarter or accounting period) is higher or lower than for a typical average period exist (Lewis, 1997).

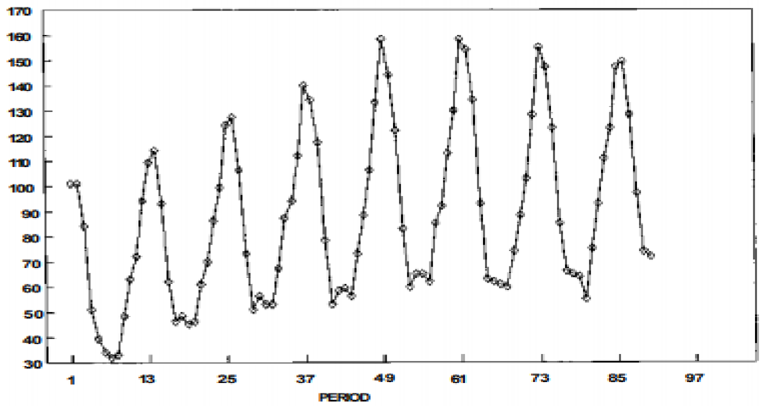


Figure 3.16: A demand pattern characterised by long term growth and seasonality

3.9.2. Forecasting Methods in a supply chain

Although demand forecasting is an important part of managing demand, its reliability often varies depending on a particular choice of forecasting methods, the length of time horizons, and the nature of demand. More importantly, if accurate demand information is not communicated back to manufacturers/service providers and their suppliers, it is meaningless to forecast (Min, 2015).

Forecasts of future demand are essential for making supply chain decisions. Demand forecasts form the basis of all supply chain planning. Forecasting methods are mainly classified according to the following four types (Chopra and Meindl, 2016):

- *Qualitative:* Qualitative forecasting methods are primarily subjective and rely on human judgment. They are most appropriate when little historical data is available or when experts have market intelligence that may affect the forecast. Such methods may also be necessary to forecast demand several years into the future in a new industry (Chopra and Meindl, 2016).
- *Time series:* Time-series forecasting methods use historical demand to make a forecast. They are based on the assumption that past demand history is a good indicator of future demand. These methods are most appropriate when the basic demand pattern does not vary significantly from one year to the next. These are the simplest methods to implement and can serve as a good starting point for a demand forecast.
- *Causal:* Causal forecasting methods assume that the demand forecast is highly correlated with certain factors in the environment (the state of the economy, interest rates, etc.). Causal forecasting methods find this correlation between demand and environmental factors and use estimates of what environmental factors will be to forecast future demand. For example, product pricing is strongly correlated with demand. Companies can thus use causal methods to determine the impact of price promotions on demand.
- *Simulation:* Simulation forecasting methods imitate the consumer choices that give rise to demand to arrive at a forecast. Using simulation, a firm can combine time-series and causal methods to answer critical questions.

3.9.3. Demand Management in a Supply Chain

The demand management process is focused on predicting customer demand and determining how that demand can be synchronized with the capabilities of the supply chain. The SCM process balances the customers' requirements with the capabilities of the supply chain. With the right process in place, management can match supply with demand proactively and execute the plan with minimal disruptions. This process is not limited to forecasting but includes synchronizing supply and demand, increasing flexibility, and reducing variability (Croxton, 2002).The concept of *Demand Management* also includes demand sensing, demand shaping, demand translation and demand orchestration throughout the value network (Cecere, 2013).

a. Demand Sensing

As the field of forecasting develops, technological improvements now allow companies to experiment with more advanced concepts such as machine learning, artificial intelligence, Internet of Things (IoT) and now demand sensing (Ackerman and Pierce, 2018). Better forecasting translates directly into making better decisions (One Network Enterprises, 2015). Demand forecasting is concerned primarily with estimating demand for future periods (Ravikumar et al., 2005). While, demand planning statistically predicts monthly or weekly demand patterns (ToolsGroup, 2015), however, near-term activities such as replenishment are usually planned daily. Demand sensing has been around for more than a decade, but has been steadily gaining interest as the significance of accuracy and insight increase (Ackerman and Pierce, 2018). It is fundamentally different from classical forecasting methods in that it uses a much broader range of demand signals (including current data from the supply chain) and different mathematics to create a more accurate forecast that responds to real-world events such as market shifts, weather changes, natural disasters, consumer buying behaviour, and so on. Demand Sensing allows companies to incorporate detailed short-term demand data into their forecasts to reduce their forecast error (One Network Enterprises, 2015). This approach uses machine learning and large amount of data to create accurate demand forecasting models. Demand sensing gets an organisation on a path to predictive demand by taking historical data, combined with future predictions of external factors (Ackerman and Pierce, 2018). The use of pattern recognition and advanced analytics to analyse order patterns to translate tactical demand planning (forecast) into a short-term, and more accurate demand signal for replenishment is also referred a demand sensing (Cecere, 2016).

Demand sensing is therefore short term forecasting with greater accuracy and is an automated process (Tsiakis, 2014). It records real-time signals from all points in the supply chain and combines them with diverse external business indicators that include point of sale data (Tsiakis, 2014). By using more frequent and near real-time customer or channel data, daily demand trends are quickly identified, providing advanced warning of problems which will affect customer service levels. Given that the network-based platform has removed the latency between the plan and execution (or in other words what is really happening in the supply chain), issues are elevated quickly, intelligent responses developed, and actions taken, driving an overall immediate response using a single version of "demand" truth (One Network Enterprises, 2015). Breaking the accuracy ceiling requires the inclusion of current demand signals throughout the supply chain as well as the application of systems and methods to sort through the masses of data and determine what is truly predictive. Demand sensing can import demand data on an hourly rather than a batch or daily basis, immediately sensing demand signal changes as compared to a detailed statistical demand pattern, and then evaluate the statistical significance of the change (One Network Enterprises, 2015).

Using enormous data processing power and predictive analytics to detect patterns and therefore daily forecasts adjustments that drive production and logistics decisions. This daily adjustment ensures that production and distribution is limited only to required quantities resulting in less buffer inventory, product availability and increases customer satisfaction. Demand sensing supports the process of establishing a platform for integrated planning that enhances visibility across the supply chain. Until now, demand-sensing uptake has been primarily limited to the world's largest organisations (Tsiakis, 2014). However, layering demand-sensing capability onto the overall demand management process will generate significant improvements to a company's core KPIs. From a supply chain perspective, companies can expect to see improvements in order fulfilment rates, the smoothing of production schedules, as well as reductions in transportation and warehousing costs (One Network Enterprises, 2015). Demand sensing involves shortening the time to sense "true" market data to understand "true" market shifts in the demand response. This is in contrast to using order-to-shipment data that can have 1-3 weeks latency in translating "true" market (or channel) demand to action (Cecere, 2013).

b. Demand shaping

When available information indicates that the demand and the supply are no longer in alignment, the organization needs to develop an appropriate demand response. The development of this response is termed demand shaping (SAS, 2014). Demand shaping activities refer to programs and events designed to stimulate sales and grow market share. These activities can be in the form of price reductions, advertising, promotions, new product launch, revenue management, assortment, merchandising and product bundling, sales incentives and so on (Cecere, 2013). These activities may be directed at individual products, group products or even corporate awareness (Oracle, 2015). Machine learning and big data drive demand shaping (ToolsGroup, 2015). Demand shaping is the process that makes the most profitable demand-and-supply decisions by using all available demand-and-supply information. Exercising the demand-shaping process requires the availability of sophisticated analytical tools to sense demand-pattern changes and supply anomalies, econometric models to address market response, optimization-based tools to develop and maintain an effective and efficient deployment of production and distribution assets, and scenario-analysis capabilities to evaluate alternative courses of action. Additionally, this approach requires an organizational culture amenable to analysis-based decision-making (SAS, 2014). Demand shaping also involves techniques to stimulate market demand (Cecere, 2013).

c. Demand translations

Translating demand outside-in from the market to each role within the organization. The system design recognizes that the requirements for each - distribution, manufacturing and procurement - are different. In this process, the forecast is based on “the selling unit” (Cecere, 2013).

d. Demand Orchestration

Making trade-offs market-to-market based on the right balance of demand risk and opportunity. These trade-off decisions depend on the use of advanced analytics to sense and shape demand simultaneously (Cecere, 2013).

3.10. Segmentation

Segmentation is not an end in itself but a possible means to an end. It is a well-established concept (Gattorna, 2010). Customer segmentation has long been a cornerstone of marketing campaigns, giving enterprises a way to partition their customer bases and plan interactions with them. However, in light of growing customer expectations for personalized experiences and the availability of AI technologies to enable smarter insights about these customers, it is time for marketers to rethink their segmentation strategies (Forrester, 2019).

Accenture (2014), argues that, in today’s market, retailers need to know their customers well-at the segment level and ideally also at the individual level-in order to know how best to serve them. This will enable companies to fine-tune their offerings to better address the need of each segment.

Essentially, the classical idea of segmentation emphasize the need to group customers with shared features together so that we match service strategies to their unique needs. However, a various number of classical segmentation strategies exist. These include segmentation using Standard Industrial Classifications (SIC), industry sectors, geography, size, profitability, product type. However, more focus is now placed on behavioural segmentation (Gattorna, 2006).

3.10.1. Behavioural Segmentation

Customer segmentation has always been important but now that personalisation and customer experience are make-or-break factors for business success today, effective segmentation is an absolute must (DeAsi, 2020). Customer segmentation has always been important. Yet, only 33% of companies using it say they find it significantly impactful. A big reason being that many companies depend *solely* on traditional approaches, such as geographical and demographic segmentation. There is no denying that knowing your average customer’s location, age, gender, etc. is essential to addressing their needs. Just understanding *who* they are is not enough, though. You must also know what they do — so leveraging other customer data, like behavioural data, is equally important. Without this, other segmentation data you have collected may be rendered less impactful (Mialki, 2019).

The secret of designing a superior supply chain is to start by re-segmenting customers along buying behaviour lines and then reverse engineer from there. Introducing such a customer focus is critical to a breakthrough in supply chain thinking. Therefore, there is need to shape specific value propositions and underpin these with appropriate organisational structures, processes and technology (Gattorna, 2006). However, customer (consumer) insight can be created using transactional data (Hjort, Lantz, Ericsson, Gattorna, 2013), and according to Gattorna (2010), the use of behavioural data alongside transactional data makes it possible to more accurately predict customer behaviours. Transactional data, including purchase and return behaviour, can therefore be useful in customer segmentation (Hjort, Lantz, Ericsson, Gattorna, 2013).

Therefore, behavioural segmentation is a form of customer segmentation that is based on patterns of behaviour displayed by customers as they interact with company/brand or make a purchasing decision (DeAsi, 2020; Mialki, 2019). It allows businesses to divide customers into groups according to their knowledge of, attitude towards, use of, or response to a product, service or brand (DeAsi, 2020). This category of segmentation studies the behavioural traits of consumers (Mialki, 2019). This allows companies to understand how different groups of customers should be targeted with different offers, at the most appropriate times through preferred channels. It also support the use of historical behavioural patterns to predict and influence future customer behaviours and outcomes. (DeAsi, 2020). Table 3.4 outlines behavioural segmentation methods which include purchasing behaviour, benefits sought, customer journey stage, usage based, occasion or timing, customer satisfaction, customer loyalty, interest based, engagement level and user status.

Table 3.4: Behavioural segmentation methods (Mialki, 2019; DeAsi, 2020)

Behavioral Segmentation types	Description	Examples
Purchasing behavior	How different customers approach the purchase decision?	The price conscious buyer
		The smart buyer
		The risk – averse buyer
		The needs proof buyer
		The "I will get it later buyer"
		The persuadable buyer
Benefits sought	What primary benefits are different customers seeking during a purchase decision?	Specific features (speed, ease of use)
		Motivating factors driving purchase behavior (ie price)
Customer buying journey stage	Which stage of the journey is a new or existing customer currently in?	Non-users
		Prospects
		First time buyers
		Regulars
		Former customers
Usage	How often (how much) are customers using your product or service? How are they using it?	Quantity (heavy users, medium users, light users)
		Quality of usage
Occasion/timing	When are customers most likely to make a purchase or engage with a brand?	Regular purchase
		Once off purchase
		Universal occasions
		Recurring-personal occasions
		Rare-personal occasions
Customer satisfaction	How satisfied are your customers?	High satisfaction
		Low satisfaction
Customer loyalty	Who are the most loyal customers, and how can you maximize their value and find more customers like them?	Airlines, preferred guests at hotels and casinos etc.
Interest	What are the different customers interested in?	Personalized experiences
Engagement Level	How engaged are your customers and who are your most and least engaged customers?	Most engaged
		Least engaged
User status	Classification of different customers by their relationship to your business	Non users, prospects, first time buyers, regular users, defector (ex-customers who have switched)

Gattorna (2006) and Gattorna (2010) further argues that there is really one ‘right’ and cost effective way to group customers and that is on the basis of their dominant buying preferences / behaviours since the behavioural segmentation approach goes to the heart of customer values and expectations. Gattorna (2006) also suggested that customer buying behaviours changes the demand and supply situation and proposed that, segmenting supply chains according to customer buying behaviours is a dynamic process.

Even though there are many combinations and permutations of possible behavioural segments; Gattorna (2010) identifies sixteen (16) most common behavioural segments which include efficient, commercial, fair deal, relationship at a price, visionaries, innovation with a human face, innovative solutions, vision to reality, partners, collaborative, let go places together ,sharing the vision, demanding, dynamic, solutions at speed, and pragmatic (Gattorna, 2010). Table 3.5 outlines the four (4) main behavioural segment types and the type of supply chains they are best aligned to (Gattorna, 2010). Furthermore, these dominating behaviours account for approximately 80% of a firm’s customers, and the same dominating patterns will fit other markets as well. The identification of segments, regardless of the segmentation technique that is used, indicates a need for a differentiated product and service delivery approach and the necessity of abandoning the old and outdated “one size fits all” approach. (Hjort, Lantz, Ericsson, Gattorna, 2013).

Table 3.5: Four most commonly observed dominant buying behaviours (Gattorna, 2006)

Behavioural segment types (dominant buying behaviours**)**	**Aligned buying propositions**	**Aligned supply chain**
Innovative solutions • Unplanned/unplannable demand • Require innovative solutions in products and services • Low sensitivity to price • Individual decision making • Flexible delivery response	Hedging and deployment strategies used to improve responsiveness on a selective basis	Fully flexible
Dynamic • Rapid response to uneven demand • Urgent delivery focus • Lower loyalty • Price aware • Commodity relationship	Focus on responding rapidly and commercially to unpredictable supply/demand conditions	Agile
Efficiency • Consistent responses required to largely predictable demands • Efficiency focus • Very price sensitive • Multiple sources of supply • Regular delivery	Focus on economies of scale, synergies and low cost production and delivery	Lean
Collaborative • Close working relationships • Mostly predictable demand • Relationship focus • Loyal • Regular delivery • Price is not an issue • Information sharing • Primary source of supply	Focus on deploying loyal customer relationship with trusty and reliable service	Continuous replenishment

3.11. Supply chain metrics and measures

The supply chain metrics and measures are attributes of a supply chain that permit it to be analysed and evaluated against competing strategies (APICS, 2017). The SCOR model metrics are used as a baseline for the purposes of this study. SCOR model provides five core supply chain performance attributes, which are discussed in detail in Table 3.6.

Table 3.6: SCOR supply chain metrics and measures, (APICS, 2017)

Metrics and measures	Description
Reliability	Capability to deliver orders in full, Delivery item accuracy, Delivery quantity accuracy, Delivery location accuracy, Delivery date achievement, Compliance documentation accuracy and Orders delivered defect free.
Responsiveness	Describes the cycle times of supply chain activities such as delivery cycle time and supplier payment cycle time.
Agility	Describes the extent of flexibility and adaptability of supply chain processes when stressed by unexpected changes in demand.
Asset management	Describes asset management efficiency such as inventory days of supply, day's payable outstanding, and inventory.
Costs	Outlines the cost of the supply chain processes and activities such as planning cost, sourcing cost, order management cost, fulfilment costs and inventory costs.

3.12. Chapter Summary

The purpose of this chapter was to investigate the key supply chain concepts. Different supply chain strategies, supply chain models and supply chain types were highlighted. Concepts such as SCV, supply chain planning, behavioural segmentation and DDMRP were also explored. Furthermore, supply chain processes outlined in the SCOR model and the Lambert et al., (2000) SCM Framework have been discussed.

Chapter 4 : Healthcare products supply chain

4.1. Introduction

This chapter describes the structure of the public healthcare products supply chain, provides a review on healthcare SCV, healthcare supply chain processes and identifies the roles of public healthcare supply chain stakeholders in South Africa. The following question is answered in this chapter:

Chapter 4

•What does the structure of public healthcare products supply chain network look like?

4.2. Structure of healthcare products supply chain

Access to medicines is influenced by many factors such as affordability, rational use, sustainable financing and reliable supply systems. This dictates the structuring of the pharmaceutical supply chain for the public healthcare sector. However, only a few studies have tried to streamline and explore explicitly the end-to-end distribution processes of medicines in developing countries in an attempt to eliminate the inefficiencies associated with public healthcare supply chains (Ncube, 2015). A public health supply chain is a network of interconnected organisations or actions that ensures the availability of health commodities to the people who need them (JSI, 2017).

Moreover, there are a number of stakeholders in the healthcare Supply Chain Network (SCN). The three major actors that make up the healthcare SCN include producers, service providers and purchasers (Narayana, Kumar Pati and Vrat, 2014). The producers consist of pharmaceutical companies, medical device manufacturers, manufacturers of capital equipment and information systems and surgical products companies while purchasers include group purchasing organisations, pharmaceutical wholesalers and distributors. The service providers include hospitals, clinics, physicians and pharmacies (Burns and DeGraaff, 2002). The healthcare supply chain also extends to include payers such as patients, government and insurance companies (Kritchanchai, 2012).

While the exact structure of healthcare supply chain varies from one nation to another, there are some commonalities (Yadav, 2015). A simplified healthcare supply chain structure is therefore, shown in Figure 4.1. The role of the primary manufacturer is to produce the active ingredients contained in the drugs. The secondary manufacturer transforms the active ingredients into usable drugs such as capsules and tablets. The secondary manufacturer also packages the medicines. Different distribution channels to the market are utilised, either through the wholesaler or direct deliveries to hospitals, clinics and pharmacies (Mustaffa and Potter, 2009).

Recent trends in healthcare supply chain management involves the *Pull based system*. In this instance the decoupling point is utilised, where a repository stock is found (Mustaffa and Potter, 2009).

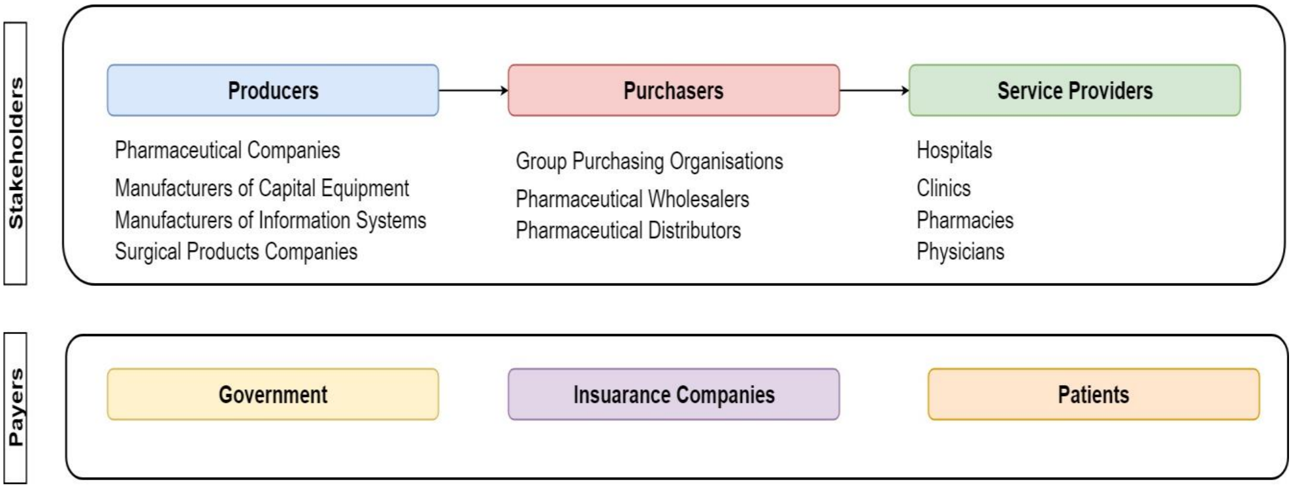


Figure 4.1: Structure of the health products supply chain

Source: (Ridwan and Norzamani, 2014)

It is important to recognise that, supply chains exist within a health system and as such, it is important to consider the characteristics of health systems when analysing supply chains. These characteristics include, health financing, health information systems and regulation. These characteristics affect the design and operation of healthcare supply chains (Yadav, 2015). Figure 4.2 outlines a framework of healthcare supply chain within a health system. The healthcare system is dependent on the efficient management of the pharmaceutical supply chain in order to deliver effective healthcare.

Other factors that affect the healthcare supply chain design and operation include product quality regulation, accurate information flows about consumption patterns and epidemiological status. In addition technically skilled people in the health system, leadership and governance also affect the supply chain configuration and operation (Yadav, 2015).

Figure 4.2: Supply Chain Framework within a health system

Source: (Yadav, 2015)

Furthermore, it is important to recognise that inventory management and control in healthcare supply chains play a vital role in ensuring the availability of health products at health facilities. Ridwan and Norzamani (2014) recognised three inventory management strategies that have been implemented within healthcare supply chains; Just in Time (JIT) approaches, stockless inventory system and Vendor Management Inventory (VMI). From their case study, they concluded that the use of the VMI system is a good initiative for healthcare supply chains. With the VMI system, the manufacturer assumes the responsibility for the management and replenishment of customer inventory. This is supported by the use of an information technology which enable the automatic order processing (Mustaffa and Potter, 2009). The success of healthcare SCM is dependent on relevant information sharing (Kim and Kwon, 2015).

4.3. Pharmaceutical management framework

Five elements define the pharmaceutical management framework as shown in Figure 4.3. Firstly, the *Selection* include the review of health problems, identification of treatment, making the choice of medicines and dosages, and the choice of levels of care in which the medicines can be used (Berger et al., 2010).

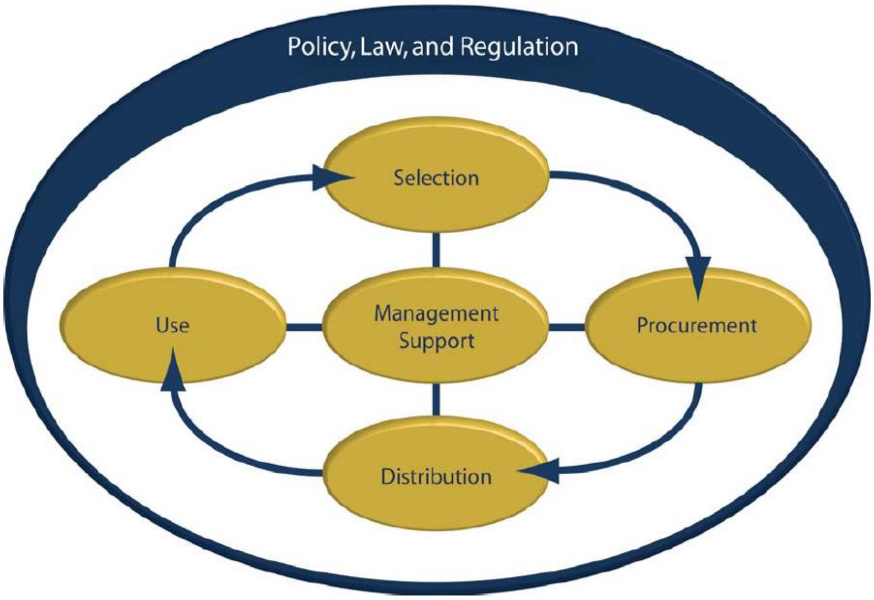


Figure 4.3: Pharmaceutical Management Framework

Source: (Berger et al., 2010)

Secondly, the *Procurement* process includes the quantification of medicines requirements, selection of procurement methods, management of tenders, establishment of contract terms, assurance of medicines quality and ensuring adherence to contract terms (Berger et al., 2010).

Thirdly, the *Distribution* process involves stores management, transport management, inventory control and customs clearance (Berger et al., 2010). Fourthly, the *Use* dimension involves the diagnosis, prescribing, dispensing and use of medicines by patients (Berger et al., 2010). Lastly, the *Management support* element entails financial management, management of information systems, human resources management, and organisation of the system, monitoring and evaluation (Berger et al., 2010). Laws and policies regulate all these five elements.

4.4. Healthcare supply chain processes

The healthcare supply chain processes are adapted from the SCM framework developed by Lambert and Cooper (2000) and the SCOR model as shown in Table 4.1.

Table 4.1: Healthcare supply chain processes

Lambert and Cooper (2000) SCM Framework	SCOR Model	Healthcare SC processes	Description
Demand Management	Plan	Demand Planning	Takes into consideration the consumption patterns of health facilities, quantity of available products to consume, historical campaigns, and epidemiology trends. It also combine actual demand, statistical forecasting techniques and judgement to profile what products are needed, when they are needed and where they are needed (Llewellyn, 2016).
Customer Relationship Management		Supply Planning	Coordinating inventory and orders to optimise the delivery of health products to meet patients' needs. It takes into account, stock at hand, lead-time, safety stock, minimum order quantity, and delivery channel costs. As such it fulfils demand plans (Llewellyn, 2016).
Customer Service Management		Distribution Planning	The scheduling of shipments of products between depots, warehouses and health facilities in response to the supply plan (Llewellyn, 2016).
Strategic Supplier Management	Source	Procurement and Contracts Management	Includes activities related to procuring goods and services to meet planned and actual demand (Stewart, 1997).
Order Fulfilment	Deliver	Warehouse Management	The process involves receiving products, products sorting and storage, quality management, dispatching and debriefing (Pillay, 2015). This can be classified as inventory management and control.
		Transportation Management	This is an attempt to provide finished goods and services to meet planned or actual demand, typically including, transportation management, and distribution management (Pillay, 2015).
Manufacturing Flow management	Make	Produce	Production execution, testing, packaging and product release (Stewart, 1997).
Returns management	Return	Expiry Management	The products that the customer does not accept are returned to the warehouse for repackaging so that they can be redelivered or returned to source.
Enable			Describes activities associated with Performance Management, Contract Management, managing regulatory compliance and Risk Management, Data Management, Resource Management, Facilities Management

4.5. Stakeholders in public healthcare product supply chains

In most sub-Saharan African countries like South Africa, the government purchases health products and distributes them to healthcare facilities using Central Medicine Store (CMS) (Yadav, 2015).

Organizations in the supply chain often include Departments of Health (DoH) (procurement, planning, drug regulatory board, human resources, and health programs), CMS, donors, Non-Governmental Organizations (NGOs), regions and districts warehouses, health facilities, community health workers, and private sector partners such as third-party logistics providers, drug manufacturers, distributors, and private service providers. This network of actors is nested within a country's health system (Berger et al., 2010).

The public healthcare supply chain in South Africa uses tendering as a procurement system. The successful outcomes of the public tendering process are contracts offered to manufacturers and producers of either medical drugs or medical devices. The Medicines Control Council (MCC) regulates all medicines in terms of medical drugs registrations and safety (Berger et al., 2010).

Manufacturers distribute the medical drugs from their warehouses to regional warehouses in each province. From the CMS, distribution is handled by the depot's transportation systems or Third Party Logistics (3PL). One of these parties deliver the medications to all healthcare facilities around the province (Berger et al., 2010) as shown in Figure 4.4.

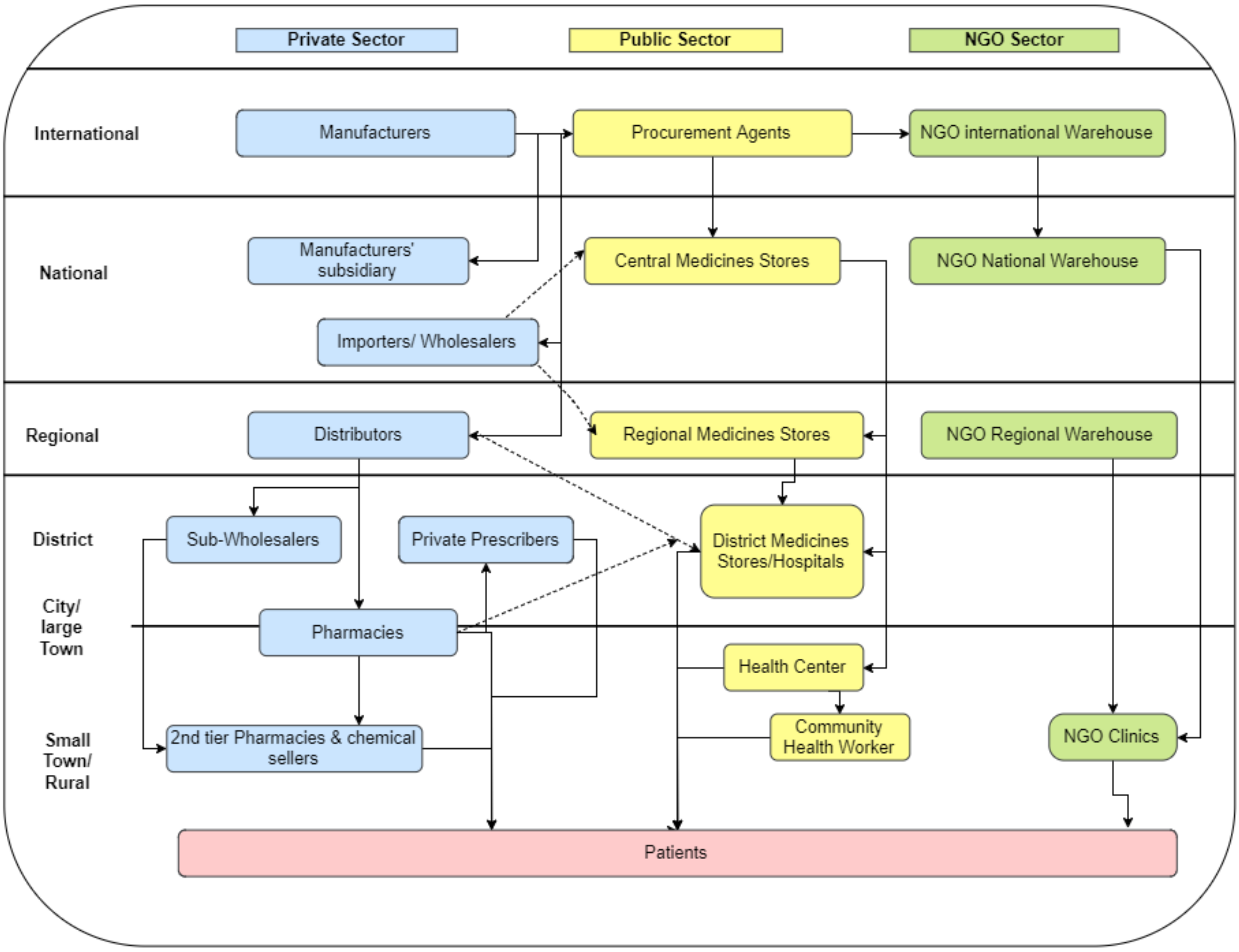


Figure 4.4: Structure of health product supply chain in developing countries

Source: (Yadav, 2015)

The key roles of stakeholders in the public healthcare supply chain in South Africa are explained in Figure 4.5.

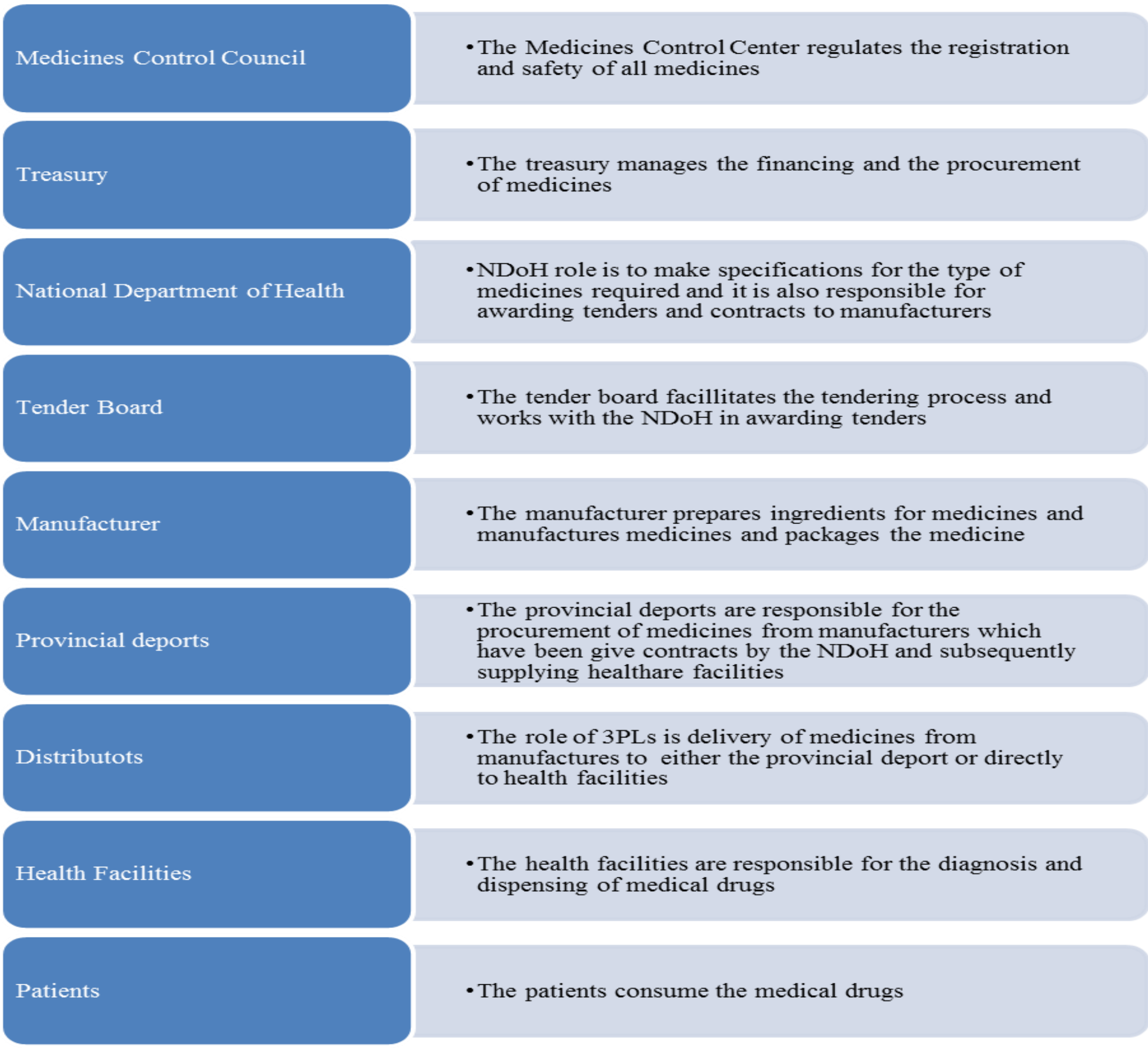


Figure 4.5: Actors in Public Healthcare Supply Chain in South Africa

Source: (Berger et al., 2010)

4.6. Healthcare supply chain visibility

The SCV in healthcare enable products to be delivered or dispensed to healthcare facilities based on their requirements (Kokilam and Joshi, 2016) thereby minimising inventory carrying costs. The capabilities of mitigating risk and collaborative decision making by healthcare facilities can also be enhanced by enhanced SCV. (Zhang, He and Lee, 2008). Healthcare SCV is illustrated in Figure 4.6.

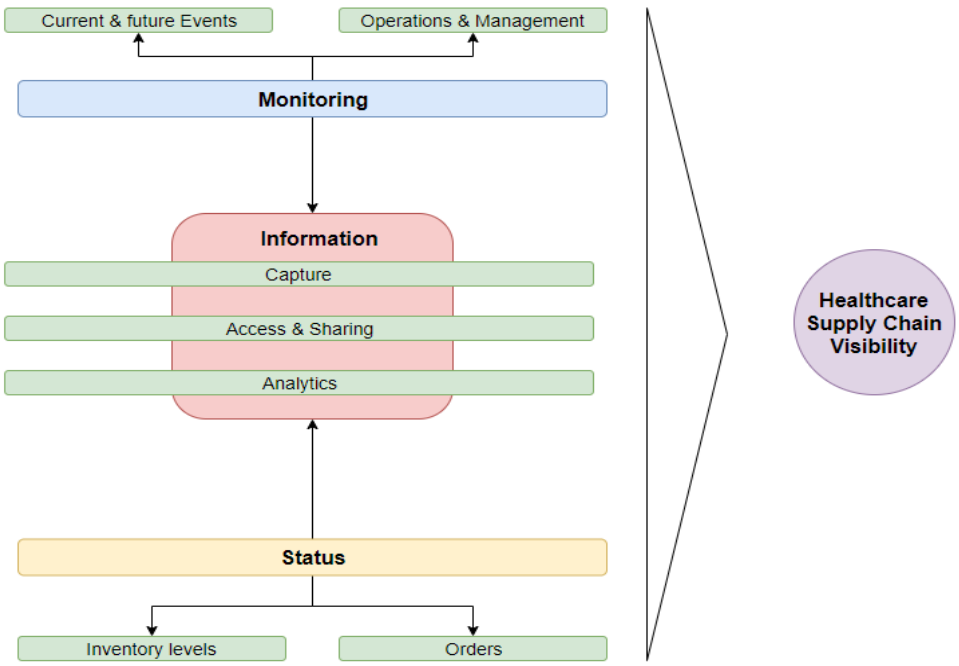


Figure 4.6: Healthcare supply chain visibility

Visibility in a supply network enhances progressive monitoring and management of supply chain operations, collaboration and synchronisation of supply and demand (Khan et al., 2012) as outlined in Table 4.2.

Table 4.2: Healthcare SCV

Dimensions	Capabilities	Healthcare SCV Overview
Monitoring	Current and future events	-Vaccines and medicines are traced and tracked by an IT system (Sarley et al., 2017). -The IT system supports the procurement and payment of medicines and vaccines (Firouzi, 2012).
	Status of operations and management of operations	- Visibility of medicines stocks and vaccines, and manufacturers' production capacity by relevant supply chain partners (Heaney, 2013). -The manufacturer and the supply chain planners also need visibility on the consumption patterns of health facilities, epidemiology trends and historical campaigns (Firouzi, 2012).
Information	Capturing, Accessibility, Analytics, Sharing	-Use of Auto-ID systems such as RFID, barcodes, sensor technologies (Heaney, 2013) for location, temperature and humidity monitoring of medicines and vaccines. Auto-ID systems can also be used for assessing out of stock situations, inventory visibility, monitoring of health products consignments and monitoring of dispatch errors (Kokilam and Joshi, 2016).
Status	Inventory levels and Orders	Visibility into the types and quantities of vaccines, and medicines (stock visibility) at health facilities through a dashboard which collects data from all the health facilities in

Dimensions	Capabilities	Healthcare SCV Overview
		the country (Sarley et al., 2017) into a cloud based management system as well as the visibility of orders and acknowledgement of orders by suppliers (Heaney, 2013).

An example of a case of SCV in South Africa is the Stock Visibility System (SVS). SVS is a mobile-based android developed application solution that provides real-time visibility on stock levels on primary healthcare facilities. This application was developed by Vodacom/Mezzanine. It has been rolled out in 3126 clinics across eight provinces in South Africa and is currently being deployed in Zambia. The solution captures medicines stock levels per facility using barcode scanning or Quick Response (QR) code. It also captures the clinic details such as the staff and the geospatial location of the clinic. It enables managers to control stock per facility. This solution enables the government to have access to information about when and where medicines are needed. Out of stock facilities are quickly replenished and critical healthcare supply chains are monitored (Botha, 2016).

This innovation intends to enhance access to medicines since the predominant paper-based processes in health facilities have been contributing to some extent to medicines stock outs. Daily stock data is captured and synchronised in a cloud based management system. A stock out report analysis and alerts are generated automatically and send by email or phone to relevant supply chain partners (Botha, 2016).

The SVS is important because the accessibility of granular stock levels data at health facility level by the sub-district, district and provincial levels actually drive improvements in the accuracy and efficiency of the distribution of medicines to the patients that are dependent on the primary healthcare system (Botha, 2016). This data is also very important for DDSCM.

4.7. The integrated public healthcare supply chain

An integrated approach to healthcare SCM takes a whole system perspective into consideration, rather than looking at separate activities such as warehousing, or separate programs such as HIV and AIDS or malaria. The purpose for the systems view perspective is that it results in a more cost-effective, agile and reliable supply chain, yielding lower stock-outs rates, reduced costs, and better order fulfilment rates. The integrated supply chains demonstrate six key attributes (JSI, 2017):

- Clarity of roles and responsibilities: Roles, responsibilities, and processes are established and publicized throughout the supply chain.

- Agility: The supply chain is able to respond and adapt quickly to changing demand or supply requirements and maintain an adequate flow of commodities to customers.
- Streamlined process: Logistics functions are performed quickly, accurately, and effectively so products, information, and decisions can move swiftly throughout the supply chain to respond promptly to customer needs.
- Visibility of information: Data are visible throughout the supply chain, so stakeholders at different levels can see where products are and what demand is, and use this information to better meet customers' needs.
- Trust and collaboration: A collaborative environment exists that can help break down functional and organizational barriers to improve supply chain performance.
- Alignment of objectives: organizations and levels have a compatible vision, goals, and objectives to ensure consistency in direction within the supply chain.

4.8. Innovations in health product distribution in Sub-Saharan Africa: An Industry mapping

New technology, better use of data, and entrepreneurial passion in improving distribution channels is reaching a critical mass with the potential to drive extraordinary improvements in availability, affordability, and quality of health products (Yadav and Glassman, 2019). This section outlines innovations in health product distribution in Sub-Saharan Africa that successfully advance healthcare by improving patient outcomes and controlling costs.

Generally, innovators in distribution are offering three (3) types of technology-enabled solutions to critical distribution challenges as shown in Figure 4.7 (Impact for Health, 2019).

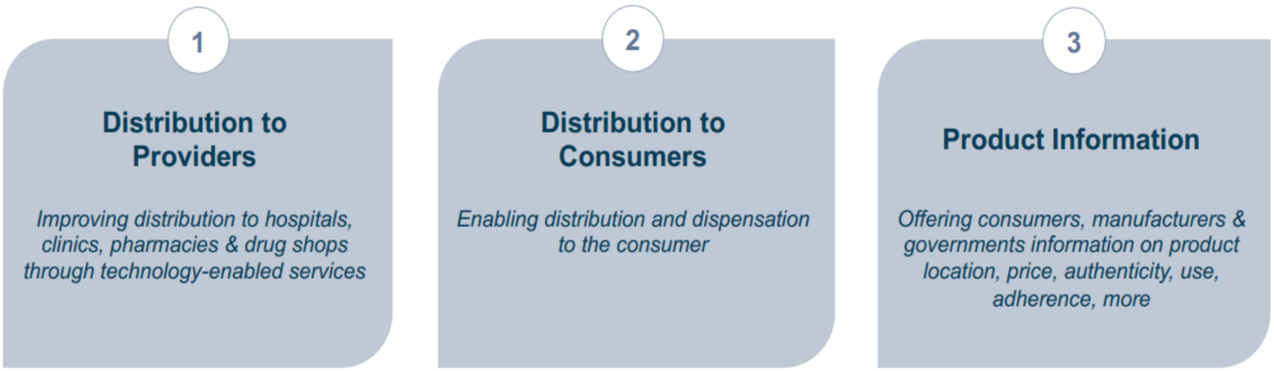


Figure 4.7: Types of Technology-enabled solutions to distribution challenges

Research identified 28 innovators in product distribution emerging across the Africa continent and beyond as shown in Figure 4.8.

Figure 4.8: Innovations in product distribution emerging across the African continent and beyond

Source :(Impact for Health, 2019)

With some exceptions, most of these innovators are new and very small and this analysis is done in Figure 4.9.

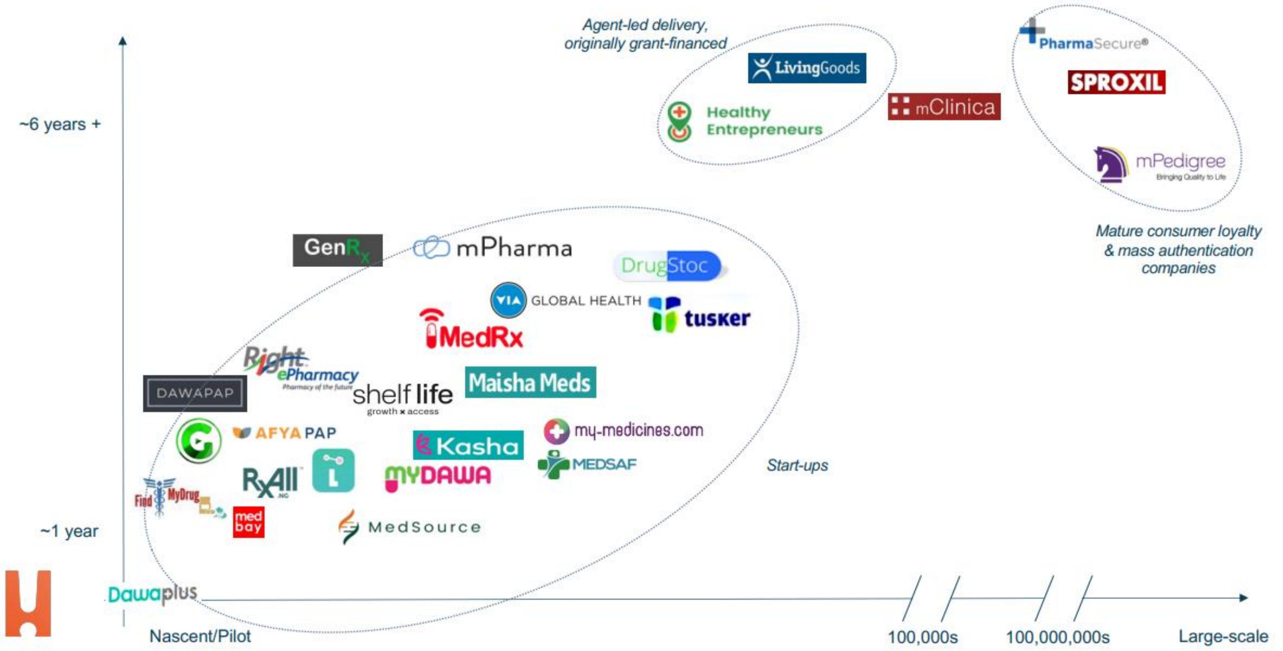


Figure 4.9: Analysis of healthcare innovations in distribution

Table 4.3: Mapping key innovations in health product distribution in Sub-Saharan Africa (Nemzoff et al., 2018; Impact forHealth, 2019; Yadav and Glassman, 2019)

	Description	Services offered	Innovators Names	Impacts
Innovations in distribution to providers	Improve distribution to hospitals, clinics, pharmacies and drug shops through technology enabled services	**Stock financing and ownership** •Providing credit, pay-as-you dispense financing, brokering payments **Inventory management** •Provision of digital inventory management services **Market place and fulfilment** •Digital market places to connect providers to suppliers **Group purchasing** •Aggregation of orders across disparate providers for volume based discounts	med bay, shelf life, MedRx, DrugStoc, tusker, mPharma, MedSource, mClinica, MEDSAF, Maisha Meds, GenRx	•Increase availability of health products •Reduce the cost and variability in cost of products •Reduce transaction costs required to stock and resupply •Improve rural reach (maisha meds)
Innovations in distribution to consumers	Enabling distribution and dispensation to the consumer	**Agent-led delivery models** •Bring products to people through low-level health workers **Digitally-enabled D2C distribution** •Allow digital ordering and delivery **Smart ATMs & lockers** •Automate dispensing, sometimes paired with tele pharmacy **Reverse price auctions** •Use technology to enable easy price comparisons **Retail partnerships** •Tech-enabled care leverages existing facilities and providers	LivingGoods, Healthy Entrepreneurs, my-medicines.com, Kasha, AFYA PAP, MYDAWA, Right ePharmacy, DAWAPAP, Dawaplus	Commercial, e-commerce D2C distribution models are emerging to serve: 1) Urban consumers who care about convenience for wellness products (MYDAWA, DawaPap) and 2) Rural consumers who need regular access to high-cost, hard-to-source products for chronic diseases (Afya Pap, MYDAWA). Rural expansion is through hybrid models that link online/offline delivery models. •increase availability of health products •reduce customer transaction costs •reduce the costs of the actual products
Innovations in the use of product information	Offering consumers, manufacturers, and governments information on product location, price, authenticity, use, adherence	**Commodity locators** •Offer consumers information on the location, price of products **Product quality scanners** •Information on chemical makeup of products **Consumer info & engagement**	mPedigree, SPROXIL, PharmaSecure, RxAll	•Unlike many innovators profiled, 'mass authenticators' such as Sproxil, mPedigree and PharmaSecure are not start-ups; they were launched ~10 years ago. They originally created smart labels for medications that could be placed or printed on the product boxes at the manufacturer.

		•Authenticate products and provide information **<u>Track and trace</u>** •Allow for increased visibility in product movement		•They generate a high perceived impact on consumer information, quality of dispensation, quality of products, rural reach. There is potential for this to improve the availability of health products. •Today, two new types of services are offered by mass authentication companies: 1) Consumer information & engagement, and 2) Track and trace.

A summary of innovations in health product distribution in Sub-Saharan Africa is shown in Table 4.3. *mPharma*, operating in six countries, provides a "pay as you sell" consignment inventory model to retail pharmacies who join its network. It uses its own distribution network to deliver products sourced from high-quality manufacturers (or large distributors) to retail pharmacies. As a result, it solves for the challenges related to too many middlemen, insufficient stocking of slow-moving items, and questionable quality. *Shelf Life* also provides a "pay as you sell" consignment inventory model to retail pharmacies as a subscription service. Others, such as *MaishaMeds*, focus their solution on quality sourcing and a technology platform to help retail pharmacies stock the right "depth" and "width" of inventory (Nemzoff et al., 2018). *mClinica* in South East Asia acts as an information intermediary between retail pharmacies, pharmaceutical companies, and government stakeholders. *Kasha* solves many of these problems by bypassing the retail channel and providing direct-to-home (or designed pick-up point) delivery of women's health products in Rwanda and Kenya. Online pharmacy as a whole is a growing sector in India with large players such as *PharmEasy*, *1mg* and *Netmeds* who have raised large amounts of private capital and expanded rapidly to become national players. While not the same as quality assurance, technology companies such as *Sproxil*, *Pharmasecure*, and *mPedigree* have created mobile authentication systems that help patients verify the authenticity of the drug they are purchasing in the private channel (Yadav and Glassman, 2019).

Furthermore, *Zipline*, a company Launched in Rwanda in October 2016 aims to provide every human on earth with access to vital medicines using cost-effective drone delivery network. The drones have the ability to fly over remote mountains, rivers and washed-out roads and have proven to work in extremes weather. Doctors place orders on-demand through a simple app for any medicine they need, when they need it (Zipline, 2019).

According to *Forbes*, "The Internet of Medical Things (IoMT) is poised to transform how we keep people safe and healthy especially as the demand for solutions to lower healthcare costs increase in the coming years." The Internet of Things is making increased visibility and connectivity throughout the supply chain possible by closely monitoring inventories, in turn, leading to less waste. Digitizing the supply chain using control towers offers a cost-effective opportunity for health care providers to deliver the right product to the right patient at the right time. Building a digital supply chain will also position health care organizations to leverage technological advances designed to improve data flow and analytics, provider-patient connectedness, asset tracking, and regulatory compliance (Deloitte, 2019).

4.9. Chapter summary

In healthcare supply chains, there is a continuous flow of healthcare products, information, finance and services between the supply chain nodes. This chapter discussed the healthcare supply chain processes such as demand planning, supply planning, distribution planning, procurement management, warehouse management and returns management. The chapter also discussed the concept of healthcare SCV in South Africa, which is driven by a mobile application called SVS. Finally, the concept of integrated supply chain systems to healthcare SCM is outlined. This concept is central to meeting customer needs, which is the premise of this research.

More importantly, the stakeholders in public healthcare supply chains are identified and consequently their roles are outlined. Lastly, the network flow logic is described and it is suggested that integrated public healthcare supply chain orientation results in cost-effective, agile and reliable supply chains, yielding lower stock-outs rates, reduced costs, and better order fulfilment rates (JSI, 2017).

Chapter 5 : Systematic Literature Review on Demand Driven Supply Chain Management

5.1. Introduction

The first section of this chapter gives a theoretical background of DDSCM, and the second section provides a systematic literature review on DDSCM. Furthermore, it provides a summary of benefits of moving towards DDSCM. To that end, this chapter contributes towards a better understanding of the DDSCM concepts. This chapter will answer the following secondary research questions:

- What is Demand-Driven Supply Chain Management?
- What are the key success factors for Demand-Driven Supply Chain Management?
- Why do we need a paradigm shift from classical supply push model to Demand Driven Healthcare Supply Chain Management?

5.2. Theoretical background of DDSCM concept

This section provides a theoretical background on the DDSCM concept, as well as a comparative analysis between demand-driven supply chains and supply-driven supply chains.

5.2.1. Foundations of DDSCM

The origins of DDSCM can be traced back to pull production systems. The first classic pull system was called a two card Kanban system which was pioneered by Toyota. The two card Kanban system implies that production on a workstation will start only when the succeeding station has requested or "pulled" parts, and not before (Hopp and Spearman, 2004).

A Production pull system is conceptualised as a system, which explicitly limit Work-In-Progress (WIP) as opposed to a Production push system, which does not limit the amount of WIP. This Production push system came into existence because of the introduction of computer applications in manufacturing. Computer applications paved the way for Materials Requirement Planning (MRP), Manufacturing Resources Planning (MRP II) and Enterprise Resource Planning (ERP) (Hopp and Spearman, 2004).

Pull-based systems can be categorised as either strategic or tactical. In strategic pull-based systems, the customers dictate the pace of production while, in tactical pull-based systems, the amount of WIP is explicitly limited by demand (Hopp and Spearman, 2004). Hull (2005) likened push and pull systems to Make-To-Stock (MTS) and Make-To-Order (MTO) respectively. Demand-driven production is therefore, conceptualized as the synchronised execution of compliant production and logistics processes across a supply network to satisfy actual customer demand (Barrett, 2007).

Furthermore, studies in Demand Chain Management (DCM) also illustrated the concept of DDSCM. DCM consists of practices that seek to manage and coordinate the demand chain, beginning with the customer, and then working backward to the raw material suppliers. DCM can be defined as extending the view of operations from a single business unit or organisation to the whole chain. It focuses on the development of synergy along the whole demand chain and customer segmentation as opposed to internal optimisation. The demand chain focuses on the product from the point of view of the customer-what the customer wants and needs (Selen and Soliman, 2002).

In contrast, supply-driven chain facilitates the availability of products downstream by "pushing" products to undifferentiated market segments and coordinating physical product flow to satisfy the forecasted customer demand. The primary goals of supply-driven chains are to increase efficiencies and to reduce costs across the supply chain. The demand-driven chain is customer centric and requires organisations to have the ability to sense demand information and rapidly adjust their capabilities to respond to the demand variations and customer requirements (Verdouw *et al.*, 2011). This implies that, customers pull products from manufacturers as opposed to manufacturers pushing products to customers.

The primary goal of demand-driven chains is to increase effectiveness through segmentation and market orientation (Seethamraju, 2014). Canever, Trijp and Beers, (2008) argues that DCM evolved from SCM and is much broader than SCM because DCM's prime focus is on customer orientation and the design of the supply chain is based on the customer needs. This implies matching supply with demand (Mendes, Leal and Thome, 2016).

In contrary to the concept of DCM, Treville, Shapiro and Hameri (2004) conceptualise the DCM concept as only a change of SCM nomenclature and suggest that this will cause confusion. However, they further acknowledge the co-existence of a demand chain and a supply chain. The only difference is in the focus of each chain. Demand chains focus on market mediation and supply chains focus on efficient physical supply (Treville, Shapiro and Hameri, 2004). What can be drawn from this argument is that, DCM focuses on internal optimisation of processes in a single organisation.

However, studies by Selen et al (2002) shows that DCM is much broader and encompases all organisation in the SCN that are responsible to satisfying customer demand.

Furthermore, many DCM studies place emphasis on customer demand orientation as the core focus of DCM (Heikkila, 2002; Markham T. Frohlich and Westbrook, 2002; Juttner, Christopher and Baker, 2007; Canever, Trijp and Beers, 2008; Bonomi and Antone, 2014; Mendes, Leal and Thome, 2016). In addition, DCM also involves the integration and alignment of demand and supply processes (Markham T. Frohlich and Westbrook, 2002; Juttner, Christopher and Baker, 2007).

Christopher and Towill (2001) further outlined the evolution of the supply chain concept using the personal computer supply chain, from product driven to customer driven operations. The product driven supply chain focuses mostly on quality while the market oriented supply chain aims at minimizing costs. The market driven supply chain focuses on ensuring the availability of products when and where they are needed. Finally the customer-driven supply chain (demand-driven) is a responsive supply chain focusing on lead-time compression and enhancing service levels for customer satisfaction (Christopher and Towill, 2001). The evolution phases are shown in Figure 5.1.

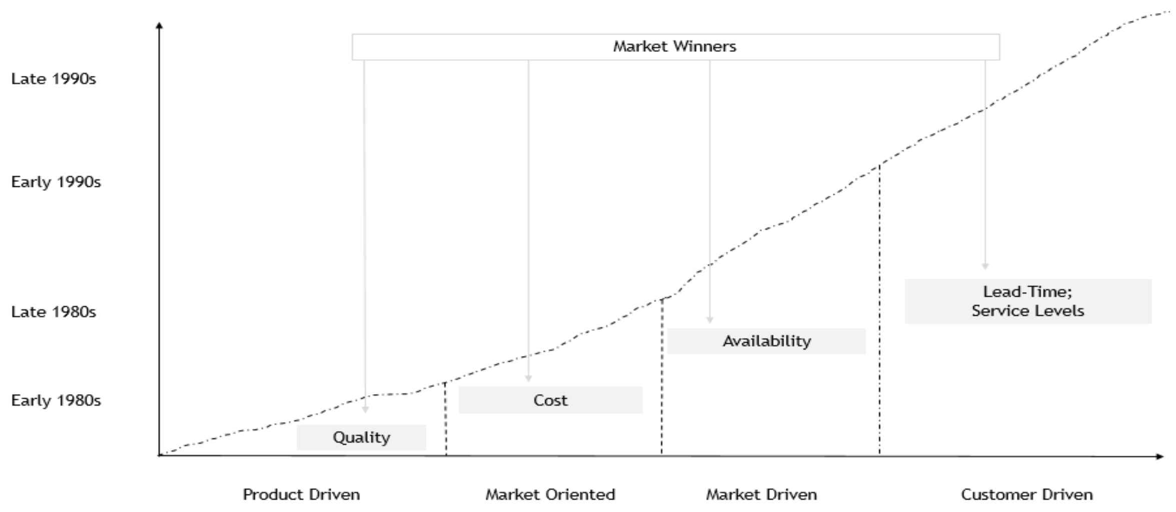


Figure 5.1: Supply chain evolution phases

Source:(Christopher and Towill, 2001)

Another characteristic of a Pull-based approach is the flow of timely and relevant information (Ashayeri and Kampstra, 2005). The flow of real-time information on demand and inventory results in the improvement of the supply chain efficiency (Heikkila, 2002). In this regard, DCM is a demand-driven process based on the Pull-based approach.

Therefore, a Demand Driven Supply Chain (DDSC) (or pull based approach) consist of coordinated technologies and processes that collect, analyse and share real-time demand and inventory information across all supply chain partners (Budd, Knizek and Tevelson, 2012). It is suggested that the combination of both demand and supply concepts give rise to a DDSC which is fundamentally a pull-based system (Mendes, Leal and Thome, 2016).

O'Marah (2005) recognises that DDSCM takes a systems perspective and coined the term Demand Driven Supply Network (DDSN). O'Marah (2005) furthermore argues that DDSN is not another name for SCM. Barrett, (2007) then defined DDSN as a system of processes, technologies and organization that captures and responds to signals across a network. Therefore, DDSCM addresses organisational areas that were not in the scope of classic SCM and this approach promises significant growth and efficiencies (O'Marah, 2005). Verdouw et al., (2011) also define DDSC as dynamic networks consisting of different participants with different allocations of business processes and different methods of control and coordination. An integrated DDSN model consists of 3 elements which are; supply management, demand management and product management (O'Marah, 2005) and this integrated model is shown in Figure 5.2.

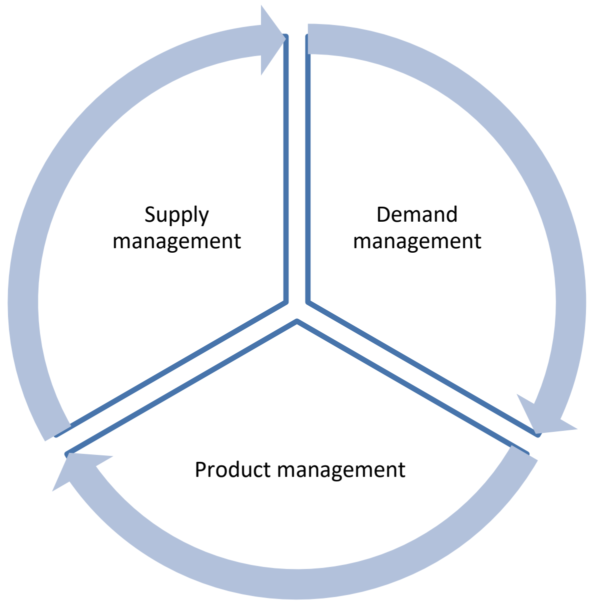


Figure 5.2 Demand-driven supply network

Source: (O'Marah, 2005)

The first element of the model is *Demand Management* (DM). DM is about capturing demand and inventory information and subsequently satisfying customer needs. This implies that demand management balances customer requirements with the capabilities of the supply chain. Figure 5.3 illustrates the notion of DM in detail (Croxton et al., 2002).

Figure 5.3: Demand management process

Source:(Croxton et al., 2002)

Supply Management (SM) entails processes such as supply planning, procurement, contract management, inventory management, warehouse management and distribution planning (O'Marah, 2005). Figure 5.4 illustrates the supply management process.

Figure 5.4: Supply management

Source: (O'Marah, 2005)

The final component of DDSN is *Product Management* (PM) as shown in Figure 5.5. It captures new product innovation, research and development, and product lifecycle management (O'Marah, 2005).

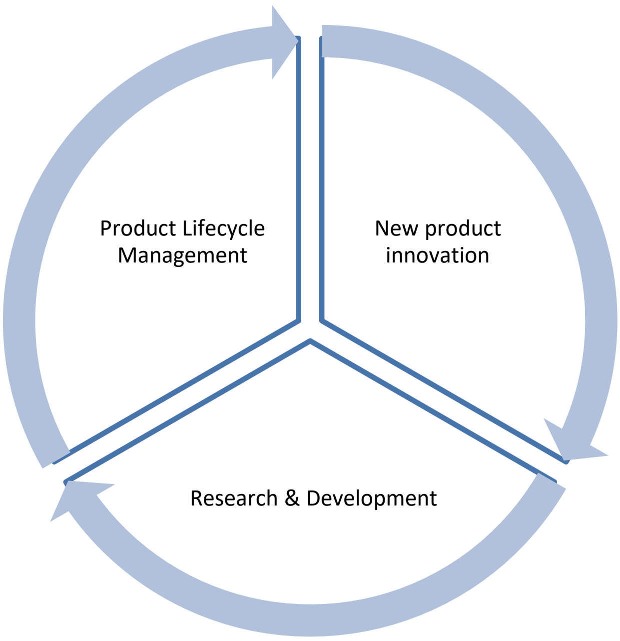


Figure 5.5: Product management

Source: (O'Marah, 2005)

For the purposes of this study, product management involves product classification into either innovative or functional product (Fisher 1997), duration of life cycle, time window for delivery, volume, variety, and variability (Childerhouse, Aitken and Towill, 2002) and does not include product development (Mendes, Leal and Thome, 2016).

Challenges occur when there is a mismatch between the type of product and type of supply chain used for that product (Payne and Peters, 2004). Functional products exhibit stable and predictable demand and are suitable for an efficient supply chain while innovative products exhibit uncertain demand and are suitable for a responsive supply chain (Payne and Peters, 2004).Therefore product management tries to match the type of product to the right supply chain.

Eagle (2017) further proposed another DDSCM model. The author defined DDSCM as segmented supply chain planning and execution process consisting of multiple intentionally planned and positioned inventory locations that can be replenished based on calculated and maintained target, in line with real demand/consumption – not on forecast. Forecasting in DDSCM is used for Sales and Operations Planning (S & OP), event management and buffer sizing (Eagle, 2017).

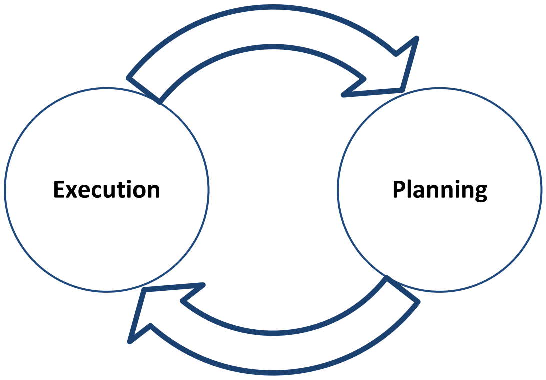


Figure 5.6: DDSCM Model

Source: (Eagle, 2017)

DDSCM consists of two key, but decoupled activities: planning and execution as shown in Figure 5.6. The planning process involves strategic buffer positioning, buffer sizing and buffer maintenance in line with significant demand changes (trends, seasonality). Execution consists of replenishment and monitoring material flow as planned within the supply chain. The DDSCM replenishment allows the supply chain to autonomously respond to real demand without creating an unplanned cost-generating buffer (Eagle, 2017). Consequently, demand-driven supply chains are highly dynamic networks of different participants operating different processes and different modes of control and coordination (Verdouw *et al.*, 2011).

5.2.2. A Comparison between Supply-driven chains and Demand-driven chains

For the purpose of this study, it is important to stress the fundamental difference between supply-push oriented chains and demand-pull oriented chain networks that are focused on demand-supply match. Therefore we use the term demand-driven supply chain and supply driven chain respectively (Lans, 2008). Demand-driven supply chains are often advocated as an alternative to supply-driven chains. Demand-driven chains are responsive and their prime goal is *customised* fulfilment of volatile demand while supply-driven chains *efficiently push* high volume standard products to the marketplace (Verdouw *et al.*, 2011).

Table 5.1 provides a comparison between supply driven chains and demand-driven chains. Hull (2005) highlights that in a supply-driven chain; the supplier activates the flow and does not wait on customer demand. Therefore, supply-driven chain management consist of practices aimed at managing and coordinating the supply chain from raw material suppliers to the end customer (Heikkilä, 2002). In this definition, it is important to note that the view of the discussion is the direction of supply chain planning and coordination. It simply covers the view that goods flow from supplier through manufacturing and distribution to the end-user (Rainbird, 2004).

In the contrary, in demand-driven chains, the customer activates flow (Selen and Soliman, 2002) either through actual demand or forecasted demand (Payne and Peters, 2004; Hull, 2005). The controlling trigger is the replenishment signal (Korhonen, Huttunen and Eloranta, 1998). By default, the demand-driven supply chain is a set of practices aimed at managing and coordinating the supply chain from the customer to the raw material manufacturer (Selen and Soliman, 2002). Demand driven supply chains are end-to-end supply chains consisting of the whole manufacturing and distribution processes (Childerhouse, Aitken and Towill, 2002).

This demand pull approach is only achievable when suppliers utilise timely demand data from customers for planning and decision making purposes (Korhonen, Huttunen and Eloranta, 1998). To excel in demand-driven supply chains, it is essential that the information is accurately captured through the chain (Selen and Soliman, 2002). In this case, DDSCM links customers and suppliers as "one entity" with the aim of creating value and reducing waste through voluntary integration and cooperation between the partners in the network (Goor, 2001).

In Table 5.1, Hull (2005) categorizes the demand-driven chain as either based on actual demand or scheduled demand. Table 5.1 outlines the unique characteristics of both supply-driven chains and demand-driven chains.

Table 5.1: Supply driven supply chains and demand driven supply chains (Fisher 1997; Hull 2005)

Category	Supply-driven	Physically efficient	Market -responsive
Activation by:	Supply	Demand (schedule)	Demand (actual)
Primary purpose	Maximize net profit, given full operating rates	Supply predictable demand efficiently at the lowest possible cost	Respond quickly to unpredictable demand to minimize stock outs and obsolete inventory
Cost objectives	Minimise supply mediation costs	Least cost operations	Minimise market mediation costs
Operational focus	Access multiple markets, develop multiple routes	Maintain high utilization	Deploy excess buffer capacity
Approach to choosing suppliers	X	Select primarily on cost and quality	Select primarily on speed, flexibility and quality
Product design strategy	X	Maximize performance and reduce cost	Use modular design in order to postpone product differentiation
Lead time focus	Either short or long lead-time	Shorten lead-time as long as it doesn't increase cost	Invest aggressively to reduce lead time
Ideal product type	Commodity-type, less costly product, low demand uncertainty	Standardized products (functional), high demand uncertainty but for which economies of scale are advantageous	Highly differentiated products (innovative), high demand uncertainty, costly products
Inventory strategy	En-route	Generate high turns and minimize inventory throughout the chain	Strategic decoupling position with buffer stocks of parts or finished goods
Information flow	Limited information flow and limited to some supply chain nodes	Information flow across all supply chain nodes	Information flow across the entire supply chain
Approach to choosing suppliers and customers	Customers buy on price and availability	Select suppliers primarily for cost and quality	Select primarily for speed, flexibility and quality

The flow in a demand driven supply chain is activated by actual consumption and orders flow backwards, up the chain as opposed to supply driven chains where the flow is activated by the supply source and is independent of customer demand (Hull, 2005).

In a demand driven supply chain, information is shared timely throughout the entire supply chain, enabling alerted organisations to respond quickly to changes in demand or supply (Verdouw et al., 2011). In the contrary, the supply driven chain has a limited flow of information across supply chain nodes. Section 5.3 describes in detail the key success factors for DDSCM. These key success factors were extracted through a systematic literature review approach.

5.3. Systematic literature review

The systematic literature review (SLR) method is an evidence-based process intended to evaluate all published and unpublished literature. It is highly replicable (Bryman et al., 2014) and transparent thereby minimizing bias (Jackson, 2004; Petticrew et al., 2006; Keele and Staffs, 2007). Figure 5.7 illustrates the process of the systematic literature review.

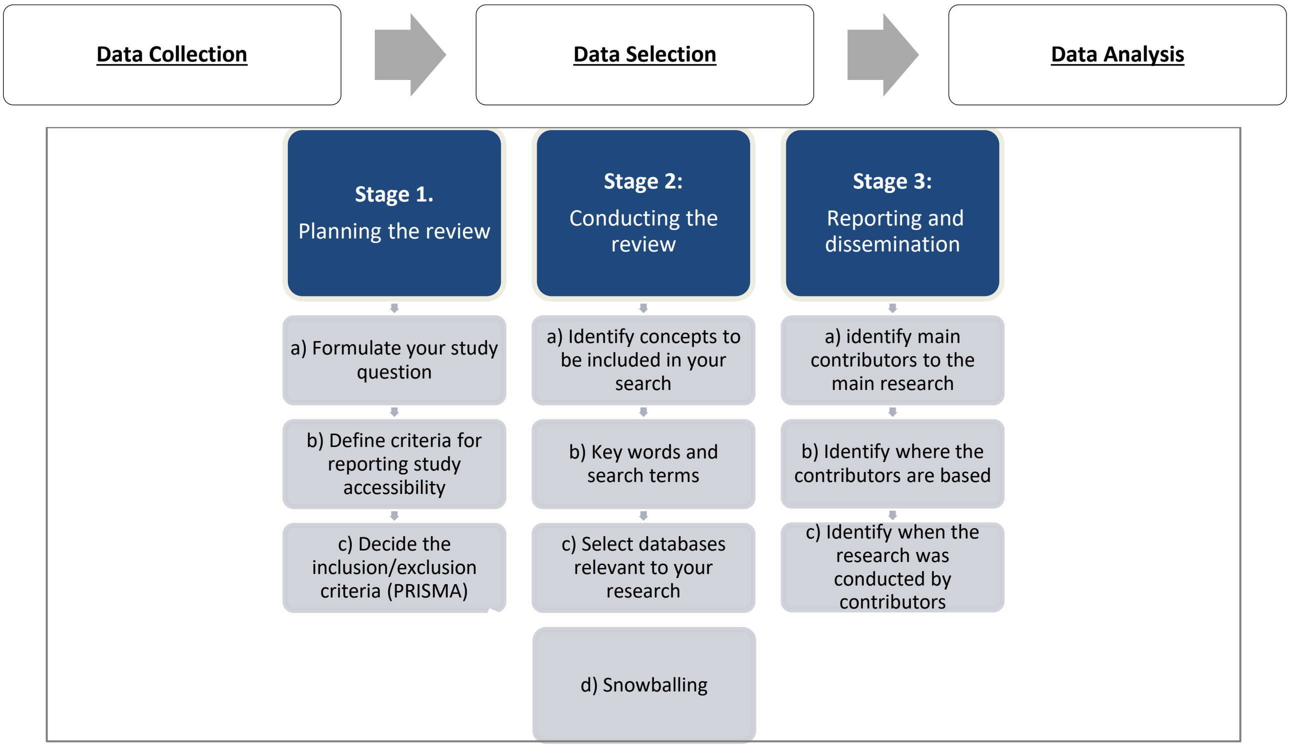


Figure 5.7: Systematic literature review process

5.4. Data collection

The search was restricted to scientific journals, conference proceedings, technical reports, and textbooks. Three data sources were searched which include Scopus, Web of Science and Science Direct. Table 5.2 shows the literature search criteria.

Table 5.2: Literature search criteria

	Search Terms	Scopus	Web of science	Science Direct
#1	((demand driven) AND (supply chain) AND ((visibility) OR (information sharing)))	64	52	178
#2	((customer driven) AND (supply chain) AND ((visibility) OR (information sharing)))	46	34	168
#3	((pull) AND (supply chain) AND ((visibility) OR (information sharing)))	34	24	1169

5.5. Data selection

Figure 5.8 describes the data section process. The initial search yielded 1000+ studies. Only 87 studies were topic related. Even so, the sample selected was based on accessibility. To that end, 76 studies were accessible. After reading the abstracts of these papers, only 35 studies were relevant for the systematic literature review. Snowball strategy was conducted on the references of these studies and 8 more studies were added to make a final data set of 43 studies.

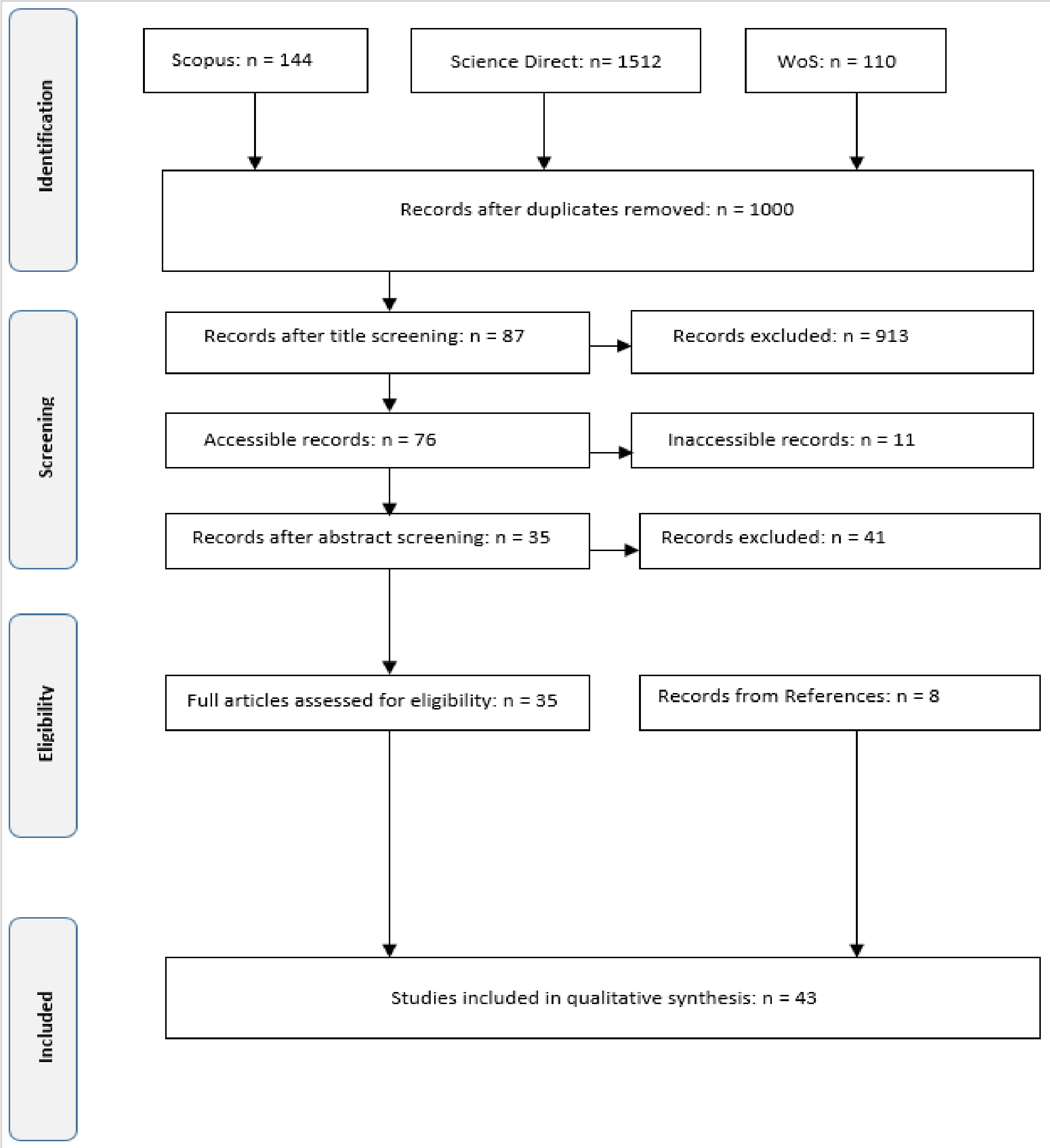


Figure 5.8: Data selection process

5.6. Data analysis

This section provides an analysis of the dataset of journals, conference papers and reports that were collected. It also provides a thorough review of DDSCM key success factors as well as the benefits of DDSCM.

5.6.1. Descriptive statistics

The 43 studies that were included for the systematic review are classified into (i) type of publication, (ii) classification by publication year, (iii) classification by industry type as well as (iv) classification by DDSCM key success factors.

i. Classification of studies by type of publication

Many publications are from journals articles (34 articles) and conference papers (7 articles). Only two reports were found in the literature. Table 5.3 provides an illustration of the type of publications. Most studies published on the concept of DDSCM are from the Journal of Operations Management.

Table 5.3: Classification of studies by the type of publication

Type of Publication	Number
Journal of Operations Management	5
Industrial management and data systems	3
Industrial marketing management	3
The International Journal of Logistics Management	3
Industrial management	2
International Journal of Physical Distribution & Logistics Management	2
International Journal of Production Economics	2
Production Planning and Control	2
Information Strategy: The Executive journal	1
Information Technology and Management	1
International Journal in supply chain management	1
Journal of Computers and Electronics in Agriculture	1
Journal of Fashion Marketing and Management	1
Journal of Industrial and Production Engineering	1
Journal of Marketing Channels	1
Journal of the Academy of Marketing Science	1
Manufacturing & Service Operations Management	1
South African Journal of Business Management	1
The Journal of Business Forecasting	1
Total number of Journals	**34**
Proceedings of International Trade and Logistics, Corporate Strategies and Global Economy	1
17th International Logistics Congress, Thessaloniki	1
16th International Conference on Industrial Engineering and Engineering Management	1
Proceedings - 2nd International Workshop on Engineering Management for Applied Technology, EMAT	1
IEEE Intelligent Transportation Systems. Proceedings	1
FIP Advances in Information and Communication Technology conference	1
IFIP Advances in Information and Communication Technology conference	1
Total number of Conference Proceedings	**7**
The Boston Consulting Group	1
American Institute of Chemical Engineers	1
Total number of Reports	**2**
Total studies for systematic review	**43**

ii. Classification of studies by year of publication

Figure 5.9 shows the studies that discussed the DDSCM approach. Between 1998 and 2003, studies for DDSCM were limited. DDSCM only gained recognition between 2003 and 2008, when the concept of Demand Chain Management (DCM) was recognised. During this period, other studies discussed the Pull-based approach from a production planning perspective. The number of studies declined between 2008 and 2013. Studies on DDSCM started to gain recognition again between 2013 and 2018 because organisations started to realise the benefits of DDSCM.

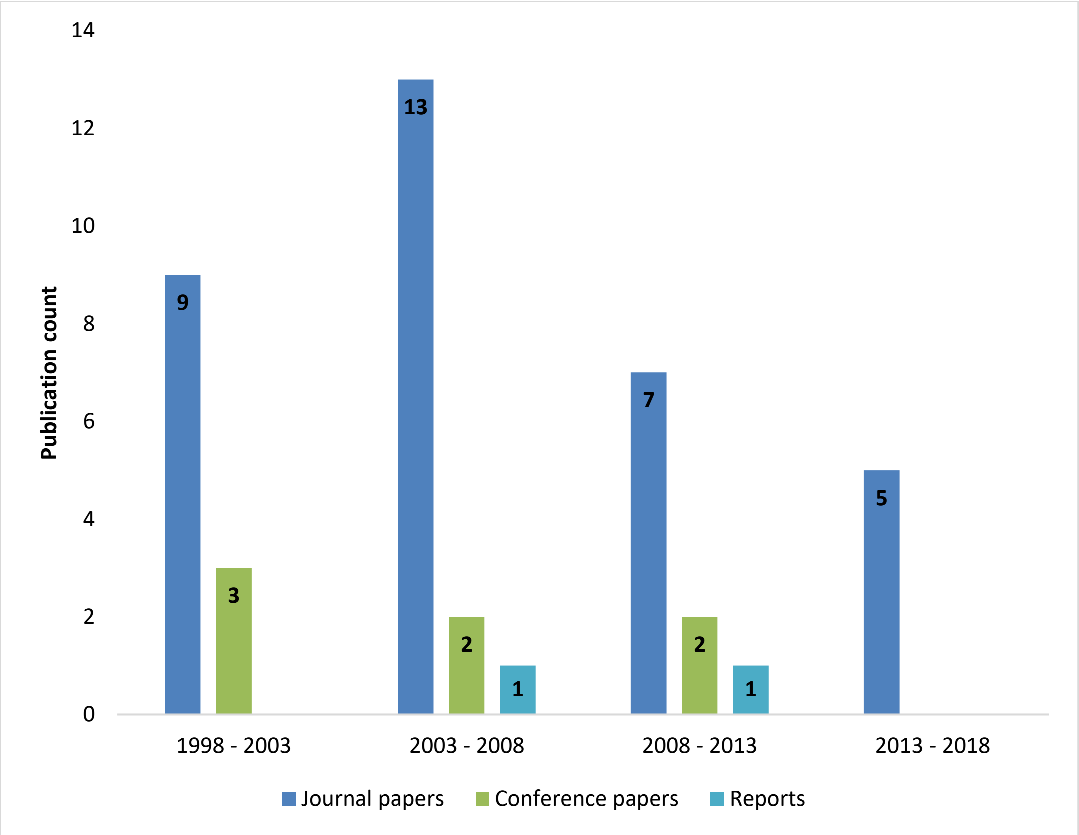


Figure 5.9: Classification of studies by year of publication

iii. Classification of DDSCM Studies by Type of Industry

The DDSCM studies found in literature are categorised into nine sectors, which include, manufacturing, beef industry, transport, fashion industry, fruit industry, flower industry, pharmaceuticals, marketing, and telecommunications. A number of studies are from manufacturing (47%), followed by industries such as fashion, marketing and flower. All at 5% contribution. Figure 5.10 outlines this in detail.

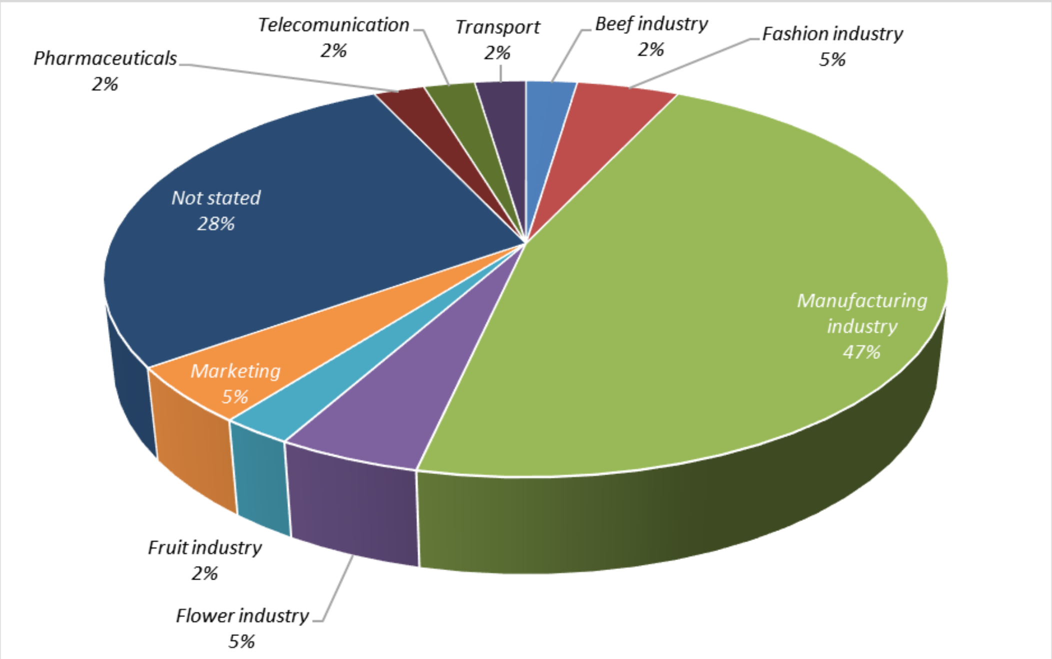


Figure 5.10: Classification of DDSCM Studies by Industry Type

Two noteworthy schools of thought arising from two different sectors are the manufacturing industry perspective and the marketing perspective. Both emphasise that the customer is the start of the supply chain. The customer drives ordering and the replenishment process (Haavik, 2000). This illustrates the "*outside - in"* approach to supply chain design (O'Marah, 2005).

The manufacturing industry perspective postulates best manufacturing practices that enable an organisation to be more responsive to customer needs such as Kanban, lean manufacturing, Vendor Managed Inventory (VMI), Collaborative Planning Forecast Replenishment (CPFR), supplier portals with collaborative planning, forecasting and replenishment tools, Sales and Operations Planning (S&OP) and agile distribution (O'Marah, 2005).

The marketing sector perspective suggests that DDSCM in an organisation is as a result of the integration between SCM and the marketing discipline (Juttner, Christopher and Baker, 2007). These authors posit that SCM interfaces the supply side of the business such as manufacturing and distribution, while marketing interfaces the downstream supply chain that identifies customer needs and requirements. However, both perspectives focus broadly on internal optimisation as opposed to multi-tier orientation.

iv. Classification by DDSCM key success factors

Figure 5.11 shows the number of studies that discuss some of the key success factors for DDSCM. It can be noticed that information sharing and information technology architecture stands out from the rest of the success factors. Essentially, Table 5.4 discusses most of the DDSCM success factors from the systematic literature review.

For organizations to become demand-driven, the most important thing is to allow the flow of timely information across the entire supply chain especially demand and inventory information through a technology platform (Budd, Knizek and Tevelson, 2012). Notably, the customer centric nature of an enterprise and supply chain relationships also stand out as important capabilities. It is suggested that good relationships and close partnerships enable information flow (Heikkila, 2002) which in turn result in supply chain efficiency. Table 5.4 outlines the logical classification of the key success factors into seven dimensions.

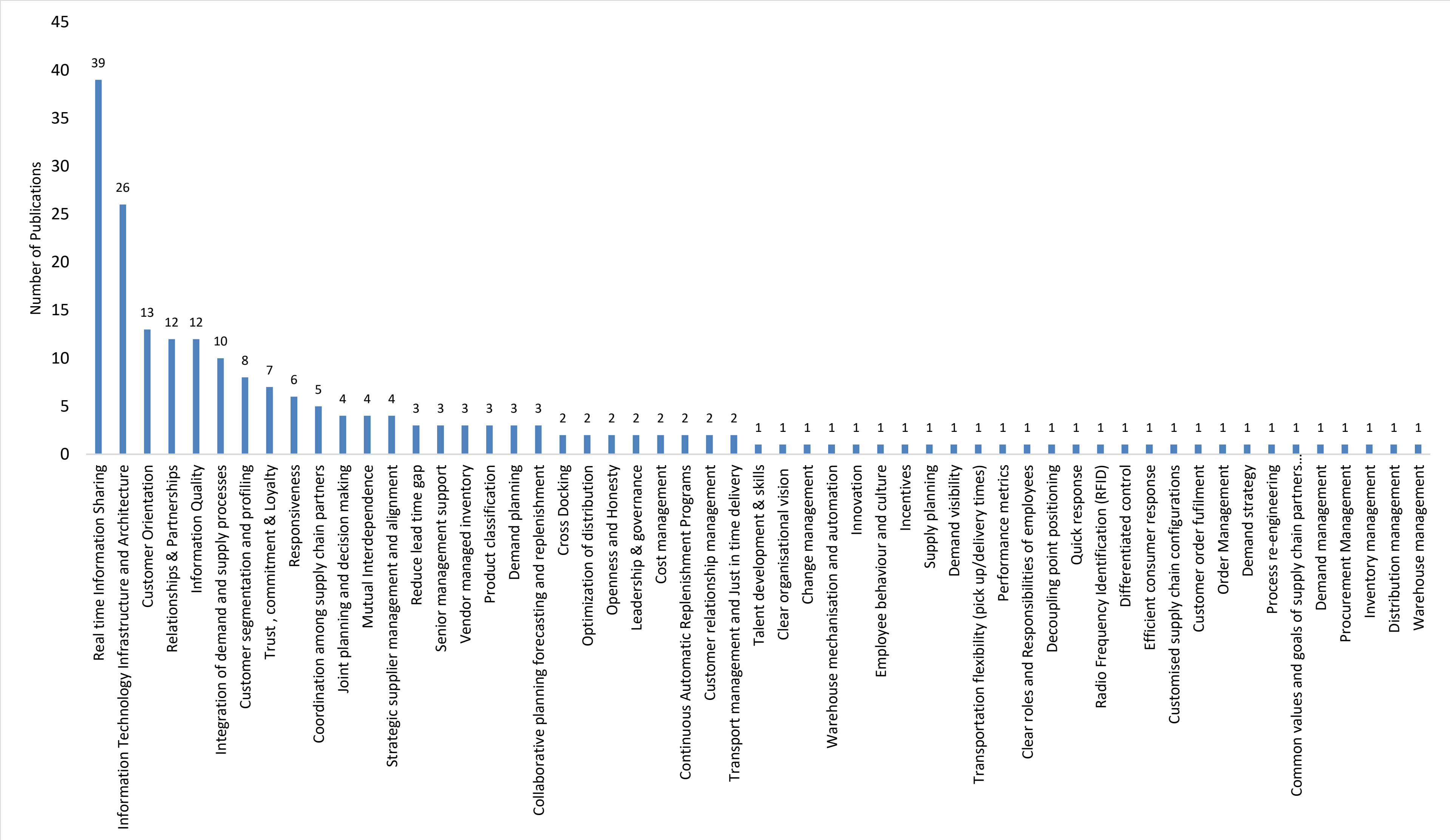


Figure 5.11: Success Factors for DDSCM

Table 5.4: DDSCM concepts classification

Dimension	Success factor (capability)	Description	References
Visibility	**Real-time information sharing**	•Timely sharing and access to downstream and upstream information by and for all supply chain actors.	Budd, Knizek and Tevelson (2012), Mendes, Leal and Thome (2016), Black and Halatsis (2001), Korhonen, Huttunen and Eloranta (1998), Dreyer et al. (2010), Fischer et al. (2016), O'Marah (2005), Christopher and Towill (2001), Verdouw et al., (2011), Juttner, Christopher and Baker, (2007), M. Frohlich and Westbrook (2002), Agrawal (2012), Hilletofth (2011), Hadaya and Cassivi (2007), Heikkilä (2002), Seethamraju (2014), Cao et al., (2010), Lapide (2006), Jacobs (2006), Rainbird (2004), Goor, (2001), Wu, Gao and Yu (2009), Esper et al., (2010), De Treville, Shapiro and Hameri, (2004), Selen and Soliman (2002), Ashayeri and Kampstra, (2005), Lebovitz and Graban (2001), O'Marah (2005), J Ayers, (2006), Hines, (2004)
	Information Quality	•Information availability, accessibility, and usability from all actors on appropriately aggregated levels at the right time at the right place.	
		•Transparent information flow (Keeping the customer informed)	
	Demand Visibility	•Visibility on actual end-user demand.	
		•Understanding customer demand on real time bases, which products customer want (market intelligence), and who wants the products (behaviour analysis).	
	Process Visibility	•Understanding where (place), when (time) and how much (quantity) of products is needed.	
		•Customer order visibility and tracking	
		•Multitier visibility (end to end visibility)	
		•Forecasts visibility across the entire chain	
		•Synchronisation along the supply chain (means that there must be visibility of transport capability across number of links)	
	Inventory Visibility	•Real-time information on end-customer inventory levels (inventory on shelf).	
Technology	**Information Technology Architecture**	•Information technology-enabled solutions such as supply chain dashboard that has the capabilities of data collection, data processing, modelling, communicating and visualization of relevant information for the purposes of collaborative advanced decision support capabilities and development of alternative demand and supply scenarios.	Korhonen, Huttunen and Eloranta (1998),), Mendes, Leal and Thome (2016), Black and Halatsis (2001), Lebovitz and Graban (2001), Mbhele (2016), Dreyer et al. (2010), Christopher and Towill (2001), Juttner, Christopher and Baker, (2007), M. Frohlich and Westbrook (2002), Agrawal (2012), Hilletofth (2011), Hadaya and Cassivi (2007), Heikkilä (2002), Haavik (2000), (Seethamraju, 2014), Cao et al., (2010), Lapide (2006), Jacobs (2006), Rainbird (2004), Goor, (2001), Wu, Gao and Yu (2009),
		•ICT based decision support tools	
		•Internet Connectivity	
		•Web-technologies	
		•IT systems to identify, track and manage each and every customer order	

Dimension	Success factor (capability)	Description	References
	Radio Frequency Identification	•Real- time information capturing and use of RFID data.	Esper et al., (2010), De Treville, Shapiro and Hameri (2004), Selen and Soliman (2002), Croxton et al., (2001), Ashayeri and Kampstra, (2005), Lebovitz and Graban (2001), O'Marah (2005), J Ayers, (2006), Bjartnes *et al.*, (2008)
	Vendor Managed Inventory software	•Supply effectuated based on knowledge of real demand and insights into the customer's stock levels	
		•Concept for planning and control of inventory, in which the supplier has access to the customer's inventory data and is responsible for maintaining the inventory level required by the customer	
		•Inter-organisational interfaces for the flow of products and information.	
		•Assignment of Responsibility for the replenishment process through co-managed inventory programs.	
		•Supplier-customer synchronisation	
	Collaborative Planning Forecasting Replenishment software	•Orchestrating supply chain activities through strategic partnerships that enable co-inventory management such as CPFR through the development of consensus–based supply and demand plans.	
		•Collaborative planning	
		•Intelligent logistics planning and control systems.	
Collaboration	**Relationships**	•Development, fostering, leveraging and management of upstream and downstream relationships with suppliers and customers for the purposes of creating customer value.	Sahay (2003), Heikkila (2002), Agrawal (2012), Ho, Kumar and Shiwakoti (2016), Hadaya and Cassivi (2007), Budd, Knizek and Tevelson (2012), Canever, Trijp and Beer (2008), Dreyer et al., (2010), Verdouw et al., (2011), Juttner, Christopher and Baker, (2007), Hilletofth (2011), Hadaya and Cassivi (2007), Heikkilä (2002), Seethamraju (2014), Cao et al., (2010), Lapide (2006), Jacobs (2006), Rainbird (2004), Walters and Rainbird (2004), Goor, (2001), Wu, Gao and Yu (2009), Esper et al., (2010), De Treville, Shapiro and Hameri, (2004), Selen and Soliman (2002), Croxton et al., (2001), Ashayeri and Kampstra, (2005), Lebovitz and Graban (2001), J Ayers, (2006), Hines, (2004)
		•Framework for collaboration strategies	
		•Partnerships and strategic alliances as opposed to adversarial relationships	
	Trust	•Trust among supply chain partners to influence the quality of information shared and partnerships in the supply chain.	
	Commitment	•Commitment for the successful implementation of supply chain methods for improvement	
	Joint Planning and Decision Making	•Supply capabilities both considered and jointly optimised with actual customer demand.	
		•End customer consumption drives decisions along the chain.	
	Mutuality and Alignment	•Vertical and horizontal dependences within and between chains, sharing risk and benefits.	

Dimension	Success factor (capability)	Description	References
		• Supply chain partners working as if they are part of a single organisation.	
	Goal Congruency	•Entire supply chain goal and objectives collaboratively developed and supply chain partners perceive that their organisation goals are satisfied by accomplishing supply chain objectives.	
	Openness and Honest	•Notifications and communication about order fulfilment dates and delays in delivery of products.	
	Decision making	•Collaborative planning and decision making	
	Participation and Collaborative Communication	•Willingness of supply chain partners to use the shared and available information to develop a collaborative decision support system.	
		•Cooperation in the field of inventory management and replenishment among supply chain partners	
	Supply Chain Partners Coordination	•The development of synergy along the entire demand chain and capabilities to meet dynamic customer needs.	
	Resources & Virtuality	•Resource sharing and pooling with other supply chain partners	
		•Ability to coordinate intangible and tangible assets within the supply chain facilitated by information communication technologies, customer confidence.	
	Systems, structures & relationships	•Collaborative and cooperative strategies for all relevant partners including customers to view supply chain information relevant to them.	
		Develop digital supply chain strategies to replace unnecessary inventories movements by exchanging information.	
Human Resources	**Roles and responsibilities**	•Clear roles and responsibilities for supply chain staff.	APICS, (2015), Ho, Kumar and Shiwakoti (2016), Haavik (2000), Ayers (2006), Dreyer et al., (2010), Heikkilä (2002), Seethamraju (2014), Cao et al., (2010), Jacobs (2006), Lans (2008), Budd, Knizek and Tevelson (2012)
	Talent Development	•Education, training, and certification of personnel by professional bodies and universities	
	Skills	•The staff has good supply chain planning capabilities and is able to use the available information for informed planning processes.	
	Innovation	•Support of ideas to improve the supply chain from the supply chain staff through knowledge creation.	
		•Proactive role by staff, suggesting a larger or smaller order if consumption data show the need	

Dimension	Success factor (capability)	Description	References
		•Systematic thinking ability by supply chain staff	
		•Innovation driven by market intelligent information	
		•Process innovation – forms of generation, dissemination and responsiveness to market intelligence information ie.. innovation on replenishment via Vendor Managed Inventory	
	Incentives	•Motivational mechanism and rewarding strategies to encourage enhanced performance.	
	Culture and Behaviour	•Good Working environment and work culture	
		•Organisational innovation	
		•Information management culture	
Organisational Alignment	**Leadership, Management Support and Involvement**	•Support of demand and supply strategies by management and all this included in organisational agenda.	Haavik (2000), Lapide (2006), Fisher (1997), Lebovitz and Graban (2001), Canever, Trijp and Beers (2008), Dreyer et al. (2010), Verdouw et al., (2011), Juttner, Christopher and Baker, (2007), Hilletofth (2011), Heikkilä (2002), Seethamraju (2014), Childerhouse, Aitken and Towill (2002), Cao et al., (2010), Lapide (2006), Jacobs (2006), Rainbird (2004), Walters and Rainbird (2004), Goor, (2001), Esper et al., (2010), De Treville, Shapiro and Hameri, (2004), Ashayeri and Kampstra, (2005), O'Marah (2005), J Ayers, (2006), (Vollmann, Cordon and Heikkila, 2000), Hines, (2004)
		•Management support in building adaptive demand based networks.	
		•Resources (human competences and technology)	
		•Development of holistic demand driven supply chain strategy (vision that clearly define customer orientation & demand-pull replenishment)	
		•Demand oriented – focus on end consumer demand (driven by market intelligence information both in fulfilment and replenishment) •Generation of market intelligence pertaining to current and future consumer needs, dissemination of the intelligence across the involved enterprises and network-wide responsiveness	
		•Partnership implementation	
		•Outsourcing and supply base development	
		•Flawless execution	
		•Clear definition of requirements for each demand channel along with specific objectives to maximize competitiveness in each segment	

Dimension	Success factor (capability)	Description	References
	Goals, Resources and Strategy Alignment	•Aligning and establishing organisational resources, strategic goals and strategies with those of other actors (streamlined processes)	
	Strategic Decoupling Points Positioning	• Inventory positions separating between push and pull approaches.	
		• Dynamic adjustment of inventory buffers	
		• Defined and optimised inventory buffer levels and sizes.	
	Customer Segmentation	•Establishing customer segments and prioritising the customer base in order to provide different service levels to each segment. .	
		•Customised response to volatile demand through the design of customised supply chain configurations(customer segments)	
	Product classification	•Product Categorization based of the type of demand; either a product with high demand uncertainty (innovative products) or a product with demand certainty (functional products), duration of life cycle, time window for delivery, volume, variety and variability.	
		•Customisation through delivering customer-specific innovative solutions instead of standardised commodity products	
		•Alignment of product categorisation with different replenishment decision rules and service levels	
	Suitability for customer	•Develop flexibility capabilities, agile, innovations and lean supply chains.	
	Cost Management	•Planning and managing supply chain costs.	
Distribution Management	**Distribution Planning**	•Scheduling shipment and transportation of products between warehouses in response to a supply plan.	Rexhausen, Pibernik and Kaiser (2012), Llewellyn (2016), Stonich and Moncrieff (2001), Garcia Reyes and Giachetti (2010), Ayers and Malmberg (2002), Fischer et al., (2016), Pillay (2015), Buijs, Vis and Carlo (2014), Verdouw et al. (2011), IBM (2007), Stewart (1997), Christopher and Towill (2001), Juttner, Christopher and Baker, (2007), Agrawal (2012), Pillay (2015), Gracia (2008), Cao et al., (2010),
		•Establish delivery cycle times and special delivery requirements	
		•Replenishment orders generated form actual end customer demand.	
	Demand Planning	•The integration of statistical forecasting techniques, experience and judgement of planners and consumption patterns to construct a demand plan	

Dimension	Success factor (capability)	Description	References
		•Forecast to capacity and execute (supply/replenish) to demand	Lapide (2006), Jacobs (2006), Goor, (2001), Wu, Gao and Yu (2009), Esper et al., (2010), De Treville, Shapiro and Hameri, (2004), Croxton et al., (2001), J Ayers, (2006), Rexhausen, Pibernik and Kaiser, (2012), Hines, (2004)
		•Demand driven planning using actual customer data	
		•Defining customer priorities	
		•Product prioritization	
	Supply Planning	•Coordinating inventory and orders to optimize the delivery of products to fulfil the demand plan.	
		•Supply/demand balancing	
	Risk Management	•Risk assessment framework detailing contingency plans	
	Warehouse Management and Automation	• Management and control of inventory of products through the process of receiving products, products sorting and storage, quality management, dispatching and debriefing.	
		•Warehouse housekeeping (5S)	
		•Intelligent decision support system in the warehouse management system	
		•Sufficient warehouse automation and mechanisation	
	Cross-docking and Direct deliveries	•Type of order picking were deliveries of products are made directly from the factory to the ultimate customer without being stored in the warehouse with the use of inbound and outbound logistics.	
	Customer Order Management	•Automated replenishment based on real time information on consumption, inventory levels and transport status.	
	Logistics and Transportation Flexibility	•Tailoring transportation to match customer segmentation needs.	
		•Flexibility in making adjustments to the content of the delivery if needed and routes through the use of "full truck loads and full pallet loads."	
		•Transport bundling to achieve economies of scale and utilization	
		•Optimisation of transport modes and routes	
		•Optimisation of scheduling routing	
	Performance measurement system	•ICT based performance measurement system	

Dimension	Success factor (capability)	Description	References
Performance Management	**Indicator characteristics**	•Use of indicators for performance monitoring for the purposes of optimising operational processes.	Bjartnes *et al.*, (2008), Korhonen, Huttunen and Eloranta (1998), Hines, (2004), Lans (2008), Budd, Knizek and Tevelson (2012), Hines, (2004)
		•Responsive to market intelligence information in a flexible, timely and cost-effective manner	
		•Indicators based on agreed upon strategies, performance targets and priorities	
		•Performance measurement should enable analysis application	
		•Aligning organisation metrics with overall supply chain metrics.	
		•Setting joint supply chain targets or metrics.	
	Performance metrics	•Reduction in supply chain costs	
		•Quality (VMI helps to assure the availability of products thereby helping to ensure better on-time delivery performance as well as greater fill-rates)	
		•Responsiveness (less time spent waiting for products, allowing the production to operate more smoothly and quickly)	
		•Reliability (faster and more accurate order fulfilment)	
		•Agility	
		•Availability (fewer stock-outs) •Higher rates of customer satisfaction	
		•Forecast accuracy	
		•Waste % (expiration, theft, damage)	
		•Inventory Turns (reduction in inventory levels and working capital)	
	Service	•The ability to deliver different quantities of goods through capacity management and capacity flexibility.	
	Sustainability	•Consistent customer value offering based on their preferences, time, place flexibility and quality.	
	Standards	•Supply chain standards to assure customer quality standards are met effectively and cooperate within supply chains.	

Dimension	Success factor (capability)	Description	References
	Speed of response	•Responsive capabilities to deliver goods and services when they are required through efficient consumer response, and quick response.	

The classes (dimensions) of key success factors (capabilities) are considered as the core elements for DDSCM. Figure 5.12 and Figure 5.13 shows the conceptual DDSCM framework developed by synthesizing and consolidating the success factors into seven dimensions for DDSCM.

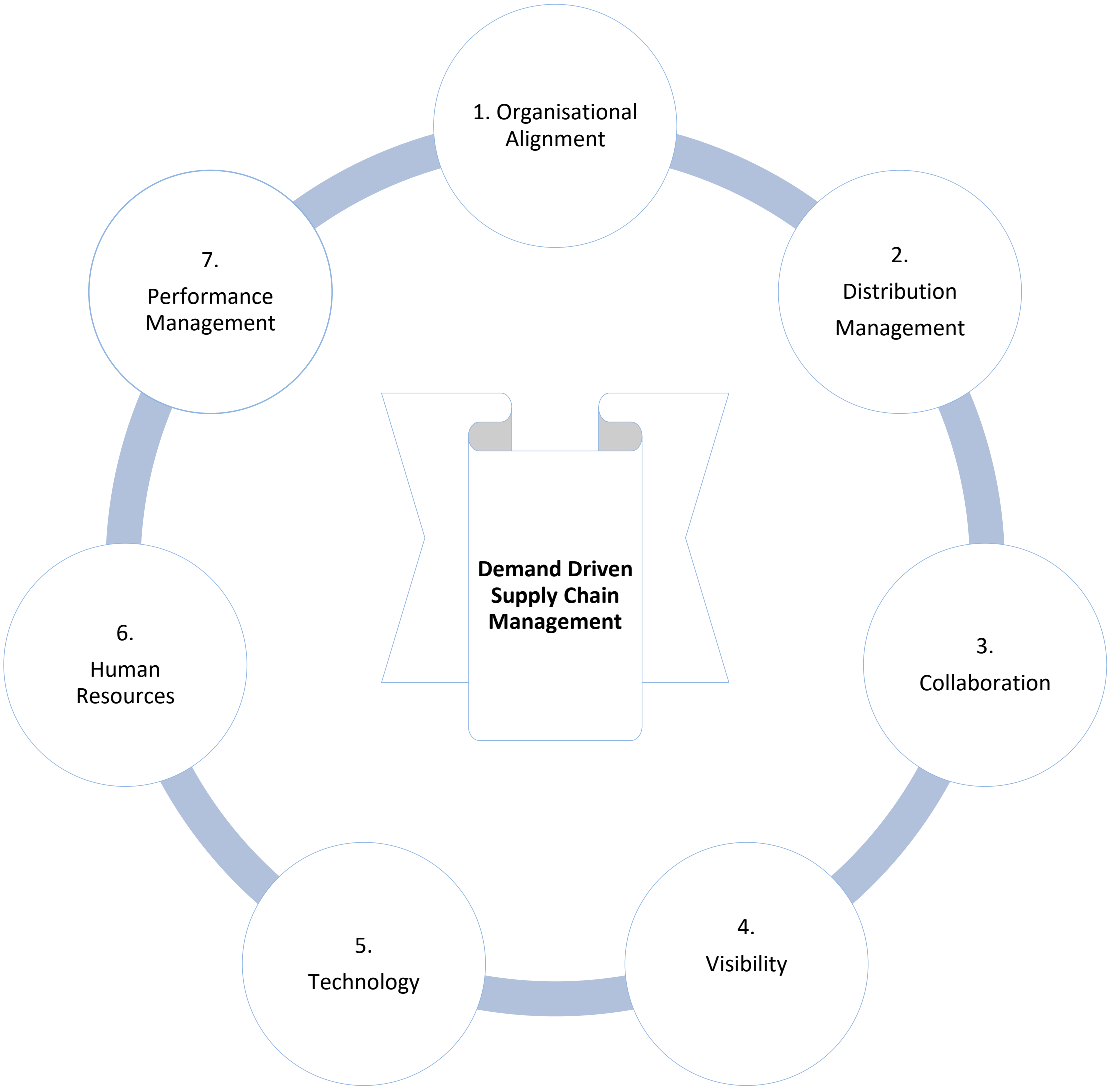


Figure 5.12: DDSCM Framework (Dimensions)

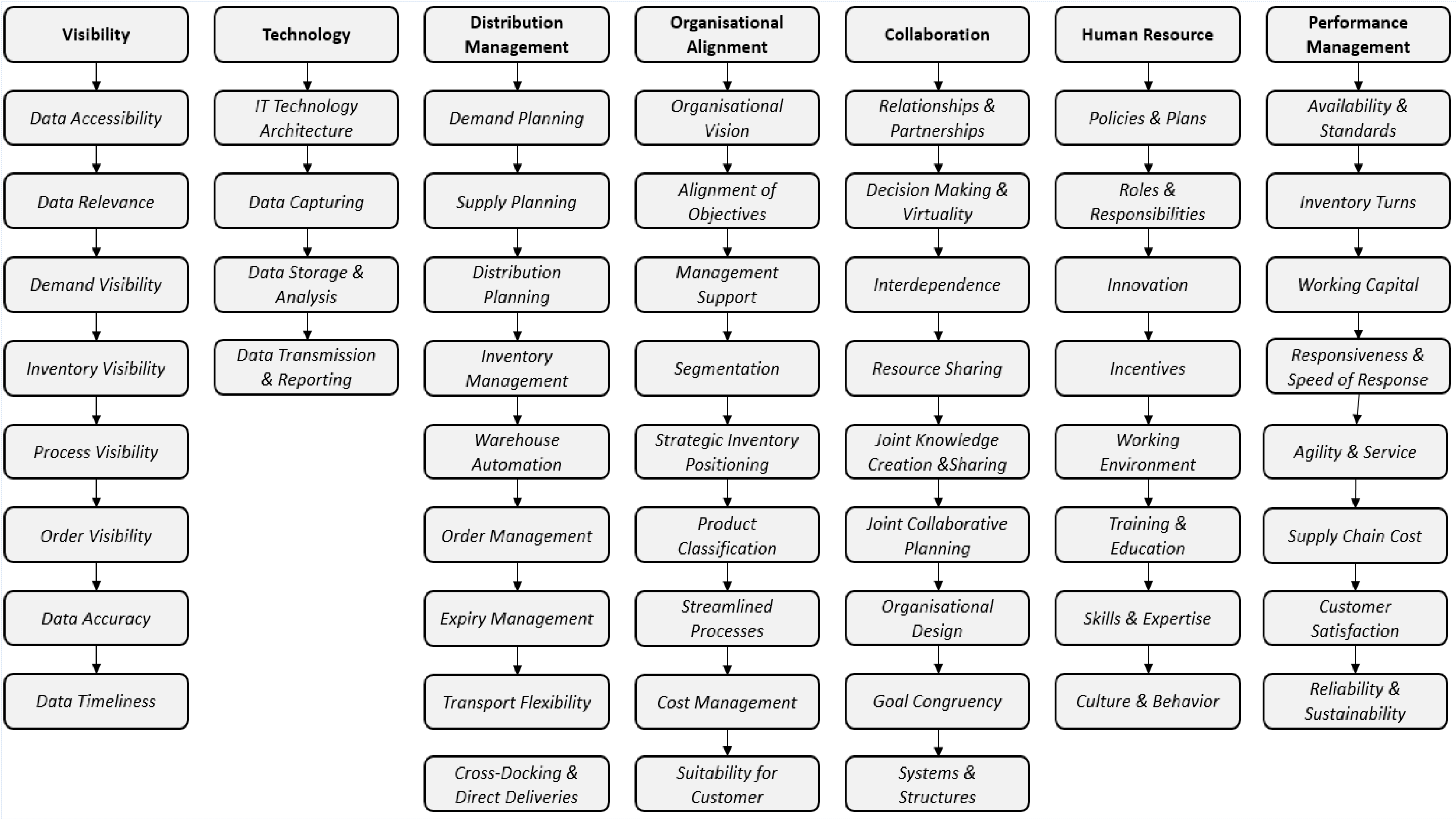


Figure 5.13: DDSCM Framework (Capabilities)

1.Organisational Alignment

Organisational alignment is a methodology that supports people, and organisations through transitions. For the purposes of this study, organisational alignment, in a demand-driven organisation, involves the transformation process in which the organisational vision focuses on the "*outside-in strategy"* (Barrett, 2007). The *outside-in* strategy has the customer as the starting point of the supply chain (Selen and Soliman, 2002). Therefore, the first step is to understand the actual customer demand and then translate that demand into strategies and plans. The strategies include customer segmentation (Heikkila, 2002) and product classification (Fisher, 1997).

Organisational alignment combines organisational vision, goals, culture, roles and responsibilities (Barrett, 2007), cost management, customer segmentation (Canever, Trijp and Beers, 2008) and product classification (Payne and Peters, 2004), senior management support (Mendes, Leal and Thome, 2016), positioning of decoupling points and demand strategy. In addition, the organisational metrics should be aligned to supply chain goals and objectives (Barrett, 2007).

2.Distribution Management

Distribution management can be defined as an organization's ability to facilitate the storage and flow of products in an attempt to satisfy customer demand in a reliable and efficient way (Rexhausen, Pibernik and Kaiser, 2012). Distribution management capabilities involves best practices such as: warehouse and inventory management, cross-docking, distribution planning and transportation management, customer order management and order fulfillment, and demand and supply planning (Rexhausen, Pibernik and Kaiser, 2012), (Buijs, Vis and Carlo, 2014).

a. Warehouse and Inventory Management

Warehouse management commonly bundles practices related to efficient handling, storage, and picking of products and inventory (Pillay, 2015). In this sense, optimizing warehouse management processes through resources, automation and technologies and Warehouse Management System (WMS) enhances responsiveness, and flexibility, reduces errors, costs and inventory levels (Rexhausen, Pibernik and Kaiser, 2012).

b. Cross-Docking

Inbound trucks deliver products to the warehouse and the products are quickly sorted and loaded to outbound trucks based on customer demands and routes without inventory being held in the warehouse (Buijs, Vis and Carlo, 2014). Cross-docking distribution strategy is a lead-time reduction technique involving processes that marry products received in a facility from different suppliers or destinations with other products being distributed to the same onward destination. These goods are distributed at the earliest opportunity without going into long-term storage (Hines, 2004). Cross docking reduces delivery time and some material handling costs.

c. Distribution Planning and Transportation Management

It involves optimization of delivery schedules and transport routes and also transport bundling to capitalize on economies of scale thereby reducing transport cost without compromising customer service (Rexhausen, Pibernik and Kaiser, 2012). This is conceptualized as internal organizational optimization (Seethamraju, 2014). Distribution optimization also encompasses capitalization of other channel members' resources such as transport systems to improve responsiveness (Agrawal, 2012). This can be accomplished through sharing and aligning information, intelligence and resources across the value chain through increased process visibility (Seethamraju, 2014).

d. Customer Order Management and Order Fulfilment

Order fulfilment can be defined as the percentage of orders that are delivered on time, accurately and that meet customer demand (Barrett, 2007). This is one of the goals of DDSCM, therefore an organisation should develop capabilities to deliver perfect orders where and when they are needed.

e. Demand and Supply Planning

Lastly, distribution management covers demand and supply planning. Demand planning entails demand forecasting, defining customer priorities and product priorities. On the other hand, Supply planning involves balancing supply and demand (Rexhausen, Pibernik and Kaiser, 2012) by coordinating inventory in response to the demand plan (Llewellyn, 2016).

3.Collaboration

Supply chain collaboration is a long-term partnership process where stakeholders with common goals work closely together to achieve mutual benefits that organisations would not be able to achieve individually (Cao et al., 2010). It involves activities related to joint planning and execution of supply chain activities (Bjartnes *et al.*, 2008). Supply chain collaboration can enhance customer satisfaction by reducing lead-times, improving service levels and decreasing costs (Goor, 2001). It enables partners to jointly gain a better understanding of product demand and this guides stakeholders in the implementation of more realistic programmes to satisfy that demand (Sahay, 2003). Consequently, the constituent components of supply chain collaboration consist of:

a. Relationships and Partnerships

The success of demand-driven processes is based on the strength of relationships among supply chain partners and the efficiency of logistics processes (Ashayeri and Kampstra, 2005). Close relationships and partnerships among supply chain partners is a key component to performance improvement (Sahay, 2003). Furthermore, a good relationship between the customer and supplier contribute significantly to reliable information flows across the supply chain (Heikkila, 2002). Failing to collaborate would result in the distortion of information (bullwhip effect) as it flows through the supply chain, which in turn, can lead to costly inefficiencies, excess inventories, slow response, and lost benefits (Sahay, 2003).

Through relationships and partnerships, the moment a product leaves the shelf of a retailer, a notification is sent to the manufacturer who in turn replenishes the products (Lummus and Vokurka, 1999). Supply chain relationships also encompass close working together of supply chain partners to plan and execute supply chain operations towards common goals, thereby achieving more benefits than acting independently. This is achieved through specific investments, knowledge sharing, complementary assets and effective governance mechanisms (Cao et al., 2010).

b. Information Exchange

Barratt (2004) defines collaboration as a process that occurs when two or more organisations share the responsibility of exchanging information that enhances an organisation’s performance. The information shared among supply chain partners can be about plans, forecasts, delivery schedules, strategic information and procedures. This information should be relevant, timely and accurate (Cao et al., 2010). It is through partnerships that organisations can reduce response time by obtaining information to streamline order fulfilment.

c. Participation and Collaborative Communication

It represents the willingness of supply chain partners to use data from other supply chain members for the purposes of collaborative joint planning and decision-making. This also involves contact and message transmission process among supply chain partners in terms of frequency, direction, mode and influence strategy (Cao et al., 2010).

d. Joint Planning and Decision Synchronisation

The collaboration process involves the joint analysis of future demand and inventory status, leading to joint collaborative planning and joint decision-making. Notably, the joint collaboration planning actions influence the strength of relationships and the use of inter-organisation information systems in a demand driven supply chain (Hadaya and Cassivi, 2007). This also entails that supply chain partners orchestrate decisions in supply chain planning and operations that optimise supply chain benefits. Joint planning is used to align supply chain plans and coordinate decisions on inventory replenishment, order placement and order delivery. The level of synchronisation in decision making process is a key element in building and maintaining mutual partnerships (Cao et al., 2010). The joint planning and decision synchronisation is further enabled by the integration of both the information flows, and product flows from a multi-organisational point of view (Goor, 2001).

e. Trust and Commitment

Heikkila (2002) identifies attributes of trust such as reliability that entails that, supply chain partners fulfil their obligations; and benevolence, that entail that partners are also interested in the other organisation welfare and will not embark on unexpected action, that might disadvantage the other partner. Goor (2001) further suggests that cooperation and coordination in a supply chain is never possible without commitment. Commitment enables the formation of relationships and partnerships and subsequent information flows in a supply chain.

f. Mutuality and Incentive Alignment

Collaboration in a supply chain is also rooted in the concept of mutuality. Mutuality involves the sharing of both supply chain risks, costs and benefits among supply chain partners (Barratt, 2004). This is achieved by integrating information systems and alignment of processes among supply chain partners. In this sense, supply chain partners work as if they were part of a single organisation (Cao et al., 2010).

g. Goal Congruency

This entails the extent to which supply chain partners perceive their own objectives are satisfied by accomplishing the supply chain objectives (Cao et al., 2010).

h. Openness and Honesty

Collaborating partners in a supply chain should have a culture of openness and honesty. An example is the notification of the recipient if there are any delays in delivery of products (Lummus and Vokurka, 1999).

i. Coordination between supply chain partners

Coordination among supply chain partners enables organizations to execute their operations effectively and efficiently (Budd, Knizek and Tevelson, 2012). This can be accomplished through the development of synergy along the entire demand chain and the development of capabilities to meet dynamic customer needs (Seethamraju, 2014). Coordination also relates to the integration of information systems and decision support systems for the purposes of enhancing supply chain visibility (Mbhele, 2016). It also relates to improving capabilities to match supply and demand (Markham T. Frohlich and Westbrook, 2002).

In addition, it also involves the integration of demand and supply processes between organisations through agreements among supply chain partners. The agreements can be on frequent small batch deliveries, long-term contracts with suppliers and the adoption of technologies in transaction execution such as order placement and order management (Markham T. Frohlich and Westbrook, 2002).

j. Resource Sharing

It is the process of leveraging capabilities and assets and investing in capabilities and assets with supply chain partners to facilitate the flow of products and information across the supply chain in an attempt to reduce uncertainty and transactional costs. Resources such as physical assets and technology such as VMI software allow suppliers to assess stock-level data via electronic data interchange, thereby facilitating necessary replenishment action (Haavik, 2000). Furthermore, it is recognised that financial and non-financial investments such as time, money, training, technology updates and other resources play a significant role (Cao et al., 2010).

k. Joint Knowledge Creation

It is described as the extent to which supply chain stakeholders develop a better understanding of and response to the customer requirements and market by working together. Joint knowledge creation can be classified as knowledge exploration (search and acquire new and relevant knowledge) and knowledge exploitation (assimilate and apply knowledge). This involves active generation and development of knowledge that is easily accessible, disseminated and easily interpreted in concert with all supply chain partners (Cao et al., 2010). The capture, exchange and assimilation of knowledge among supply chain stakeholders enable innovation and facilitate long-term performance improvements and customer satisfaction.

4.Visibility

Information sharing is an optimisation strategy aimed at improving supply chain coordination and integration (Mbhele, 2016). Information quality can be described by the following characteristics (Korhonen, Huttunen and Eloranta, 1998):

- Relevance
- Timeliness
- Continuous flow
- Validity
- Accuracy
- Intelligibility
- Usefulness

To that end, the intersection between information sharing and information quality is interpreted as visibility (Barratt and Oke, 2007). This information can be about customer demand, supply or inventory levels (Barrett, 2007) and must be transparent across the whole network (Budd, Knizek and Tevelson, 2012).

Visibility throughout the supply chain enables organisations to be responsive to changes in demand (Verdouw et al., 2011). In this sense real demand and inventory visibility coupled with continuous replenishment programs ensures that DDSCM becomes a reality (Christopher and Towill, 2001). This is a capability that enables organisations to be able to match demand and supply (Markham T Frohlich and Westbrook, 2002).

5.Technology

Technology enables the capturing, analysis and distribution of seamless, real-time demand and inventory information (Agrawal, 2012). A fast data-exchange platform can facilitate the exchange of data among supply chain partners. This is key to the implementation of DDSCM (Budd, Knizek and Tevelson, 2012). This fast data-exchange platform can be a shared information technology platform among supply chain partners (Goor, 2001). The distributed and linked supply chain platform serves as information and communication platform that enable integration of operations and interactive planning across various geographical locations and organisational levels. The supply chain platform provides members with access to network-wide real-time information, enable visualisation of available information, secure interaction between advanced ICT based decision support tools and human decision making, and create a coordinated and collaborative environment for planning and decision making (Bjartnes *et al.*, 2008).

Integration of information systems and technology platforms is making it possible to build demand driven supply chains enhancing the link between the customer and the supply chain system that deliver the customer requirements (Hines, 2004).

Technology also facilitates supply chain visibility, information integration, and transparency enhancing demand-based decisions (Korhonen, Huttunen and Eloranta, 1998). This can be accomplished with demand driven control systems such as CPFR (Fliedner and Fliedner, 2007), VMI, quick (consumer) response, and efficient consumer response (Caridi et al., 2014). The VMI software receives inputs of inventory and demand information and recommends to the distributor the correct order amounts and delivery schedules to meet the actual demand (Haavik, 2000). In this sense, information technology and logistics are essential in facilitating functions for DDSCM (Goor, 2001). Key requirements for state of the art demand driven supply chain management information management solution can be summarised as (Korhonen, Huttunen and Eloranta, 1998):

- Strategic direction and focus – need to be derived from organisational strategy and organisational process requirements.
- Integration - Key aspects of integration to be covered are organisational process integration including customers and suppliers, end-to-end demand and integration of process-wise performance management.

- Information coverage and availability - Access to real-time demand information and distribution channel information, and sharing the demand information between all parties in the chain.
- Flexibility and adaptability - IT solution that is able to adapt to changes in organisational processes and requirements.
- Information quality - Information management solution must be designed in such a way that the best information quality is accessed.

6.Human Resources

This key success factor describes the required skills, expertise, experience and capacity of supply chain staff to manage and coordinate the supply chain (APICS, 2017). To enhance this capability organisations need to invest in talent development through continuous training programs. These training programs can be certified by professional bodies. In addition, since people are the drivers of innovation, mechanisms should be in place to capture new ideas within supply chain staff and move the ideas into action (Korhonen, Huttunen and Eloranta, 1998). Lastly, since DDSCM is centred on the concept of "sense and respond", information is a capability for the success of DDSCM. Therefore, information management culture and skills are crucial for the success of the DDSCM approach (Seethamraju, 2014).

7.Performance Management

As part of the DDSCM concept, performance indicators should be defined because they are fundamental for monitoring operations and evaluation of performance in the supply chain. Secondly, performance measurements should support analysis. This entails that historical and current data can be used to analyse data across multiple dimensions, revealing trends, problems and so on. Thirdly, performance indicators should have a management application, fostering communication among executives, managers and staff (Bjartnes *et al.*, 2008).

Performance management entails measurement of supply chain performance (Du Toit and Vlok, 2014) and supply chain performance measurements require a consistent and comparable holistic hierarchy of indicators, based on agreed upon strategies, performance targets and priorities (Dreyer *et al.*, 2010). It is therefore important to set appropriate metrics and goals since these help the organisation to evaluate its performance and guide improvement (Croxton et al., 2002). Through an

ICT based performance measurement system, it is easy to realise real-time measurements and enhance decision making with a collaborative perspective (Bjartnes *et al.*, 2008). Since all organisations in a demand chain are customer centric, it is vital to align organisational performance metrics with value chain performance metrics (Seethamraju, 2014).

The supply chain metrics adopted from the SCOR model (reliability, cost, responsiveness, and agility) (APICS, 2017) that measure and monitor the performance of supply chain processes, will be used to evaluate the DDSCM processes and are shown in Table 5.5.

Table 5.5: Performance metrics, (Hines, 2004 ; APICS, 2017)

	Attribute	**Metric**
Internal	Cost	Supply chain management cost
	Assets	Return on working capital
		Return on investment
Customer	Reliability	Average delivery time vs promised delivery time.
		Percentage of stock availability.
		Percentage of orders complete and on time.
		Percentage of defects and scrap.
		Number of customer complaints.
	Responsiveness	Delivery and replenishment cycle times.
		Order fulfilment cycle time
	Agility	Time it take to change capacity.
		Time it take to change schedules.

5.7. The potential benefits of demand driven supply chain management

The seamless coordination of operations across demand driven chains lead to enhanced supply chain performance (Markham T. Frohlich and Westbrook, 2002). The supply chain performance encompasses the reduction of supply chain costs (M. Frohlich and Westbrook, 2002; Rainbird, 2004; Juttner, Christopher and Baker, 2007; Canever, Trijp and Beers, 2008; Santos and D'Antone, 2014). DDSCM seeks to eliminate supply chain costs associated with ordering and stocking unneeded supplies by focusing on understanding and responding to actual demand or current needs for medical supplies (Haavik, 2000). Demand drives product ordering and replenishment processes. Another potential benefit of DDSCM is the effective management of demand volatility which in most instances lead to stock outs (Canever, Trijp and Beers, 2008). Table 5.6 outlines in detail the potential benefits of transitioning towards DDSCM.

Table 5.6: Potential benefits of DDSCM

	Heikkila (2002)	Frohlich & Westbrook (2002)	Hines (2004)	Jacobs (2006)	Canever et al., (2008)	Treville et al., (2004)	Juttner et al., (2007)	Rainbird (2004)	Bonomi & D'Antone (2014)	Selen & Soliman (2002)	Korhonen et al., (1998)	Hilletofth (2011)	Agrawal (2012)	(Eagle, 2017)
Enhanced supply chain delivery performance	X	X	X		X	X	X	X	X	X	X	X	X	
Supply Chain Cost reductions			X	X			X		X					X
Reduction in the lead time gap	X	X		X		X						X		X
Inventory levels reductions	X	X	X	X		X	X							X
Supply chain efficiency improvement	X													
Enhanced communication and reduction in forecast errors and risks		X		X	X		X		X					
Delivery accuracy/ perfect order fulfilment											X			
Responsiveness and quick response times		X		X		X			X	X	X		X	
Improved customer service and satisfaction	X	X			X	X	X	X	X		X			
Reduction in stock outs	X	X		X	X		X	X		X	X			
Quality improvement and reduction in product obsolesce	X	X		X	X		X	X		X	X			
High capacity utilization and service levels														X

Building demand driven supply chains (DDSC) has been the aim of supply chain strategists. DDSC lowers risk by replacing forecast data with real-time consumption information, which has the advantage of being more accurate. Some organisations with advanced DDSC reduced inventories by 33 per cent, improved delivery performance by 20 per cent and reduced total supply chain costs (Hines, 2004).

The availability of timely demand and inventory information enhances responsiveness, delivery accuracy and order fulfilment (Korhonen, Huttunen and Eloranta, 1998; Markham T. Frohlich and

Westbrook, 2002). This information results in the improvement of inventory management, which in turn leads to the reduction of stock-outs and obsolete stock. Access to and sharing of information contributes to reduced demand variability and uncertainty in the supply chain and consequently reduction of the bullwhip effect (Dreyer *et al.*, 2010). By relying on a system of coordinated technologies and processes that senses and reacts to real-time demand signals across a tight network of customers, suppliers and employees, a demand-driven supply network can minimize demand distortion (Hadaya and Cassivi, 2007). With DDSCM, customers are always satisfied (Heikkilä, 2002) since they are receiving the products that they need at the right time and in the right quantity (Canever, Trijp and Beers, 2008).

5.8. Chapter summary

Supply chain strategies need to be configured to match customer demand by being customer facing and customer focused. The DDSCM links customer demand to the supply chain to reduce waste, lower risk and improve profitability (Hines, 2004) or availability of medicines in the case of healthcare facilities. DDSCM consists of coordinated systems and processes that are designed to capture, analyse, and share demand and inventory information for the purposes of collaborative decision-making. A demand-driven supply chain responds to actual customer consumption. The premise of demand driven supply chains is to develop synergy along the chain wherein end customers trigger action and products and services are pulled up from one link to the next based on demand. All actors in the demand driven supply chain are sensitive and responsive to demand information of the ultimate consumer and should be able to meet those varied and variable demands in a timely and cost-effective manner. This entails that an event occurring at the demand side will trigger the replenishment process (Seethamraju, 2014). Because demand ultimately drives the product ordering and replenishment, orders are generated on the basis of an economic order quantity calculations that takes into account factors such as safety stock, lead-time, seasonality and demand created by exceptional circumstances (Haavik, 2000).

In the context of the public healthcare sector, the supply chain begins with the patient and the primary objective of the supply chain is to ensure that the health Service Delivery Point (SDP) is never without products. Health SDP include the health facilities, polyclinics and hospitals where care is provided. These facilities are the *customers* that the supply chains serve. To that end, it is important to note that, to improve the healthcare outcomes of the marginalised population; healthcare providers need access to medicines at the right time and in the right quantity. Without products and non-drug consumable materials, health facilities are unable to serve their patients and clients, as a result, countries are unable to realize good outcomes for their populations (USAID, 2010). It is therefore, the role of the healthcare supply chains to ensure that medicines are always available at the healthcare facilities. However, poor management of healthcare supply chains can be a barrier to the availability of medicines and a source of high cost in healthcare systems.

This chapter provides a literature review and SLR on the DDSCM approach as associated benefits of DDSCM. Some of the potential benefits that the healthcare system can reap include enhanced healthcare supply chain performance, reduction in supply chain costs, enhanced healthcare outcomes, and improved inventory management leading to reduction in medicines stock outs and medicines obsolescence.

Through a systematic literature review, this chapter classified the DDSCM success factors into seven key dimensions, which include distribution management, visibility, technology, collaboration, human resources, organisational alignment and performance management.

Firstly, supply chain configurations in healthcare systems have to be developed, starting with the health facilities because that is where demand for healthcare medicines emanates from. This is the customer centric view of the supply chain. Another aspect that is core to demand driven healthcare supply chains is the visibility of demand and inventory at each level. This can be consumption patterns of medicines at each health facility, epidemiological trends or the status of medicines inventory. This information is used in demand and supply planning. To enhance this demand and inventory visibility, there is a need for technologies to capture, analyse and share real time information to each level of the healthcare supply chain. In addition, demand-driven healthcare SCM requires collaboration between the upstream and downstream supply chain partners. This can be achieved through strategic supplier relationships, mutuality and trust. Moreover, the integration of the supply and demand processes in healthcare supply chains is a necessity for DDSCM. Integration can also be conceptualised as the integration of information systems and decision support systems through a technology platform.

However, the distribution strategies should also be able to complement other DDSCM key success factors. Strategies such as cross-docking, optimised distribution through third party logistics (3PLs), and responsive and flexible distribution systems are prerequisite requirements for DDSCM in healthcare supply chains. Lastly, all of these key success factors can only be practical if there is good leadership, governance, skills and talent development programs.

Chapter 6 : A Comparative Review on Supply Chain Maturity Models

6.1. Introduction

In this chapter, a comparative review of supply chain maturity models is conducted. The major contribution of this chapter is that it provides a framework for designing and testing maturity models for empirical validity. The framework also outlines the necessary traits that a maturity model must possess. (Fraser et al., 2002). By the end of this chapter, the following questions are addressed:

Chapter 6

- What are the origins of maturity models?
- What design requirements should a maturity model satisfy so that it can be used as an assessment tool and guide the development of roadmaps for performance improvement?
- What kind of maturity models have already been developed to assess the maturity and capability of supply chain practices?
- How do the supply chain maturity models differ from each other?
- To what extent do existing supply chain maturity model meet the design requirements?

6.2. Origins and nature of maturity models

The notion of evolution from an initial state to some more advanced state is called maturity (Fraser, Moultrie and Gregory, 2002). Maturity can be defined by a series of stages that form a desired path towards a goal (Pöppelbuß and Röglinger, 2011). In an organisation, process maturity implies that processes are well comprehended, supported, monitored, documented and there is continuous training and improvement throughout the organisation (Fraser, Moultrie and Gregory, 2002).

The concept of maturity models represent the stages through which processes and organisations progress as they are defined, implemented and improved upon (Clark and Jones, 1999). This can be achieved through institutionalization, policies and corporate culture (Paulk et al., 1993). Pöppelbuß and Röglinger (2011) suggest that, maturity models should not only focus on stages of development but should emphasise the elements that drive the evolution process towards a better state. The purpose of a maturity model is to assist companies in comparing the maturity of their processes against best practice (Netland and Alfnes, 2008) and moreover to provide a roadmap for improvement (Battista, Fumi and Schiraldi, 2012).

6.2.1. Foundation of maturity models

Several maturity models have been developed for different disciplines such as innovation, quality management, research and development, product and software development, supplier relationships and SCM (Fraser, Moultrie and Gregory, 2002). However, the origins of maturity models can be traced back to the work of Crosby (1979) who developed a quality maturity grid (Fraser, Moultrie and Gregory, 2002). The quality maturity grid provides a way of measuring and managing organisational processes according to five maturity stages; uncertainty, awakening, enlightenment, wisdom and certainty (Crosby, 1979). In a quality maturity grid, an organisation can be situated at any level in the continuum. The first stages of the maturity grid outline poor knowledge about quality and subsequent stages represent the transformation of attitude and understanding of quality as a management tool (Garcia, 2008).

The quality management grid inspired the development of a Capability Maturity Model (CMM) by the United States of America Defence Software Engineering Institute. This is the most popular maturity model concept representation (Netland and Alfnes, 2008).The CMM provides a continuous software improvement path towards process capability (Paulk et al., 1993) as shown in Figure 6.1. The CMM consist of five evolutionary levels; initial, repeatable, defined, managed, and optimising (Paulk et al., 1993).

The difference between the CMM and quality maturity grid is that the CMM further identifies key process areas (KPAs) that need to be performed at each maturity level before going to the next level. It is postulated that CMM was the trigger to the development of numerous of maturity models (Van Dyk, 2013).

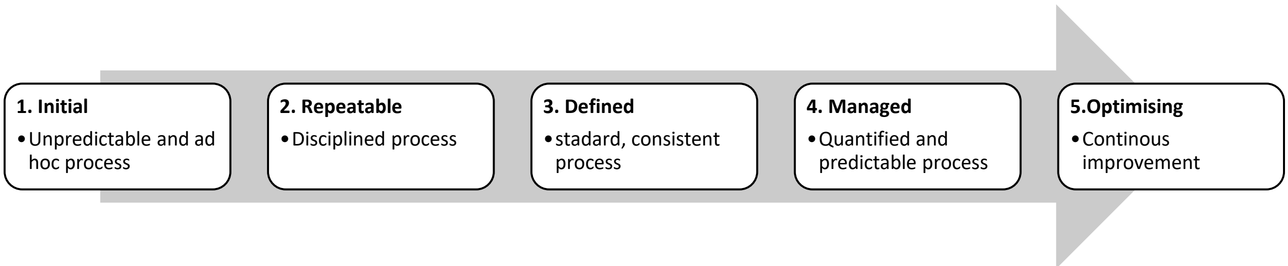


Figure 6.1: Capability Maturity Model

Source: (Paulk et al., 1993)

6.2.2. Characteristics of maturity models

The concept of process maturity proposes that a process has a lifecycle that can be assessed by the extent to which the process is defined, managed, measured and controlled (Reyes and Giachetti, 2010). Figure 6.2 provides a detailed outline for the characteristics of maturity models.

a. Maturity model purpose

Pöppelbuß and Röglinger (2011) and van Dyk (2013) postulate that a maturity model can be used as a tool to assess the "*As-Is*" situation (*descriptive maturity model*), so as to guide the development of an improvement and control roadmap (*To-Be*) (*prescriptive maturity model*). Furthermore, a maturity model can be used as a benchmarking model for similar processes in other industries (*comparative maturity model*)(Pöppelbuß and Röglinger, 2011). Descriptive, prescriptive and comparative perspectives reflect the purpose of the maturity model, what the maturity model intends to achieve.

b. Maturity model traits

Fraser et al., (2002) provides a framework for designing maturity models. The framework outlines the necessary traits that a maturity model must possess. Maturity models usually have: (i) three to six maturity levels, (ii) a generic level descriptor, (iii) a number of dimensions, and (iv) each level description is based upon the activities associated that level.

c. Maturity model typology

The framework developed by Fraser et al., (2002) further classifies maturity models into different types:

- Maturity grids

Maturity grids consist of concise descriptions of each activity for each maturity level. The textual descriptions outline all activities and capabilities of that maturity level.

- Likert-like questionnaires

Likert-like questionnaires maturity models consist of a question or statement of best practices and the respondents are to provide score on a scale from 1 to n. The scale 1 to n represents the respondent's preferences.

- Hybrid

Hybrid maturity models combine questionnaires with definitions of maturity. The maturity levels are described then a respondent is to score a preference based on the questions asked regarding that maturity level.

- Capability maturity model type

Capability maturity model type, contain both generic and specific goals and key practices for each process area and maturity level (Mendes, Leal and Thome, 2016).

d. Maturity model dimensions

A framework for classifying maturity model dimensions was developed by Mettler (2011). The framework outlines whether a maturity model addresses dimensions such as Process, Technology, People or all the three dimensions. For example, the CMM model addresses the process dimension only (Paulk et al., 1993).

- Process maturity

The process dimension represents the extent to which a process is explicitly defined, managed, measured, and controlled,

- People maturity

The people dimension provides an overview of the extent to which people can develop knowledge and improve proficiency and;

- Technology maturity

The technology dimension defines the extent to which a technology reaches a threshold level. A detailed description of the characteristics of maturity models is shown in Figure 6.2.

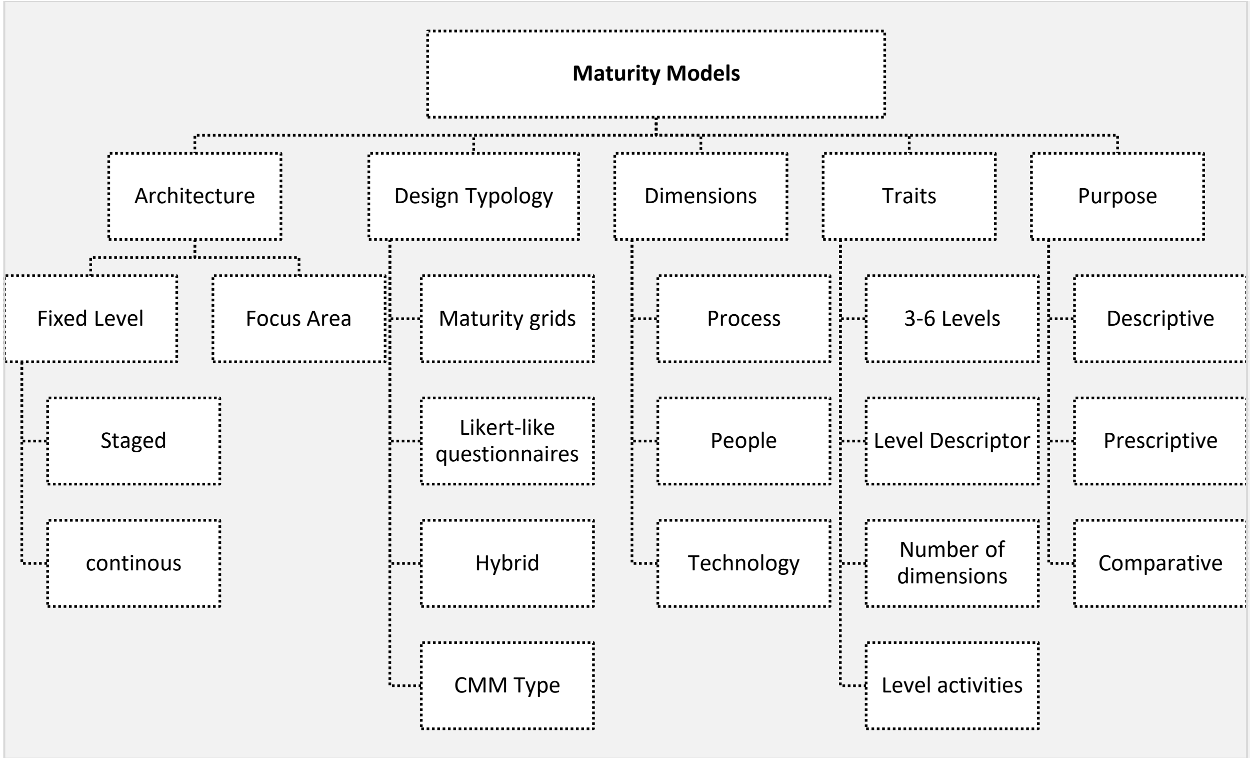


Figure 6.2: Framework for designing maturity models

Source: (Fraser et al., 2002; Steenbergen, 2011; Mettler, 2011; Pöppelbuß and Röglinger 2011)

e. Maturity model architecture

Steenbergen (2011) classified maturity models according to the architecture of the maturity models. There are two types of maturity model architectures; fixed level maturity model and focus area maturity model as shown in Figure 6.2. Fixed level maturity models are further classified into staged maturity models and continuous maturity models.

In Staged maturity models, the achievement of a level is measured by having a key process area fully implemented. Table 6.1 provides a clear description of the Staged maturity model. A Staged maturity model contains fixed number of levels usually between three and six (Steenbergen, 2011). Each maturity level contains a number of key process areas that have to be satisfied for the firm to achieve that specific level and proceed to the next stage (Brooks, El-Gayar and Sarnikar, 2013).

Table 6.1: Staged maturity model , (Steenbergen, 2011)

Key process area	1	2	3	4	5
KPA1	x				
KPA2			x		
…				x	

Conversely, the Continuous maturity model requires having the key process area implemented to an extent required by the maturity level as shown in Table 6.2. It contains a fixed number of levels usually between three and six (Steenbergen, 2011). Continuous maturity models allows for the evaluation of each dimension (Brooks, El-Gayar and Sarnikar, 2013). Key process areas are not attributed to a level, but the generic maturity levels are distinguished within each key process area.

Table 6.2: Continuous maturity model , (Steenbergen, 2011)

Key process area	1	2	3	4	5
KPA1	x	x	x	x	x
KPA2	x	x	x	x	x
…	x	x	x	x	x

For Focus area maturity model, maturity levels are distinguished that are for a specific focus area, and the number of levels differ depending on the focus area (Steenbergen, 2011) as shown in Table 6.3. No fixed number of maturity levels exists, but instead the maturity model defines specific maturity levels for each focus area. The overall maturity of an organisation is expressed as a combination of the specific maturity level.

Table 6.3: Focus area maturity model , (Steenbergen, 2011)

Focus area	1	2	3	4	5	6	7	…
FA1	x	x					x	
FA2			x	x		x		
…	x			x				x

6.3. Comparative review of supply chain maturity models

Scopus, Web of Science (WoS) and Science Direct databases were searched with the following key words: "*supply chain management" AND "maturity models*". Papers were selected based on the relevance of both the topic and abstract. Papers that were excluded from this study did not address the following attributes:

- Did not define the traits of maturity models,
- Did not present a new model but quote an existing model,
- Only presented assessment methodology not a holistic maturity model and,
- Only focused on a specific supply chain aspect such as supply chain human resources or supply chain risk.

Only 13 papers on SC maturity models were relevant to our study for comparative analysis.

6.3.1. Comparative analysis framework for supply chain maturity models

A framework for comparative analysis of the SC maturity models was developed from the literature and is shown in Figure 6.3. It combines maturity model design requirements (Rosemann and Bruin, 2005; Becker, Knackstedt and Pöppelbuß, 2009; Mettler, 2011) and maturity model characteristics (Fraser, Moultrie and Gregory, 2002; Mettler, 2011; Steenbergen, 2011).

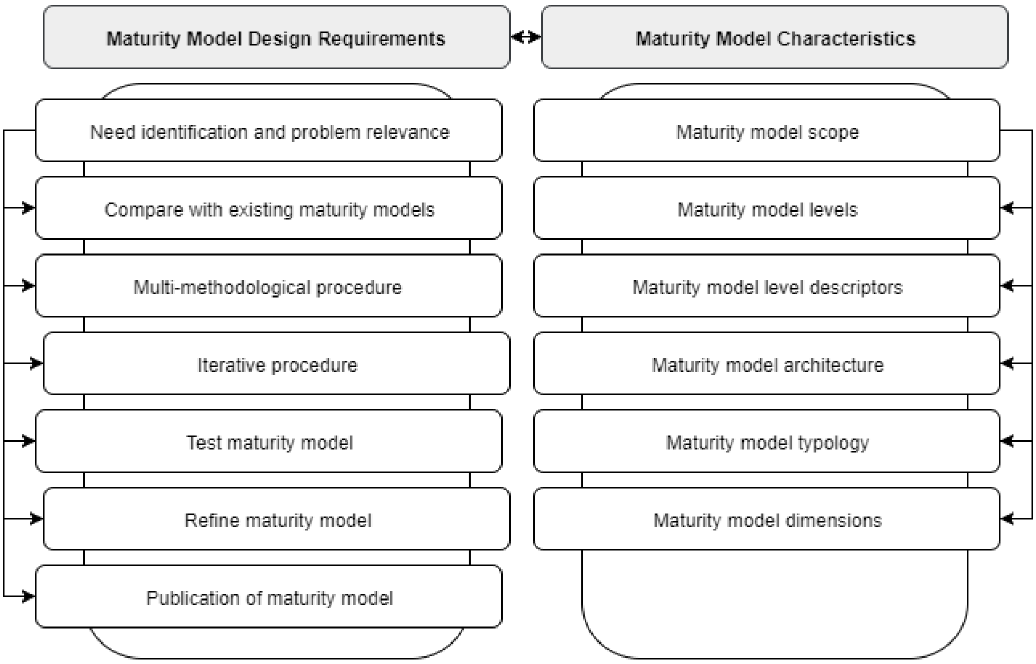


Figure 6.3: Comparative Analysis Framework

Source: (Rosemann and Bruin, 2005; Becker, Knackstedt and Pöppelbuß, 2009; Mettler, 2011; Fraser, Moultrie and Gregory, 2002; Steenbergen, 2011)

a. Maturity model design requirements

Table 6.4 shows a set of maturity model design requirements.

Table 6.4: Design requirements for maturity models

	Design Requirement	Description
1	Need identification and problem relevance	Outline the application domain and the benefits of developing the maturity model. It also identifies the gap that can be filled by the maturity model.
2	Compare with existing supply chain maturity models	The development of a maturity model should be substantiated by comparison with previous maturity models. The new maturity model can be an improvement of an existing maturity model
3	Multi-methodological procedure	Several research methods should be applied during the development of the maturity model: case studies, literature reviews, surveys and interviews.
4	Iterative procedure	The development of a maturity model should be a systematic process
5	Test and Evaluate Model	The testing and evaluation of the developed maturity model is based on the review of the maturity model in terms of its ability to satisfy all the design requirements as well as to evaluate its usefulness and effectiveness.
6	Refine Model	Using the results and feedback from the maturity model testing and evaluation, refine the maturity model to improve its usefulness
7	Target publication	Decide on the mechanism through which you will communicate the refined maturity model either, journal articles, conference publications or reports

b. Maturity model characteristics

Fraser et al., (2002) claims that the maturity model characteristics guide researchers to understand maturity models much better. The maturity model characteristics contained in the comparative analysis framework are illustrated in Table 6.5.

Table 6.5: Maturity model characteristics

	Maturity model characteristics	Description
1	Maturity model scope	Outlines the supply chain area covered by the maturity model.
2	Maturity model levels	Represent the progressive evolutionary steps of the maturity model, with each step outlining enhanced capabilities.
3	Maturity model architecture	Represent whether a maturity model is a staged, continuous or focus area.
4	Maturity model typology	Typology provides an outline of the maturity model design.
5	Level descriptors	Level descriptors provides a description of a maturity level. name

Using the comparative analysis framework, Table 6.6 provides a comparative analysis for SC maturity models based on the design requirements of maturity models. In addition, Table 6.7 provides a comparative analysis of SC maturity models based on characteristics of maturity models.

Table 6.6: Comparative analysis of supply chain maturity models based on design requirements

Design Requirements for maturity model development	Stevens (1989)	Stonich and Moncrieff (2001)	Ayers and Malmberg (2002)	Lockamy and McCormack (2004)	McLaren (2006)	Vaidyanathan and Howell (2007)	IBM (2007)
Compare with other maturity models	No comparison with other existing maturity models. Model developed by consultancy firm.	Not specified	No comparison with other MM	Transfer of Business Process Orientation (BPO) MM to SCM and adoption of SCOR Processes	Comparison of existing supply chain models. The model integrate two dominant supply chain maturity models	Review of SCM MM, CMM and other maturity models	No comparison with other MM. IBM also looks at management consultancy
Iterative Procedure	No methodology specified for the development of the MM.	Not specified	No complete description of how the dimensions and stages of MM are chosen	Development of model from the principles of business process orientation	Integration of two maturity models into one	Conceptual model developed based on the concepts of process maturity.	Survey instrument used to collect data on what leading companies are doing
Evaluation	The model is not applied	Applied in a discrete electronic equipment sector	MM is not tested	Survey instrument to investigate SCM process maturity and overall supply chain performance	Case company	No validation	Application of model in a manufacturing organization and logistics , customer order management as well
Multi-methodological approach	Literature review	Case study	Literature search	Literature Search, survey instrument	Case study, interviews and questionnaires	Only Literature review	Only experts through a survey instrument
Problem Relevance	Supply chain issues such as lead-time,	It is vital that organizations	Many obstacles to complex Supply	No published studies which examine the	Despite apparent benefit of web-enabled supply	Construction industry is still in	As supply chains evolve from static to

Design Requirements for maturity model development	Stevens (1989)	Stonich and Moncrieff (2001)	Ayers and Malmberg (2002)	Lockamy and McCormack (2004)	McLaren (2006)	Vaidyanathan and Howell (2007)	IBM (2007)
	inventory levels, availability caused by conflicting functional goals and attitudes can be resolved by an integrated supply chain, therefore there is need of a supply chain strategy to ensure a structured approach to supply chain integration	determine their strategic intent in leveraging their supply chain and implement best practices to enable improvements	chains Improvements and some initiatives fall short of objectives	concept of process maturity relative to SCM	chain integration , its further study and application is hindered by the lack of empirically supported model for classifying the varying levels of supply chain integration that are now possible using e-business technologies	infancy but however other maturity models such as CMM cannot be applied directly to guide in the development of the industry	demand driven other companies are striving to meet their objectives and there is room for improvement but developing top supply chains is hard
Problem definition	Model to guide organizations towards an integrated supply chain	Model describing stages of operational capabilities within a supply chain and providing a roadmap for improvement	Framework showing how supply chain organization and demand driven supply chain can support the introduction of information technology to SC	SC process MM that can be used to help facilitate enhanced SC performance	Framework to assess the level and integration dimensions including supply chain strategy ,performance management and decision making	Framework to be used to assess processes, technologies, strategy and value in construction industry and provide a roadmap towards	Framework for describing how different supply chains for organizations address challenges for different supply chain process areas

Design Requirements for maturity model development	Stevens (1989)	Stonich and Moncrieff (2001)	Ayers and Malmberg (2002)	Lockamy and McCormack (2004)	McLaren (2006)	Vaidyanathan and Howell (2007)	IBM (2007)
						operational excellence.	
Publication	Journal Paper	Report	Journal Paper	Journal Paper	Conference Paper	Conference Paper	Report

Table 6.6: Comparative analysis of supply chain maturity models based on design requirements (continued)

Design Requirements for maturity model development	Lahti, Shamsuzzoha and Helo, (2009)	Garcia Reyes and Giachetti, (2010)	Battista, Fumi and Schiraldi, (2012)	Fischer et al., (2016)	Ho, Kumar and Shiwakoti, (2016)	Mendes, Leal and Thome, (2016)
Compare with other maturity models	Comparison with SC and logistics MM	Evaluation of enterprise reference frameworks, SCOR, and CMM	Stages of the logistics maturity model are developed from the Capability maturity model integration	Recognizes MM such as quality maturity grid, CMM, BPO, SCOR, SCM	Model developed based on capability maturity model integration approach	Comparison with other SCM maturity models
Iterative Procedure	Development of a new model using a model developed by PMG and PRT management consultants as a development guideline	Literature search to determine structure of a MM then use of Delphi study to identify dimension, stages, improvement tools and factors	No clear methodology explained that was used to develop the logistics maturity model	No complete description of methodology used for the development of the MM and how the dimensions and stages are derived	Only adopted the CMMI approach and used literature search on collaboration to populate the model	Dimensions and stages adopted from literature search. Then SC executives applied Analytical hierarchy process to assign priorities and rank the actual and desired dimensions

Design Requirements for maturity model development	Lahti, Shamsuzzoha and Helo, (2009)	Garcia Reyes and Giachetti, (2010)	Battista, Fumi and Schiraldi, (2012)	Fischer et al., (2016)	Ho, Kumar and Shiwakoti, (2016)	Mendes, Leal and Thome, (2016)
Evaluation	Application of model in a case company	Validation with experts	The model is not applied in any supply chain settings	The model is applied in a toy case in the automotive supply chain	The MM is not tested	Tested in a large beverage company in three different countries
Multi-methodological approach	Literature search, case study	Literature search, Delphi method, experts, case study	Literature review only	Literature review and case study in a toy case automotive supply chain	Literature review only	Literature search, experts, case study
Problem Relevance	A supply chain strategy for the visibility of supply and demand collaboration determines the success of a firm	Lack of guidelines in SC assessment and improvement. Also existing models are theoretical constructs and not tested with actual Supply chains	There is lack of an easy to use framework, hard criterion of process modelling and evaluation of maturity and lack of framework that in cooperate global vision of business logistics processes	Currently, there is a gap in literature for models that measure the maturity of supply chain flexibility	There is lack of clear theoretical framework which guides organizations in implementing or improving the collaboration maturity level for a supply chain	No framework that combine dimensions of demand driven supply chain of Ayers (2002) and Lambert (2008) supply chain processes
Problem definition	A framework for organizing disparate supply chain efforts around business processes, tools and standards	Framework that can evaluate their current supply chains and develop an improvement roadmap. Highlights the best practices	Model to support the enterprises to understand immature processes, improvement actions.	Model to measure the maturity of flexibility in inter-organizational supply chains	Framework to analyze collaboration practices in organizations and develop a roadmap towards advanced collaboration in supply chain	Frame work for assessment of organization current DDSC maturity levels and helps in the development of a roadmap to set SC strategies

Design Requirements for maturity model development	Lahti, Shamsuzzoha and Helo, (2009)	Garcia Reyes and Giachetti, (2010)	Battista, Fumi and Schiraldi, (2012)	Fischer et al., (2016)	Ho, Kumar and Shiwakoti, (2016)	Mendes, Leal and Thome, (2016)
		that a company should focus on in improving.				
Publication	Journal Paper	Journal Paper	Conference paper	Conference paper	Conference Paper	Journal Paper

Table 6.7: Comparative analysis of supply chain maturity models based on maturity model characteristics

Reference	Scope	No. of levels	Level Descriptors	Architecture	Typology	Dimensions
Stevens (1989)	SCI	4	Baseline, functional, internal integration, external integration	Continuous	Grid	7 focus areas; Supply chain planning, organisational structure, customers, information flow, performance metrics, planning technologies and collaboration
Moncrieff and Stonich (2001)	SCM	4	Functional focus, internal integration, external integration, cross enterprise collaboration	Staged	Grid	4 focus areas; Supply chain strategy, supply chain performance management, supply chain processes, supply chain organisation
Ayers (2002)	SC	4	Infrastructure, cost reduction, collaboration, strategic	Staged	Grid	4 focus areas; supply chain organisation, demand driven supply chain, supply chain systems, stage challenges
Lockamy & McCormack (2004)	SCM	5	Ad hoc, Defined, Linked, Integrated, Extended	Staged	CMM	6 Focus Areas; suppliers, customers, source, make, deliver, plan
Mc Laren (2006)	SCI	5	Functional focus, internal integration, linked network, integrated network, optimised network	Continuous	Grid	4 focus areas; Supply chain strategy, supply chain performance management, supply chain processes, supply chain decision making
IBM (2007)	SCM	5	Static, functional, horizontal integration, external collaboration, demand driven	Staged	Grid	3 focus areas; customer order management, manufacturing operations, logistics excellence
Vaidyanathan & Howell (2007)	CSCM	4	Ad hoc, defined, managed, controlled	Staged	Hybrid	5 key areas: Project management, collaboration, information flow, planning , automation
Lahti et al., (2009)	SCM	4	Functional focus, internal integration, external integration, cross enterprise collaboration	Staged	Hybrid	7 focus areas; Supply chain processes, information flow, organisational roles and responsibilities, supplier and customer partnerships, performance measurements, resources

Reference	Scope	No. of levels	Level Descriptors	Architecture	Typology	Dimensions
Reyes and Giachetti (2010)	SC	5	Undefined, defined, manageable, collaborative, leading	Continuous	Hybrid	7 focus areas; suppliers, customers, production, inventories, human resources, information systems and technology, performance measurement systems
Battista et al. (2012)	LMM	5	Start-up, managed, defined, measured, optimised	Continuous	Grid	4 focus areas; procurement, plan, distribute, storage
Mendes et al., (2016)	DDSC	5	Basic push, optimised push, hybrid push-pull, advanced demand driven, optimised demand driven	Continuous	CMM	3 focus areas: Demand management, Supply and operations management, Product Lifecycle management
Fischer et al., (2016)	SC Flexibility	5	No flexibility, intra-firm flexibility, reactive flexibility, proactive flexibility, paradigmatic flexibility	Continuous	Grid	5 focus areas; collaboration, information flow, information technology, internal flexibility types, performance measurement
Ho et al., (2016)	SCC	5	Initial, managed, defined, quantitatively managed, optimizing	Staged	Grid	15 focus areas including, Information sharing, goal congruence, decision synchronization, incentive alignment, resource sharing, collaborative communication, managerial support, internal alignment, relationships

Prior to the development of many SC maturity models in literature, a comparison of existing maturity models is conducted. A number of SC maturity models were developed iteratively. Literature review, experts, Delphi method, case studies and surveys are predominant research methods used. Notably, there are only a few studies that attempt to empirically evaluate the maturity models, and only a few SC maturity models were evaluated with the use of case studies (Lahti, Shamsuzzoha and Helo, 2009), interviews, experts (Garcia Reyes and Giachetti, 2010) and surveys (Lockamy and McCormack, 2004). Other maturity models were developed only using extensive literature review (Vaidyanathan and Howell, 2007).

The scope for the supply chain maturity models covered; SCM, Supply Chain Integration (SCI), SC, Supply Chain Collaboration (SCC), Construction Supply Chain Management (CSCM), Logistics Maturity Model (LMM), Supply Chain Flexibility (SC Flexibility) as shown in Figure 6.4. Dominate maturity models are from SCM.

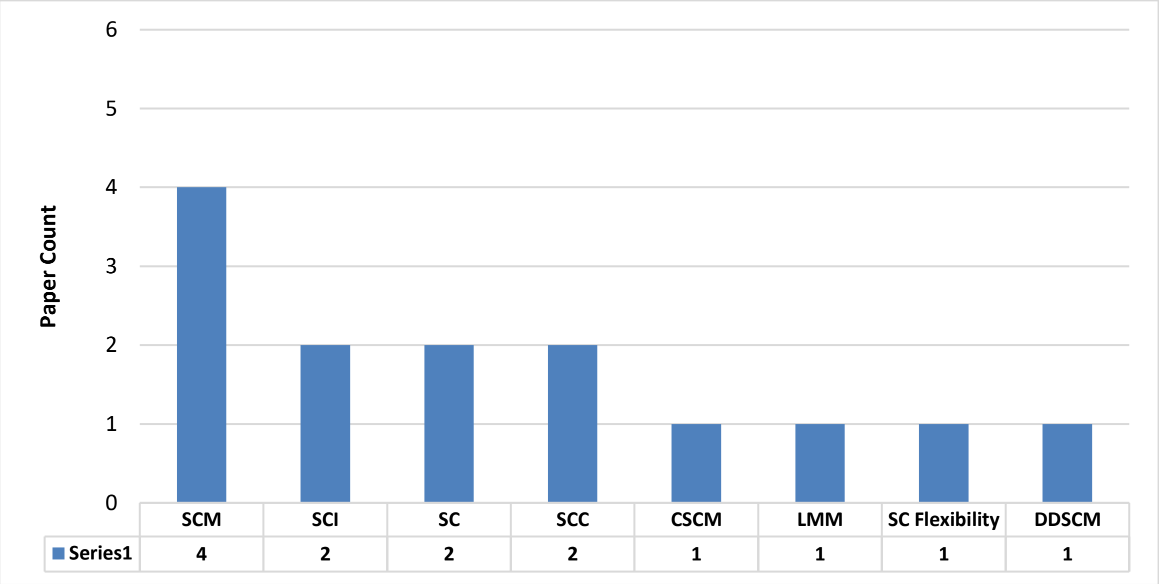


Figure 6.4: Scope of maturity models

Furthermore, the maturity levels for the SC maturity models ranged between three and six and have different level descriptors depending on the scope of the maturity model, with initial maturity reflecting processes that are ill-defined and high maturity representing a level where processes are well measured and managed.

In addition, staged models are dominating under the maturity model architecture classification. This implies that maturity models require all key process areas in a maturity level to be accomplished before progressing to the next level as opposed to the incremental approach reflected by continuous maturity models. Furthermore, concerning maturity models typology, maturity grids have a higher frequency, followed by hybrids and then by CMM-type due to their complex nature. Maturity grids consist of the descriptor of the maturity level followed by a few expressions describing the maturity level. The hybrid maturity models consist of both maturity model description and a checklist to assess the maturity of an organisation. Figure 6.5 provides an outline of the maturity model typology.

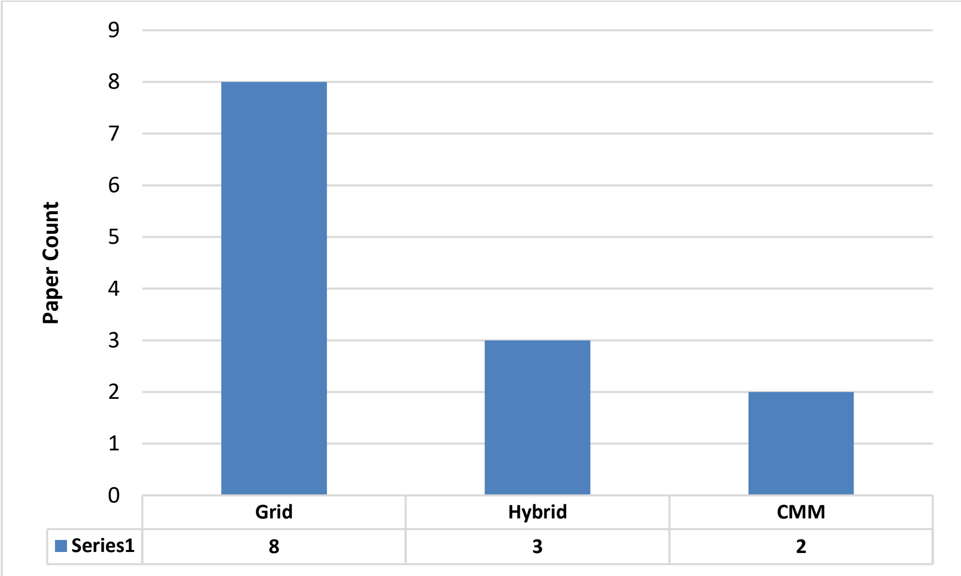


Figure 6.5: Maturity Model Typology

Lastly, the dimensions of the maturity models vary significantly between three and fifteen key process areas. The dimensions that are most common across most SC maturity models include information flow, information technology, collaboration, organisational roles and responsibilities and are categorised in Table 6.8. Some of the concepts from the SC maturity models were extracted and included in the DDSCM maturity model.

Table 6.8: Concepts extracted from the existing supply chain maturity models

Classification	Dimension	References
Visibility	Information flow and information sharing	Ho et al., (2016), Fischer et al., (2016), Lahti et al., (2009), Vaidyanathan & Howell (2007), IBM (2007), Ayers (2002), Moncrieff and Stonich (2001), Stevens (1989)
Technology	Technologies that assist in planning Information systems and technologies	Fischer et al., (2016), Mendes et al., (2016), Reyes and Giachetti (2010), Lahti et al., (2009), Moncrieff and Stonich (2001), Stevens (1989)
Collaboration	Collaborative communication	Ho et al., (2016), Fischer et al., (2016), Lahti et al., (2009), Mc Laren (2006), Lockamy & McCormack (2004), Moncrieff and Stonich (2001), Stevens (1989)

	Goal congruency	
	Decision synchronisation	
	Incentive alignment	
	Resource sharing	
	Relationships and partnerships	
Human resources	Organisational roles and responsibilities	Reyes and Giachetti (2010), Lahti et al., (2009)
Distribution management	Supply chain planning	Fischer et al., (2016), Mendes et al., (2016), Battista et al. (2012), Reyes and Giachetti (2010), Vaidyanathan & Howell (2007), IBM (2007), Lockamy & McCormack (2004), Stevens (1989)
	Order management an automation	
	Inventory storage and distribution	
	Demand management	
	Supply and operations management	
	Product life cycle management	
	Flexibility	
Organisational alignment	Organisational structure	Ho et al., (2016), Battista et al. (2012), Reyes and Giachetti (2010), IBM (2007), Mc Laren (2006), Ayers (2002), Stevens (1989)
	Procurement	
	Management support	
Performance management	Performance measurement systems	Fischer et al., (2016), Reyes and Giachetti (2010), Lahti et al., (2009), Vaidyanathan & Howell (2007), Mc Laren (2006), Moncrieff and Stonich (2001), Stevens (1989)

6.4. Healthcare supply chain maturity models: An industry view

In literature, only two healthcare SC maturity models could be accessible. Firstly, the maturity model developed by USAID (2011), which is a four staged model that focuses on strengthening the national healthcare supply chain through the definition, measurement and management of supply chain processes. In addition, the other maturity model was developed by Levenger et al., (2013) which focuses on assessing the capability and performance of supply chain functions and enablers so as to help supply chain mangers to develop strategic and operational plans to improve performance. A detailed illustration of the healthcare SC maturity models is shown in Table 6.9.

Both maturity models are not able to manage properly the typical complexities encountered in managing DDSCM in public healthcare supply chain networks, since they focus on individual performance evaluation of organisations. However, some concepts were extracted such as clear roles, agility, streamlined processes, visibility, collaboration, alignment of objectives, human resources, information systems, inventory management, transportation and waste management.

Table 6.9: Healthcare supply chain maturity models

	USAID (2011)	Levenger et al., (2013)
Definition	Maturity model for supply chain strengthening and improvement of SCM capacity through definition, measurement and management of the public healthcare supply chain processes.	Tool for assessing the Capability and Performance of supply chain functions. The results of the assessment tool help supply chain managers and implementing partners to develop their strategic and operational plans and monitor whether activities are achieving their expected outcomes.
Number of levels	Four (4)	Five (5)
Level descriptor	Ad-hoc, Organised, Integrated, Extended	Minimal, Marginal, Qualified, Advanced practices, Best practices
Architecture	Staged	Staged
Typology	Maturity grid	Hybrid
Dimensions	Clarity of roles and responsibilities, Agility, Streamlined processes, Visibility of information, Trust and collaboration, alignment of objectives	Processes and tools, infrastructure, oversight, human resources and management information systems, product selection, forecasting and supply planning, procurement, warehouse and inventory management, transportation, dispensing, waste management, lab issuing
Design Requirements	The development process for this maturity model is not outlined	The development process for this maturity model is not outlined but assessment results for public supply chain are outlined and discussed.

6.5. Gartner Demand Driven Value Network (DDVN) Maturity Model: An industry perspective

The Gartner maturity model follows four stages (reacting, anticipating, collaboration and orchestrating) of progressive maturity along each dimension (demand management, supply management and product management) and tracks corporate supply chains through a journey from reactively operating in silos to eventually orchestrating for value across both internal and partner networks. Leading companies have achieved a much higher degree of visibility, coordination and reliable processes both within and across the Plan, Source, Make, Deliver and Return functions, but also in partnership with sales and marketing and product management organizations in lines of business. The design of their supply chains starts with what brings value to customers and then looks back through the supply network. The ability to sense, translate and shape demand, and pair up appropriate supply is also improved and both demand and supply are determined in close collaboration with customers and upstream suppliers (Purchase, 2016).

6.5.1. Gartner DDVN Maturity Model

Demand-driven value network (DDVN) is a business environment holistically designed to maximize value of and optimize risk across the set of extended supply chain processes and technologies that senses and orchestrates demand based on a near-zero-latency demand signal across multiple networks of corporate stakeholders and trading partners.

Before embarking on any transformation, supply chain leaders must evaluate their organizations' readiness to start transforming their supply chain. An organization goes through several stages of maturity as it goes throughout its journey of transforming its supply chain (Diaz, 2015). Originally developed and researched by AMR Research, Gartner has continued to expand on the DDVN maturity model (Payne 2010). The maturity model defines the maturity of an organization's supply network in terms of information and process (O'Marah 2005). The DDVN maturity framework has four stages: react, anticipate, collaborate, and orchestrate (Payne 2010). The framework (Figure 6.6) looks at a mix of business processes, technology, innovation, organization and leadership, culture, vision, response model talent, metrics, and risk (Barrett 2007; Payne 2010). In stage 1, reacting, a company is in the first step to developing basic supply chain capabilities and is still a traditional supply chain where integration barely occurs (Payne 2010). Stage 2, anticipate, at this stage, the organization is becoming more internally integrating, and is beginning to align supply and demand (O'Marah 2005). At stage 3, the organization has matured to have a demand driven supply network with strong collaborations internally and externally (Payne 2010). In stage 4, orchestrate, the organization has achieved a DDVN successfully.

The organization focuses on value creation across the entire supply chain and incorporates operational excellence and innovation excellence (Payne 2010). By orchestrating demand at the mature stage, it allows organizations' to effectively balance growth and efficiency, costs, customer service, agility, and demand variability while reducing costs. Despite all the advancements in SCM in the last decades, research shows that 65% of organizations are still in Stage 1, react, or Stage 2 anticipate of the DDVN maturity model (Hofman, 2014). Organizations are still operating in silos. Silos set personal goals that often work against each other; this in turn leads to an inefficient supply chain. Every organization is different, transforming the supply chain involves assessing what the customer wants, and then satisfying those want by adjusting the organization in the capabilities of the supply chain

(Chakravarty, 2014). For organizations to transform successfully it is required to restructure relationships with suppliers and customers, eliminate barriers, access new technology and its implementation, and have a customer driven mind-set (Chakravarty 2014). The DDVN maturity model is shown in Figure 6.6.

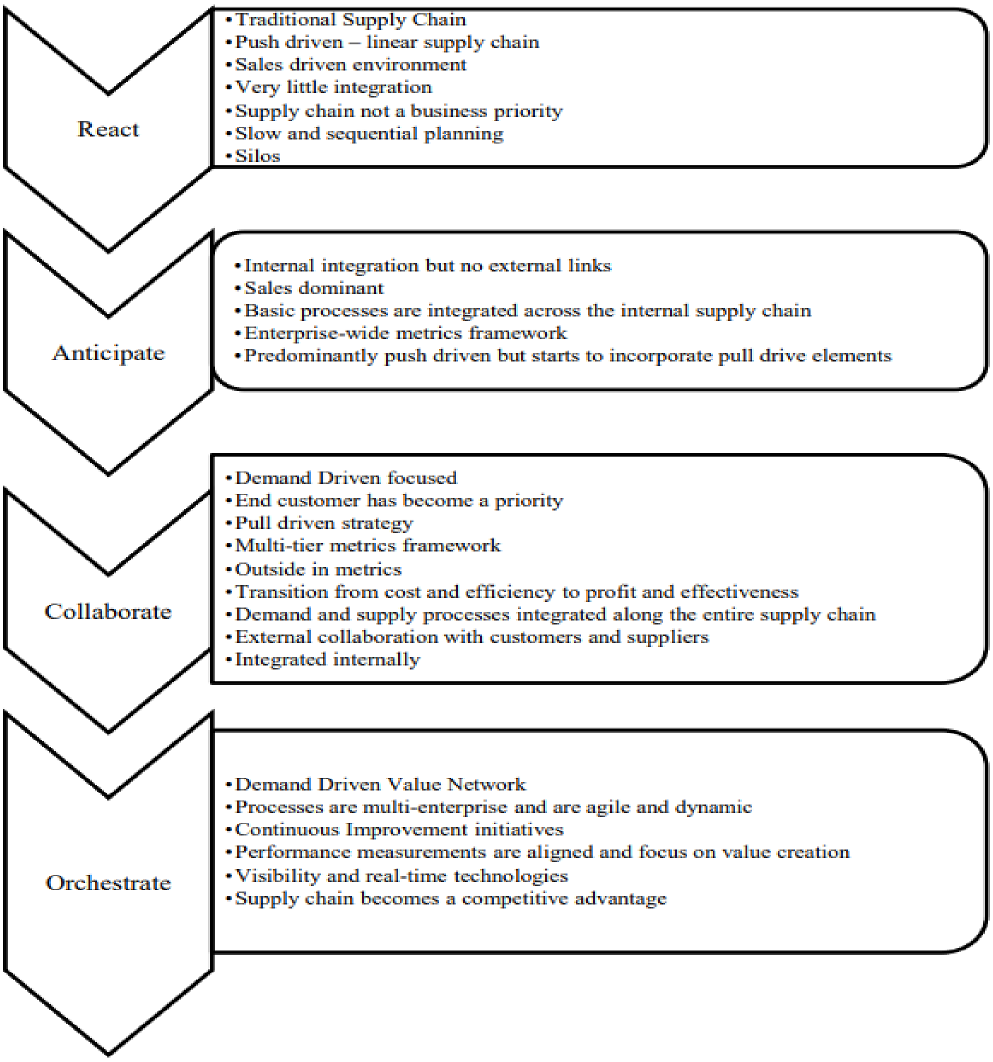


Figure 6.6: DDVN Maturity Model (adapted from Payne, 2010)

6.5.2. Experience of users of the DDVN Maturity Model: Top 25 Supply Chain Leaders in 2016

These leading supply chains are focusing on initiatives that understand and elevate the customer needs and the operational performance points needed to support them and work backward from those requirements to the process and technological transformations that will enable them.

As always, a primary goal of the Gartner Top 25 is to outline trends, capabilities and share best practices as a way to raise the bar of performance for all organisations. The ranking is focused on identifying supply chain leadership, which includes operational and innovation excellence, but also other behaviours such as corporate social responsibility and a desire to improve the broader practice of supply chain management (Purchase, 2016).

A key aspect of the Supply Chain Top 25 ranking for 2016 is the demonstration of demand-driven leadership. Transforming from inward-focused supply management functions to supply chains that orchestrate a profitable response to demand. Three key trends (Table 6.10) emerged among the leaders: closer, customer-driven partner integration, further adoption of advanced analytics and a strong focus on corporate social responsibility (Gartner, 2016). Furthermore, an analysis of the companies that demonstrate strong leadership in demand driven principles and associated best practices is shown in Appendix 15.

Table 6.10: Description of Trends among supply chain leaders

Dimension	Description	Capability (enabler)	Best practices by companies
Customer-Driven Partner Integration	Build closer integration with suppliers, partners and customers in support of more value-added end-user solutions.	Customer centricity	Centralize customer service and other customer facing functions in more cost effective regional hubs (staying relatively close to individual customers) to allow for standardization of best practices and economies of scale
		Collaboration (deeper level of integration)	Supplier representatives sit side by-side with their supply chain support counterparts in service centers to speed up collaboration cycles and ultimately, the response to customer requests, issues and priorities
		Dynamic federations of supply chain partners	hardware, software and service providers coming together for the sole purpose of bringing solutions to customers' requirements
		Digital Business	Particularly seeing this type of arrangement in the delivery of Internet of Things (IoT)-based solutions (remote monitoring and management of inventory in a large number of distributed locations using sensor chips, gateway devices, embedded software and an analytics platform for tracking inventory replenishment requirements and other performance parameters)
			Getting better visibility into own manufacturing and outbound transportation networks, but also integrating that visibility with similar data from upstream partners to provide a holistic view of supply to their customers and to sense and respond to potential disrupters earlier than they have in the past.
Adoption of Advanced Analytics	Invest in advanced analytics capabilities to make step-function improvements in performance within and across supply chain functions.	Analytics	Use of advanced analytics to aid in running multiple parts of their operations, spanning the entire end-to-end supply chain.
			Using machine learning algorithms to predict which deals in the pipeline have the highest probability of converting into real demand and which are at risk, requiring intervention.

Dimension	Description	Capability (enabler)	Best practices by companies
			Permission-based auto-replenishment of their products based on signals from internet-connected smart sensors embedded in the products at consumers' homes
		Data utilization	Usage of data captured as part of the process is used to generate better demand forecasts based on usage personas and to inform the design of new products entering the pipeline
		Artificial intelligence	Discrete manufacturing industries are using artificial intelligence to analyze digital photographs of their products from source through manufacturing and delivery. They are matching this information up with customer complaint data to spot negative patterns and identify quality problems sooner.
		Big data analytics	Consolidating near-real-time information from customers, internal manufacturing and distribution nodes, suppliers, logistics partners, and complementary third-party sources. It then applies data analytics combined with business rules to generate prescriptive recommendations and support daily decision-making, business optimization, and long-term planning of network capacity and capabilities.
			Algorithms that convert disparate data points into operational insights. In most cases, the output is predictive of a future outcome or prescriptive of what the supply chain planner or operator should do about it.
Increasing Emphasis on Corporate Social Responsibility	Link corporate strategy and social responsibility-focused efforts within supply chain.	Non-financial indicators	Increase transparency and performance in running socially responsible supply chains.
	Describe how you are capitalizing on opportunities or mitigating risks to drive your company's competitive advantage.	Environment, Social, Governance factors	Send zero waste to landfills from its global manufacturing facilities and being an overall zero waste to landfill company

6.6. Chapter summary

In order to define, manage measure and control supply chain performance, a wide range of SC maturity assessment models have been developed. A framework that outlines the necessary traits that maturity models should possess is developed in this chapter, and used as a baseline to conduct a comparative analysis on SC maturity models.

The maturity models represent stages through which supply chain processes improve, as they are defined, and implemented. The purpose of maturity models is to assist organisations in comparing the maturity of their processes against best practices and further guide them in the development of an improvement roadmap. There has been previous work in developing maturity models for supply chains. Some of these models are theoretical constructs that were not tested for empirical validity. Others models reflect the practices based strongly on the idea of benchmarking performance with other companies (Reyes and Giachetti, 2010). Despite the proliferation of SC maturity models, the maturity models have been subject to criticism, such as; maturity models lack strong theoretical foundation and empirical validity.

Moreover, there is not any supply chain maturity model able to manage properly the typical complexities in management of supply chain networks, although several efforts have been taken for improving and expanding individual performance evaluation into companies 'suppliers, distributors and customers (Lahti, Shamsuzzoha and Helo, 2009). Consequently, the findings from this chapter are a foundation to the development of the DDSCM maturity model in the next chapter 7.

Chapter 7 : Conceptual Maturity Model

7.1. Introduction

In terms of methodologies to assess an organisation's performance, several maturity models in the previous chapter 6 show the importance of having a structured process to improve performance overtime and place emphasis on the capabilities that drive the evolution process towards a better state. However, when it comes to methods for assessing performance based on DDSCM concepts, the available maturity models do not have a clear and practical framework to support organisations in identifying and assessing the maturity of DDSCM concepts in public healthcare sector.

Therefore, this chapter outlines the development of the DDSCM maturity model. The maturity model unifies relevant components from existing SC maturity models with concepts emanating from the systematic literature review on DDSCM and healthcare supply chain processes. The maturity model provides a framework to assess both where an organisation is today along the DDSCM maturity scale and how it can move towards more advanced maturity levels. Furthermore, this chapter will answer the following research question:

<u>Chapter 7</u>

What is the difference between mature and immature demand-driven healthcare supply chains?

The first section of this chapter provides an overview of the design requirements for the DDSCM maturity model. Figure 7.1 shows an outline of the relationship that exists between the design requirements and the development of the DDSCM maturity model.

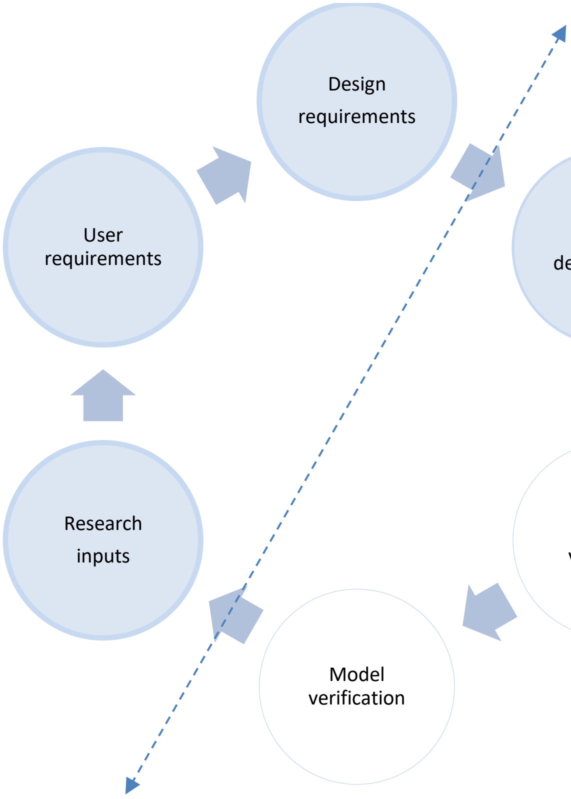


Figure 7.1: Maturity model development

Source: (van Eeden, 2018)

7.2. Design requirements for the DDSCM maturity model

The design requirements for the DDSCM maturity model were derived from literature. Table 7.1 provides an overview of the five design requirements that guide the development of the DDSCM maturity model.

Table 7.1: Design requirements for the DDSCM maturity model

ID	Design requirements for maturity model	Motivation
DR1	The maturity model should be easy to use.	The maturity model should be a self-assessment tool. The user will not require any assistance from either external players or consultants.
DR2	The maturity model should be able to identify gaps and guide the users to develop an improvement roadmap.	After assessment, the maturity model should be able to identify gaps in the healthcare supply chain. The gaps present opportunities for improvement to progress to higher maturity stages.
DR3	The assessment using the maturity model should not be time consuming.	The people using the maturity model should not spend more time and effort in the assessment process but more time should be spent in strategy development and implementation.

ID	Design requirements for maturity model	Motivation
DR4	The maturity model development should be substantiated by comparison with existing maturity models.	This highlights the importance of identifying other concepts from existing supply chain models and integrating them into the DDSCM maturity model.
DR5	The maturity model should use multi-inputs from several stakeholders involved in the supply chain.	For the maturity model to be reliable, complete, effective, applicable and valid; there is need to include several inputs from several players involved in the healthcare supply chain.

7.3. Maturity model dimensions

The maturity model is an assessment tool to assist organisations to evaluate their current stage of maturity for DDSCM and a guide to develop strategies to progress towards higher maturity levels of DDSCM in public healthcare supply chains. The DDSCM maturity model comprises of seven dimensions measured on a five-stage maturity scale. The DDSCM dimensions consist of a combination of the key success factors for DDSCM with constructs from SC maturity models and healthcare SC processes.

These dimensions represent process areas and capability areas structuring the domain of DDSCM. It is these capability areas and process areas that are assessed in a maturity model (Brooks, El-Gayar and Sarnikar, 2013). The core dimensions for the DDSCM maturity model are distribution management, visibility, technology, collaboration, human resources, organisational alignment and performance management.

7.3.1. Distribution Management

Distribution management can be defined as an organization's ability to facilitate the storage and flow of products in an attempt to satisfy customer demand in a reliable and efficient way (Rexhausen, Pibernik and Kaiser, 2012). The capabilities of distribution management are discussed in Table 7.2.

Table 7.2: Distribution Management

Capabilities	Considerations
Demand Planning and Forecasting	-The demand plan should integrate statistical forecasting techniques, experience and judgement of planners (Llewellyn, 2016). -Successful demand integration typically relies on information technologies including the internet (Frohlich 2002). -This demand plan should take into consideration the consumption patterns of health facilities, epidemiology and historical campaigns (Llewellyn, 2016).

Capabilities	Considerations
	-It is important for the demand plan to consider constraints such as budget, available supply and product changes (Llewellyn, 2016). -To promote co-creation the demand plan is jointly developed using real time data (Stonich and Moncrieff, 2001). -Ability of an organisation to understand customer demand and requirements, and balance them against the capabilities of the supply chain (Rexhausen, Pibernik and Kaiser, 2012).
Supply Planning	-The supply plan should coordinate inventory and orders to optimize the delivery of health products to fulfil the demand plan (Llewellyn, 2016). -The outputs of supply planning should be purchase orders and replenishment orders (Llewellyn, 2016). -Supply planning should take into consideration lead-time, stock at hand, safety stock, minimum order quantity and delivery channel costs (Llewellyn, 2016).
Distribution Planning & Transportation Management	-Scheduling shipment and transportation of healthcare products between warehouses and health facilities in response to a supply plan (Llewellyn, 2016). -Establishing a link between an organisation's internal (physical) operations and its customers (Rexhausen, Pibernik and Kaiser, 2012) -The distribution plan takes into consideration the constraints of storage space and vehicle capacity, to optimize distribution activities (Llewellyn, 2016). -Quality assurance in the delivery system (Garcia Reyes and Giachetti, 2010). -Logistics and delivery systems should be flexible and responsive (Ayers and Malmberg, 2002; Fischer et al., 2016).
Warehouse Operations	-The management and control of inventory of healthcare products to respond to demand (Garcia, 2008). -Receiving products, products sorting and storage, quality management, dispatching and debriefing (PILLAY, 2015). -Cross docking (Buijs, Vis and Carlo, 2014) and direct deliveries (Verdouw et al., 2011). -Replenishment is order-driven based on long term contracts (Verdouw et al., 2011). -Material flow from suppliers to customers is controlled by daily consumption (demand visibility) in order to guarantee the availability of goods in demand and at the same time minimise the inventories (Korhonen, Huttunen and Eloranta, 1998). -Warehouse automation technology and warehouse management systems (Rexhausen, Pibernik and Kaiser, 2012).
Order Management	-Order entry, management of customer databases, order processing and order fulfilment transactions (IBM, 2007).
Expiry Management	-Management, sorting and picking of products (Stewart, 1997).

7.3.2. Visibility

This dimension outlines the extent to which supply chain partners have access to or share real-time data, which they consider useful and of mutual benefit (Barratt and Oke, 2007). The capabilities of visibility are described in Table 7.3.

Table 7.3: Visibility

Capabilities	Considerations
Data Relevance Demand Visibility Inventory Visibility Process Visibility Order Visibility	-Information flow in the supply chain about demand, inventory levels (Budd, Knizek and Tevelson, 2012), product types and location of products (Mendes, Leal and Thome, 2016), and planning information (Fischer et al., 2016). -Using the principle of demand instead of supply as the factor integrating information needs in the supply chain (Korhonen, Huttunen and Eloranta, 1998). -Demand information of customers is used as input for forecasting processes of suppliers upstream in the supply chain (flow dependence) (Verdouw *et al.*, 2011) -Synchronisation along the supply chains – visibility of transport capabilities across a number of links for the purposes of integration of transport resources over more than one supply chain link (Black and Halatsis, 2001) -Trace the status of orders in the pipeline (IBM, 2007), (Lebovitz and Graban, 2001).
Data Accessibility	-Quality information reaches all relevant supply chain partners to facilitate informed decision-making (Korhonen, Huttunen and Eloranta, 1998). -Organisations can access information on appropriately aggregated levels for all participants in the chain (Dreyer et al., 2010). -Integration of internal and external information (Fischer et al., 2016).
Data Accuracy and Timeliness	-Transparent demand and inventory information (Budd, Knizek and Tevelson, 2012). -Real time data in the correct format when and where it is needed (O'Marah, 2005) in order to drive all related functions within the whole chain (Black and Halatsis, 2001).

7.3.3. Technology

Technology enables the capturing, analysis and distribution of seamless, real-time demand and inventory information (Agrawal, 2012). This can be achieved through a fast data-exchange platform that can facilitate the exchange of data in real-time among partners (Budd, Knizek and Tevelson, 2012). Technology also facilitates supply chain visibility, information integration, and transparency. This enhances demand-based decisions (Korhonen, Huttunen and Eloranta, 1998). The capabilities for Technology are shown in Table 7.4.

Table 7.4: Technology

Capabilities	Considerations
IT Infrastructure	-Standardisation of components, systems and software for interoperability and complexity reduction (Korhonen, Huttunen and Eloranta, 1998). -Interface (devices used to access the system) (Gastaldi, Pietrosi and Corso, 2017). -Information systems are the enablers to supply chain integration (cross functional teams, key organisational processes, performance management, information and knowledge – all this with a customer driven focus) (Korhonen, Huttunen and Eloranta, 1998). -Technology that captures accurate and actual customer demand behaviours (Selen and Soliman, 2002). -Management of performance in real time based on process mode instead of traditional functional performance management (Korhonen, Huttunen and Eloranta, 1998). -A fast data - exchange platform that can share inventory and demand data in real time among participants (Haavik, 2000). - The capabilities of an IT infrastructure architecture are; to keep track plans and trigger automatically alerts in case of unexpected deviations so as to guide management in decision making to these critical areas (Korhonen, Huttunen and Eloranta, 1998). -Supply chain platform that processes transactions, supports the integration of the whole chain, support decision making and that simulates capabilities and supply alternatives in real-time, in order to serve customer demand (Korhonen, Huttunen and Eloranta, 1998). -The IT architecture is able to identify, track and manage each and every customer order (Lebovitz and Graban, 2001) -Advanced, integrated information systems support accurate forecasting and planning systems, and communicate the plans as well as the exceptions more effectively up and down the supply chain (Korhonen, Huttunen and Eloranta, 1998). -Vendor-managed inventory software that tracks an organisation's actual supply demand and generates automatic purchase orders, providing supplies on as-needed basis (Haavik, 2000). -To improve the relevance, quality, timeliness, and visibility to customer driven needs enabling demand-based steering of the supply chain (Korhonen, Huttunen and Eloranta, 1998). -Information management enhancing transparency and visibility to customer demand and then supporting effective and efficient ways to respond to these needs (Korhonen, Huttunen and Eloranta, 1998). -IT necessitates the ability to being able to (in a proactive manner) to simulate supply alternatives and scenarios, carry out risk and benefit analysis in almost real time manner to serve customer demand (Korhonen, Huttunen and Eloranta, 1998).
Data Capture	-Technologies associated with collecting supply chain information, such as VMI software, CPFR software and RFID (Mendes, Leal and Thome, 2016), barcode scanning and RF –Data transmission (Black and Halatsis, 2001) are available. -Tools to communicate and coordinate activities in real-time (Lebovitz and Graban, 2001). -Collection of accurate information on supply demand (Haavik, 2000). -The role of information management and technology is to facilitate capturing the market and end user information in an accurate, timely (real-time) and relevant manner and channel inventory.

Capabilities	Considerations
	-Clear, institutionwide policies for reporting and recording of supply and inventory usage (Haavik, 2000).
Data Storage and Analysis	-Integrated database systems are available with analytical tools for synchronised decision making and active coordination (Mbhele, 2016).
Data Transmission and Reporting	-Frequency with which the data is transmitted and reported (Gastaldi, Pietrosi and Corso, 2017). -Communication of the data related to the supply chain.

7.3.4. Collaboration

Supply chain collaboration is a long-term partnership process where stakeholders with common goals work closely together to achieve mutual benefits that organisations would not be able achieve individually (Cao et al., 2010). Supply chain collaboration involves processes across multiple organisations that are participating in the supply chain. The processes include joint decision-making, sharing resources and problem solving among supply chain partners. The purpose of supply chain collaboration is to develop a synchronized supply chain, which is able to match supply and demand. This leads to improved responsiveness, mutual interdependence and customer satisfaction (Ho, Kumar and Shiwakoti, 2016). The capabilities for Collaboration are shown in Table 7.5.

Table 7.5: Collaboration

Capabilities	Considerations
Relationships and Partnerships	-Close relationships and partnerships among supply chain partners should be a key component in performance improvement (Sahay, 2003). -Good relationships between the customer and supplier should contribute considerably to reliable information flows across the supply chain (Heikkila, 2002). -Replenishment responsibility (Dreyer et al., 2010) using VMI (Haavik, 2000). -Joint collaboration planning actions and the strength of relationships positively affect Inter Organisational Information Systems (IOIS) use, which in turn positively affects firm flexibility (Hadaya et al., 2007)
Resource Sharing	-Pooling channel resources (Agrawal, 2012) -Resource investment and development (Ho, Kumar and Shiwakoti, 2016).
Joint Planning and Decision Synchronisation	-Joint planning and decision-making (Hadaya and Cassivi, 2007). -Defining customer and product priorities, and performance measurements (Rexhausen, Pibernik and Kaiser, 2012). -The level of synchronisation in the decision-making process is a key element in building and maintaining mutual partnerships (Cao et al., 2010). -The decision making process in the supply chain is facilitated by a supply chain control dashboard (Dreyer et al., 2010).

Capabilities	Considerations
Joint Knowledge Creation	-Knowledge exploration (search and acquire new and relevant knowledge) and knowledge exploitation (assimilate and apply knowledge). This involves active generation and development of knowledge that is easily accessible, disseminated and easily interpreted in concert with all supply chain partners (Cao et al., 2010).
Interdependence	-Trust, commitment, loyalty, openness and honesty (Heikkila, 2002).
Systems & Structures	-Collaborative and cooperative strategies for all relevant partners including customers to view supply chain information relevant to them. -Develop digital supply chain strategies to replace unnecessary inventories movements by exchanging information.
Organisation design	-Formalisation of rules and procedures in areas such as roles and responsibilities, communicating mechanisms, vision, goals and objectives, performance metrics, planning and scheduling and type of information to be shared (Ho, Kumar and Shiwakoti, 2016).
Goal congruency	-The extent to which supply chain partners perceive that their own organisational objectives are satisfied by accomplishing the supply chain objectives (Cao et al., 2010).

7.3.5. Human resources

This dimension describes the required skills, expertise and capacity of supply chain staff to manage and coordinate the supply chain (APICS, 2017). The capabilities for Human Resources are shown in Table 7.6.

Table 7.6: Human Resources

Capabilities	Considerations
Skills and Expertise	-Identify skills requirement, available skills and match skills (APICS, 2015) -Sufficient staffing of materials management department (Haavik, 2000).
Training and Talent Development	-Investment in talent development through continuous training programs (Ho, Kumar and Shiwakoti, 2016). -Providing materials management personnel with training and incentives for proper data reporting and analysis (Haavik, 2000)
Innovation	-Knowledge to reform and optimise supply chain processes (Jim Ayers, 2006).
Incentives	-Performance targets and incentives of all supply chain partners should all be aligned (Budd, Knizek and Tevelson, 2012). -Align metrics and incentives to enable benchmark of supply chain performance and identification of gaps and inefficiencies that can be addressed in partnerships with supplies (Budd, Knizek and Tevelson, 2012).
Culture & Behaviour	-Good working environment and work culture

Capabilities	Considerations
	-Information management culture – Collecting and sharing data on inventory levels frequently and increased degree of data granularity analysed (Korhonen, Huttunen and Eloranta, 1998)
Roles and Responsibilities	-Clear supply chain roles and responsibilities -Roles in forecasting and replenishment organised by product groups (Dreyer et al., 2010). -Accurate reporting of supply and inventory usage by clinical personnel (Haavik, 2000).

7.3.6. Organisational alignment

The transition towards DDSCM requires a paradigm shift in people and the organisations they represent. To this end, this dimension captures elements such as clear organisational vision, roles and responsibilities, management support (Mendes, Leal and Thome, 2016), cost management, customer segmentation and product classification (Canever, Trijp and Beers, 2008). DDSCM also integrates several management concerns such as flawless execution, transition from supply push to demand-driven supply chain management, outsourcing and supply base development, and partnership implementation (Vollmann, Cordon and Heikkila, 2000). The organization should be customer oriented and customer focused (Canever, Trijp and Beers, 2008). This imply an "outside-in" approach. The capabilities for the organisational alignment dimension are shown in Table 7.7.

Table 7.7: Organisational alignment

Capabilities	Considerations
Cost Management	-Elimination of supply chain costs associated with ordering and stocking unneeded supplies, by focusing on understanding and responding to actual customer demand or current needs for medicines (Haavik, 2000).
Customer Segmentation	-Customer segmentation is important for the purposes of matching supply with demand so as to provide different levels of service for each segment (Lapide, 2006). -Bundles of goods and services being provided are customised for individual customer segments (Selen and Soliman, 2002).
Product Classification	-Relates to product classification in relation to customer requirements. -Products should be categorised as either functional products or innovative products. (Fisher, 1997). This reduces the chances of mismatching products to customer requirements (Mendes, Leal and Thome, 2016). -Product classification with respect to the duration of product life cycle (Childerhouse, Aitken and Towill, 2002). -Product classification with respect to delivery lead-time or window for delivery that reflects on the responsiveness requirements placed on the network. This further determines the feasible position of the decoupling points (Childerhouse, Aitken and Towill, 2002).

Capabilities	Considerations
	-Product classification based on volume. High volume and critical importance of products to the organisation (Childerhouse, Aitken and Towill, 2002). -Classification based on product variety. Postponement is a feasible strategy to easy these problems (Childerhouse, Aitken and Towill, 2002). -Classification based on demand variability. This reflects demand spikes and demand uncertainty (Childerhouse, Aitken and Towill, 2002). This is core to DDSCM since the final consumer demand organises the entire flow of products and services (Canever, Trijp and Beers, 2008).
Suitability for customer	-Developed flexibility capabilities, agile, innovations and lean supply chains to satisfy customer demand (Hines, 2004)
Management Support	-Management supporting resource allocation and partnering strategies (Santos and D'Antone, 2014). -Clear, institution-wide policies for reporting and recording of supply and inventory usage (Haavik, 2000). -The organization should be customer oriented and customer focused (Canever, Trijp and Beers, 2008). -Top management understanding of DDSCM principles and the management is committed to and persistent in achieving excellence in DDSCM (Lebovitz and Graban, 2001).
Organisational Vision	-Organisational norms and values that encourage behaviours that are consistent with customer orientation, pertaining to current and future customer needs (Canever, Trijp and Beers, 2008).
Decoupling Points Positioning	-Strategic inventory positioning (Canever, Trijp and Beers, 2008). -Determine downstream inventory buffer levels and buffer sizes (Dreyer et al., 2010).

7.3.7. Performance management

This dimension entails measurement of supply chain performance (Du Toit and Vlok, 2014). The supply chain attributes are reliability, cost, availability, inventory turns, working capital, responsiveness, and agility (APICS, 2017), (Budd, Knizek and Tevelson, 2012). Table 7.8 illustrates the capabilities for the performance management dimension.

Table 7.8: Performance Management

Capabilities	Considerations
Reliability & Sustainability	-Achievement of perfect customer order fulfilment (Lapide, 2006). -Higher rates of customer satisfaction (Budd, Knizek and Tevelson, 2012). -Consistent customer value offering based on their preferences, time, place flexibility and quality (Hines, 2004)
Responsiveness & Speed of Response	-Delivery and order fulfilment **(**APICS, 2015) -Replenishment cycle time (APICS, 2015) -Responsive capabilities to deliver goods and services when they are required through efficient consumer response, and quick response (Hines, 2004) -Receive, configure, enter and validate order cycle time(APICS, 2015)

Capabilities	Considerations
	-Route transport and schedule installation cycle time (APICS, 2015)
Agility & Service	-Time it takes to change schedules (APICS, 2015) -The ability to deliver different quantities of goods through capacity management and capacity flexibility (Hines, 2004) -Time it takes to change capacity (APICS, 2015)
Cost	-Reduction of supply chain cost (Budd, Knizek and Tevelson, 2012), (APICS,2015)
Availability & Standards	-Greater fill rates and reducing stock-outs leading to customer satisfaction (Budd, Knizek and Tevelson, 2012). -Supply chain standards to assure customer quality standards are met effectively and cooperate within supply chains (Hines, 2004)
Inventory turns	-Reducing the inventory levels and limiting trapped working capital (Budd, Knizek and Tevelson, 2012).

7.4. Maturity model stages

The DDSCM maturity model adopts five maturity stages from Capabilities Maturity Model (CMM) that was developed by Paulk et al., (1993). The reason for adopting these five maturity stages is that CMM contains the foundational concepts of maturity model literature and it provides a guideline on how processes can be improved, from an initial state to a more advanced state (Netland and Alfnes, 2008).

Initial stages of the maturity model represent processes that are poorly understood and managed. On the contrary, higher maturity stages represent processes that are well understood, supported, implemented and managed, as discussed in the Table 7.9.

Table 7.9: Maturity stages for DDSCM model (adopted from Paulk et al., 1993)

Stage	Description
Stage 1:Initial	-The processes are highly unpredictable and ad hoc. - At this stage, there is poor knowledge of processes. This represents the beginning point for use of a new process. -In addition, there are wide variations in plans. - Furthermore, there are no standard operating procedures for the supply chain processes. -Silo-thinking
Stage 2: Repeatable	- The processes start to become more disciplined. - Some plans are met but there are still some variations. - Standard operating procedures (SOPs) are in place and these SOPs enable the repetition of the same steps to be attempted. - Internal alignment
Stage 3: Defined	-The processes become standardized and consistent. -The processes are now well defined and confirmed as standard organisational processes. -Processes are now well understood, supported, monitored and well documented. -Customer alignment
Stage 4: Managed	-Quantified and predictable processes. -The processes are quantitatively measured and managed. -Processes are improved based on the quantitative data that has been collected. -Extended alignment
Stage 5: Optimising	-The focus is on continuous improvement of the processes. -New technologies and systems are put in place to support continuous improvement. -Demand-driven

7.5. Linking dimensions to maturity stages

The development of the DDSCM maturity model is based on the notion of evolution from an initial state to some more advanced state as suggested by Fraser et al., (2002). The maturity model shows the way the dimensions progress on the maturity curve from immature states to more advanced mature states. Each dimension is split into a number of practices and activities at each stage called capabilities (Brooks, El-Gayar and Sarnikar, 2013).

Figure 7.2 provides an outline of the considerations taken during the development of the DDSCM maturity model. The maturity model unifies relevant components in existing supply chain maturity models with concepts emanating from the systematic literature review on DDSCM and the literature review on healthcare supply chain processes.

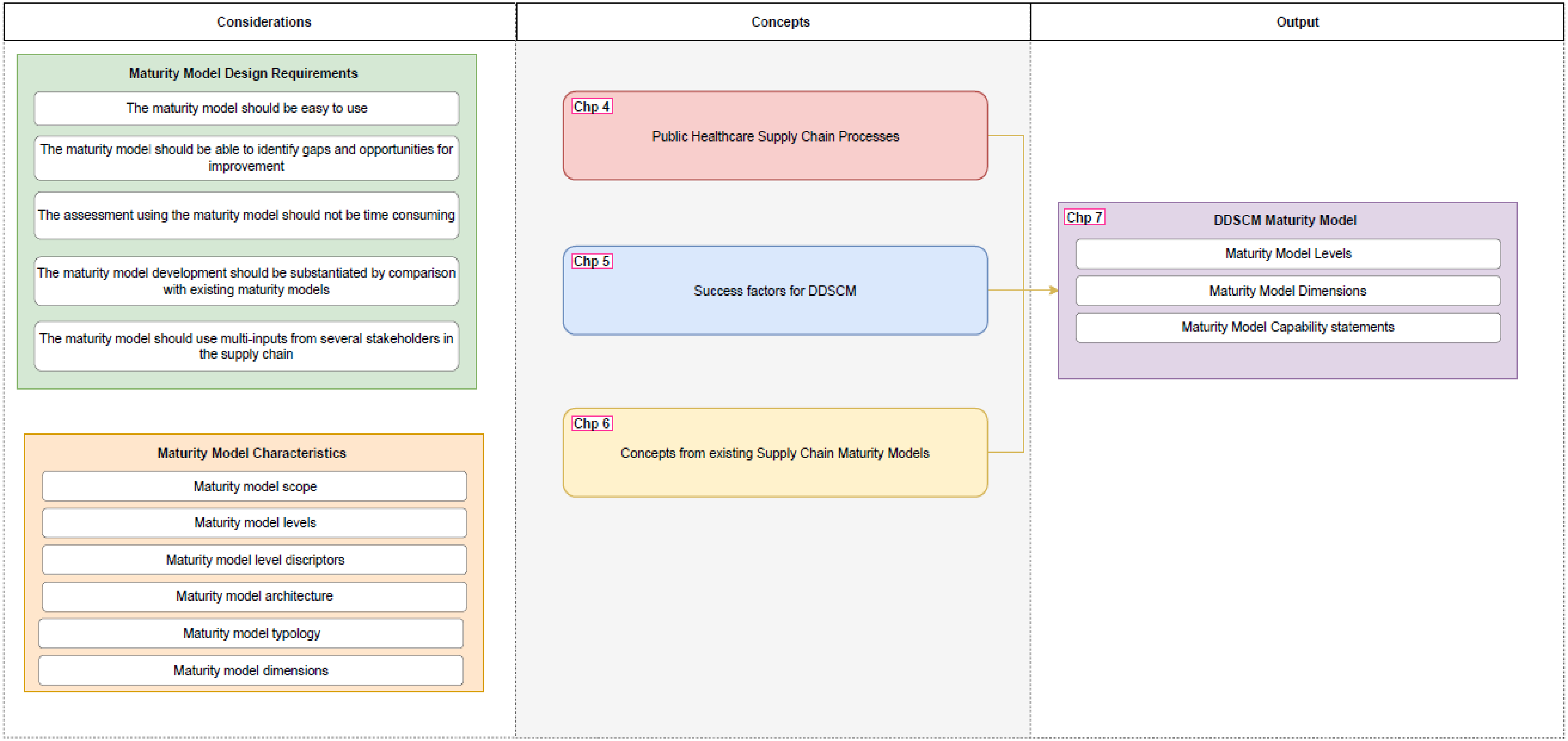


Figure 7.2: Maturity model development considerations

7.5.1. The conceptual DDSCM maturity model

The main purpose of the conceptual DDSCM maturity model is to support organisations in public healthcare supply chains in the process of implementing concepts of DDSCM. Its a framework to assess both where an organisation is today and how it can progress to more advanced DDSCM maturity levels. This is accomplished by means of:

- Identifying the current status of DDSCM implementation (DDSCM capability maturity mapping)
- Identifying the desired (target) status
- Identifying methods and techniques that must be implemented to transition from current to the target status

The DDSCM maturity model embodies a change of focus, away from being forecast-driven to being customer-oriented, penetrating deep into the customer organisation to understand their products, culture, market and organisation. This ensures that an organisation is attuned to the customer's needs and requirements (Stevens, 1989). Table 7.10 outlines the DDSCM maturity model.

Table 7.10: Conceptual DDSCM maturity model

Capability	Initial	Repeatable	Defined	Managed	Optimising
Product Classification	•No product categorisation strategy in place	•Specific products and their related service levels are identified and tailored to product categories with emphasis on prioritisation of service, quality, cost	•Categorisation of products into clusters with similar characteristics using the different decision rules related to replenishment (DWV3) demand variability, volume, variety, life cycle maturity, delivery lead-time, value, delivery channels costs, cold/cool chain requirements	•Customisation through customer-specific innovative solutions (differentiate functional and innovative products)	•Alignment of product categories with different supply chain strategies i.e. Functional products for the Physical efficient supply chain and innovative products for a Responsiveness supply chain
Segmentation	•No formal segmentation plan in place for both suppliers and customers •Internal and external supplier /customer "status" is unknown	• Segmentation analysis specifying supply chain goals, scope •Defined "status" (i.e. preferred, key, strategic) supplier/customer with explicit criteria for each echelon	•Established customer segments and priority to customer base in order to provide different service levels to each segment •Service objectives and standard operating procedures for each segment defined • Suppliers segmented and expectations communicated to the suppliers	•Customised response to volatile demand through the design of customised SC configurations • SOPs developed for managing the segments may quickly and easily applied to new product reducing the need for system design and redesign for new product	•Customer segmentation strategy reviewed yearly and customer segments updated •Segments are flexible and adaptable •Supplier segmentation drives the behaviour of sourcing organisation
Risk Management	•No framework detailing all potential supply chain risks and associated contingency plans	•Formal Risk assessment framework in place •Potential Supply Chain Risks Identified	•Framework to support Risk Analysis and Evaluation •Weight factors applied to risks	•Contingency plans to mitigate supply chain risks and supply chain disruptions in place •Detailed risk management plan with anticipated scenarios	•Predictive analytics capabilities utilised to timely mitigate supply chain risk •Monitor the supply chain risk status and contingency plans
Demand Planning	•Demand plan is based on statistical forecasts, historical data and trends •Forecasts are reconciled & communicated with other organisational functions	•Judgements and experience of demand planners included in the demand plan •What if-scenarios, constraints (i.e. Budget) integrated into the demand plan	•Synchronised joint demand planning with other external supply chain partners utilising inventory and consumption patterns data •Demand plan is tracked for accuracy	•Demand planners have the right skills set (quantitative, computer, interpersonal and process management)	•Demand driven planning based on actual customer consumption. •Inventory strategies are clearly formulated & monitored by all stakeholders periodically •Demand plan included in the standardised digital supply chain platform that is accessible to relevant supply chain partners

Capability	Initial	Repeatable	Defined	Managed	Optimising
Inventory Positioning	•Staged inventories (medicines stock) caused by failure to integrate and synchronise	•Cross-docking & direct deliveries to achieve delivery efficiencies (small inventory volume)	•Strategic decoupling points positioning	•Strategic decoupling points are protected by buffer profiles of optimised sizes (replenished based on actual customer demand) •Right stock at the right time and at the right place	•Dynamic adjustments of Buffer profiles and sizes based on events and seasonality
Supply Planning	•Supply plan created based on inventory policies	•Supply plan is created from basic demand plan and does not make use of master data	•Integrated organisational supply planning created that is based on data within the whole organisation (lead-time, supplier constraints and stock-holding) •Supply chain planners have visibility to stock on hand and consumption data	•Supply plan is included in the standardised digital supply chain platform that is accessible to relevant supply chain partners	•Automatic supply order generation by the digital supply chain platform and supply chain staff just authorise
Distribution Planning	•Location of customers (facilities) is documented • Synchronisation: Visibility of transport capability across the number of supply chain links	•Route planning completed using planning tool to assign transport requests •Delivery scheduling	•3PL Service Levels Agreements defined and their performance is measured	•Data on replenishment orders, transport reliability, and costs of transport used to create a distribution plan. •Replenishment orders generated from actual end customer demand	•Strategic capacity planning (warehouse, labour and transport capacity).
Warehouse Operations	•Customer oriented KPIs in place (fill rate, perfect order etc.) in place •Product prioritization in the order processing system •Basic storage rack structures in place to maximise warehouse density •Warehouse density is prioritised to increase asset utilisation •Warehouse layout is formally reviewed on a regular basis to increase warehouse productivity and reduce safety risks	•Warehouse operations are well executed with good operational performance (Good inventory accuracy-greater than 99%, increased warehouse productivity, downward trend on warehouse cost) •Racking structures are implemented and increased warehouse density (e.g., more than 10%), maximizing asset utilization. •Double forklifts are used most of the time (greater than 50% of the time) to perform product put-away, retrieval and truck	•Lean practices (5S) implemented and owned by all, to ensure clean, safe and efficient workplace in the warehouse •Warehouse employees are well trained with all skills required to excel in the job and deliver the expected customer service, keep good product integrity, high picking accuracy, low cycle time and low operational costs.	•Warehouse is fully oriented towards customer service, meeting expected perfect order goals (greater than 99%) based on actual customer orders. • Warehouse layout is designed to provide flexibility, high density and speed to cope with customer demand •Simulation tool is regularly used to review layout and labour requirements aligned with demand • Triples or Quad forklifts are used most of the time (greater than 50%) to perform product	•Segments Out of stock monitoring & Product Out-of-Stock in the segments (not OOS in the warehouse) is a key performance indicator in the warehouse metrics. •Demand driven replenishment (replenishment/fulfilment based on actual demand as opposed to forecasts)

Capability	Initial	Repeatable	Defined	Managed	Optimising
	•Single forklifts are used most of the time to perform product put-away, retrieval and truck loading •Inventory management system is entirely manual	loading. •There is a performance management process implemented that increase productivity •Front line supervisors can lead, and coach the warehouse team towards a continuous improvement process •Full housekeeping in place •Dynamic policy on how much inventory should be kept at the warehouse with defined min/max levels		put-away, retrieval and truck loading. • Innovation through skilled workforce, standard operating procedures and multifunctional teams.	
Warehouse Visibility & Automation	•Technologies & Data is leveraged to improve warehouse operations such as the ability to locate specific product within warehouse and tracking of both inventory levels and order status	•Basic warehouse automation using barcodes to ensure warehouse visibility	•Sufficient warehouse automation and mechanisation •Advanced warehouse automation and mechanisation leveraged (RFID technologies)	•Warehouse Management System utilised •Real-time exception management through alert messaging.	•Warehouse Management Systems integrated with the standardised supply chain platform
Order Management	•Formal standards for order management	•Procedures in place to review, process & prioritise customer orders •Customer order accuracy with specific customer requirements	•Integrating customer order management with supply chain planning and execution processes	•Holistic, real-time order process support with value-added functions like manufacturing/distribution capacity reservation or order configuration based on a collaborative design and execution portal	•Automated order management by supply chain platform •Integrated Supply chain platform exist to identify, track, manage each customer order
Logistics and Transport Flexibility	•Distribution operation is customer driven (oriented on customer service i.e. On time and In full delivery) • Routing optimisation tool to optimise distribution •Track and trace solution to manage the distribution operation	•Distribution operation is well executed with dynamic dispatching based on customer orders received •Distribution Fleet policy in place •Planned and Scheduled delivery routes documented	•Delivery variances and root causes used to define action plans/adjust plan or execution, depending on the root cause variance & root cause analysis •Formal returns management •Dynamic routing based on actual demand needs •Flexibility to change the	• Real time track and trace tool is implemented and allows managing and acting to solve distribution problems during the delivery route. •There is a closed loop process that feedback actual information to the route optimization planning tool to improve	•Estimated Time Arrival (ETA) is dynamically updated as the route is executed and communicated to customers to ensure right delivery •Proof of Delivery (POD) used and returned to the warehouse •Coordinated replenishment programs

Capability	Initial	Repeatable	Defined	Managed	Optimising
	•Bundling of goods to utilise available truck capacity efficiently as possible to meet replenishment plan	•Tailoring transportation to meet segmentation needs •Quality assurance in transport and delivery systems	content of delivery and routes through full "truck loads" & full "pallet loads"	compliance to plan of the distribution route • Estimated Time of Arrival (ETA) is provided to all customers before delivery of products •Transport arrives on time for warehouse/facilities appointments with defined service level agreements that are measured and managed •Optimisation of scheduling routing based on actual demand data	•Optimisation of transport modes and routes continuously
Expiry Management	•Procedures in place for expired healthcare products management	•Norms and standards for healthcare products wastage are defined •Adherence to inventory management and control strategies (ie.routine cycle counting)	•Tracking of expiry dates for medicines and wastage risk	•Established picking policy for expired medicines (FEFO)	•Expired medicines quantity is measured, managed and reported on the digital supply chain platform that is accessible to relevant supply chain partners •Policy for expiry management continuously audited
Information sharing & Information Quality	•Information sharing is not a priority	•Information sharing identified as a capability but focus placed on information quality in silos (Formal policies and procedures established)	•Information accessibility across the entire organisation	•Transparency across demand, inventory & capacity information amongst supply chain stakeholders in the network	•Information availability, accessibility, and usability from all actors on a supply chain platform driving joint planning
Demand and Inventory Visibility	•Demand and inventory visibility (< 20%)	•Some visibility on inventory and consumption patterns (< 40%) •Access to Minimum Order Quantity (MOQ) & Economic Batch Quantity (EBQ)	•Market intelligence to identify which products customer want •Behaviour analysis to understand who wants the products •Lead-time visibility of all suppliers and partners	•Demand-driven software tools like CPFR and VMI provide actual demand and inventory information between customers and suppliers •Inventory and demand information is shared across the supply chain to provide visibility to all echelons (< 80%)	•Real time visibility on consumption patterns, inventory status and scheduled deliveries (<100%) shared across the entire pipeline & is used to make informed decisions •Master data accuracy and availability & timeliness to relevant supply chain partners available on a standardised digital supply chain platform

Capability	Initial	Repeatable	Defined	Managed	Optimising
Order Visibility	•Customer order visibility & tracking (< 20%)	•Customer order visibility & tracking (< 40%)	•Order status visibility & tracking (< 60%)	•Order transaction and movement is visible to supply chain partners and customers (< 80%)	•Real-time status throughout the order pipeline, online real-time order configuration and updates through the supply chain platform
Information Technology Infrastructure	•Legacy technologies that are not integrated with other technology systems	•Basic integration of Information Management Systems and database systems within an organisation •Planning (demand and supply) software systems in place •Standardisation of components, systems and software for interoperability and complexity reduction	•Expanded, IT tools in place integrated in the supply chain •IT Systems to identify, track and manage each and every customer order •Fast-data exchange platform (robust technology infrastructure) that can share inventory data in real-time among all participants in the supply chain	•IT architecture keeps tracks of plans and monitors buffers and triggers alerts in case of unexpected deviations •New technologies & sophisticated analytics to make the supply chain more responsive to customer demand •Demand planning software with more advanced functionalities such as statistical analysis to generate sequentially optimised plans	•A scalable IT architecture that is flexible and robust enough to dynamically incorporate needed changes as they arise •It platform necessitate the ability to simulate supply alternatives, carry out risk and benefit analysis in real-time
Data Transmission and Reporting	•IT architecture produces static reports and the reports are distributed in paper format • Reports from an information technology are generated but are hardly ever used and are only accessible upon request	•IT supports static reports with graphical data & reports are distributed digitally •Efficient information management system that produce management reports on stock levels, usage patterns and expenditure trends	•IT architecture supports dynamic data navigation and reports are distributed automatically and digitally	•IT architecture supports dynamic statistical analysis and reports are directly and constantly available to relevant supply chain partners	•IT architecture support dynamic scenario analysis and reports are directly and constantly available to relevant supply chain partners
Data Capturing	•Clear institution wide policies for reporting and recording supply and inventory usage •Manual capturing and reporting of medicines consumption data	•Standardisation of data collection processes •Electronic solutions to strengthen data collection and reporting	•Most master data consistently defined but not entirely harmonised throughout the organisation	•Master data proactively managed internally but not externally	•Master data consistently defined and harmonised throughout the supply chain

Capability	Initial	Repeatable	Defined	Managed	Optimising
Relationships	•Formalised & rationalised framework for collaboration in place •Policies to select and develop suppliers in place	•Supply chain actors value collaboration (internally) •Supply chain actors trust and collaborate with each other	•Great efforts made on building good relationships with suppliers (Supplier Relationship Management) and strategic alliances as opposed to adversarial relationships •Organisation and top strategic suppliers work together to fulfil actual demand through a true demand driven process. •Service level agreements (SLAs) with critical suppliers are in place and define operational goals, penalties	•Partnerships and advanced relationships with suppliers and customers. •Trust among supply chain partners to influence the quality of information shared and partnerships in the supply chain. •Supplier performance measurement & supplier delivery performance analysis •Supplier takes responsibility for the operational inventory management within a mutually agreed framework of performance targets	•Supplier development and long term contracts with suppliers •Supplier sustainability gap analysis to identify the constraints faced by suppliers •Commitment for the successful implementation of supply chain methods for improvement •Supply chain partners working as if they are part of a single organisation
Interdependence and Resource Sharing	•Commitment by supply chain partners with respect to collaborative resource investment and resource pooling	•Pooling & sharing resources together with other supply chain partners to reduce the supply chain risk due to supply chain disruptions •Ability to coordinate intangible and tangible assets within the supply chain facilitated by information communication technologies, customer confidence.	•Commitment agreements signed for collaborative resource investment and sharing with supply chain partners	•Vertical and horizontal dependences within and between chains, sharing risk and benefits.	•Resource sharing and pooling included in organisational strategy and are continually reviewed
Decision Making	•Joint knowledge creation and innovation with supply chain partners (internally) •Supply capabilities both considered and jointly optimised with actual customer demand.	•Collaborative setting & alignment of KPIs with other supply chain partners	•Data is used as an input to decision making	•Collaborative decision making & problem solving with other supply chain partners driven by available data (externally)	•End customer consumption drives decisions along the chain. •Advanced decision support system with analytical tool and modelling capabilities (supply chain platform)

Capability	Initial	Repeatable	Defined	Managed	Optimising
Key Performance Indicators	•Basic performance management plans are defined & imbedded in the organisation with indicators •Performance measures target customer service and product availability •Hierarchy of indicators based on agreed, performance targets and priorities	•ICT based measurement systems •Regular reporting of KPIs through a KPI Dashboard accessible by all partners in the supply chain •Historical and current data is used to analyse across multiple dimensions, revealing trends, explanations, problems	•Regular monitoring, tracking and updating of KPIs against goals & there is transparency to create an environment of continuous improvement	•KPIs support managers to assess the overall supply chain performance, diagnose problems and plan actions progressively	•Root cause analysis & corrective actions consistently taken into consideration to improve performance based on monitoring and evaluation results. •Responsiveness (less time spent waiting for products, allowing the production/distribution to operate more smoothly and quickly)
Metrics	•On Time In Full (OTIF) Tracking not important •Key metrics not defined in the organisational strategy (RELIABILITY, STABILITY, SPEED/VELOCITY, RESPONSIVENESS)	•Need for On Time In Full (OTIF) Tracking recognised •Need recognised for defining key metrics (RELIABILITY, STABILITY, SPEED/VELOCITY, RESPONSIVENESS) •Standards to assure customer quality	•On Time In Full (OTIF) Tracking. •Key Metrics defined (RELIABILITY, STABILITY, SPEED/VELOCITY, RESPONSIVENESS) •Reduction in inventory levels, stock-outs and working capital •Faster and more accurate order fulfilment •On time delivery & percentage of returned goods established against well-defined targets	•Ability to deliver different quantities of goods through capacity management and capacity flexibility. •Customer order fulfilment and on-time deliveries are (<100%) and high customer satisfaction, •Key metrics measured and quantified (RELIABILITY, STABILITY, SPEED/VELOCITY, RESPONSIVENESS)	•Controls in place to improve supply chain RELIABILITY, AGILITY, STABILITY, SPEED/VELOCITY and RESPONSIVENESS •Higher rates of customer satisfaction •Consistent customer value offering based on customer preferences, time, place & quality
Policies and plans	•A strategic plan that addresses human resource requirements for supply chain functions and personnel is authored	•Supply chain organisation structure adequately supports supply chain functions	•Clear & detailed human resource policies, norms, standards are available and fully implemented and adhered to at all levels , guiding and supporting the management of human resources in the supply chain •Succession plans are updated annually and used to inform recruiting, workforce development and other staffing decisions	•Distinct and permanent budget exists for supply chain human resource strengthening activities (i.e. training, incentives, coaching, performance management)	•Workforce plans are updated annually and used to inform recruiting and other staffing decisions •Mentoring and coaching is based on either a performance development and /or succession plan

Capability	Initial	Repeatable	Defined	Managed	Optimising
Clear roles & responsibilities	•Roles & responsibilities are not clearly defined	•Job tasks are based on applicable competency model and are used for recruiting •Job descriptions are authored for all supply chain roles at all levels	•Roles & responsibilities are clarified & documented •Accurate reporting of supply usage by supply chain personnel	•Suitable & qualified SC Official observing SOPs to ensure staff is motivated and receives continuous training •Sufficient material management (supply chain) staff	•High performing teams are formed & supply chain managers are empowered
Innovation	•Basic approaches to supply chain improvement and problem solving	•Innovative ideas tolerated and utilised to improve supply chains as well as solve supply chain issues	•Supply chain personnel have expertise and are able to improve supply chain operations as well as define and solve complex problems •Proactive approach by staff through suggesting larger or smaller order if consumption data show the need and contacting the customer before the order has been placed	•Skilled staff with proactive approach to evidence-based quality improvements •Innovation driven by market intelligent information •Supply chain staff have knowledge to reform and optimise supply chain processes	•Systematic thinking capabilities •Strategies to promote innovation and creativity among supply chain staff
Incentives and working environment	•Motivational mechanism and rewarding strategies to encourage enhanced performance (financial and non-financial).	•Motivation to supply chain staff for proper and accurate demand and inventory data collection, reporting and analysis	•Good working environment and working conditions support performance	•Workers have good work culture and have a sense of ownership for their roles and are motivated to do their jobs	•Supply chain staff has high accountability, engagement and empowerment •Performance targets and incentives of all supply chain partners aligned
Training & Education	•A human resource information system is regularly updated at all applicable levels and is used to make human resource decisions	•The connection between experienced supply chain staff and access to products is clearly understood (systems understanding). •Recognised need to invest in talent development through continuous programs	•Performance development plans exist for all supply chain personnel and are regularly reviewed •Education & development framework & Programme in place which directs & coordinates the delivery of a learning environment & continuous training for staff	•Personnel with supply chain expertise guide and inform supply chain-related strategies, & policies •Staff has good supply chain planning capabilities and is able to use the available information for informed planning processes.	•Sufficient budget and authority given to senior level SC champions to fully empower the development of SC staff
Management Support	•No management support for supply chain processes and resource allocation	•Upper Management support •Developed flexibility capabilities, agility, innovations and lean supply chains.	•Top management supporting resource allocation and partnering strategies •Development of holistic demand driven supply chain	•Top management strongly support the demand driven supply chain management approach and also support the	•Support of demand and supply strategies by management and all this included in organisational agenda.

Capability	Initial	Repeatable	Defined	Managed	Optimising
		•Developed digital supply chain strategies to replace unnecessary inventories movements by exchanging information.	strategy (vision that clearly define customer orientation & demand-pull replenishment)	building of adaptive demand based networks •Outsourcing and supply base development	•Appointed supply chain director who sits on the organisational board •A culture of continuous improvement in the organisation is entrenched and sustained
Organisational Vision	•Little understanding of the value of actual customer demand data (forecast driven organisation)	•Understanding of actual customer demand and translation of that into strategies and plans to satisfy the actual demand	•Organisational vision does clearly define customer orientation & demand-pull replenishment as a core competency	•Customer-pull-driven fulfilment as well as outsourcing all non-core supply chain activities to third -party logistics	•Customer -focused, collaborative culture is firmly in place (demand-driven organisation) •Culture for data collection and sharing established •Supply chain scope encompasses multi-echelon supply network
Streamlined Processes	•Basic definition of supply chain Processes and stock management processes	•Innovation excellence is key & is infused into all supply chain processes •Processes are well-defined and well-run	•Supply chain standards to assure customer quality standards are met effectively and cooperate within supply chains.	•Organisational strategy integrates demand processes & supply processes	•Processes are optimised & continuously improved to ensure agility
Alignment of Objectives	•Forecast-driven supply chain strategy for all product types	•A demand-driven supply chain strategy is defined	•A comprehensive demand-driven supply chain strategy is implemented	•End-to End supply chain goals and objectives collaboratively developed and supply chain partners perceive that their organisation goals are satisfied by accomplishing supply chain objectives.	•Continuous review & update of the demand-driven supply chain strategy
Cost Management	•Identified need to track supply chain cost	•All supply chain Supply chain costs are identified	•Supply chain costs are measured, controlled and managed •Ability to track supply chain costs	•Financial deviations from target are actively managed •Elimination of SC costs associated with ordering and stocking incorrect inventory by focusing and responding to actual customer demand	•Full visibility of supply chain costs amongst supply chain partners through the digitalised supply chain platform

7.6. Chapter summary

A supply chain maturity model can be considered as a methodology that is related to definition, measurement, management and the controlling of organisational processes (Lahti, Shamsuzzoha and Helo, 2009). The DDSCM maturity model developed in this chapter is evolutionistic in nature and describes seven (7) dimensions and thirty-three (33) capabilities that are measured on five-stage scale. One maturity stage is a precursor for the next. The model outlines the methodology that can help organisations in the public healthcare supply chain to improve their supply chain processes towards DDSCM. This model unifies concepts from healthcare supply chain with DDSCM success factors and components of existing supply chain maturity models.

Conceptual maturity model was published in the International Conference on Management of Technology (IAMOT) 2018 proceedings and presented in Birmingham, United Kingdom. The reason for submitting the paper for publication to the conference proceedings was to test for the validity of the contents of the maturity model using subject matter expert opinions of reviewers.

In the context of public healthcare supply chains, the conceptual DDSCM maturity model clearly outlines key process areas for immature and mature healthcare supply chain processes. Immature processes are described in Stage 1 of the maturity model and mature processes are outlined in Stage 5. In Stage 1, healthcare supply chain processes are basic and unpredictable. People responsible for supply chain activities have poor knowledge, skills and competence in their roles. Secondly, visibility on demand, inventory levels and orders, is limited. Furthermore, the internal and external information sources of supply chain partners are not integrated, but rather each partner exists in a silo. In addition, there are no attempts by partners to partake in collaborative decision-making. Lastly, the metrics and goals in the supply chain are not aligned across the entire supply chain. Lastly, there are no attempts to segment customers and to categorise products.

A mature healthcare supply chain focuses on continuous improvement of processes. Supply chain platforms that connect all supply chain actors, technologies and systems are developed to support continuous supply chain improvements. The high maturity stage represents processes that are well understood, supported, monitored, and documented. It is however, important to recognise that organisations in public healthcare supply chains should progress in sequence through the stages by building on practices that have been solidly established in each stage. Furthermore, in order for an organisation to be considered mature for a given maturity stage, it must be effectively using the majority of the DDSCM practices from that stage.

Chapter 8 : Maturity Model Validation

8.1. Introduction

In the previous chapter, a conceptual DDSCM maturity model was developed based on the literature. The purpose of this chapter is to validate the DDSCM concepts in the maturity model with subject matter experts. Figure 8.1 shows the iterative development process that was followed in this study.

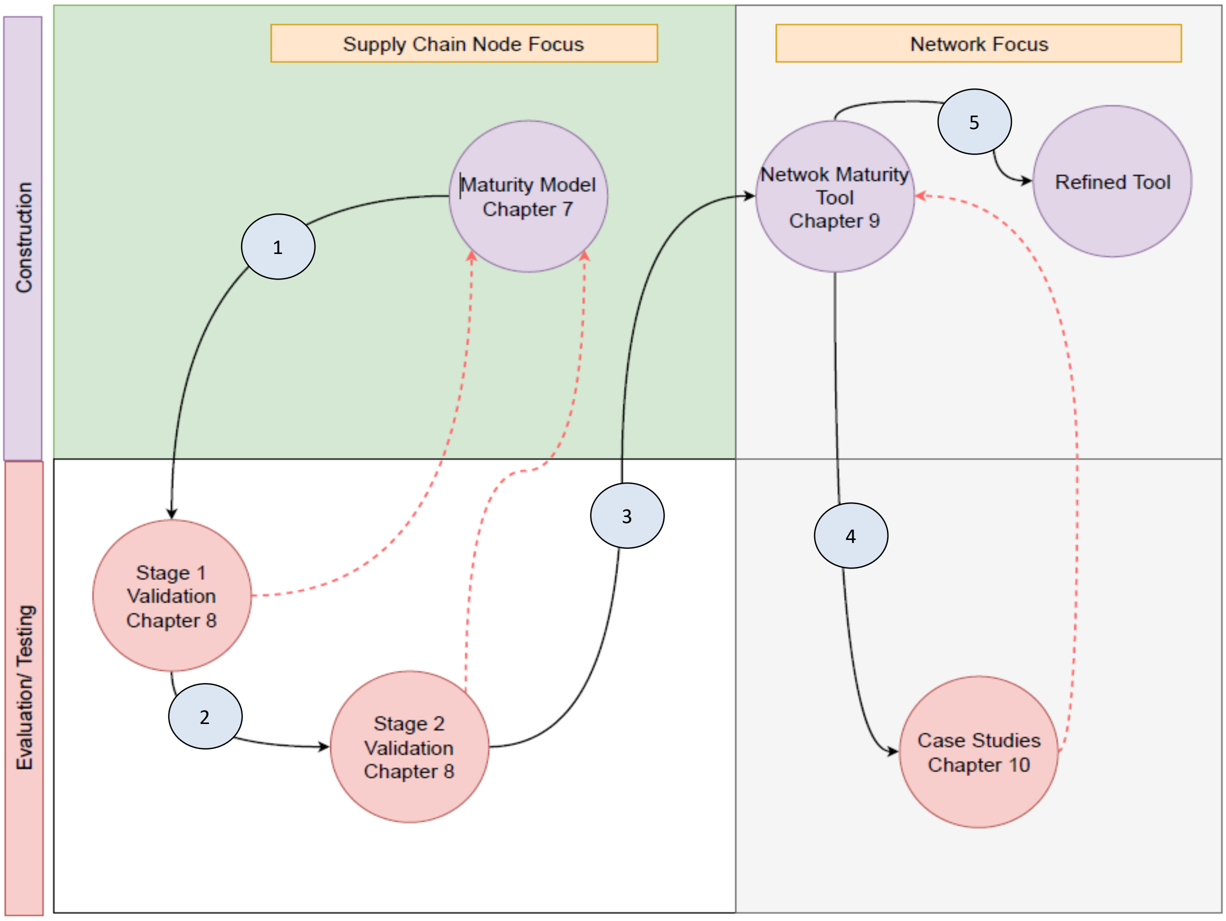


Figure 8.1: Iterative development process

<u>Chapter 8</u>

•Test the credibility, completeness, and usefulness of the conceptual DDSCM maturity model.

8.2. Validation stage 1

The concepts were first validated using semi-structured interviews with fourteen (14) subject matter experts. The motivation for using semi-structured interviews was to enable the researcher to gather pragmatic insights on DDSCM. Most of the experts used at this validation stage had knowledge of DDSCM approaches and a solid experience in supply chains.

To collect rich data from the subject matter experts, the researcher developed an interview guide, which contained semi-structured questions. The questions in the interview guide were developed based on the concepts in the DDSCM maturity model. The interview guide was pilot tested with supervisors to ensure that the questions were not vague and were indeed representative of the concepts of DDSCM.

Prior to the semi-structured interview, the author sent the Microsoft Excel sheet to the participant so that the participant would familiarise him/herself with both the concepts and the questions. The reason for doing this was to limit the time in explaining all the concepts that are contained in the maturity model, thereby saving the participant contact time as well. This semi-structured interview guide is shown in Table 8.1.

Table 8.1:Semi-structured interview guideline

Dimensions	Questions
Distribution Management	Are there any major things that one must take into consideration when developing a demand plan, supply plan and distribution plan in demand-driven supply chain management context?
	Can you think of any best practices that can be implemented in a warehouse to enhance demand-driven supply chain management processes?
	How do you capture, process and manage customer orders in a demand-driven supply chain?
	Concerning expired goods and products, are there any procedures and policies that you use to manage expired \products?
Visibility	What type of information is important to you in a supply chain to enable a demand-driven supply chain management process?
	How important is it to integrate internal and external information sources in demand-driven supply chain management?
	To what extent does real-time information in the correct format important to supply chain partners in demand-driven supply chain?
Technology	Concerning IT architecture, how important is the approach of standardisation of components, modules and, systems for interoperability and complexity reduction?
	What capabilities should an IT architecture have in order to guide demand-driven supply chain management and decision-making?
	Do you think a supply chain platform that processes transactions, supports integration of the whole chain, supports decision-making and that simulates capabilities and supply alternatives in real-time, will be able to facilitate and support demand-driven supply chain management?
	Can you think of any technologies and information systems that will support demand-driven supply chain management?
Collaboration	What collaborative initiatives would you recommend for demand-driven supply chain management to be a success?
Human Resources	How important are skills and expertise in demand-driven supply chain management?
	Do you think training; innovation and, clear roles and responsibilities play a vital role in demand-driven supply chain management?
Organisational Alignment	Can the strategic positioning of decoupling points play a critical role in enabling demand-driven supply chain management?
	To what extent does customer segmentation and product classification drive demand-driven supply chain management?
	In your experience what drives organisational alignment in demand-driven supply chain?
Performance Management	What performance metrics are important to measure in a demand-driven supply chain?
	How important is reporting of performance metrics and alignment of incentives of all supply chain partners?
General	Do you see any additional factors to consider when implementing demand-driven supply chain management that are not represented in the DDSCM Framework?

8.3. Validation outcomes

Purposive sampling was used in selecting participants for this validation stage because the research needed to be validated by people who can provide information by virtue of their knowledge and experience. Purposive sampling is a non-probability sampling method that is most relevant when one needs to collect practical data on a certain domain from subject matter experts (Tongco, 2007). The domain for this research is DDSCM. The primary source of the participants was LinkedIn. The response rate to the invitation to participate in the study was 8.8%. To this end, this first phase of the validation process consisted of fourteen (14) participants as shown in Table 8.2.

Table 8.2: Subject matter experts' profiles

Participant	Organisational Role of the Participant	Sector	Accumulated Experience (years)
1	Founder/Consultant	Educator	33
2	Co-founder/Trainer (Demand Driven)	Educator	30
3	Supply Chain Manager	Industry	29
4	Supply Chain Executive	Industry	27
5	Co-founder/Trainer (Demand Driven)	Educator	26
6	Demand Driven Instructor	Educator	20
7	Supply Chain Director	Industry	20
8	Supply Chain Manger	Industry	17
9	Supply Chain Capacity Development Executive	Industry	12
10	Demand Driven Business Development Manager	Industry	10
11	Senior Demand Driven Consultant	Industry	10
12	Supply Chain Specialist	Industry	8
13	Consultant/Trainer (Demand Driven)	Industry	6
14	Demand Planner	Industry	3

8.3.1. Results and discussion

The validation process captured the opinions and judgements of the subject matter experts. Table 8.3 outlines a comprehensive outline of the key DDSCM concepts that were *Validated, Modified* and *Added* to the maturity model. Concepts that are emphasised by *two* participants and *not contradicted* by any of the participants are considered *Validated.* Those concepts that are *described differently* by participants but are *similar to the concepts* that are in the maturity model, are *Modified. New concepts* that participants pointed out, that were not in the maturity model, are *Added* into the maturity model. However, some concepts may not be the most important and influential for the DDSCM approach, but are included in the maturity model.

Table 8.3: Influential DDSCM Concepts (Subject Matter Experts Judgements)

		Distribution Management	Visibility	Technology	Collaboration	Human resources	Organisational alignment	Performance Management
Validations	V1	Demand planning	Demand visibility	Integration of internal and external information sources	Collaborative decision making	Education, training, and certification of personnel by professional bodies and universities	Strategic decoupling points (inventory positioning)	Development Key performance indicators
	V2	Warehouse inventory management	Order visibility	A technological architecture that is able to perform scenario analysis and buffer replenishment calculations	Strategic supplier relationship management	Skills, expertise and competencies	Product classification	Supply chain agility
	V3	Warehouse management system (WMS) and technologies	Visibility to relevant reports	Data capturing through the use of technologies and sensors	Customer relationship management	Innovation to solve complex SC problems	Segmentation	Supply chain reliability
	V4	Warehouse layout reviews, picking and sorting	Lead-time visibility	Data transmission and reporting through a common standardised supply chain platform	Risks and benefits sharing	Clear roles and responsibilities	Buffer profiles and sizes	Supply chain responsiveness
	V5	Order Management	Forecasts visibility	IT systems that are interoperable	Mutual interdependence	Incentives	Customer oriented organisation (organisational vision)	-
	V6	SOPs for Expired medicines management	Access to MOQ/EBQ information	Standardisation of data collection process	Information exchange and reports sharing	-	Leadership and management support	-
	V7	Risk management		-	Trust and commitment	-	-	-
Modifications	M1	Cross-Docking	Buffer (inventory visibility)	Buffer monitoring and automatic order generation	Resource sharing and scheduling	Development of rewarding strategies	Optimise strategic outsourcing activities	Perfect order fulfilment
	M2	Flexible and responsive logistics systems	-	-	Long term Contracts and service level agreements with suppliers	Management infrastructure that manage human resources	-	Customer satisfaction

		Distribution Management	Visibility	Technology	Collaboration	Human resources	Organisational alignment	Performance Management
	M3	Warehouse automation technologies	-	-	Coordination among supply chain partners	Supportive structure for performance management	Streamlined processes	-
	M4	Cycle counting and audit of cycle counting	-	-	Supplier development	Retention structure	Cost management	-
	M5	-	-	-	Supplier performance measurement	Working environment and work culture	Alignment of metrics	-
	M6	-	-	-	Collaboration for problem solving	Systematic thinking ability of supply chain staff	-	-
	M7	-	-	-	-	-	End-to-End alignment of supply chain goals and objectives	-
Additions	A1	Dynamic buffer adjustments	-	Simulation and route optimisation	-	Workforce planning	Innovation to fusion all the DDSCM components	Stability
	A2	Buffer stock modelling and calculations	-	Supply chain control tower	-	Organisational structure	-	Speed/Velocity
	A3	Usage behaviour	-	Big data analytics	-	Human resources policies and plans	-	-
	A4	Usage of industry 4.0 to capture demand	-	-	-	Human resource information system	-	-
	A5		-	-	-	Succession Planning	-	-

Using the data extracted from subject matter expert judgements, the author established Influential Ratings (IR) as indicators to analyse the importance of a concept on DDSCM. The IR represent the number of participants that agreed on the importance of a DDSCM concept. The calculation for the IR is as follows:

$$\boldsymbol{Influential\ Rating\ (IR)} = \frac{Number\ of\ participants\ that\ highlighted\ the\ DDSCM\ concept}{Total\ number\ of\ participants}\ x\ 100$$

The best way to explain the calculation for IR might be to present an example. Taking *Demand and supply planning* in Figure 8.1 as an example:

- 12 people highlighted the importance of the concept of Demand and supply planning
- Total number of participants is fourteen (14)

Therefore,

$$\boldsymbol{IR} = \ (Demand\ Planning) = \frac{12}{14}\ x\ 100 = 86\%$$

Table 8.4 shows a guideline developed for assigning influential ratings to the DDSCM concepts.

Table 8.4: Guideline for assigning Influential Ratings on DDSCM concepts

	Description
	0-20 % of participants highlighted and agreed on the importance of a DDSCM concept
	21-40 % of participants highlighted and agreed on the importance of a DDSCM concept
	41-60 % of participants highlighted and agreed on the importance of a DDSCM concept
	61-80 % of participants highlighted and agreed on the importance of a DDSCM concept
	81-100 % of participants highlighted and agreed on the importance of a DDSCM concept

8.3.2. Distribution management

Figure 8.2 outlines the key concepts under distribution management and the number of experts that agreed on the importance of the DDSCM concepts.

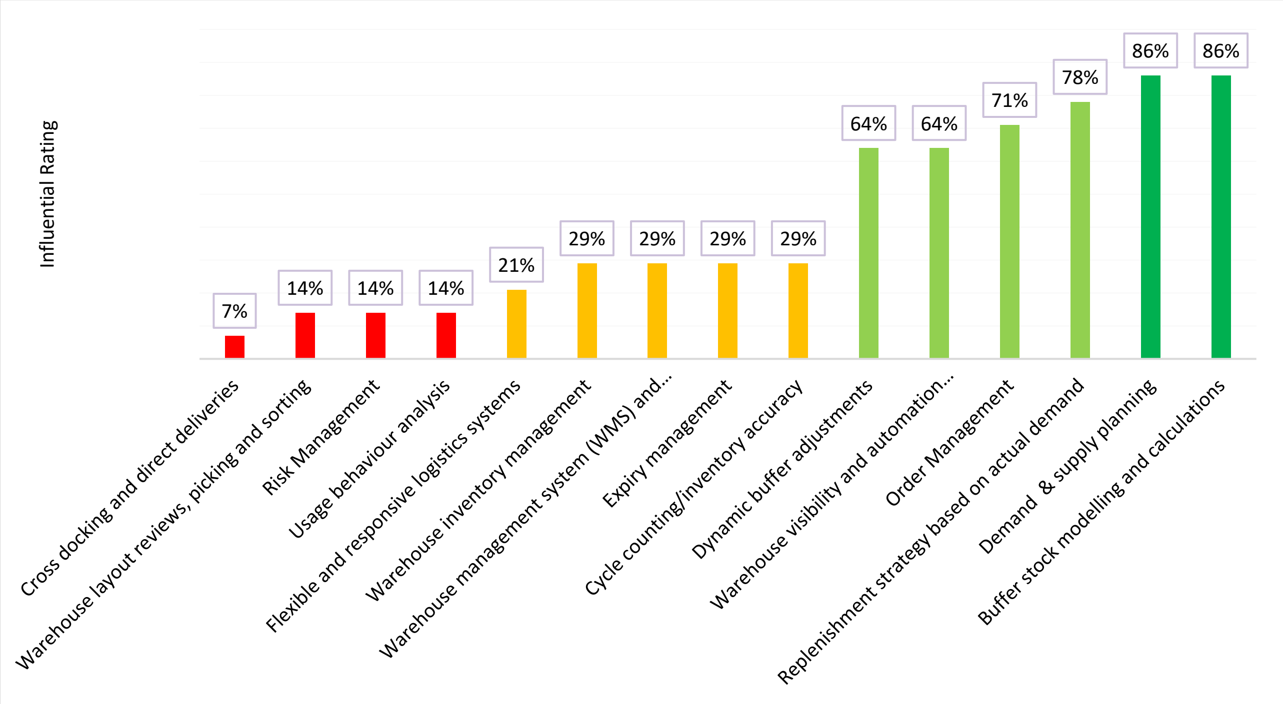


Figure 8.2: Distribution management

The demand planning and supply planning, and buffer stock modelling concepts have the highest IR percentage. Most experts highlighted that these concepts are very important to the success of DDSCM. The second highest IR percentage is on demand driven replenishment strategy followed by order management, and warehouse visibility and automation, respectively. On the contrary, the lowest IR percentage is on cross-docking and direct deliveries, as well as warehouse layout reviews, picking and sorting. Despite being added as new concepts into the maturity model, concepts such as dynamic buffer adjustments, buffer stock modelling and calculation received highest IR percentages. This implies that these concepts play a pivotal role in DDSCM success.

8.3.3. Visibility

Figure 8.3, illustrates the key concepts associated with the visibility dimension. Concepts such as demand visibility and buffer visibility (inventory visibility) attained a high IR percentage of 86% and 71% respectively. This imply that these concepts are critical to the DDSCM approach. However, a few participants acknowledged the importance of having access to real-time information on Minimum Order Quantity (MOQ) and Economic Batch Quantity (EBQ). Therefore, these concepts have lowest IR percentage (7%). Moreover, concepts such as lead-time visibility and forecasts visibility across the supply chain are considered not as very important in the context of DDSCM compared to order visibility and reports visibility, which attained IR percentages of 29% and 14% respectively.

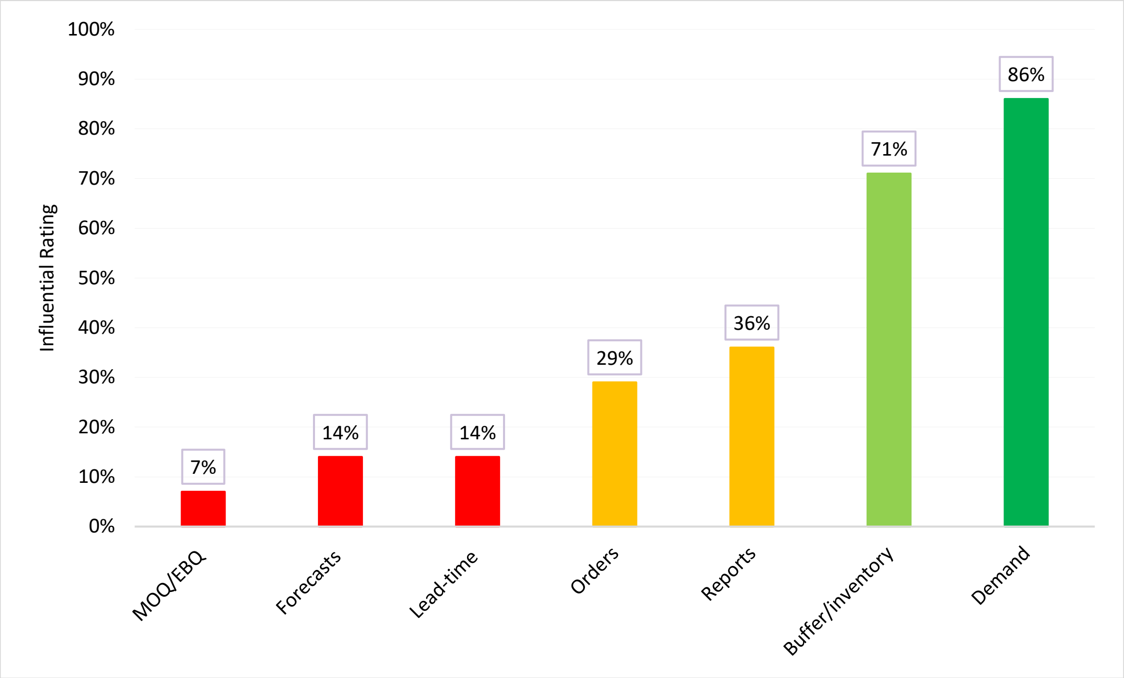


Figure 8.3: Visibility

8.3.4. Technology

Figure 8.4 illustrates the key concepts that are addressed under the Technology dimension. While literature argues that DDSCM success is centred on interoperable information systems, and integration of internal and external information sources through a common supply chain platform (integrated IT architecture) (Korhonen, Huttunen and Eloranta, 1998), it can be seen in Figure 8.3 that the participants reinforced these findings. These concepts attained highest IR percentages.

New concepts that were added by subject matter experts such as big data analytics attained also medium IR percentages. This implies the high importance of the concept in enabling DDSCM. In contrary, new concepts that were also added by subject matter experts such as control tower for tracking and tracing products flow throughout the supply chain (process visibility), and simulation and route optimisation received the lowest IR percentages.

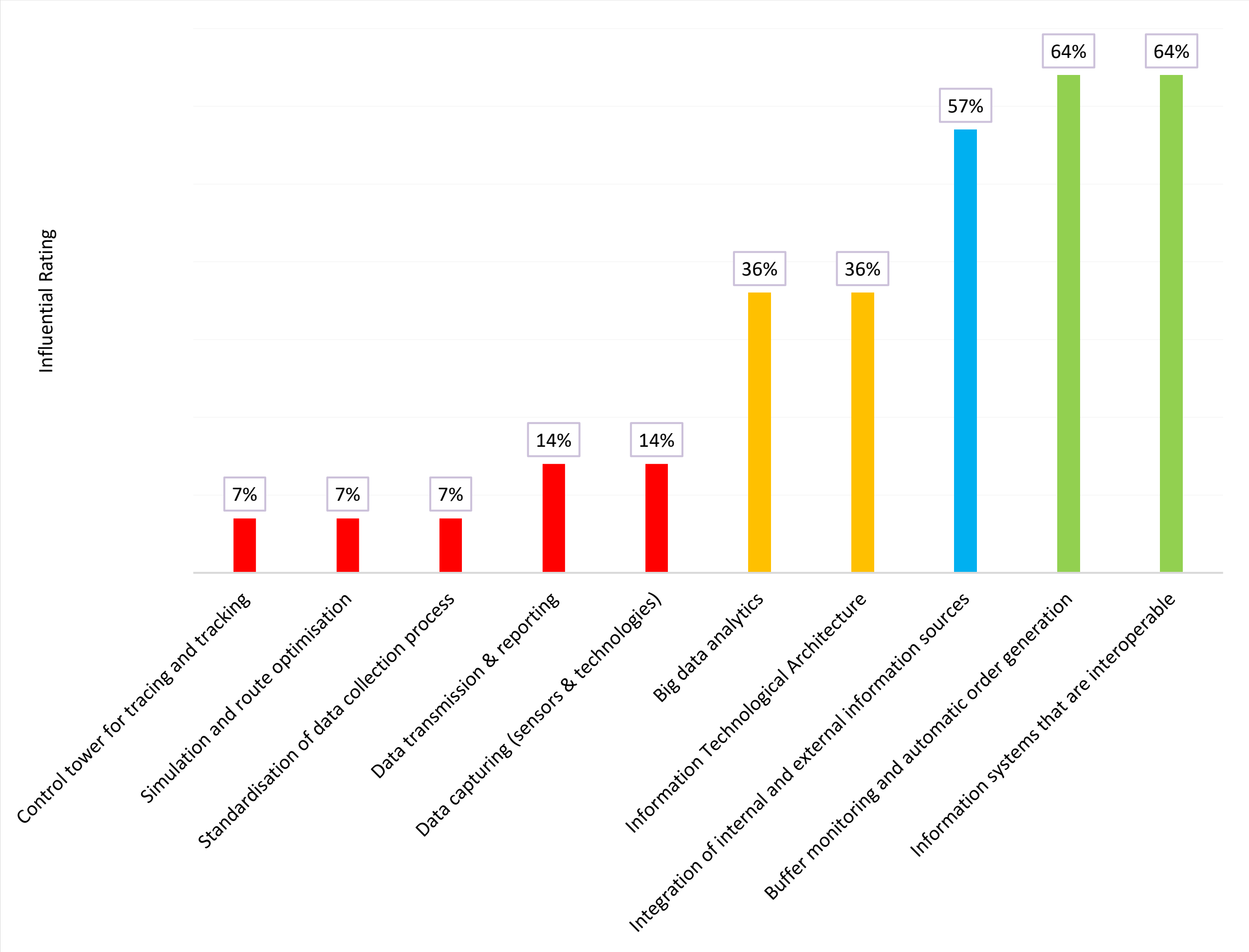


Figure 8.4: Technology

8.3.5. Collaboration

Figure 8.5 outlines the key concepts considered under the collaboration dimension. Subject matter experts support the importance of relationships and partnerships in the supply chain. This can be seen by the highest IR percentages of Strategic Supplier Management (SSM), and Customer Relationship Management (CRM), with 100% and 71% respectively. Moreover, both collaboration for problem solving and collaborative decision-making in the supply chain are also recognised as important concepts as reflected by their high IR percentages as well.

However, subject matter experts suggest that the concepts such as resource sharing and scheduling, long-term contract and agreements, with suppliers are of little importance, hence the low IR percentages as shown in Figure 8.5.

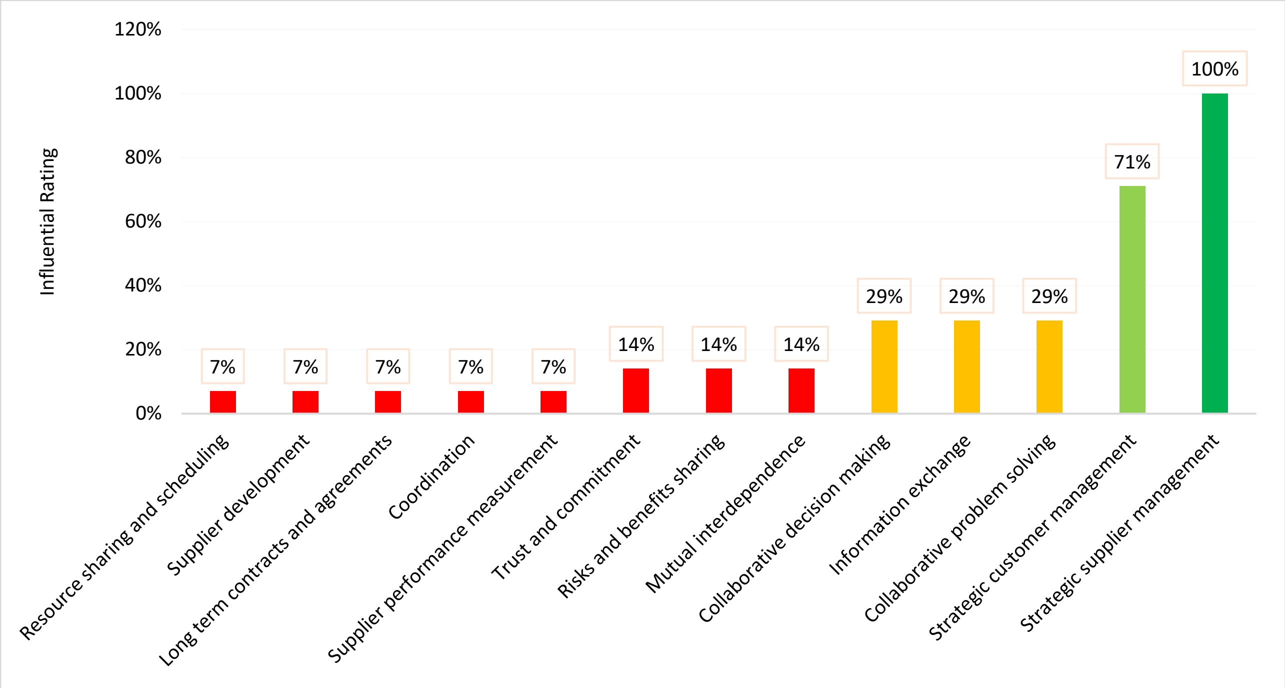


Figure 8.5: Collaboration

8.3.6. Organisational alignment

The key concepts under organisational alignment dimension are outlined in Figure 8.6. Supply chain leadership and management concept has the highest IR percentage, because it plays a vital role in the achievement of DDSCM. The three DDSCM concepts that attained an IR percentage of 64% are product classification, inventory positioning (strategic decoupling points) and segmentation. Average IR percentages are associated with concepts such as buffer profiles and sizes, and streamlined processes. Furthermore, concepts such as customer-oriented organisation (organisational vision) are recognised as influential concepts to the success of DDSCM. In contrary, the cost management concept is regarded as the least influential concept on DDSCM.

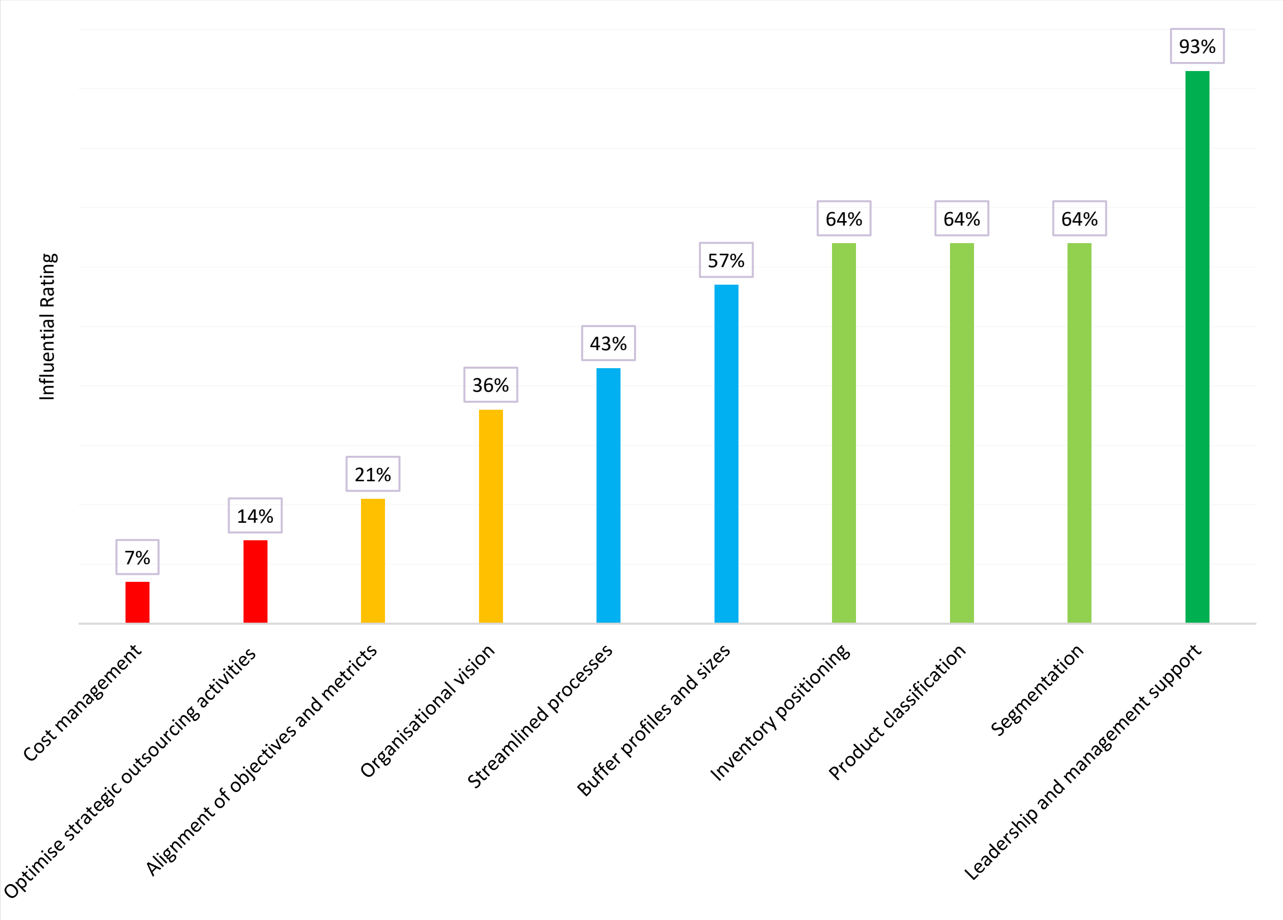


Figure 8.6: Organisational Alignment

8.3.7. Human resources

With respect to human resources, key concepts such as education, training, and certification of personnel by professional bodies and universities, and systematic thinking ability by supply chain staff scored have high IR percentages. This reflects the significant importance these concepts have. The concepts that have medium influence on DDSCM include enhanced skills, expertise and competencies.

However, concepts such as human resources strategy, retention structures, workforce planning, succession planning, and organisational structure, were added as new concepts to the model. Despite the low IR percentage of these concepts, these concepts are *Added* in the maturity model based on the argument that these concepts were strongly suggested by participants that are directly involved in supply chain capacity development in public healthcare supply chains. They suggested that the human resource dimension should not exclusively focus on the personal development of supply chain staff but should extend to cover the organisational policies that guide the management and development of supply chain staff.

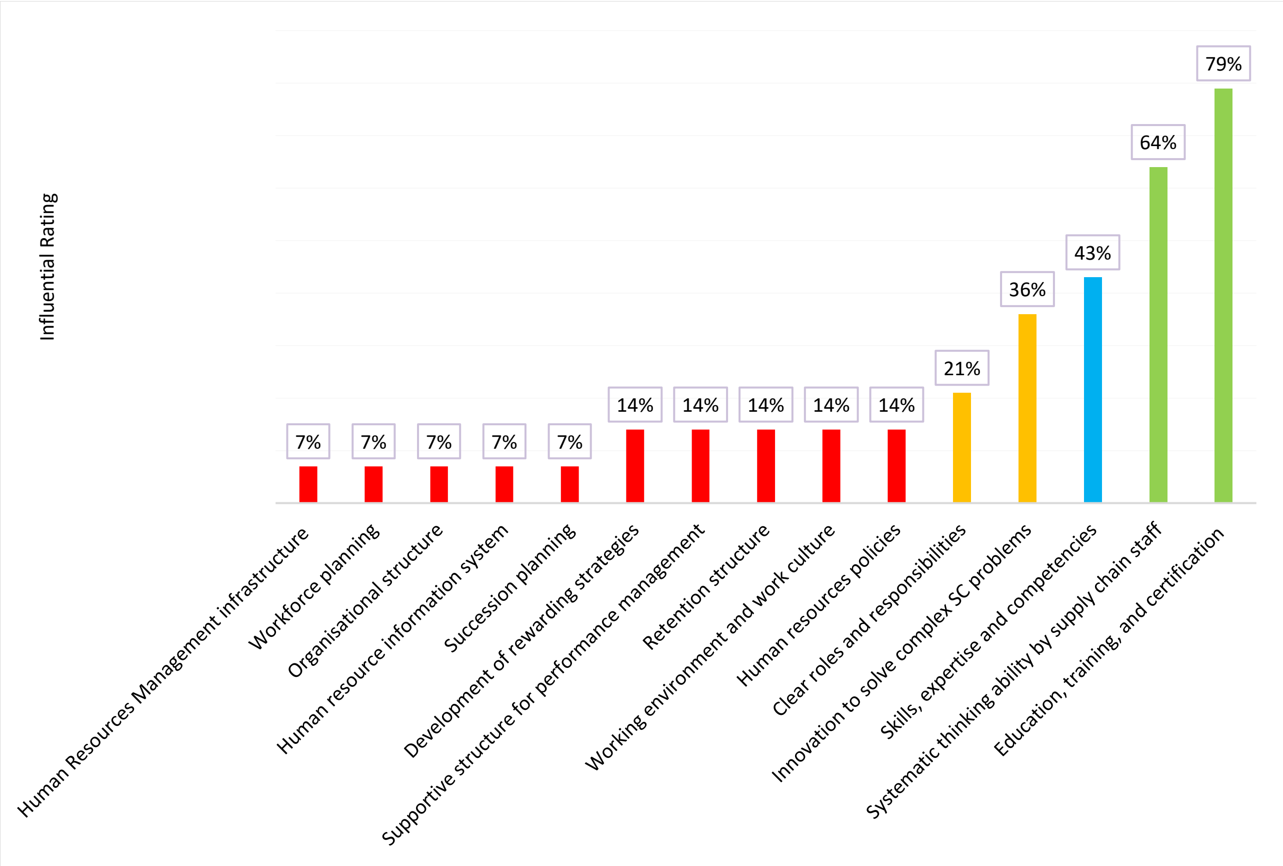


Figure 8.7: Human Resources

8.3.8. Performance management

Figure 8.8 illustrates the key concepts under performance management. It is notable that, it is important for organisations to first define their key performance indicators that can be used to evaluate the targets and goals of the organisation. To this end, this concept has the highest IR percentage alongside customer satisfaction. Furthermore, it is noticeable that the SCOR model metrics, such as supply chain responsiveness, agility and reliability that were adopted for the DDSCM maturity model, were deemed highly credible to measure performance. They attained IR percentages of 71%, 71% and 57% respectively. New concepts added to the maturity model such as supply chain stability and supply chain speed/velocity were deemed of great importance and, as such, have high IR percentages as compared to the SCOR model metrics.

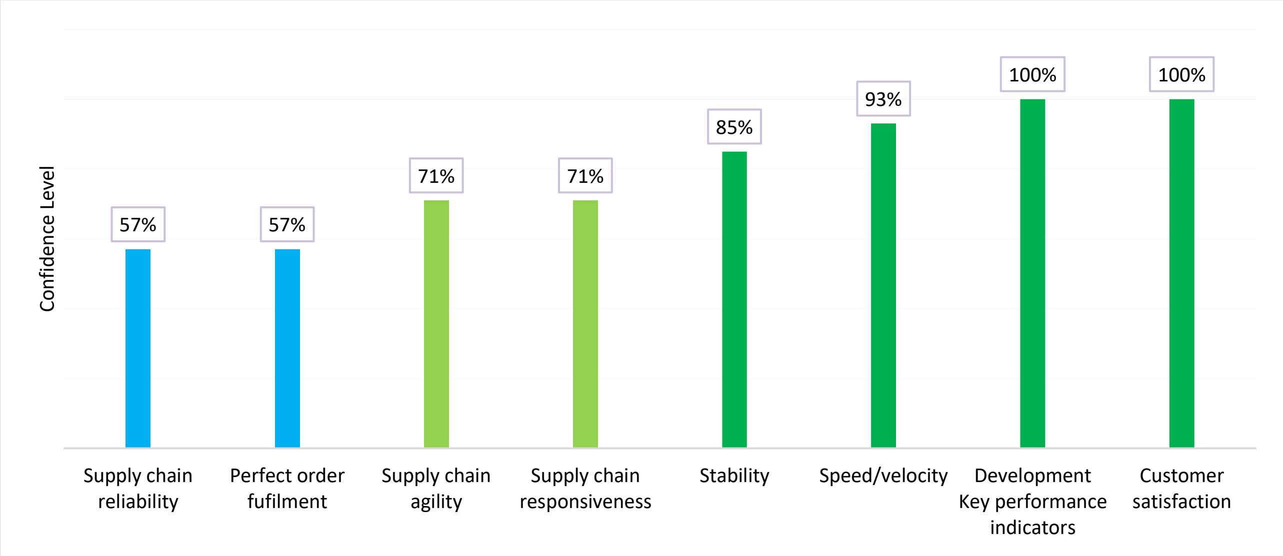


Figure 8.8: Performance Management

8.4. Validation stage 2

The next validation phase involved maturity model ranking interviews to test the model for usefulness, relevance and to test whether it is needed in public healthcare supply chains. Semi-structured interviews were conducted with subject matter experts specifically in the field of healthcare supply chains. The profiles for the nine (9) participants are shown in Table 8.5.

Table 8.5: Participants profiles for maturity model ranking interviews

Participant	Organisational Role of the Participant	Sector	Accumulated Experience (years)
1	Healthcare supply chain , warehouse and distribution consultant	Industry	34
2	Vice president of healthcare supply chain operations	Industry	29
3	Consultant (Healthcare supply chains)	Industry	18
4	Supply Chain Development Lead	Industry	15
5	Healthcare supply Chain Strategist	Industry	13
6	General Manager Public Health	Industry	11
7	Director of Healthcare Supply Chain	Industry	10
8	Director General National Medicines Supplies	Industry	10
9	Demand, Supply & Inbound Logistics Manager	Industry	9

8.4.1. Results and discussion

The questions asked to the healthcare supply chain experts required their responses to be ranked on a five-point Likert scale. The questions are shown in Appendix 2. Table 8.6 illustrates the results from the interviews.

Table 8.6: Importance of DDSCM in public healthcare supply chain

Respondents	P1	P2	P3	P4	P5	P6	P7	P8	P9	Importance	Mean	Standard deviation
Visibility	5	5	5	4	5	5	5	5	5	97,8%	4,9	0,3
Technology	4	5	4	4	5	5	5	5	4	91,1%	4,6	0,5
Collaboration	5	4	4	3	5	5	5	5	5	91,1%	4,6	0,7
Human resources	5	5	5	3	4	5	4	4	5	88,9%	4,4	0,7
Distribution Management	5	1	4	5	5	5	5	5	5	88,9%	4,4	1,3
Organisational alignment	5	1	5	5	5	5	4	4	5	86,7%	4,3	1,3
Performance management	5	1	3	5	5	5	4	4	5	82,2%	4,1	1,4

Table 8.6 show that the distribution of the answers on the relevance and usefulness of DDSCM in public healthcare supply chains is acceptable with no expert opinions over or under represented. This can also be illustrated graphically in Figure 8.9.

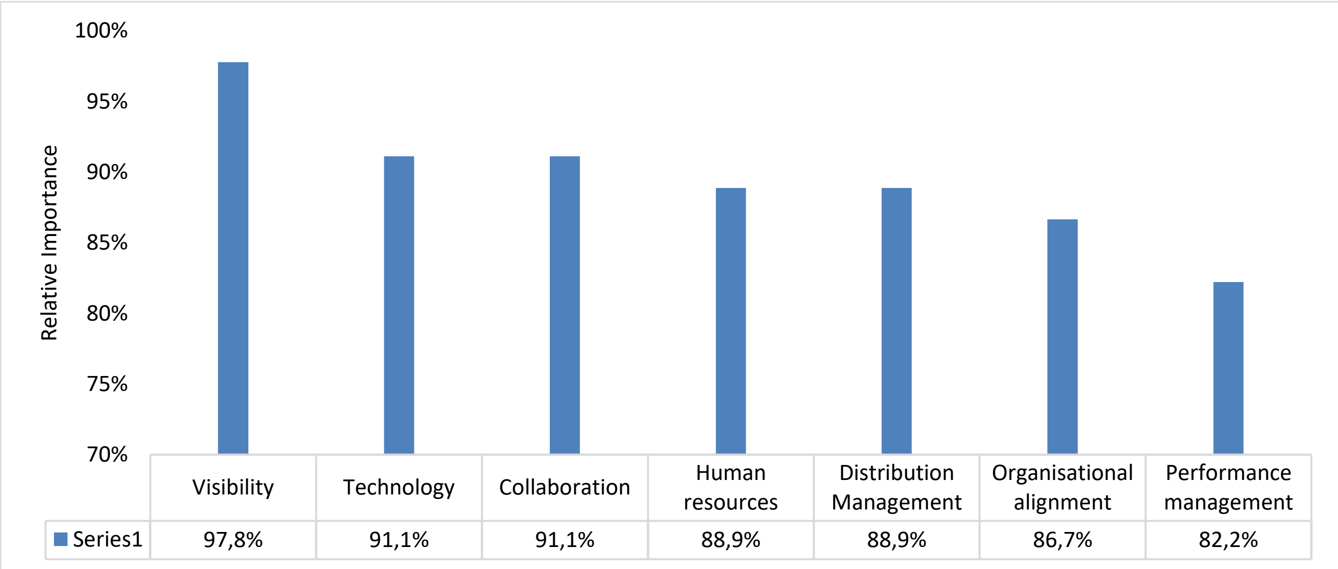


Figure 8.9: Expert ranking of importance of DDSCM in healthcare supply chains

It can be noted in Figure 8.9 that, the most important dimension in public healthcare supply chains is visibility (97.8%) which can be enhanced by the technology dimension (91.1%) and collaboration (91.1%). Next, the importance of both human resources and distribution management dimensions in public healthcare supply chain is 88.9%. Organisational alignment and performance management dimensions have 86.7% and 82.2% respectively.

8.5. Empirical relationship mapping of DDSCM dimensions

The purpose of this section is to identify and test the interrelationships between the DDSCM dimensions. As processes mature, they move from an internally focused perspective to an externally focused systems perspective. This implies that, for the seven dimensions to be fully realised, amplified and unlocked to their full potential, they need to be comprehended through a total systems view as opposed to an internally focused perspective.

8.5.1. Survey methodology

Drawing from an extensive Systematic Literature Review (SLR) (Section 5.6.1), interrelationships between DDSCM dimensions were identified. A survey was then conducted using google forms to test the interrelationships with 78 supply chain professionals from the South African Production and Inventory Control Society (SAPICS).

Participants were asked to give their expert opinions on the relationships among the seven DDSCM dimensions. The participants were given the DDSCM framework (Figure 5.12) highlighting the dimensions and underlying capabilities as a guide to answering the questions (survey questions shown in Appendix 6).

The criteria for answering the survey questions is outlined in Table 8.7. Participants were asked to judge the extent a DDSCM dimension influence another dimension on a five-point scale. This scale captured a cluster of attitudes from *(not at all)* to *(to a larger extent).*

Table 8.7: Survey criteria

Participant choice of outcomes	Numeric value associated with participant choice of outcome	Description
A	**0**	Not at all
B	**2**	To a smaller extent
C	**3**	To some extent
D	**4**	To a moderate extent
E	**5**	To a larger extent

Each relationship mapping score was calculated as a weighted average as follows:

$$R_i = \frac{\sum_{K=1}^{78} Participant\ choice\ of\ outcome}{\boldsymbol{E}\ (maximum\ numeric\ value\ (\mathbf{5})) * \boldsymbol{Total\ number\ of\ responses}\ (78\ participants)}$$

$$= \frac{\mathbf{A} * (no\ of\ responses) + \mathbf{B} * (no\ of\ responses) + \mathbf{C} * (no\ of\ responses) + \mathbf{D} * (no\ of\ responses) + \mathbf{E} * (no\ of\ responses)}{(\mathbf{5} * \mathbf{78}) = 390}$$

8.5.2. Survey outcomes

The subject matter experts articulated that, supply chains are integrated and are controlled by multiple and linked methods and decision rules. These methods and decision rules influence the flow of products in the supply chain. Moreover, they argued that supply chains must ensure effective flow of products from point of origin to the end user. Consequently, close relationships and partnerships among supply chain partners is a key component to performance improvement (Sahay, 2003) and it significantly contribute to reliable information flow across the supply chain (Heikkila, 2002).

Subject matter experts from the survey remarked that technology is key to the supply chain and that technology can only serve that which the human resource intends to automate for process effectiveness and efficiency. Other subject matter experts noted that, fourth industrial revolution technologies have the potential of becoming the main link in the supply chain. This is in line with arguments in literature that suggest that, leveraging information technology, visibility and a collaborative environment between suppliers and customers facilitate supply chain agility, responsiveness and competitiveness (Agrawal, 2012). Furthermore, subject matter experts suggested that, any technology development and utilisation must be in support of enhancing a collaborative environment between suppliers and customers.

A large number of participants acknowledged the relationships among most DDSCM dimensions, with only a few participants arguing that, there exist no relationships among a few dimensions.

Moreover, from Table 8.8, other subject matter experts failed to identify and validate the following interrelationships; Human resources – Technology (21.8%), Collaboration – Distribution management (21.8%), Collaboration – Human resources (19.2%), Distribution management – Performance management (23.1%), Organisational alignment – Performance management (23.1%), Human resources – Performance management (17.9%).

Table 8.8: Survey summary

Survey Question		To a greater extent	To a moderate extent	To some extent	To a smaller extent	Not at all
		Number of responses				
Q1	To what extent does Technology enhance Supply Chain Visibility?	64	11	3	0	0
Q2	To what extent does Supply Chain Visibility enhance Collaboration?	48	23	5	2	0
Q3	To what extent does human resources enhance supply chain visibility?	19	21	24	11	3
Q4	To what extent does Supply Chain Visibility enhance Distribution Management?	40	31	7	0	0
Q5	To what extent does Supply Chain visibility enhance Performance Management?	35	30	13	0	0
Q6	To what extent does Organisational Alignment influence Supply Chain Visibility?	22	24	29	3	0
Q7	To what extent does Technology enhance Distribution Management?	45	26	7	0	0
Q8	To what extent does Human Resources influence Distribution Management?	16	28	24	8	2
Q9	To what extent does Technology enhance collaborative activities?	32	28	13	4	1
Q10	To what extent does Technology enhance Performance Management?	34	35	8	1	0
Q11	To what extent does Technology support Organisational Alignment?	16	31	24	7	0
Q12	To what extent does Collaboration support Organisational Alignment?	31	31	13	3	0
Q13	To what extent does Organisational Alignment support Distribution	13	14	31	15	5
Q14	To what extent does Organisational Alignment support Human Resources?	38	28	7	4	1
Q15	To what extent does Collaboration enhance Performance Management?	30	28	18	2	0
Q16	To what extend do Human Resources influence Technology?	17	17	14	13	17
Q17	To what extent does Collaboration support Distribution Management?	10	25	12	14	17
Q18	To what extent do Collaboration influence Human Resources?	15	16	13	19	15
Q19	To what extent does Distribution Management influence Performance	19	8	18	15	18
Q20	To what extent does Organisation Alignment enhance performance management?	19	12	15	14	18
Q21	To what extent does Human Resources influence Performance Management?	24	18	10	12	14

Relationship mapping scores are shown in Table 8.9 and are diagrammatically illustrated as well in Figure 8.10. The survey found that the strongest relationship exists between technology and visibility (96%), followed by the relationship between visibility and collaboration (90%), and technology and distribution management (90%). This is in line with literature that suggest that Information Technology (IT) has the ability to collect and analyse data, generate specific recommendations and match insights with strategies (Korhonen, Huttunen and Eloranta, 1998). The data collected can be on the status of orders, inventory, identity and location of products in the supply chain (Francis, 2008). It is through partnerships that organisations can reduce response time by obtaining information to streamline their processes (Agrawal, 2012).

On the contrary, the weakest relationship exists between organisational alignment and performance management (57%). This is because other subject matter experts (23.1%) failed to identify and validate this relationship, and then this weakens the relationship score between the two dimensions.

Table 8.9: DDSCM dimensions relationship mappings scores

		Effect						
		Technology	Visibility	Collaboration	Distribution Management	Organisational Alignment	Performance Management	Human Resources
Cause	Technology	-	0,96	0,82	0,9	0,86	0,82	-
	Visibility	-	-	0,9	0,88	-	0,86	-
	Collaboration	-	-	-	0,82	0,74	0,7	0,64
	Distribution Management	-	-	-	-	-	0,61	-
	Organisational Alignment	-	0,77	-	0,83	-	0,57	0,64
	Performance Management	-	-	-	-	-	-	-
	Human Resources	0,85	0,71	-	0,72	-	0,59	-

From Figure 8.10, it can be seen that, according to the participants, technology enhances visibility, collaboration, distribution management, organisational alignment, and performance management. This entails that, participants believe that, if we enhance the maturity of the technology dimension, the maturity of the five (5) other dimensions will be enhanced as well, since they are related to the dimension. The same logic applies on the visibility dimension, which in turn influence dimensions such as collaboration, distribution management, and performance management.

Next, from the survey results, it can be concluded that respondents think collaboration, enhances distribution management, organisational alignment, performance management and human resources. Organisational alignment influence distribution management, visibility, performance management and human resources. Distribution management influence performance management. Lastly, human resources dimension has impact on distribution management, visibility, technology and performance management.

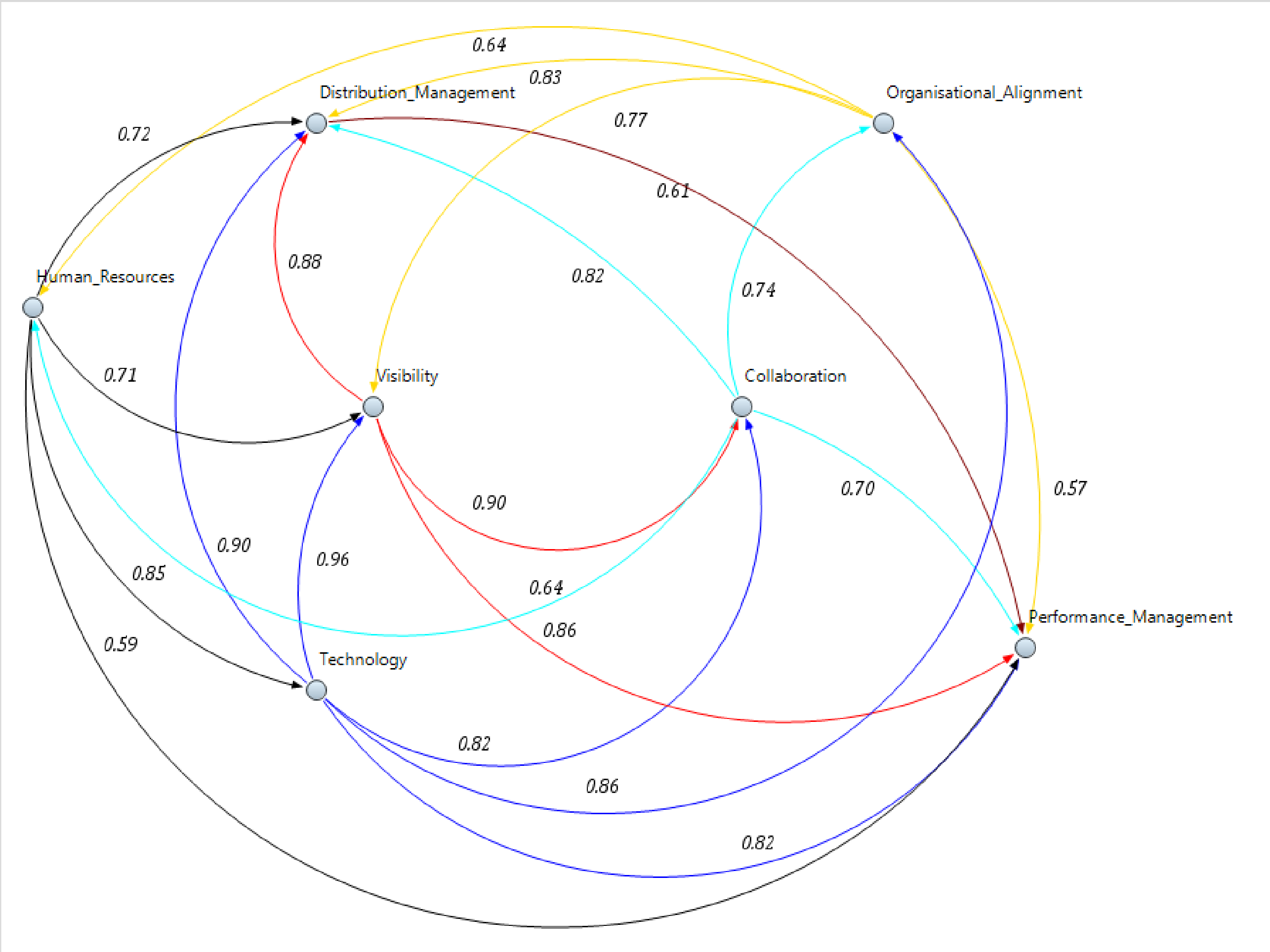


Figure 8.10: DDSCM Dimensions interrelationships

8.5.3. Reflection on the relationship mappings

Systems thinking guide people to view complex systems from a broad perspective. This includes seeing overall structures, patterns and cycles in systems, rather than seeing only specific events in the system. This broad view can support quick identification of real causes of issues in organisations and know just where to address them. By focusing on the entire system, people can attempt to identify solutions that address as many problems as possible in the system (Arnold and Wade, 2015).

Following this line of reasoning, it immediately becomes apparent that the public healthcare Supply Chain Network (SCN) can be viewed as a system. The relationship mappings among DDSCM dimensions can be used on a network level to prioritise which dimensions in the public healthcare SCN to improve through planned interventions. It is imperative to identify a dimension that will have impact on many other dimensions. Enhancing the maturity of this dimension results in the enhancement of the maturity state of other dimensions in the entire public healthcare SCN.

In order to convey this argument, it can be seen in Figure 8.10 that the technology dimension has significant impact on multiple dimensions, which in turn have impact on other dimensions. It becomes logical to first plan interventions around the technology dimension.

The bias for this approach is on the assumption that all respondents interpret key terms similarly when they answer a question on interrelationships in a questionnaire (Tongco, 2007). Another criticism of this approach may be that one may question whether the respondents' answers to questions relate to their actual behaviour or practice in their organisations (Tongco, 2007). While Figure 8.10 represents ideal DDSCM interrelationships derived from literature and empirically validated by subject matter experts in the supply chain field, there is a need to further explore the practical application, analysis and validation of the DDSCM interrelationships within the context of public healthcare SCN.

Consequently, at this point, these interrelationships derived from literature and validated by subject matter experts in the supply chain field remain suggestive and hypothetical within the context of public healthcare SCN. There is need to explore in more detail the practical validity of the inter-relationships since each organisation in the public healthcare SCN has unique characteristics.

8.6. Chapter summary

This chapter validated the concepts in the DDSCM maturity model using fourteen (14) subject matter experts within the DDSCM field. During this validation stage, some DDSCM concepts were modified and new ones added. Findings from this validation stage confirmed the credibility and completeness of the maturity model.

Furthermore, this chapter established the importance ranking of the maturity model dimensions using nine (9) subject matter experts working directly within public healthcare supply chains. These findings also show that the concepts in the maturity model are useful, relevant and needed. This resulted in a refined maturity model that can guide the development of a DDSCM network maturity-mapping tool designed for specific and unique public healthcare supply chain nodes.

Finally, this chapter outlined the empirical interrelationships between the DDSCM dimensions using a survey of 78 participants. The outcomes from this validation stage presents a guideline of prioritising dimensions to address across the network by planning interventions. However, these mappings remain suggestive and hypothetical due to uniqueness and dynamic nature of the public healthcare supply chain nodes.

Chapter 9 : Network Maturity Mapping Tool

9.1. Introduction

It appears that, there exist no supply chain maturity model that is able to manage properly the typical complexities in management of Supply Chain Networks (SCN), although several efforts have been taken for improving and expanding individual performance evaluation into organisations' suppliers, distributors and customers (Lahti, Shamsuzzoha and Helo, 2009). In particular, network level studies of the healthcare sector are still scarce (Marques et al., 2019).

Studies mapped in the systematic literature review show that, when studying DDSCM, there is an over-emphasis on a single supply chain node at a time (Chapter 5). This study reinforces the need to take a network-level analysis when addressing DDSCM. A network perspective improves and facilitates the understanding of the complexities of public healthcare sector. Therefore, this chapter adopts a network lens in the development of the DDSCM network maturity-mapping tool for the public healthcare SCN. The tool captures the notion of end-to-end supply chain (integrated supply chain) (Stevens, 1989) as opposed to single supply chain node focus, thereby addressing the gap highlighted by Lahti et al., (2009). Therefore, the objectives of this chapter are:

- To provide a design outline for the network-maturity-mapping tool.
- To explain how the network-maturity-mapping tool functions and will be applied in the case studies in chapter 10.

9.2. Purpose of the network maturity mapping tool

Given that a public healthcare Supply Chain Network (SCN) is only as strong as its weakest link, it is important to develop a network maturity-mapping tool that assists supply management at national, provincial, district and even at health facility level to perform a network analysis on the entire public healthcare SCN. A broken link in any part of the public healthcare SCN can cause a domino effect that can ultimately affect downstream supply chain partners such as hospitals and health facilities leading to stock outs and poor healthcare outcomes. This tool is vital since it helps supply chain managers to collate and analyse information from different supply chain nodes in the public healthcare SCN.

The network maturity-mapping tool simplifies analysis of the collated information by providing a visual presentation of the DDSCM assessment outcomes of the entire public healthcare SCN. This allows a systems level approach, helping supply chain managers to identify the DDSCM capabilities that need to be prioritised, leading ultimately to the development of strategic and operational suggestions that have impact on the entire public healthcare SCN. This facilitates benchmarking, drives continuous improvement across the public healthcare SCN and encourages process ownership.

9.3. Design outline for the network maturity-mapping tool

This section outlines the approach that was considered during the development of the network maturity-mapping tool. The design considerations for the network maturity-mapping tool are based on the findings from literature review on supply chain mapping as illustrated in Table 9.1, DDSCM maturity model (Table 7.10) and the structure of the public healthcare SCN in South Africa (Figure 4.4).

Supply chain mapping outlines the representation of linkages and partners of a supply chain. This ensures that the supply chain strategy conforms to the organisational strategy (Gardner and Cooper, 2003; Srai and Gregory, 2008; Farris, 2012; Kumar *et al.*, 2013).

The supply chain mapping techniques and approaches were critically reviewed against good supply chain mapping characteristics (Srai and Gregory, 2008; Farris, 2012) and this resulted in a network-mapping approach.

While Table 9.1 represents ideal characteristics for supply chain mapping, the actual number of potential mapping approaches is large. A summary of the supply chain mapping characteristics used for selection of supply chain mapping techniques and approaches is shown below (Srai and Gregory, 2008; Farris, 2012):

- Emphasis: external orientation, low/moderate detail, strategic capabilities, and primary nodes and links.
- Attributes: relevant tiers, upstream and downstream, and network centric.
- Scope: product family, supply network processes, replenishment/innovation/product life cycles.
- Complexity: information density (the data required to provide sufficient network configuration and description).
- Confidentiality: data provides all necessary details without compromising confidentiality.
- Scalability: future ability to update and add new data as the mapping activity requires.
- Supply chain mapping should produce Interpretable, Recognisable maps in Easy to distribute format.

Table 9.1: Supply chain mapping tools and techniques

References	ID	Supply chain mapping techniques and approaches	Supply chain mapping characteristics									
			Emphasis	Attributes	Scope	Low Complexity	Confidentiality	Scalability	Interpretable	Recognisable	Easy Format	**Select**
Gardner and Cooper (2003)	1	Direction (Coverage up or down the channel of distribution)	✓	✓	x	✓	✓	x	✓	✓	✓	
	2	Length (number of levels in each Direction)	✓	✓	x	✓	✓	✓	✓	✓	✓	
	3	Aggregation (Width) -Degree of specificity within a Tier	✓	✓	x	x	x	x	x	x	x	
	4	Spatial (Geographical relations)	✓	✓	x	x	x	x	✓	✓	✓	
	5	Focal Point (A map takes a firm-centric view or and industry-centric view)	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	6	Product breath (This is the breadth of product coverage included in the map)	x	✓	x	✓	x	✓	x	x	x	
	7	Supply chain perspective (Supply chain includes key processes beyond logistics)	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	8	Process View Depth (The depth of the process view is the extent to which a map incorporates a complete set of key business processes)	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	9	Cycle View (Includes returns channels and others feedback loops)	x	✓	✓	✓	x	x	x	✓	x	
	10	Organisations/Facilities	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	11	Flows	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
Srai and Gregory (2008)	12	Network tier structure and shape (Tier 1 and Tier 2 players)	✓	✓	x	✓	✓	x	✓	✓	✓	
	13	Organisational (outlining organisational network)	x	x	x	✓	x	✓	✓	✓	✓	
	14	Geometry (network flow/logic)	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	15	Levels of vertical and horizontal integration	x	x	✓	x	x	✓	x	x	x	
	16	Location (geographic spread)	✓	✓	x	x	x	x	✓	✓	✓	
	17	Coordination, and levels of flexibility	x	✓	✓	x	x	x	x	x	x	
	18	Manufacturing processes (Lean manufacturing map outlining component flow)	x	x	✓	x	x	✓	x	✓	✓	
	19	Optimum sequence (process flows outlining activities and mechanics)	x	x	✓	✓	✓	✓	✓	✓	✓	

References	ID	Supply chain mapping techniques and approaches	Supply chain mapping characteristics									
			Emphasis	Attributes	Scope	Low Complexity	Confidentiality	Scalability	Interpretable	Recognisable	Easy Format	**Select**
	20	Partner roles	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	21	Governance and trust	x	✓	x	x	✓	x	x	x	x	
	22	Nature of transactions	x	x	✓	x	x	✓	✓	✓	x	
	23	Value and non-value adding activities (value stream maps)	x	✓	✓	✓	✓	✓	✓	✓	✓	
	24	Process steps (functional map outlining process mapping)	x	x	x	✓	✓	✓	✓	✓	✓	
	25	Network dynamics (replenishment modes)	x	x	x	x	x	✓	x	x	x	
	26	Strategy charting (strategy mapping)	x	x	x	x	x	✓	x	x	✓	
	27	Enabling IT systems	x	x	x	x	✓	✓	x	x	x	
	28	Product structure(components, sub-assembly, modularity)	x	x	✓	✓	x	✓	✓	✓	x	
	29	Product replenishment mode (is the product make-to stock, make to order, configure to order.)	✓	✓	✓	x	✓	x	✓	x	x	
	30	Reverse logistics/service (directional flows)	x	✓	✓	✓	x	x	x	✓	x	
Kumar *et al.*, (2013)	31	Key actors (primary and secondary stakeholders)	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	32	Levels of integration	✓	✓	x	x	✓	x	x	x	x	
	33	Levels of visibility	✓	✓	x	x	✓	x	x	x	x	
	34	Relationships between actors	✓	✓	x	x	✓	x	x	x	x	
	35	Roles and influence of actors	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	36	Past and future trends within the supply chain network	x	x	x	x	x	x	✓	x	x	
	37	Basic flow of the supply chain	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	38	Core products	x	x	x	x	✓	✓	✓	✓	✓	
	39	Core firms/organisations	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes

References	ID	Supply chain mapping techniques and approaches	Supply chain mapping characteristics									
			Emphasis	Attributes	Scope	Low Complexity	Confidentiality	Scalability	Interpretable	Recognisable	Easy Format	**Select**
Farris (2012)	40	Economic input/output model	✓	✓	x	✓	✓	x	✓	✓	✓	
	41	Trading relationships (“buy from” or “sell-to”)	✓	✓	x	x	✓	x	x	x	x	
	42	Tier relationships	✓	✓	x	x	✓	x	x	x	x	
	43	Visualization (Tableau graphics)	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	44	Flow (inventory, finance, information)	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	45	Weighted arrows, lines and symbols	x	x	x	✓	✓	x	✓	✓	✓	
Carvalho, Cruz-Machado and Tavares (2012)	46	State of current operations	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	47	Possible transition states	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	48	Vulnerable points in the supply chain	✓	✓	✓	✓	x	✓	✓	✓	✓	
Taylor (2005)	49	Current state map	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	50	Key issues and opportunities map	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	51	Future state map	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes
	52	Action map	✓	✓	✓	✓	✓	✓	✓	✓	✓	Yes

Table 9.2: Considerations for the network-maturity mapping tool

ID	Selected supply chain mapping tools and techniques	Classification	Network Mapping Approach
44	Flow (inventory, finance, information)	Network flow logic (inventory, finance, information)	Network Flow Logic (inventory, finance, information)
37	Basic flows of the supply chain		
11	Flows		
14	Geometry (network flow/logic)		
5	Focal point		
39	Core firms/organisations	Supply Chain Nodes	Stakeholder Mapping
31	Key actors (primary and secondary stakeholders)		
10	Organisations/facilities		
35	Roles and influence of actors	Actor Roles	
20	Partner roles		
8	Process view depth	Capabilities	Capabilities Mapping
7	Key processes beyond logistics		
46	State of current operations		Capabilities Maturity Mapping
47	Possible transition states		
49	Current state map		
50	Key issues and opportunities map		
51	Future state map		
52	Action map		
43	Visualisation	Output	Visualisation (Tableau Software Tool)

Table 9.2 and Figure 9.1 provides foundational elements for the design outline for the network maturity-mapping tool. *Network flow logic* outlines the three major flows in a public healthcare SCN: inventory, information and finance.

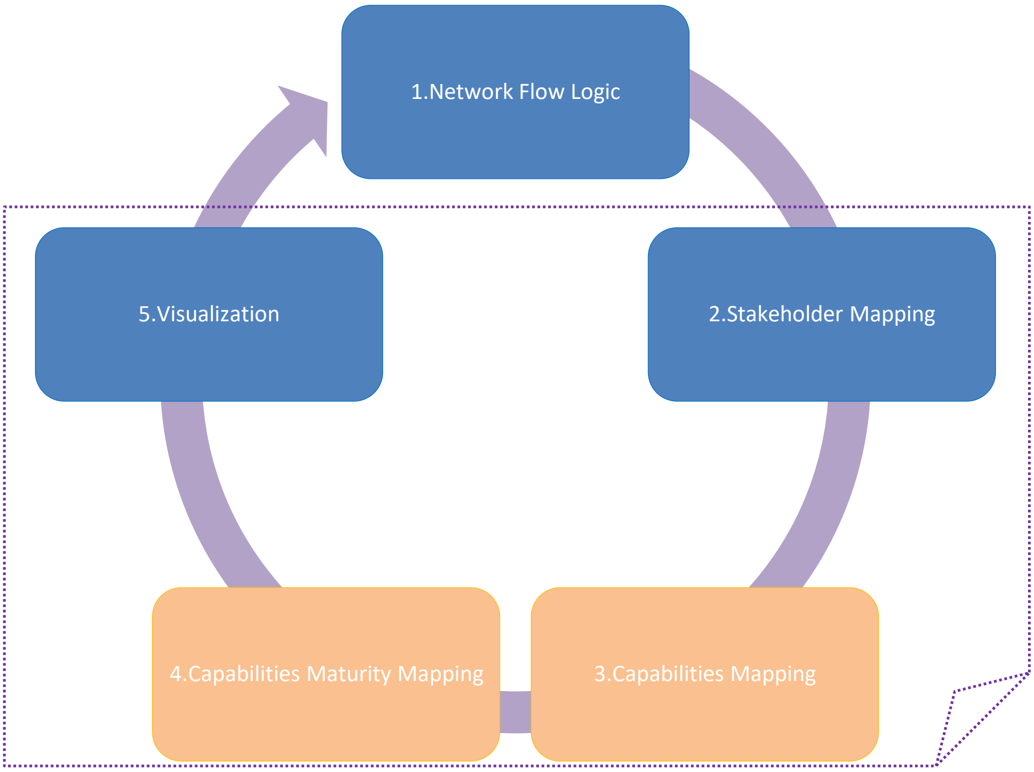


Figure 9.1: Network mapping approach

Stakeholder mapping and analysis is the process of identifying all the stakeholders that may affect or be affected by the actions or decisions of a focal organisation (Yu-Chun, Tang and Gulliver, 2013). *Stakeholder mapping and analysis* is a collaborative process of identifying, analysing, mapping and prioritising stakeholder relevance. It also encompasses techniques for analysing the power, predictability and interest of stakeholders (Newcombe, 2010; Almutairia *et al.*, 2019). In principle, stakeholders can be categorised and clustered into primary and secondary stakeholders (Almutairia *et al.*, 2019). Primary stakeholders include supply chain participants and organisations involved in the entire process of delivering the final product to its end consumer; i.e. from suppliers to end consumers. Secondary stakeholders are not directly involved in the organisation's primary activities (Yu-Chun, Tang and Gulliver, 2013).

In this research, *Stakeholder mapping and analysis* involves identifying the supply chain nodes to which the capabilities of DDSCM will be valid, applicable and useful. This *Stakeholder mapping and analysis* also involves categorising stakeholders with regards to their impact and influence on the availability of medicines at healthcare facilities. To that end, *Stakeholder mapping and analysis* for the public healthcare SCN in South Africa is shown in Table 9.3.

Table 9.3: Public healthcare supply chain stakeholders (Adapted from Berger et al., 2010)

Stakeholder/Node category	Type of stakeholders/Node	Stakeholders/Node activities and processes	Intended audience for the tool
Manufacturing	Primary	Manufactures and packages medicines	Supply chain managers
Central Medicines Stores	Primary	Procurement of the medicines, planning, warehousing and supplying health facilities with medicines	Senior technical supply chain staff (Operations managers)
Distribution	Primary	Logistics and transport management	Transport managers
Hospitals	Primary	Service delivery point, diagnosis and dispensing of medicines	Pharmacy managers
Clinics	Primary	Service delivery point, diagnosis and dispensing of medicines	Pharmacists
Medicines control Council	Secondary	Regulation and registration of medicines Ensuring medicines safety	x
Treasury	Secondary	Financing the procurement of medicines Creating budgets	x
Tender board	Secondary	Facilitates the tendering process for contracts	x
National Department of Health	Secondary	Make specifications on the type of medicines to be used and procured and is responsible for awarding contracts to manufactures with the help of the tender board	Programme managers in Ministries of Health
Patients	Secondary	Consume the medicines	x

Capabilities mapping captures relevant capabilities of the supply chain network (Srai and Gregory, 2008). Thus, helping in the understanding of an organisation's supply chain, for the purposes of evaluating the current supply chain performance and contemplating realignment of a supply chain (Gardner and Cooper, 2003; Srai and Gregory, 2008; Farris, 2012; Kumar *et al.*, 2013).

Capabilities represent a structured set of building blocks that define an organisation – "what" an organisation does or has the capacity to do (Ulrich and Kuehn, 2015). Capabilities are usually modelled using concepts used in the capabilities model (Grabis and Bērziša, 2015).

In this research, *Capabilities mapping* entails the process of matching DDSCM capabilities to the selected supply chain nodes in the public healthcare SCN. This is because all DDSCM capabilities do not match all the unique supply chain nodes in the public healthcare SCN.

Semi-structured interviews with participants at the unique supply chain nodes were conducted to match the DDSCM capabilities to the supply chain nodes in public healthcare SCN. The interview questions were based on the DDSCM capabilities in the DDSCM maturity model as shown in Appendix 7.

The output from the capabilities mapping interviews is a capabilities profile as shown in Table 9.4 and detailed in Appendix 8. The capabilities profile outlines the alignment of DDSCM capabilities to the unique supply chain nodes. In Table 9.4, it can be observed that 100% capabilities have been matched to the pharmaceutical manufacturers. However, some manufactures outsource their warehousing and transport capabilities to 3PLs. On the other hand, 81.81% of the capabilities are relevant to the central medicines stores while 57.58% of the capabilities are relevant to both health facilities and hospitals. To add on, 3PLs have 6.06% of capabilities relevant to them and lastly the NDoH has about 18.18% of the DDSCM capabilities that are relevant to them.

Table 9.4: Capability mapping profiles (Public Healthcare Supply Chain in SA**)**

ID#	Capability	Manufacturing	Central Medicines Stores	Hospitals	Clinics	NDoH	3PLs
1	Product Classification	✓	x	x	x	✓	x
2	Segmentation	✓	x	x	x	✓	x
3	Risk Management	✓	✓	✓	✓	x	x
4	Demand Planning	✓	x	x	x	✓	x
5	Inventory Positioning	✓	x	x	x	✓	x
6	Supply Planning	✓	✓	x	x	✓	x
7	Distribution Planning	✓	✓	x	x	✓	x
8	Warehouse Operations (Inventory Management)	✓	✓	✓	✓	x	x
9	Warehouse Visibility & Automation	✓	✓	✓	✓	x	x
10	Order Management	✓	✓	✓	✓	x	x
11	Logistics and transport Flexibility	x	x	x	x	x	✓
12	Expiry Management	✓	✓	✓	✓	x	x
13	Information sharing & Information Quality	✓	✓	✓	✓	x	✓
14	Demand and Inventory Visibility	✓	✓	✓	✓	x	x
15	Order Visibility	✓	✓	✓	✓	x	x
16	Information Technology Infrastructure	✓	✓	✓	✓	x	x
17	Data Transmission and Reporting	✓	✓	✓	✓	x	x
18	Data Capturing	✓	✓	✓	✓	x	x
19	Relationships	✓	✓	✓	✓	x	x
20	Interdependence & resource sharing	✓	x	x	x	x	x
21	Decision Making	✓	✓	✓	✓	x	x
22	Key Performance Indicators	✓	✓	✓	✓	x	x
23	Metrics	✓	✓	✓	✓	x	x
24	Policies and plans	✓	✓	✓	✓	x	x
25	Roles and responsibilities	✓	✓	✓	✓	x	x
26	Innovation	✓	✓	✓	✓	x	x

ID#	Capability	Manufacturing	Central Medicines Stores	Hospitals	Clinics	NDoH	3PLs
27	Incentives & Working environment	✓	✓	✓	✓	x	x
28	Training & Education	✓	✓	✓	✓	x	x
29	Management Support	✓	✓	x	x	x	x
30	Organisational Vision	✓	✓	x	x	x	x
31	Streamlined Processes	✓	✓	✓	✓	x	x
32	Alignment of Objectives	✓	✓	x	x	x	x
33	Cost Management	✓	✓	✓	✓	x	x

Finally, it is imperative to decide on the software tool that can be used to provide *visual* representation of outcomes. This will allow a systems level visual representation, helping management to identify the DDSCM capabilities that need to be prioritised. This study utilised *Tableau Software Platform* that has been used in other studies related to supply chain mapping (Gardner and Cooper, 2003; Farris, 2012). This decision was made by the author from a convenience perspective only, and thus other visualisation tools can also be used.

Consequently, Figure 9.2 provides in detail a design outline for the network maturity-mapping tool as well as the application methodology for the network maturity-mapping tool in the public healthcare SCN.

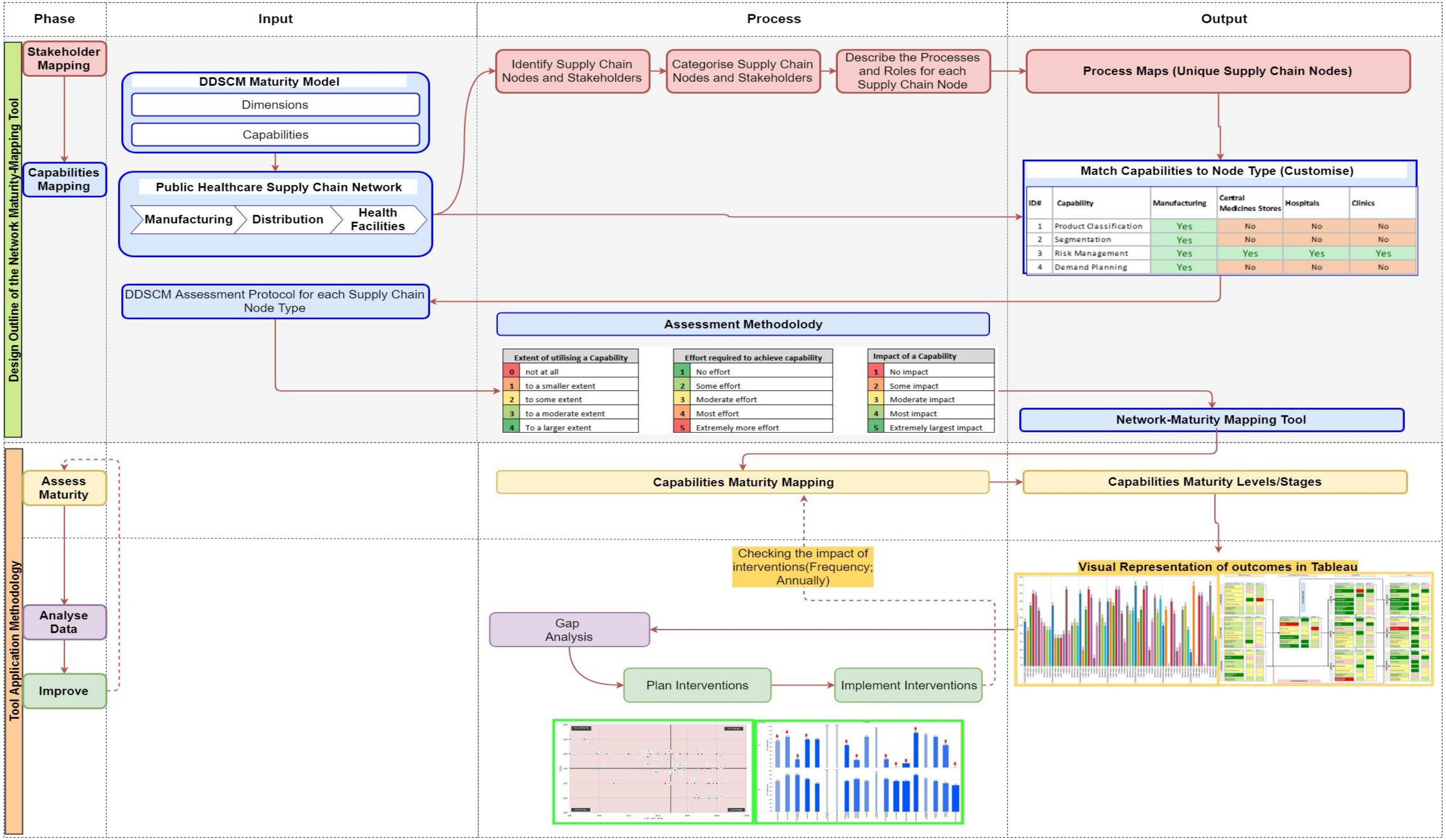


Figure 9.2: Network maturity-mapping tool overview

9.4. Tool application methodology

The network maturity-mapping tool is not intended to be a narrative tool to be read from beginning to end but it is a reference tool that the user can interact with to collect data, analyse data on a systems level to identify immature DDSCM capabilities in the public healthcare SCN. It helps users to develop strategic and operational suggestions/interventions by looking at the mapping outcomes. These outcomes support network analysis of the entire public healthcare SCN through visual presentation of outcomes and highlighting dependencies.

In Figure 9.2, a guideline of how to use the network maturity-mapping tool when implementing DDSCM capabilities at the unique nodes in the public healthcare SCN is illustrated. The first stage of implementing the network-maturity mapping tool is the *Capabilities maturity mapping stage*. It entails the evaluation of the DDSCM capabilities of a supply chain node. This is a data collection phase. The data is collected using semi-structured interviews based on the network-maturity mapping tool shown in Appendix 9.

Capabilities maturity mapping involved determining the extent a supply chain node utilises DDSCM capabilities, the effort required to achieve the capabilities and the perceived impact of the DDSCM capabilities on the performance of the supply chain node. This is illustrated in Table 9.5. Using the tool as a whole offers naturally the most extensive picture from the maturity of DDSCM capabilities. This is in line with the concept of process maturity (Reyes and Giachetti, 2010), that proposes that a process has a lifecycle that can be assessed by the extent to which processes are defined, managed, measured and controlled.

Table 9.5: DDSCM capabilities mapping guidelines

Extent of utilising a Capability X_i	
0	not at all
1	to a smaller extent
2	to some extent
3	to a moderate extent
4	To a larger extent

Effort required to achieve capability	
1	No effort
2	Some effort
3	Moderate effort
4	Most effort
5	Extremely more effort

Impact of a Capability	
1	No impact
2	Some impact
3	Moderate impact
4	Most impact
5	Extremely largest impact

The capability Maturity Score (MS) can be determined for each capability using the average weighting approach as shown in the following equation:

$$MS = \frac{\sum W_i X_i}{\sum W_i}$$

Where $W_i \;\; = Particular\ Weight$

And $\quad X_i \quad = "Particular\ value\ of\ the\ Extent\ of\ utilising\ a\ Capability"$

After the *Capabilities maturity mapping*, the next step is to identify the DDSCM capabilities that the supply chain node should prioritise (*Gap analysis*). This allows specific opportunities for improvement to be identified from the mappings. Table 9.6 gives a guideline to the *Gap analysis stage*. Priorities are placed on immature DDSCM capabilities, which have high impact on the performance of the supply chain node and requires minimum effort for implementation and sustaining.

Table 9.6: Gap analysis guide

Quadrant	Description
'Last priority'	Both the degree of impact and maturity of capabilities is high but effort to achieve these capabilities is very low. For these capabilities, current strategic action plans are maintained.
'Third priority'	The maturity of capabilities is high as well as the effort required to achieve these capabilities but the capabilities have low impact on the organisation.
'Second priority'	The maturity and the degree of impact of these capabilities is low but the capabilities require high effort for implementation.
'First priority'	These are capabilities with low maturity but have great impact on the organisation. They also require less effort for implementation. For maximized results, improvement strategic actions should be applied to the capabilities in this quadrant.

This approach to *Gap Analysis* guide is drawn from the work of Martilla and James (1977). They explored service attributes of transit ridership using Importance-Performance Analysis (IPA) approach. This approach supports the identification of improvement priorities as shown in Table 9.7.

Table 9.7: Importance-Performance Analysis (Martilla and James, 1977)

Importance	Performance: Low	Performance: High
High	2. Focus Here	1. Keep up the Good Work
Low	3. Low Priority	4. Possible Overkill

The *Interventions stage* deals with planning interventions to address the prioritised capabilities that are identified in the *Gap analysis* stage through investments and resource allocations. The impact of the interventions is evaluated on an annual basis through re-assessment of the organisational processes.

Lastly, using theory of constraints (TOC) approach, the overall maturity of an organisation with regards to DDSCM is determined by the DDSCM dimension with the lowest maturity. A maturity scale shown in Table 9.8 guides this process. TOC is a systems based management philosophy which seeks to understand and identify the core causes that limit a system from achieving higher performance (Rahman, 2012). This corroborate with the adage, "a supply chain is only as strong as its weakest link."

Table 9.8: Criteria for assigning scores to maturity stages

Maturity Stage Name	**Maturity Scores (%)**				
	20	**40**	**60**	**80**	**100**
Initial					
Repeatable					
Defined					
Managed					
Optimised					

9.5. Summary of chapter

A Supply Chain Network (SCN) is an integrated system of processes performed by a set of organisations working together vertically and horizontally in controlling and managing the flow of materials and information from suppliers to final customers. Importantly, the SCN is viewed as a single system of interdependent organisations. This notion supports the concept of cooperation and collaboration of different organisations between and within specific links in the network (Lans, 2008).

In this chapter, a design outline for the DDSCM network maturity-mapping tool was discussed as well as the application methodology of the tool. The tool supports the establishment of current maturity profiles of DDSCM capabilities of organisations in the public healthcare SCN. This takes into account individual and unique characteristics of the organisations in public healthcare SCN. This chapter is the link between the public healthcare SCN structure in chapter 4 and the validated DDSCM maturity model in chapter 7 and chapter 8. Moreover, the maturity model capabilities are aligned and matched with different supply chain nodes in the public healthcare SCN to produce a network maturity-mapping tool in chapter 9. This tool is tested for applicability and validity through case studies in chapter 10.

Chapter 10 : Case Studies

10.1. Introduction

This chapter presents the testing of the applicability of the network maturity-mapping tool in the context of public healthcare SCN in South Africa and Kenya. The tool enables public healthcare SCN analysis from both an organisational perspective and systems view (entire network). A multiple case study approach is used since case studies emphasize external validity and test the rigor of the research (Gibbert, Ruigrok and Wicki, 2008). Therefore, the goal of this chapter is to:

- Test the applicability and validity of the network maturity-mapping tool using case studies
- Test whether the network maturity-mapping tool can be used as a network analysis tool

The case study approach is used in explanatory and exploratory research. It involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence. This study approach allows investigators to retain the holistic and meaningful characteristics of real life events such as organisational processes and group behaviour (Yin, 2009). Also, case studies deal with complex phenomena that cannot be studied outside rich, real-world context (Verdouw *et al.*, 2011). One of the advantages of following the case study approach in this study is that, the investigation is conducted in close interaction with practitioners. Therefore, case studies represent a methodology that is ideally suited to dealing with real management situations and subsequently creating managerially relevant knowledge (Gibbert, Ruigrok and Wicki, 2008).

10.2. Multiple case study methodology

Twelve (12) case studies were selected and case study data was collected using semi-structured interviews based on the network maturity-mapping tool (Appendix 9). However, the ideal sample could not be achieved, because access to data was granted to specific supply chain nodes by the Department of Health (DoH). The researcher, nevertheless, acknowledge this limitation but due to strong links between the supply chain nodes that were empirically explored, the researcher showed some aspect of the public healthcare SCN. By adopting this network perspective, the study reinforces the applicability and validity of the tool at the unique supply chain nodes in the public healthcare SCN.

Case study participants provided information by virtue of their knowledge and experience in public healthcare supply chains. The application of semi-structured interviews in multiple case studies ensures consistency and allow corroboration of data emerging from multiple sources (Maree, 2011).

10.2.1. Sampling

It is argued that a case analysis involving four (4) to ten (10) case studies may provide a good basis for relative analytical comparison (Gibbert, Ruigrok and Wicki, 2008). Moreover, Bryman et al., (2014) argue that multiple case studies are undertaken to compare and contrast the findings. This enables the researcher to establish the concepts that are unique to a case and those that are common across cases. This approach reveals the applicability and validity of the network maturity-mapping tool at different supply chain nodes in the public healthcare SCN.

The organisations included in the case studies were categorised into four (4) groups; manufacturers, distribution, hospitals and health facilities as illustrated in Table 10.1. However, when analysing the outcomes from the case studies, the organisations were anonymised. This is in line with the ethics guidelines. The structure of the SCN that was mapped involves the flow of healthcare products from manufacturers to the Central Medicines Stores (CMS) that subsequently delivers the healthcare products to health facilities and hospitals. This is an indirect product flow path. The other product flow path is characterised by the flow of products from manufacturers directly to health facilities and hospitals. In some cases when there are supply disruptions in the network, healthcare facilities and hospitals self-organise and share healthcare products among themselves. Figure 10.1 illustrates the basic public healthcare SCN. However, it is important to highlight that each CMS in a province is supplied by many manufactures and the CMS also supplies to multiple health facilities and hospitals.

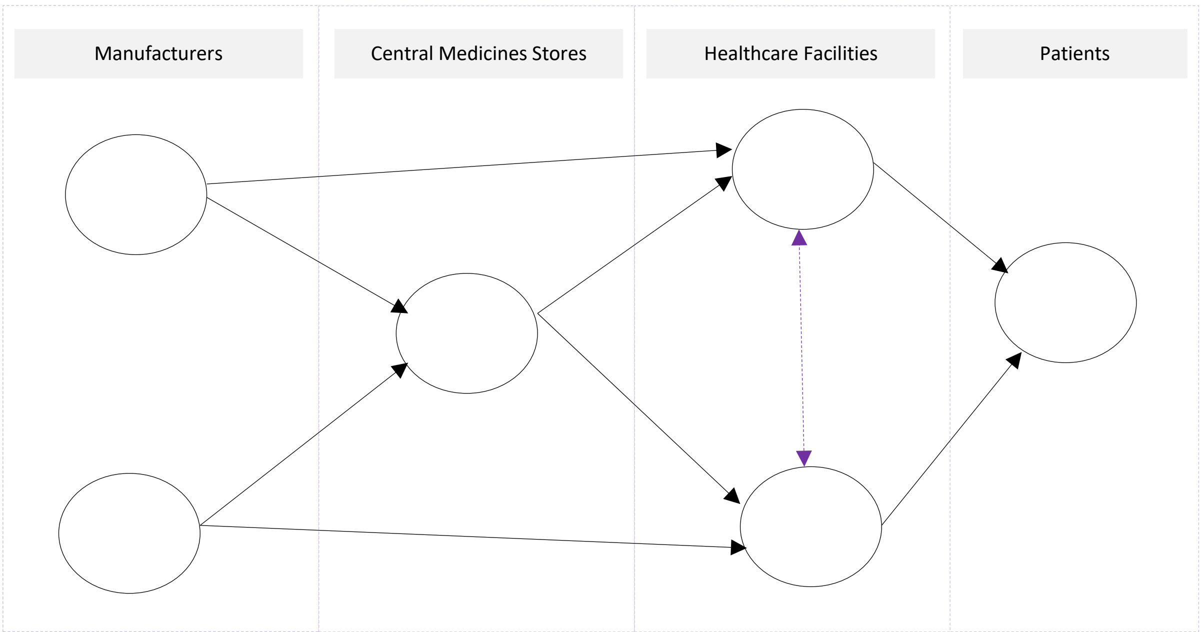


Figure 10.1 : Basic illustration of the public healthcare SCN in SA

Table 10.1 outlines the stakeholders in the SCN that were mapped. Note that, Central Medicines Stores was used as a base to identify the manufacturers that supply to its warehouse. Moreover, Central Medicines stores were used to identify downstream stakeholders that it supplies to.

Table 10.1: Characteristics of the sampled organisations

Supply chain node	Key Stakeholders	Description
Manufacturers	GlaxoSmithKline Pharmaceutical Company	•A science led global healthcare company that aims to improve the health of people globally. •It focuses on the research and development of products that include pharmaceuticals, vaccines and consumer health products.
	Johnson & Johnson Pharmaceutical Company	•Johnson & Johnson is an American multinational medical device, pharmaceutical and consumer packaged goods manufacturing company formed in 1886. •It strives to improve access, affordability and create healthcare communities.
	Cipla	•Cipla Limited is an Indian multinational pharmaceutical and biotechnology company, headquartered in Mumbai, India. Cipla primarily develops medicines to treat respiratory, cardiovascular disease, arthritis, diabetes, weight control and depression; other medical conditions. •It also manufactures world class generic medicines at affordable prices.
Distribution	Cape Medical Depot (CMD) + Kawari Logistics (Province 1)	• Provincial Pharmaceutical Distributor and wholesaler for the Western Cape province. • Procure, warehouse and distribute drugs. • Kawari Logistics is contracted by the CMD to transport medicines to facilities and hospitals from the medical depot.
	Gauteng Medical Depot (Province 2)	• Provincial Pharmaceutical Distributor and wholesaler for the Gauteng province • Procure, warehouse and distribute drugs.
	Kenya Medical Supplies Depot	• Central Pharmaceutical Distributor and wholesaler for Kenya. • Procure, warehouse and distribute drugs and medical supplies for prescribed public health programs, the national strategic stock reserve, prescribed essential health packages and national referral hospitals.
Hospitals	Eerste River Hospital	•The hospital operates is a district hospital operating in the Tygerberg Health District of the Metro Region.
	Stellenbosch Hospital	•The hospital is a provincial hospital which is owned and funded by Western Cape DoH. •It operates in the Stellenbosch Health District of the West Coast Region.
	Groote Schuur Hospital	• Groote Schuur hospital is one of Cape Town's premier tertiary academic hospitals and was opened in 1938. • It provides outstanding tertiary and quaternary care for patients of the Western Cape and beyond. • This hospital operates in the Cape Town Central Health District of the Metro Region and is owned and supported by the Western Cape DoH.
Health facilities	Khayelitsha Community Health Centre (CHC)	•Khayelitsha CHC operates in the Khayelitsha Health district of the Metro Region •Health facility is owned and funded by Western Cape DoH.
	Cloetsville Day Care Centre (CDCC)	• Health facility operates in the Stellenbosch Health District of the West Coast Region. • CDCC is owned and funded by Western Cape DoH.
	Khayamandi clinic	• Clinic operates in Stellenbosch Health District of the West Coast Region. • Health facility is owned and funded by Breede Valley Local Municipality.

10.3. Case study findings

Only a selection of the case studies can be displayed and discussed in this document. Furthermore, multiple options exist on how to group the cases, view or analyse the outcomes of the maturity mappings, but these options are far beyond the purpose of this dissertation, thus some selected views and analysis would be shown in this document. Although the reader might envisage other options, take note that this is just a few options and not all of them.

Three (3) case studies are presented in detail in this section to demonstrate and illustrate how the network maturity-mapping tool could be applied. The other nine (9) case studies are outlined in Appendix 10, Appendix 11 and Appendix 12.

The outcomes of the case studies enabled minor refinements to the network maturity-mapping tool in terms of its practical application. Figure 10.2 shows the mapping approaches that were considered.

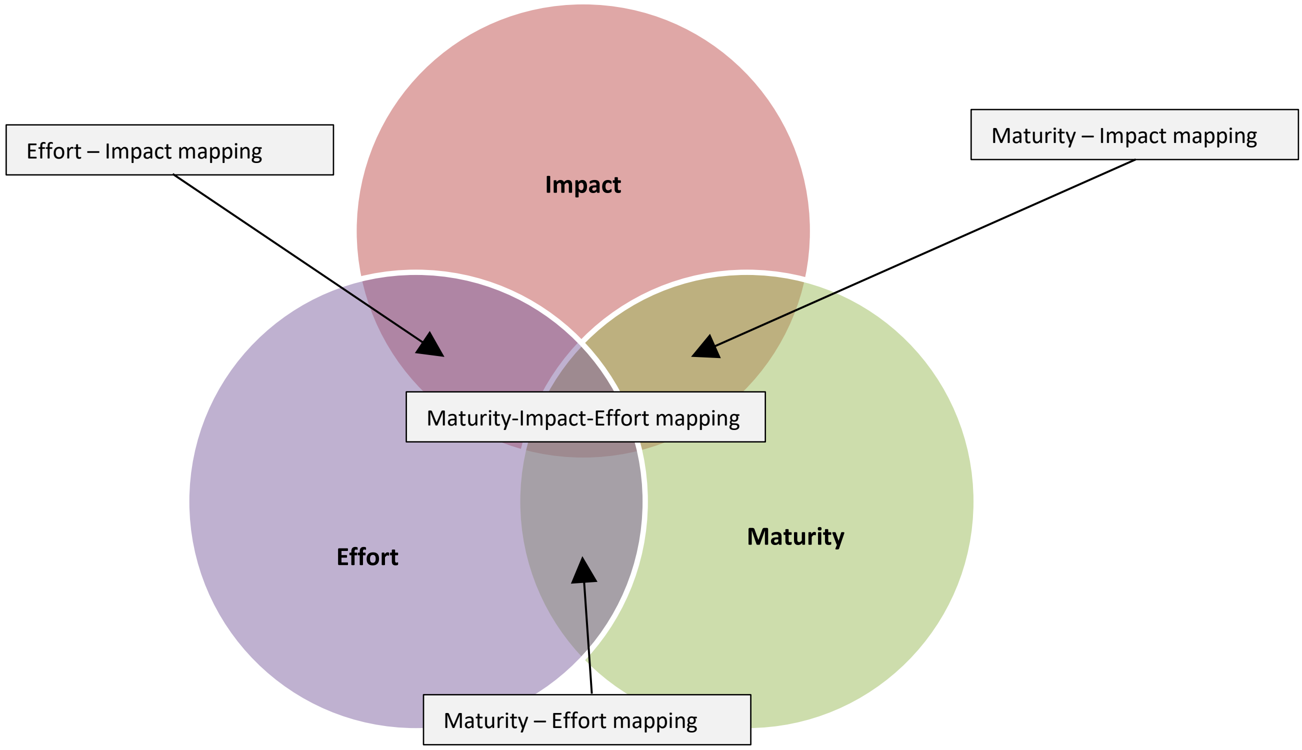


Figure 10.2: Case study analysis approach

10.4. Supply chain node analysis

The key findings from the three (3) illustrative case studies in this section focused on hospitals. The hospitals involved in the case studies ranged from small hospitals to large provincial hospitals. The assessment outcomes for the hospitals are shown in Table 10.2.

Table 10.2: Hospitals assessment outcomes

ID#	DDSCM Capability	Hospital 1			Hospital 2			Hospital 3			Across All Hospitals					
		Maturity	Effort	Impact	Maturity	Effort	Impact	Maturity	Effort	Impact	Maturity		Effort		Impact	
											Average	STD	Average	STD	Average	STD
3	Risk Management	75%	4	4	85%	3	5	55%	4	4	71,7%	15,3%	3,67	0,58	4,33	0,58
8	Inventory Management	80%	4	4	95%	1	2	70%	4	5	81,7%	12,6%	3,00	1,73	3,67	1,53
9	Storeroom Visibility & Automation	40%	4	4	0%	5	5	40%	3	4	26,7%	23,1%	4,00	1,00	4,33	0,58
12	Expiry Management	90%	3	3	100%	1	1	85%	1	5	91,7%	7,6%	1,67	1,15	3,00	2,00
14	Demand and Inventory Visibility	88%	1	3	100%	1	1	75%	3	5	87,5%	12,5%	1,67	1,15	3,00	2,00
15	Order Visibility	88%	1	2	0%	4	5	100%	1	5	62,5%	54,5%	2,00	1,73	4,00	1,73
16	Information Technology Infrastructure	100%	2	4	19%	4	4	50%	3	3	56,3%	41,0%	3,00	1,00	3,67	0,58
17	Data Transmission and Reporting	100%	3	5	20%	3	4	25%	4	4	48,3%	44,8%	3,33	0,58	4,33	0,58
18	Data Capturing	65%	2	5	75%	3	3	55%	4	4	65,0%	10,0%	3,00	1,00	4,00	1,00
19	Relationships	94%	3	3	69%	3	5	69%	3	5	77,1%	14,4%	3,00	0,00	4,33	1,15
21	Decision Making	88%	4	4	69%	3	5	94%	2	5	83,3%	13,0%	3,00	1,00	4,67	0,58
22	Key Performance Indicators	100%	4	4	20%	3	4	55%	4	4	58,3%	40,1%	3,67	0,58	4,00	0,00
24	Policies and plans	90%	4	4	10%	5	5	50%	3	3	50,0%	40,0%	4,00	1,00	4,00	1,00
25	Clear roles & responsibilities	95%	3	4	80%	2	2	65%	4	4	80,0%	15,0%	3,00	1,00	3,33	1,15
26	Innovation	85%	3	3	75%	3	3	65%	4	4	75,0%	10,0%	3,33	0,58	3,33	0,58
27	Incentives and working environment	95%	3	4	55%	3	5	60%	4	4	70,0%	21,8%	3,33	0,58	4,33	0,58
28	Training & Education	95%	2	4	55%	4	4	60%	3	4	70,0%	21,8%	3,00	1,00	4,00	0,00
31	Streamlined Processes	95%	3	4	75%	3	4	85%	2	4	85,0%	10,0%	2,67	0,58	4,00	0,00
33	Cost Management	100%	4	4	65%	3	2	30%	2	3	65,0%	35,0%	3,00	1,00	3,00	1,00
	Average Weightings	87%	3,0	3,8	56%	3,0	3,63	63%	3,1	4,2						
	Standard Deviation (STD)	14,7%	1,0	0,71	34%	1,2	1,4	19,9%	1,0	0,69						

The first stage of analysis focused exclusively on a single supply chain node[4]. The aim is to improve performance of the unique supply chain node by identifying least mature DDSCM capabilities that have high impact on the supply chain node and require low effort to implement/sustain. Subsequently interventions are planned to address these capabilities.

The second stage of analysis explores the entire public healthcare SCN (multiple supply chain nodes at once). It explores the performance of the DDSCM capabilities that are least mature across the entire network, that have high impact on the entire network and require low effort to implement/sustain. Subsequently interventions are planned to address these capabilities.

Evidence from case studies illustrated in Table 10.2 demonstrates that, Hospital 1 has more mature DDSCM capabilities, followed by Hospital 3 and Hospital 2 respectively. Analysing data in Table 10.2, the top five underperforming DDSCM capabilities across hospitals are illustrated in Table 10.3.

Table 10.3: Top five underperforming capabilities across hospitals

Node type	Under performing Capability 1	Underperforming Capability 2	Underperforming Capability 3	Underperforming Capability 4	Underperforming Capability 5
Hospital 1	9. Storeroom visibility and automation	18.Data capturing	3.Risk management	8.Inventory management	26.Innovation
Hospital 2	9.Storeroom visibility and automation	15.Order visibility	24.Policies and plans	16.Information technology infrastructure	17.Data transmission and reporting
Hospital 3	33.Cost management	17.Data transmission and reporting	9.Storeroom visibility and automation	16.Information technology infrastructure	24.Policies and plans

Key findings from the case studies show that, for those DDSCM capabilities that require higher effort to implement/sustain, it is common for the DDSCM capabilities to be less mature. Moreover, a large number of respondents suggested that, the higher the impact of the DDSCM capabilities, the more mature the capabilities. Furthermore, the higher the impact of the DDSCM capability, the less effort required to implement/sustain the DDSCM capability.

It can be observed from Table 10.3 that, all three hospitals struggle with warehouse (storeroom) visibility and automation, which can be achieved through tools such as barcodes and RFID

[4] The term Supply Chain Node is used interchangeably with Organisation in this study. Organisations such as Manufacturers, Central Medicines Stores, Health Facilities and Hospitals represent Supply Chain Nodes in the public Healthcare SCN.

technologies. Warehouse visibility and automation technologies ensures inventory visibility, and facilitates inventory tracking and management.

Hospital 2 and Hospital 3 do not have integrated IT infrastructure that facilitate data capturing, order visibility, data transmission and reporting. Furthermore, Hospital 2 and Hospital 3 still have least mature human resources policies and plans that support supply chain staff.

Lastly, from the data it can be seen that, Hospital 3 struggle with cost management. This reflects that the hospital struggles with measuring, quantifying and reporting their supply chain costs to relevant supply chain partners using a technology platform that connects them.

It is also important to demonstrate the impact of DDSCM capabilities on the performance of the three (3) hospitals as well as the effort that is required to implement/sustain the DDSCM capabilities. Figure 10.3 and Figure 10.4 helps management and pharmacists in outlining priorities and subsequent intervention plans. First priority should be placed on capabilities that have a low maturity score, high impact and require little effort to implement/sustain.

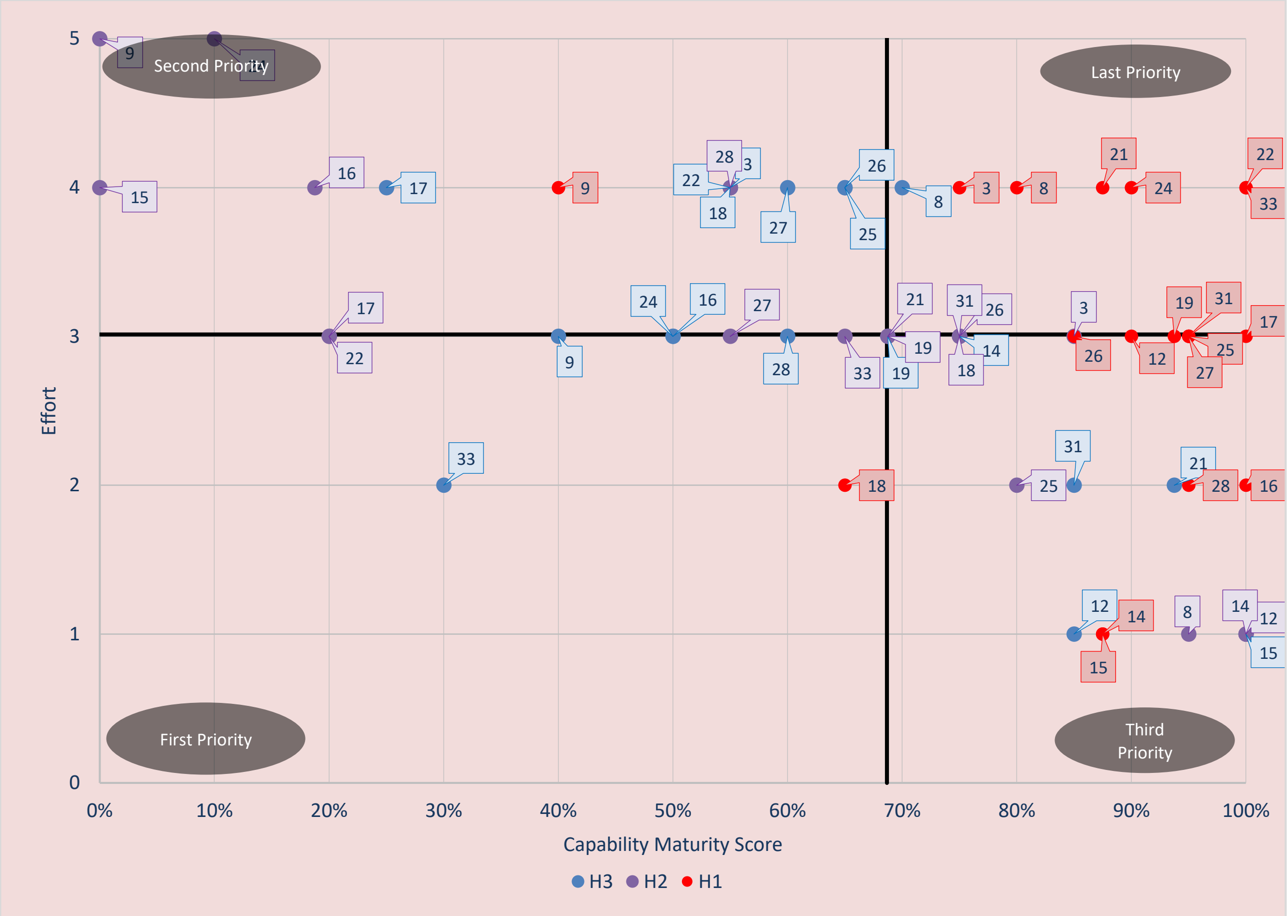


Figure 10.3 : Maturity – Effort Mapping

Key

ID	Capability		ID	Capability
3	Risk Management		21	Decision Making
8	Inventory Management		22	Key Performance Indicators
9	Storeroom Visibility & Automation		24	Policies and plans
12	Expiry Management		25	Clear roles & responsibilities
14	Demand and Inventory Visibility		26	Innovation
15	Order Visibility		27	Incentives and working environment
16	Information Technology Infrastructure		28	Training & Education
17	Data Transmission and Reporting		31	Streamlined Processes
18	Data Capturing		33	Cost Management
19	Relationships			

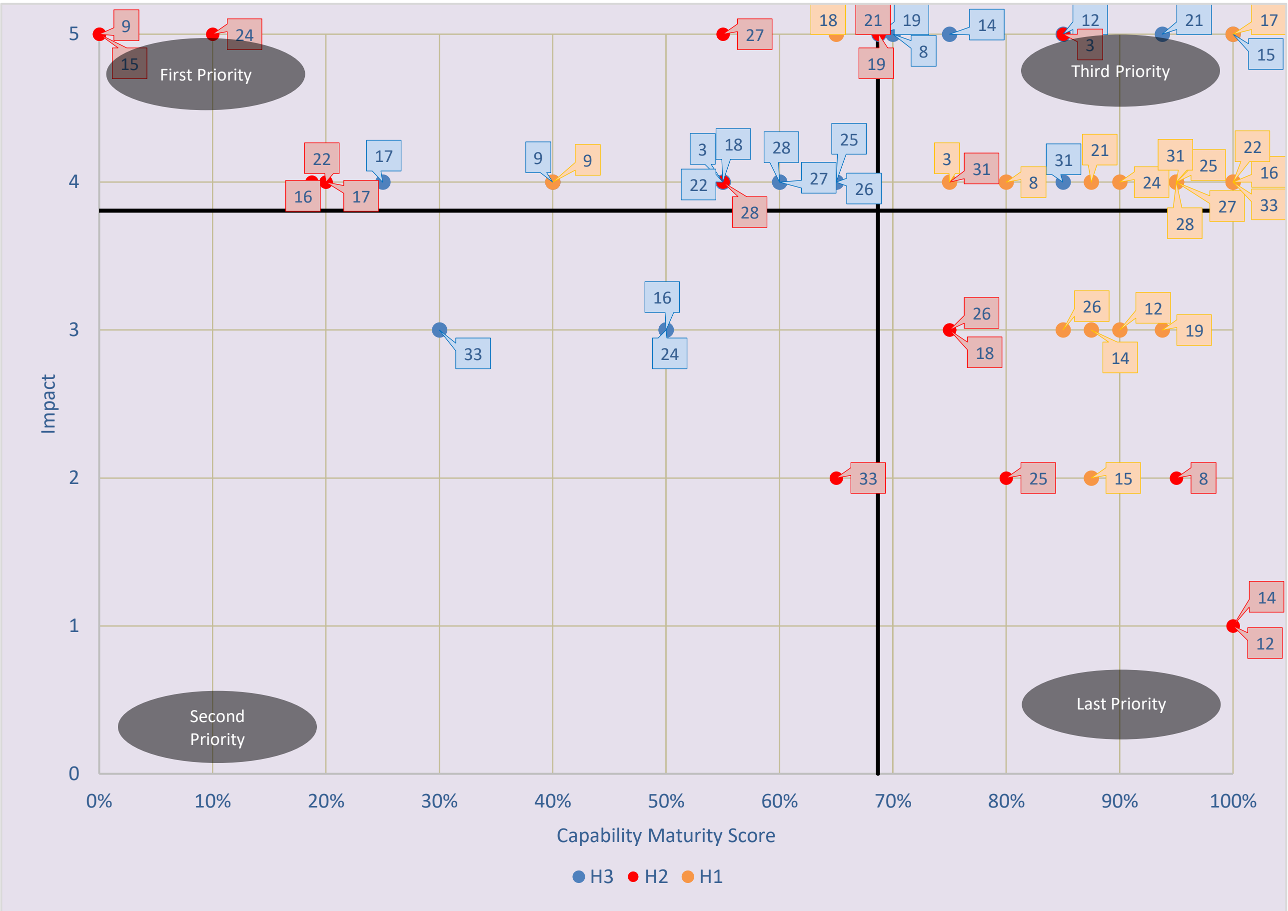


Figure 10.4: Maturity –Impact Mapping

Key

ID	Capability		ID	Capability
3	Risk Management		21	Decision Making
8	Inventory Management		22	Key Performance Indicators
9	Storeroom Visibility & Automation		24	Policies and plans
12	Expiry Management		25	Clear roles & responsibilities
14	Demand and Inventory Visibility		26	Innovation
15	Order Visibility		27	Incentives and working environment
16	Information Technology Infrastructure		28	Training & Education
17	Data Transmission and Reporting		31	Streamlined Processes
18	Data Capturing		33	Cost Management
19	Relationships			

Furthermore, Figure 10.5 outlines the *impact – effort mapping* of the DDSCM capabilities of the three (3) hospitals explored in this section. From the mappings, it can be seen that, most of the DDSCM capabilities have significant impact on the hospitals. However, some DDSCM capabilities have high impact but require considerable effort to implement/sustain. Moreover, the higher the impact of the DDSCM capability, the less effort required to implement/sustain the DDSCM capability.

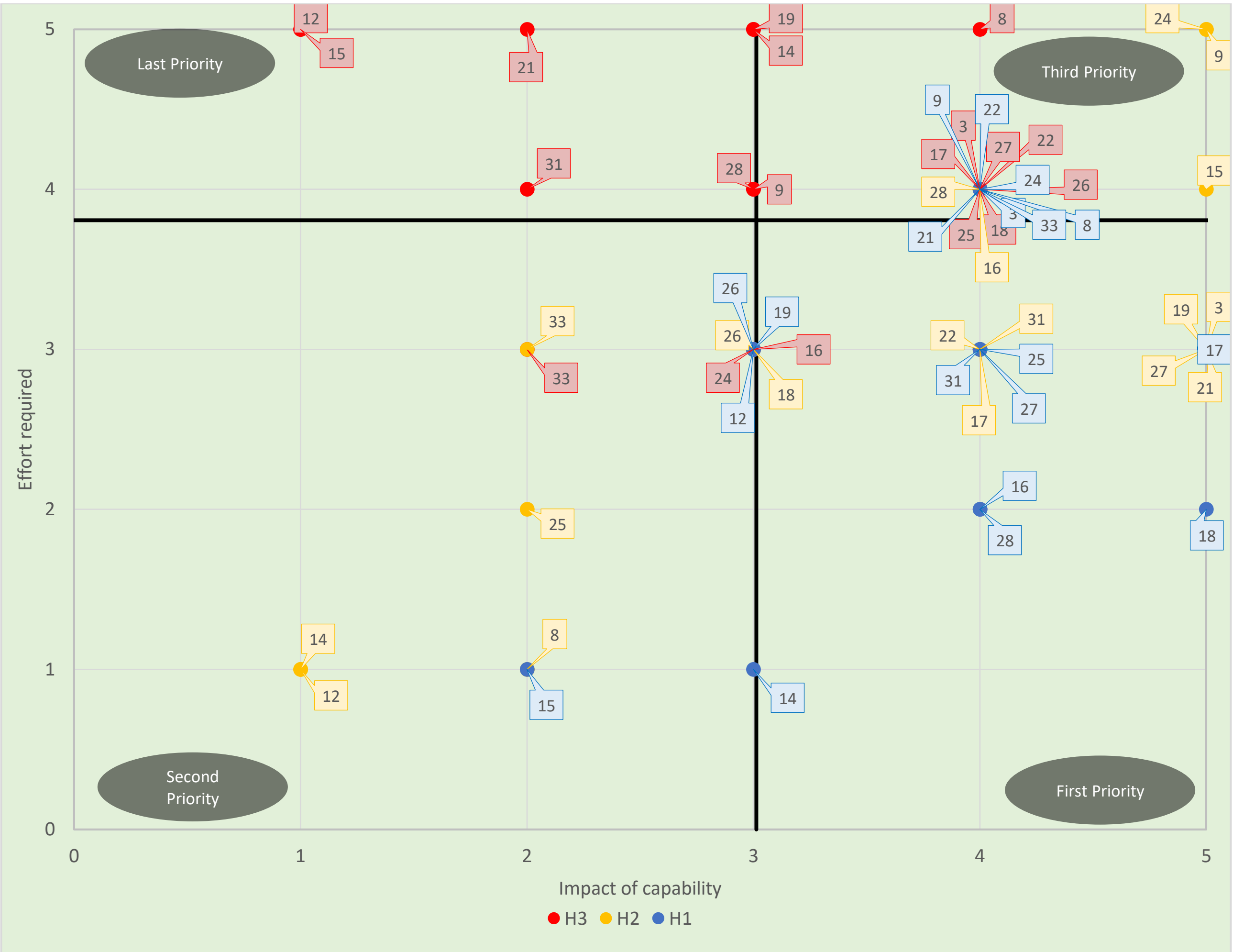


Figure 10.5: Impact Effort Mapping

Key

ID	Capability		ID	Capability
3	Risk Management		21	Decision Making
8	Inventory Management		22	Key Performance Indicators
9	Storeroom Visibility & Automation		24	Policies and plans
12	Expiry Management		25	Clear roles & responsibilities
14	Demand and Inventory Visibility		26	Innovation
15	Order Visibility		27	Incentives and working environment
16	Information Technology Infrastructure		28	Training & Education
17	Data Transmission and Reporting		31	Streamlined Processes
18	Data Capturing		33	Cost Management
19	Relationships			

10.5. Supply Chain Network Analysis

Public healthcare SCNs consist of many links of different and unique organisations that are interdependent. The overall performance (primarily determined by the availability of medicines at the health facilities) of the network is limited by the weakest link in the network. This thinking is borrowed from Theory of Constraints (TOC) which is a systems based management philosophy which seeks to understand and identify the core causes that limit a system from achieving higher performance (Rahman, 2012).

The proposed concept of DDSCM in public healthcare sector view supply chains from the systems perspective and the recurring patterns in the relationships between links in the public healthcare SCN. Therefore, if there are any plans and interventions to improve the performance of the public healthcare SCN, it is important to identify the weakest link first.

The network maturity-mapping tool enables a systematic approach of identifying DDSCM capabilities that are immature by mapping the entire public healthcare SCN from the point of view of the current state, depicting the current reality, as it exists. This systems view of the entire public healthcare SCN allows management to have an understanding of issues underpinning the network with regards to DDSCM.

However, it is also vital that, the network maturity-mapping tool be merged with performance data on a network level such as stock-out issues at health facilities, order fulfilment rates at central medicines stores and manufacturing.

10.5.1. Network maturity mapping tool as a management tool

This section will illustrate how the network maturity-mapping tool could be used as a management tool. The assessment outcomes from the theoretical network maturity-mapping tool were embedded into Tableau Software Platform to give a visual representation of the state of DDSCM at the different SCN links. This enhances informed decision making by provincial managers, district managers and facility managers. The tool enables public healthcare SCN analysis from both an organisational perspective and systems view (entire network). The tool allows managers to page through visual representations of the state of DDSCM for different manufacturers, distribution centres, hospitals and health facilities. In particular, the tool supports the managers to determine the least mature link in the network. After identifying a weakest link in the network and associated immature DDSCM capabilities in the whole network, the managers can strategically prioritise capabilities to address, by implementing interventions. The tool also supports the monitoring and evaluation of the effectiveness and impact of the interventions over a timeframe. This is achieved through re-assessment of the maturity of capabilities after interventions had been put in place.

Hospital 2 has been chosen as an illustrative case (from an organisational analysis perspective) since it has most of the DDSCM capabilities that are immature as shown in Figure 10.6. The rest of the visual representations from Tableau Software Platform can be found in Appendix 13.

To illustrate that the tool can be used as a monitoring and evaluation tool for interventions that are put in place to facilitate the DDSCM improvement path; *data is randomly generated for 2020* (which will be the second assessment a year later after initiating interventions). This data is compared with the *actual assessment data of 2019*. From Figure 10.6, it is shown that managers are able to view the status of DDSCM capabilities and their associated maturity scores as well as opportunities for improvement for different timeframes.

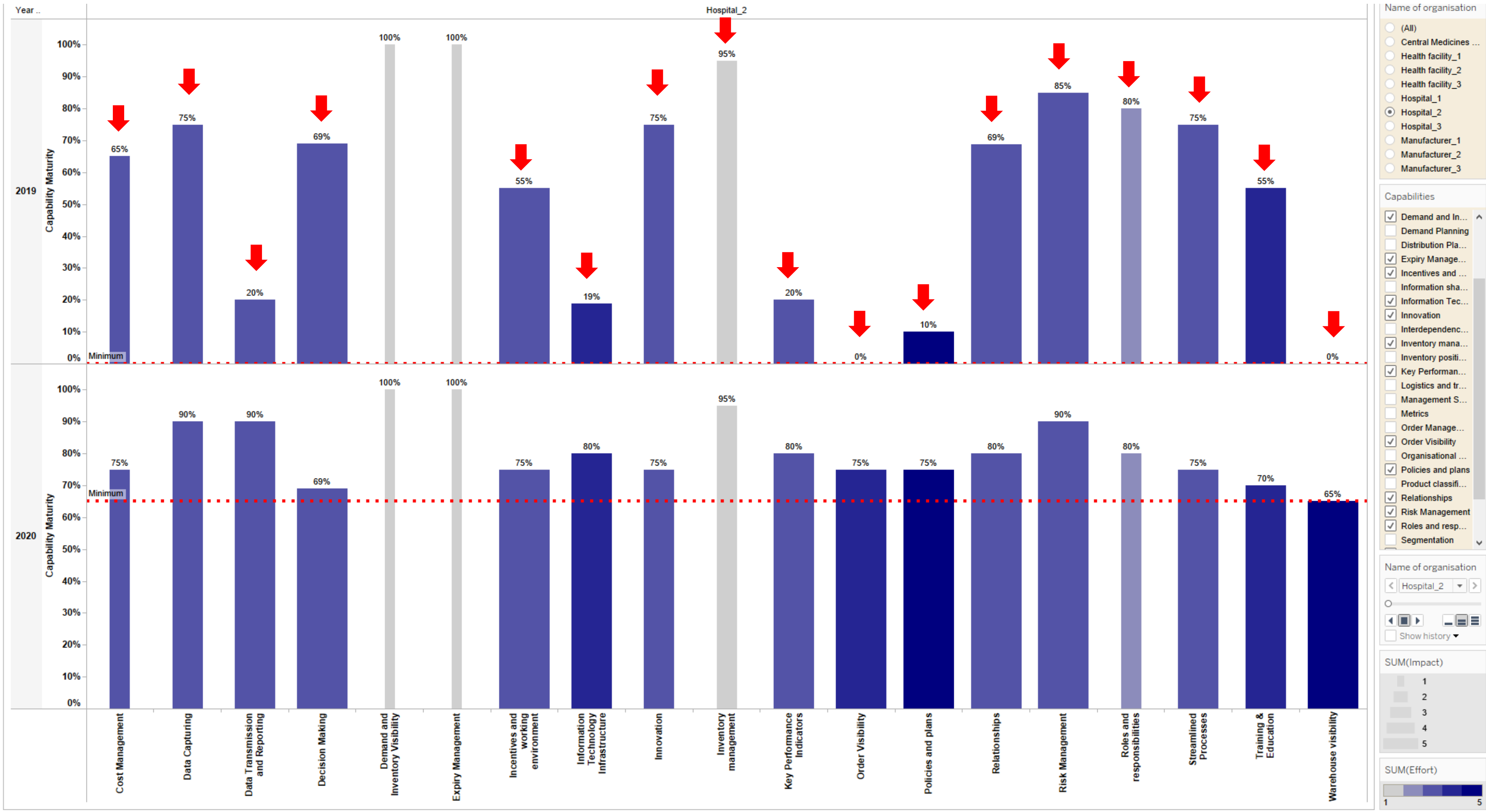


Figure 10.6: Visual representation of outcomes of assessment of Hospital 2 (1st time & 2nd time assessment respectively)

Paging and filtering through the visual representations in the tool (as shown here in Tableau Software Platform) gives a systems view of the entire public healthcare SCN on the maturity state of DDSCM. This systems view approach supports network analysis. By focusing on the entire network, management can attempt to identify interventions and leverage points on key dimensions and their associated capabilities that will have a positive influence on multiple immature dimensions and capabilities in the entire network. The positive effect of these interventions leverage improvement throughout the entire network.

SCN analysis based on the DDSCM dimensions[5] in Figure 10.7 below; demonstrate that, the underperforming link with respect to Collaboration is Health Facility 1 (44%), while the best in class link is Health Facility 3 (90%). Next, both Health Facility 1 (35%) and Health Facility 2 (35%) have immature Distribution Management activities but Hospital 2 (95%) is the best link with respect to Distribution Management activities. Furthermore, Hospital 2 (10%) and Health Facility 3 (95%) are underperforming and performing links respectively, with respect to Human Resource Management. Hospital 3 (30%) has least maturity score on Organisational Alignment and Health Facility 3 (95%) and Hospital 1 (95%) score highly on the maturity scale of Organisational Alignment. In regards to Performance Management, Hospital 2 (20%) is underperforming, while Central Medicines Store 1 (100%) and Hospital 1 (100%) are the best in class. Based on the Technology dimension, Health Facility 1 (0%) does not have an IT infrastructure to connect with other supply chain partners while Health Facility 3 (80%) has a higher maturity score for the Technology dimension. Lastly, Health Facility 2 (0%) and Hospital 2 (0%) struggles with ensuring visibility of inventory, consumption and orders across the relevant supply chain partners. On the contrary, Health Facility 1 (100%) and Manufacturer 1 (100%) have a high maturity score with respect to supply chain visibility. Figure 10.6 outlines the analysis in more detail.

[5] A Dimension represent a category that captures related DDSCM capabilities.

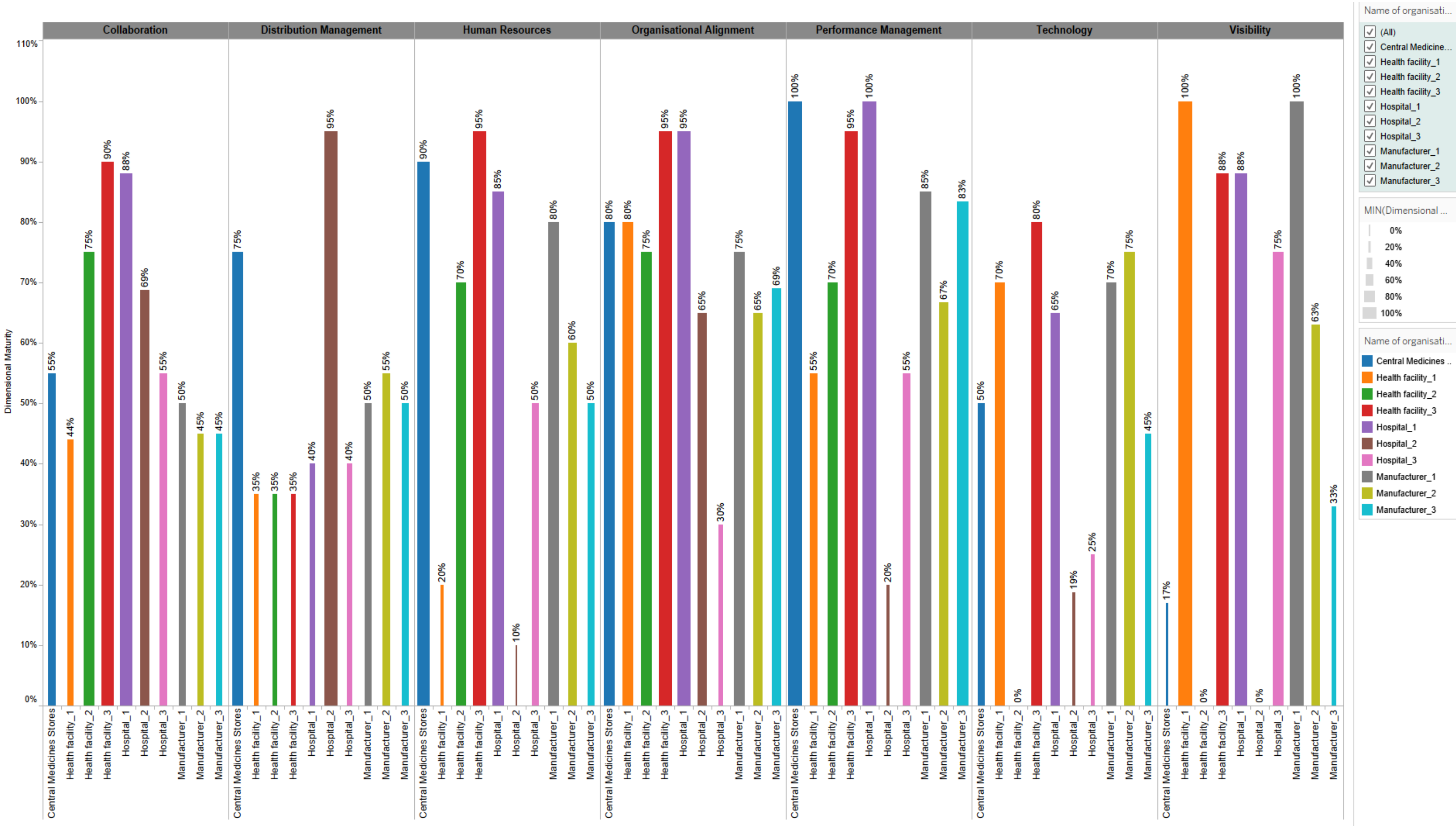


Figure 10.7: Network Analysis from DDSCM Dimensions Perspective

From the systems perspective, Figure 10.7 and Figure 10.8 reflect that the least mature dimension across the public healthcare SCN is Technology (50%), with Distribution Management (51%), Visibility (56%), and Human Resources (61%) respectively. The most mature dimensions across the network are Organisational Alignment (73%), and Performance Management (73%). Table 10.4 gives a guideline to the interpretation of Figure 10.8.

Table 10.4: Key for analysis of the public healthcare SCN

Extent of utilising a Capability	
0	not at all
1	to a smaller extent
2	to some extent
3	to a moderate extent
4	To a larger extent

Effort required to achieve capability	
1	No effort
2	Some effort
3	Moderate effort
4	Most effort
5	Extremely more effort

Impact of a Capability	
1	No impact
2	Some impact
3	Moderate impact
4	Most impact
5	Extremely largest impact

Literature suggest that, a robust IT infrastructure (fast-data exchange platform) that connects all relevant supply chain partners will ensure quality information sharing and transparency on inventory, consumption, orders and lead-time in real-time among all participants (Agrawal, 2012; Budd, Knizek and Tevelson, 2012; Bjartnes *et al.*, 2008; Goor, 2001). This allows supply chain players to adapt their operational processes quickly to short term changes in supply and demand (Verdouw *et al.*, 2011). Moreover, this IT infrastructure should not focus exclusively on internal optimisation but should connect all relevant supply chain partners (Lebovitz and Graban, 2001).

Advanced integrated information systems and technology platforms enable the creation of more accurate forecasts, plans and enhance communication of these plans as well as their exceptions more effectively up and down the supply chain and this eliminate the need for decision making to traverse hierarchical levels. Furthermore, IT based performance measurement systems enable tracking, managing and sharing of metrics in real-time and enhance decision-making. Proper metrics allow benchmark of supply chain performance across the network and assist in the identification of gaps that can be addressed through collaboration and partnerships (Korhonen, Huttunen and Eloranta, 1998).

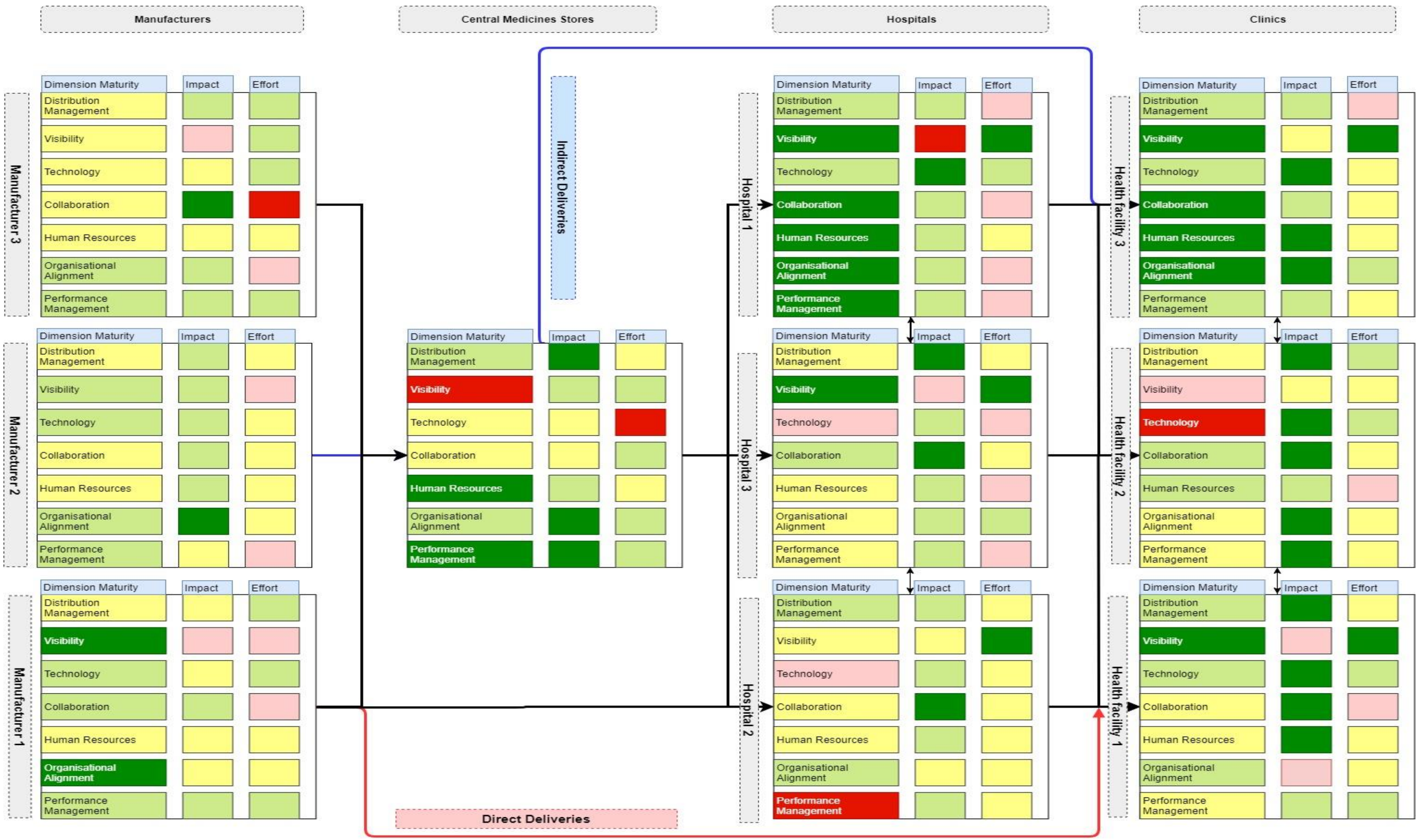


Figure 10.8: Network Analysis using Product Flow Path Perspective

Using theory of constraints (TOC) approach, the overall DDSCM maturity of organisations in the public healthcare SCN is determined by the DDSCM dimension with the lowest maturity. The data in Table 10.5 is derived from Figure 10.9.

Table 10.5: Maturity mappings of organisations in the public healthcare SCN

		Node Maturity Score	Maturity Stages				
			Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
			Initial	Repeatable	Defined	Managed	Optimised
Supply chain node type	Manufacturer 1	50%					
	Manufacturer 2	45%					
	Manufacturer 3	33%					
	Central Medicines Stores	17%					
	Hospital 1	40%					
	Hospital 2	0%					
	Hospital 3	25%					
	Health facility 1	20%					
	Health facility 2	0%					
	Health facility 3	35%					

Figure 10.9 shows that both Health facility 2 and Hospital 2 are the least mature links in the public healthcare SCN (*Stage 1*). Rahman (2012) argues that a weak link in a SCN limit a system from achieving higher performance. It can also be seen from Figure 10.9 that Manufacturer 1 and Manufacturer 2 are the strongest links in the public healthcare SCN (*Stage 3*).

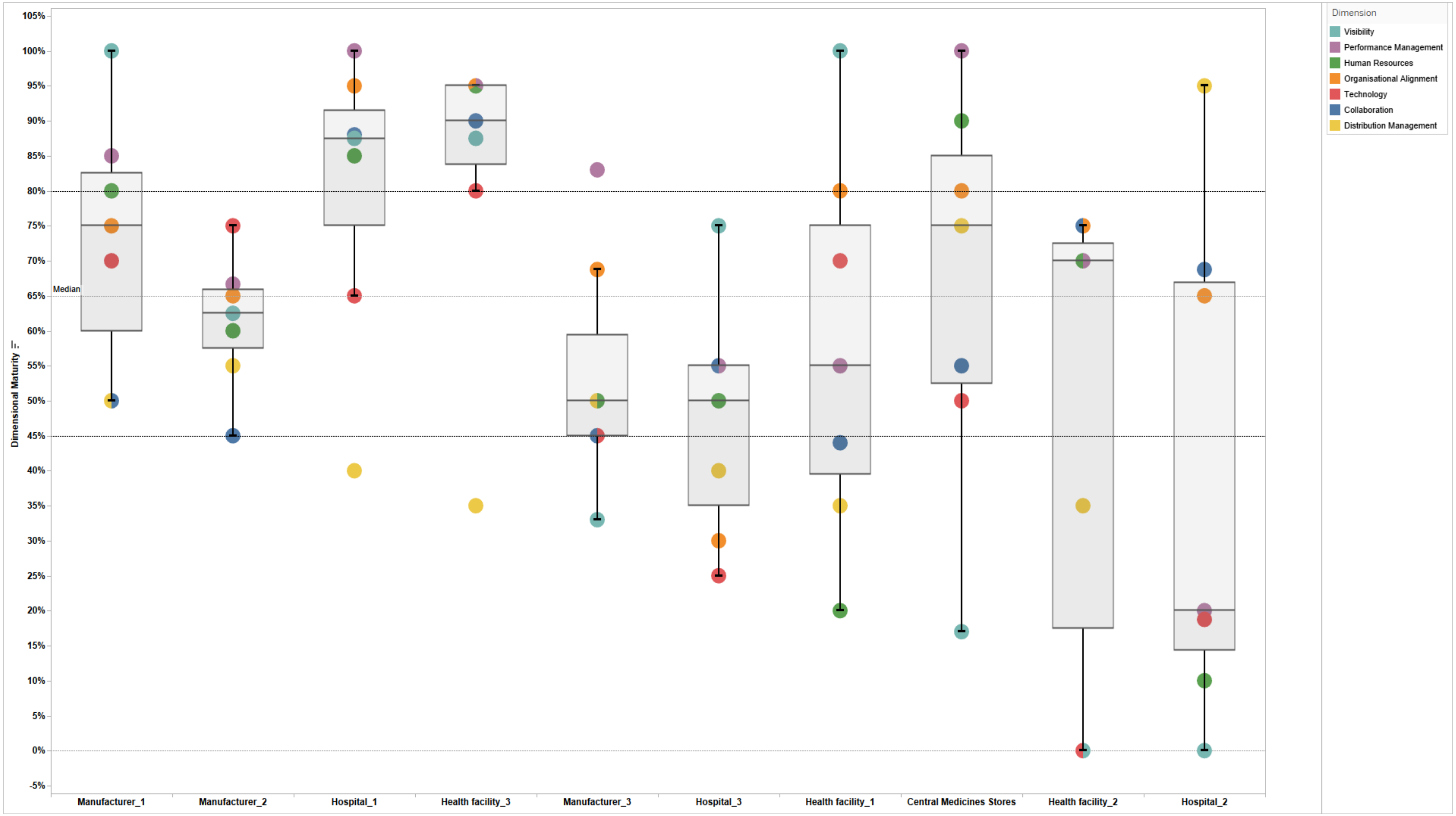


Figure 10.9: Network Analysis using Supply Chain Node Perspective

10.6. Discussions and verification of the tool

To verify the design requirements that were established during the design of the tool (Table 7.1), follow-up interviews were done with seven (7) participants who had participated in the case studies earlier. The outcomes are shown in Table 10.6.

The respondents acknowledged that the network maturity-mapping tool was clear, structured logically and allows for comprehensive assessment. They welcomed the network maturity-mapping tool as helpful for their efforts to plan improvement measures. The application of the tool in 12 case studies proved that the tool is effective in measuring DDSCM maturity across unique organisations in the public healthcare SCN. Furthermore, they acknowledge that the tool guide improvement efforts towards more mature DDSCM levels.

However, some participants suggested that the tool should also take into account clinical knowledge of the person conducting the assessment. It is however, important to note that, people with supply chain experience should perform the assessment exercise to reduce bias. Clinical knowledge is important but should be supplemented with supply chain knowledge. Table 10.6 outlines the verification of the network maturity-mapping tool based on subject matter experts judgements. This was achieved through semi-structured interviews at the unique supply chain nodes.

Table 10.6: Verification of network maturity mapping tool based on subject matter experts judgements

	Interview question	Design requirement satisfied (User requirement)	Participants remarks		
			Clinics & hospitals (N=2)	Central medicines stores (N=3)	Manufacturing (N=2)
1	Was the assessment tool easy to use?	The maturity model should be easy to use	- **Yes,** however it was not always easy to rate the effort required to implement a capability - It also required some time to carefully consider the questions	**Yes**, it was	**Yes,** but consider breaking it up into bite size chunks
2	Where you able to identify opportunities for improvement?	The maturity model should be able to identify gaps and guide the users to develop an improvement roadmap.	- **Yes,** it made the participants think about their current systems in place - **Yes,** It could be used to assess one facility's service and compare to others on the platform - **Yes,** from the identified dimensions, we managed to identify how we can improve them especially through the use of technology	- **Yes,** collaborative activities with internal and external stakeholders is of importance	- **Yes**, it can be used as an assessment tool. - The tool is very comprehensive and covers all relevant supply chain dimensions and one critically assess the current state of the supply chains - Increasing the timely and accurate visibility of supply chain data throughout the network and improving the level of collaboration among the different actors in the supply chain are critical enablers to improving medicine availability in the supply chain
3	Was the assessment useful?				
4	Was the assessment time consuming?	The assessment using the maturity model should not be time consuming.	- **Yes,** fairly easy	- **Yes**	- **Yes** - It was long but interesting though
5	What dimensions are missing in the tool?	Additions/Modifications to model	- Model should take into account the impact of clinical knowledge on the functional official.	- The tool is comprehensive and no dimensions are missing	- Modify your demand planning and supply planning capabilities into Sales & Operations Planning (S&OP) or Integrated Business Planning (IBP)
6	How can we improve the tool?				

Furthermore, the verification process involved testing of the tool to see if it meets a catalogue of design requirements for the design of maturity assessment tools (Becker et al., 2009). Moreover, seven guidelines developed by Becker et al., (2009) (Table 6.4) were chosen as a basis to support the verification of the tool and the findings are shown in Table 10.7. It can be seen that the tool satisfies six design requirements with an exception of the design requirement that highlight the need to communicate the tool to stakeholders through publications.

Table 10.7: Verification of the tool based on the Becker et al., (2009) design requirements catalogue

	Design Requirement	Network-Maturity Mapping Tool
1	**Need identification and problem relevance**	Few methodologies or well defined processes exit that impartially measure and support the implementation of DDSCM from a network perspective in public healthcare sector.
2	**Compare with existing supply chain maturity models**	The development of the tool was substantiated by comparison with previous supply chain maturity models.
3	**Multi-methodological procedure**	Research methods that were used include literature reviews, semi-structured interviews with subject matter experts, and case studies.
4	**Iterative procedure**	A systematic process was followed during the development of the tool. At each stage, inputs from subject matter experts were used to iteratively refine the tool. Case studies were then used to establish the practical applicability of the tool.
5	**Test and Evaluate Model**	The tool designed meet the design requirements set in Table 7.1 (also refer to Table 10.6). 12 case studies conducted established the usefulness and effectiveness of the tool.
6	**Refine Model**	Using the results and feedback from the tool testing and evaluation, the tool was refined to improve its usefulness.
7	**Target publication**	The refined tool will be submitted to a journal for publication.

10.7. Chapter summary

Reference maturity profiles of DDSCM have been established for twelve (12) organisations in the public healthcare SCN, taking into account unique characteristics of these organisations. The maturity profiles describe an organisational progression in terms of DDSCM. This demonstrated the validity and applicability of the tool at these unique supply chain nodes in the public healthcare SCN.

Conclusions from the empirical investigations outline that network maturity-mapping and analysis has two levels of complexity. The first level of complexity focus on a single organisation perspective and the second level of complexity focus on a systems perspective (entire network).

The systems view perspective allow management and decision makers to identify immature dimensions and associated capabilities across the entire public healthcare SCN and then leveraging interventions on dimensions and the associated capabilities that influence as many dimensions as possible in the entire public healthcare SCN.

Another interesting contribution from this chapter is that, the case studies demonstrated the tremendous impact that the DDSCM concepts may have on organisation performance and the network at large. The effort to implement/or sustain these DDSCM concepts was also illustrated. Drawing from these findings, this chapter reinforces the validation outcomes in section 8.4, which illustrates the importance of the DDSCM dimensions in public healthcare SCN. Therefore, at this point, it can be argued that the DDSCM concepts are relevant and applicable in public healthcare SCN.

Chapter 11 : Conclusions and Recommendations

11.1. Introduction

This chapter provides a critical reflection on the research outcomes presented in the thesis. Suggestions on how the findings could be applied in the design of DDSCM in the public healthcare sector in South Africa are also outlined. Furthermore, the unique contributions made by the author in the field of DDSCM and public healthcare supply chains in South Africa are presented. Finally, limitations of the study are discussed and recommendations are made on future research areas.

<u>Chapter 11</u>

- Research findings
- Research contributions
- Research limitations
- Recommendations and future research work

11.2. Reflection on the study methodology

The development of the DDSCM network maturity-mapping tool followed a systems engineering approach as shown in Figure 11.1- the research design canvas which was also shown earlier (chapter 2). A conceptual DDSCM framework was first developed from literature. This framework was a baseline to the development of the DDSCM maturity model, which was extensively validated by twenty-three (23) semi-structured interviews with subject matter experts. Through DDSCM capabilities mapping at each unique node in the public healthcare SCN, a network maturity-mapping tool was developed. The tool was then tested at these unique nodes using twelve (12) extensive case studies.

A survey of seventy-eight (78) participants was also conducted to establish inter-relationships between DDSCM dimensions. These inter-relationships present a methodology for prioritising the dimensions across the entire network. Interventions will firstly be planned for an immature DDSCM dimension that has significant influence on multiple dimensions. However, these interrelationships derived from literature and validated by subject matter experts in the supply chain field remain suggestive and hypothetical within the context of public healthcare SCN. There is need to explore more the practical validity of the inter-relationships.

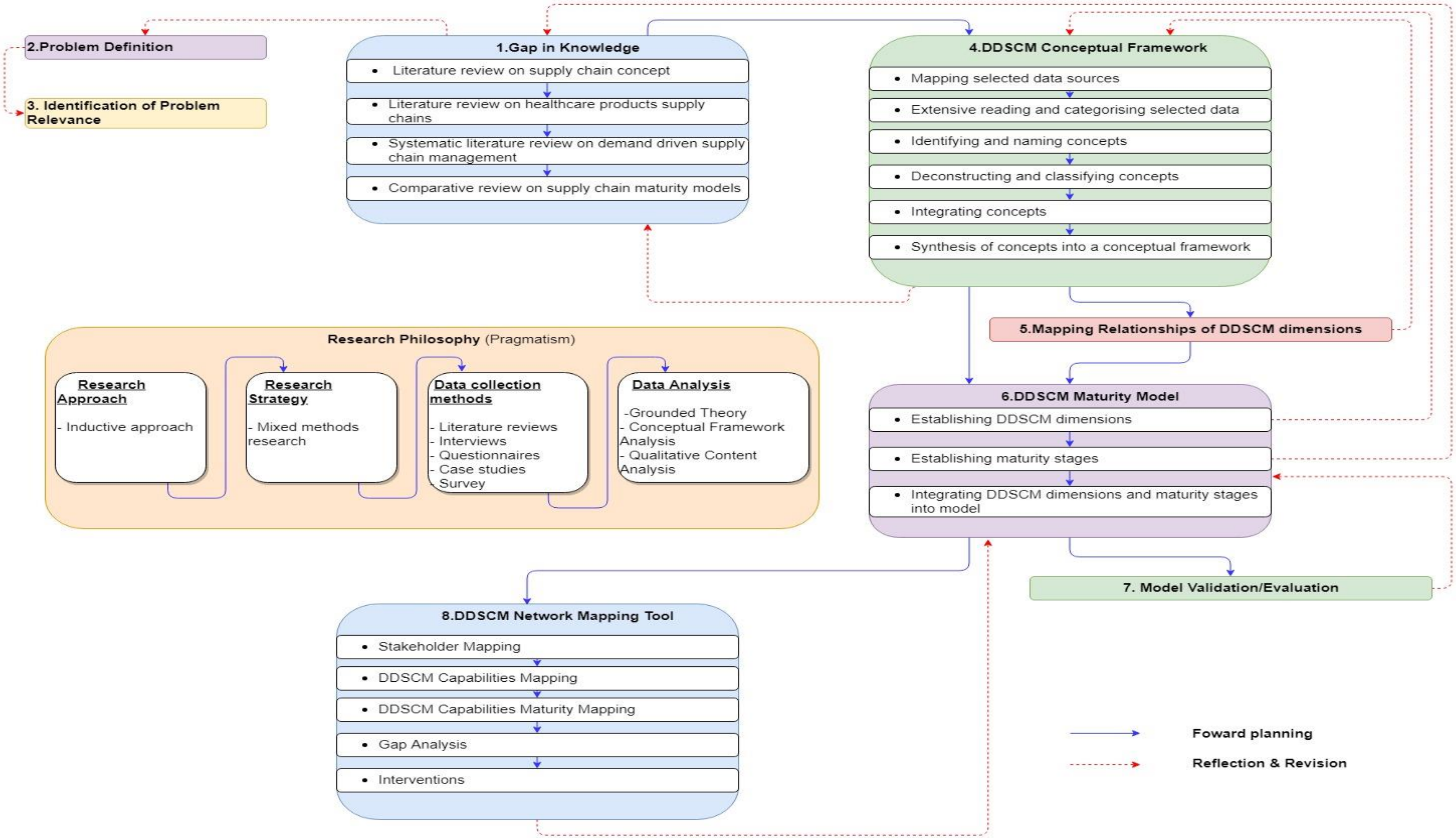


Figure 11.1: Research design canvas

11.3. Achievements

The research aim of this study was to develop a network-maturity mapping tool that support the design, implementation and assessment of DDSCM performance for unique supply chain nodes in the public healthcare Supply Chain Network (SCN) as well as provide guidance on how the unique supply chain nodes in the SCN can progress towards advanced DDSCM maturity stages. Therefore, this section reflects on the seven objectives of the study.

11.3.1. RO 1: To understand the concept of DDSCM

For the purpose of this study, the fundamental difference was established between supply-push and demand-pull oriented chains. Consequently, the term Demand-Driven Supply Chain Management is used for demand-pull oriented chains that are driven by actual customer demand (Lans, 2008).

DDSCM is most dependent on aligning all entities across the SCN through supply chain visibility. In comparison with the traditional supply chain, DDSCM uses demand-pull technique, which is achieved by collaboration and sharing information over the different tiers of the entire network. The final consumer demand organises the entire flow of products and services (Selen and Soliman, 2002). This actual demand drives product ordering, replenishment processes and the flow of medical supplies in the public healthcare SCN.

This concept of DDSCM starts with the customer and drives strategic and operational alignment by focusing on optimising the positioning of inventory positions, streamlining, rationalising and continuously improving processes that move the right products to the right customers instead of starting with supplier/manufacturer and working forward. To this end, some studies have further defined DDSCM as a segmented supply chain planning and execution process, consisting of intentionally planned and positioned inventory locations across the network. These strategic inventory positions are replenished based on actual/real customer demand - not forecasts. Forecasts are only used to design and size buffer profiles that are in turn replenished using real demand. This highlights the change from supply to demand focus. The focus needs to be on the final customer and the ways in which the overall chain can optimise the flow, produce maximum benefits, takeout unneeded transactions or other costs and continually improve (Eagle, 2017).

Moreover, DDSCM consists of systems and processes that capture demand and inventory information, to enable supply chain partners to adjust their capabilities in response to the actual demand (O'Marah, 2005). Consequently, DDSCM is a network that senses and reacts to real-time demand-information of the ultimate consumer and meets those varied and variable demands in a timely and cost effective manner (Verdouw et al., 2011).

Therefore, the concept of DDSCM in public healthcare sector view supply chains from the perspective of the whole network and the recurring patterns in the relationships between entities in the SCN. This objective is outlined in detail in section 5.2.

11.3.2. RO2: To investigate the key success factors for DDSCM.

The study utilised the systematic literature review methodology (section 5.3) to identify multiple key success factors for DDSCM. It reveals that seven key dimensions, which are distribution management, technology, visibility, collaboration, organisational alignment, human resources and performance management, can capture the concept of DDSCM (Figure 11.2) and its associated success factors. Table 5.4, section 5.6 and section 7.3 discuss the dimensions and key success factors for the DDSCM approach in detail.

Figure 11.2: Key Dimensions for DDSCM success

11.3.3. RO3: To investigate the benefits of transforming healthcare supply chains from classical supply push model into Demand-Driven Healthcare supply chains.

In analysing the data set from the systematic literature review, the DDSCM approach has potential to provide the following benefits to public healthcare supply chains (section 5.7):

- Enhanced supply chain performance;
- Inventory reductions;
- Reduction in stock-outs and product expiry;
- Supply chain cost reductions;
- Enhanced supply chain reliability;
- Perfect order fulfilment;
- Reduction in lead-time gap;
- Enhanced supply chain responsiveness;

- Controlled and managed demand variabilities;
- Enhanced supply chain efficiency and effectiveness;
- Optimised capacity utilization and high service levels;
- Synchronised execution of supply chain processes;
- Enhanced communication among supply chain partners;
- Reduction in forecast errors and risks.

Seamless coordination of DDSCM operations leads to enhanced supply chain performance and supply chain effectiveness. The enhanced supply chain performance and supply chain effectiveness encompasses the reduction in supply chain cost, stock-outs, product expiry, and inventory loss. Another potential benefit of DDSCM is the effective management of the demand volatility, which in most instances leads to stock-outs and poor capacity utilisation.

Of equal importance is the availability and sharing of timely demand and inventory information. This information enhances supply chain responsiveness, and supply chain reliability, such as delivery accuracy and order fulfilment. This information results in the reduction of forecast errors and improvement in inventory management. To this end, the recognition of the importance of SCV results both in synchronised execution of supply chain processes and enhanced communication among supply chain partners. With DDSCM, customers are also satisfied as they are getting the products that they need at the right time and in the right quantity. It can be argued that, the benefits of DDSCM are found to extend beyond improvements to operational efficiency of organisational processes or strategic competences of a single organisation.

11.3.4. RO4: To understand the distinction between mature and immature demand-driven healthcare supply chains

The DDSCM maturity model clearly outlines key process areas of immature and mature healthcare supply chain processes. Immature processes are described in Stage 1(*Initial*) of the maturity model and mature processes are outlined in Stage 5 (*Optimising*). In Stage 1, healthcare supply chain processes are basic and unpredictable. People responsible for supply chain activities have poor knowledge, skills and competence in their roles. Secondly, visibility on demand, inventory levels and orders is limited. Furthermore, the internal and external information sources of supply chain partners are not integrated and each partner exists in a silo. In addition, there are no attempts by partners in collaborative decision-making. The metrics and goals in the supply chain are not aligned across the entire supply chain. Lastly, there are no attempts to segment customers and to categorise healthcare products into classes to enhance demand driven replenishment and customer satisfaction.

As organisations increase their process maturity, they move from an internally focused perspective to an externally focused and systems perspective. A mature healthcare supply chain, Stage 5 (*Optimising*), focuses on continuous improvement of healthcare supply chain processes. Supply chain platforms that connect all supply chain actors, technologies and systems are developed to support continuous supply chain improvements. A mature healthcare supply chain represents processes and systems that are well understood, supported, monitored, and documented.

It is however, important to recognise that organisations in public healthcare supply chains should progress in sequence through the maturity stages by building on practices that have been solidly established in each preceding stage. Furthermore, in order for an organisation to be considered mature for a given maturity stage, it must be effectively using the majority (if not all) of the DDSCM practices from that stage.

11.3.5. RO5: To develop a maturity model to assess the current state "AS-IS" of DDSCM in public healthcare supply chains

A new five-stage DDSCM maturity model for public healthcare supply chains was developed. The maturity model provides a framework to assess both where an organisation is today on the DDSCM maturity scale and how it can progress towards more advanced maturity levels. Each stage of the maturity model represents enhanced DDSCM capabilities in the development process, and an organisation can only progress from one stage to another upon achieving all capabilities in that stage.

The significance of this incremental development process goes beyond just scale alone. It embodies a change of focus away from being supply-driven to being customer-oriented, penetrating deep into the customer organisation to understand their products, culture, market and organisation. This should ensure that the organisation is attuned to the customer's needs and requirements.

A detailed description of the development of the conceptual maturity model is outlined in section 7.1 up to section 7.5. An integrated conceptual model is presented in Table 7.10. This conceptual model was published in international conference proceedings (refer to Table 1.2).

11.3.6. RO6: To validate the DDSCM maturity model

The validation process for the DDSCM maturity model was a three-stage process. The purpose of the maturity model validation is to enable a better understanding and refinement of the DDSCM maturity model through semi-structured interviews with subject matter experts. The validation process used in this study is reflected in Figure 11.3 and Table 11.1.

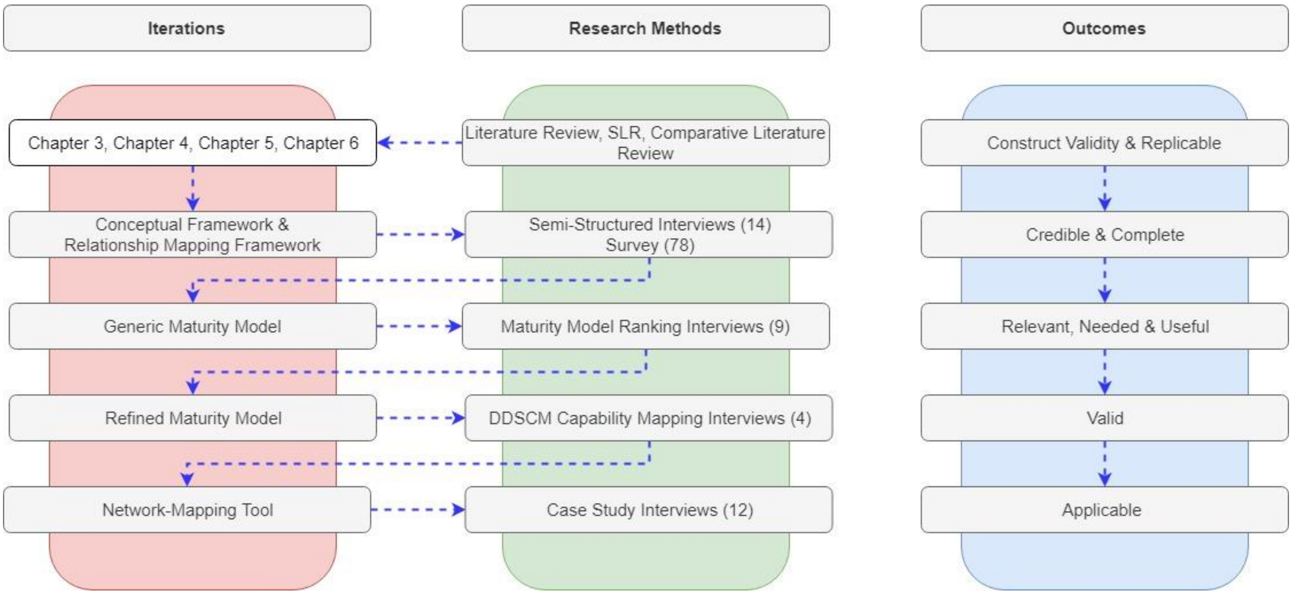


Figure 11.3: Research Evaluation Methodology

Table 11.1: Reflection on the validation process (adapted from Marais, 2018)

Validation stage	Outcome	Overview	Methods
Stage 1	Credible Complete	The model needs to be developed on credible concepts and should be complete.	-Semi-structured interviews -Skype interviews
Stage 2	Needed Relevant Useful	The model needs to be based on an empirical foundation. It should be needed, reliable, relevant and useful.	-Model ranking interviews
Stage 3	Applicable Valid	Empirical testing of the model on organisational processes to assess the validity and applicability of the maturity model.	-Case study interviews -Questionnaires

11.3.7. RO7: To develop a network maturity mapping tool that supports network analysis and maturation of DDSCM from both an organisational and systems view perspective

From literature review, it appeared like there was not any supply chain maturity model that is able to manage properly the typical complexities in management of supply chain networks, although several efforts have been taken for improving and expanding individual performance evaluation into organisations' suppliers, distributors and customers (Lahti, Shamsuzzoha and Helo, 2009).

Therefore, the network maturity-mapping tool enables a systematic approach of identifying DDSCM dimensions and their associated capabilities that are immature by mapping both the organisations and the entire public healthcare SCN. It also supports the assessment of the SCN progress and identification of those interventions, which are required at each point in the journey towards DDSCM in the public healthcare sector.

The first step to the development of the tool was to identify the nodes at which the *maturity model was relevant*. This was achieved by performing capabilities mapping interviews with subject matter experts at the unique nodes in the SCN. The tool was then tested for applicability on 12 case studies. This allows a systems level approach, helping supply chain managers identify the DDSCM capabilities that need to be prioritised.

11.4. Unique contributions

With low forecast accuracy and high demand variability, organisations usually have to increase safety stock levels or move products from one location to another, on an expedite basis. However, these initiatives hurt operational efficiency and increase supply chain costs. To cope with this scenario, many organisations are trying to move from a pure Push strategy, which is only driven by forecast, to a Pull system, which is driven by actual customer demand. This system ensures a better balance between supply and customer demand, thereby delivering expected customer service levels, and supply chain efficiency.

In particular, current management systems and practices in public healthcare supply chains are less and less able to cope with the growing complexities of low forecast accuracy and demand variability, thereby resulting in medicine stock-outs, poor healthcare outcomes, high supply chain costs and operational inefficiencies. It is therefore, argued in this study that, a Pull system driven by actual customer demand (termed Demand Driven Supply Chain Management (DDSCM) in this study) is a potential remedy to managing supply chain complexities.

Although this Pull system has been established in industries such as computer, fruit, flower, telecommunications, transport, beef and fashion to manage supply chain complexity, demand volatility and uncertainty, previous work has not comprehensively considered this system in the public healthcare SCN. Therefore, this study makes multiple significant contributions.

Firstly, this study used a systems engineering research design and provides a systematic literature review on the success factors of DDSCM. These approaches enabled the researcher to analyse, interpret and comprehensively integrate DDSCM success factors from various industries into a new comprehensive DDSCM framework for implementing DDSCM in complex end-to-end public healthcare supply chains (systems orientation). Therefore, the study contributes to the limited literature on DDSCM and public healthcare supply chains in developing countries.

Secondly, literature has demonstrated that supply chain maturity models have wide applications for performance measurement and continuous improvement within and across organisations. Until now, very few methodologies or well-defined processes were available that impartially measures and supports implementation of DDSCM practices in multifaceted organisations in public healthcare supply chains. This is a challenge for organisations that want to adopt DDSCM practices. Therefore, the maturity model for public healthcare supply chains that was developed in this study provides a framework to assess both where an organisation is today on the DDSCM maturity scale as well as how it can progress to more advanced maturity levels. This allows for systematic and structural lift of the organisational maturity by improving capacity, processes and infrastructure. Also, by creating mature DDSCM operations, organisations in public healthcare supply chains are better positioned to tackle supply chain complexities and ensure availability of medicines.

Thirdly, although several efforts have been taken for improving and expanding individual performance evaluation into organisations' suppliers, distributors and customers, literature has also highlighted that, there exist no supply chain maturity model that is able to manage properly the typical complexities in management of supply chain networks (Lahti, Shamsuzzoha and Helo, 2009). A network maturity-mapping tool for public healthcare SCNs was developed to assist supply chain managers at national, provincial, district and even at facility level to perform a network analysis. A broken or weak link in any part of the public healthcare SCN can in severe cases cause a domino effect that can ultimately affect downstream supply chain partners such as hospitals and health facilities. This tool is vital since it helps managers to collate and analyse information from unique organisations/facilities in the SCN. The tool simplifies analysis of the collated information by providing a visual presentation of the DDSCM assessment outcomes of the entire network. This allows a systems level approach to driving interventions on particular DDSCM dimensions and their associated capabilities that will enhance the performance of the entire public healthcare SCN. The contribution of using the network maturity-mapping tool is that, it offers a more extensive picture of the maturity of DDSCM dimensions and their associated capabilities in the SCN.

Fourthly, the network maturity-mapping tool was also empirical validated through 12 extensive case studies. Since most of the supply chain maturity models reviewed in this study are theoretical constructs and are not empirically tested, this study makes some strides towards addressing this limitation. The outputs from the tool will also help managers, policy makers and decision makers to identify dimensions and their associated capabilities that need individual focus. In addition, this tool will allow the provincial or district managers to recognise the dimensions and their associated capabilities that are lacking in all healthcare facilities in the province/or district and then they can implement a roadmap to improve the performance of the whole province.

Fifthly, another interesting contribution from this research is that the case studies demonstrated the tremendous impact that DDSCM concepts may have on an organisation's performance. The effort to implement/or sustain these DDSCM concepts was also illustrated. Drawing from these findings, this research suggest that DDSCM concepts are relevant and equally important in the public healthcare SCN.

The sixth and last contribution of the study relates to the identified benefits that unique organisations in the public healthcare SCN can reap from the implementation of DDSCM within their organisations and subsequently across the entire network.

11.5. Practical implications

Ensuring medicines availability at health facilities requires more than a series of improvement projects in the public healthcare supply chain but demands the alignment of leadership, culture, customers and operational performance across end-to-end supply chain. In particular, if organisations in public healthcare SCN could provide everyone in the supply chain with accurate data about demand, inventory, and lead times, then organisations are less likely to make decisions that lead to erratic swings in inventory. Next, if suppliers can see actual demand downstream in the supply chain, they are less likely to overreact to small variations. This visibility is accelerated by technology that automates, digitises data and connects every function within an organisation and every layer of the supply chain. The study underlines that clear agreements and collaboration between all players involved in the public healthcare supply chain can help solve problems caused by lack of supply chain visibility, which has a significant impact on the availability of medicines at healthcare facilities.

Finally, to truly reap the benefits of DDSCM requires that organisations make sure their operational processes are as agile as possible.

11.6. Study limitations

Like any other study, this study also has its limitations. DDSCM is a relatively new approach and for this reason, there is little published data in this field. In addition, few studies found in the literature, outline DDSCM from a functional perspective within a single organisation. The present work aims to go a step further to analyse the DDSCM from an end-to-end supply chain perspective, and focus on the alignment of all supply chain partners towards customer demand. This has been a significant contribution for this study.

However, it is imperative to mention that, the Demand Driven Institute (DDI) is pushing an agenda on Demand-Driven Material Requirements Planning (DDMRP) (section 3.8) which has strong orientation towards manufacturing planning systems. Future research is needed to explore further this DDMRP concept since it is still in infancy and very few academic papers on the concepts are available.

It was also a very difficult process to get ethical clearance to do case studies for the organisations in the public healthcare supply chain. Hence, the tool was tested only with 12 case studies. However, the purpose of the case studies was to validate the applicability of the tool at different types of supply chain nodes in the public healthcare SCN. This was successfully achieved. It would be great however, to get an extensive picture from the maturity of DDSCM dimensions and their associated capabilities in the whole Western Cape Province and the nation of South Africa at large. Future work could be considered to address this limitation. The output from this tool will reflect the readiness of the downstream partners to scale up and implement the VAN model (section 1.2) and further inform the creation of the VAN roadmap. This study only provided a snapshot of DDSCM capabilities maturity mapping of a wider national context to validate the maturity assessment tool and illustrate the visualisation benefit of the tool.

It is also vital, to clearly point out that, the tool is biased towards people with supply chain experience. There is a higher risk that people without supply chain experience, will interpret the contents of the tool wrongly resulting in the tool giving assessment outcomes that are biased. Thus implementation should be done with the necessary care and change management effort.

11.7. Future work

Although, this study established the concept of DDSCM and its benefits in public healthcare supply chains, it has not assessed and considered the barriers to the application of the network maturity-mapping tool for performance measurement and possible improvements. Another interesting research area would be to perform an empirical study that explores the type of benefits more mature organisations in the network enjoy compared to less mature organisations.

Future research could also try to find a correlation between DDSCM maturity of an organisation with several healthcare performance metrics such as stock availability, cost, quality and efficiency of organisations. This investigation will establish whether the DDSCM network maturity-mapping tool could be used as an indicator of organisational performance. This notion is borrowed from other studies that have established that there is a dramatic performance difference between lower maturity stages and higher maturity stages, where higher levels of maturity indicate the superior performance of the organisation (Lockamy and McCormack, 2004). In this line of thinking, it would also be interesting to investigate how the DDSCM maturity of one organisation in the public healthcare SCN will affect or enhance the maturity of other organisations.

The costs and investments in planning and implementing the network maturity-mapping tool also needed to be critically investigated. This will highlight the readiness of the public healthcare supply chain to adopt the DDSCM approach and furthermore guide the development of the VAN roadmap. Furthermore, future research can focus on applying and benchmarking the tool across different provinces in South Africa and also in other geographies such as developing nations in Africa other than South Africa. Lastly, the tool should be continuously refined to reflect advances in the latest knowledge of DDSCM. This could further determine and evaluate DDSCM maturity levels more effectively.

11.8. Recommendations and concluding remarks

The primary research question was to investigate how unique supply chain nodes in public healthcare Supply Chain Networks can become more responsive and be guided towards advanced DDSCM stages.

The DDSCM approach that has been adopted in other industries was proposed. This study then outlined a network maturity-mapping tool that guide actors in the public healthcare supply chain to transform towards DDSCM in the unique context of SA (a developing nation). The tool is a methodology to assess both where any unique organisation in public healthcare SCN is today on the maturity scale and how it can progress to more advanced stages of DDSCM.

To reduce biased output from the tool, it is recommended that at least three people complete the assessment questionnaire separately, and then the results are critically compared and objectively aggregated if possible. This is important because it removes the power dynamics influence – subordinate agreeing to everything the superior will be saying even if it does not reflect the actual maturity of the organisation. In addition, the people applying the tool must have supply chain experience.

It is however, important to recognise that organisations in public healthcare supply chains should progress in sequence through the maturity stages by building on practices that have been solidly established in preceding stages. Moreover, in order for an organisation to be considered mature for a given maturity stage, it must be effectively using the majority (if not all) of the DDSCM practices from that stage.

Even when supply chain system redesign proposals such as the one evaluated in this study exist, they often require navigating through a complex political economy within the overall health system and its actors. Therefore, it is important to consider and improve characteristics in health systems such as health financing (tendering and procurement) and regulations. Consequently, the role of the government must be considered in the medicine supply chain. Government policies and strategies decide the rules and regulations of medicine supply chains. These characteristics affect the design and operation of healthcare supply chains and therefore the implementation of DDSCM practices. In conclusion, to make DDSCM sustainable, an organisation has to adopt a continuous improvement commitment that focuses on enhancing the supply chain processes, supporting the people, and fixing the data issues. This implies that organisations need to develop strategically aligned capabilities, not only within the organisation itself, but also among the other organisations that are part of the value-adding networks.

References

Accenture (2014). An Approach for Social Data (online). Available: https://www.accenture.com/us-en/blogs/blogs-an-approach-for-social-data-customer-segmentation (Accessed: 4 January 2020).

Ackerman and Pierce, (2018). Demand Sensing: Artificial Intelligence and Analytics in the 21st century supply chain (online). Available: https://www.futureinsights.org/insights/demand-sensing-neil-ackerman. (Accessed 11 January 2020.)

Agrawal, D. K. (2012) 'Demand Chain Management: Factors Enhancing Market Responsiveness Capabilities', *Journal of Marketing Channels*, 19(2), pp. 101–119. doi: 10.1080/1046669x.2012.667760.

Alexandiris, K.T. (2006) 'Exploring Complex Dynamics in Multi Agent-Based Intelligent Systems: Theoretical and experimental approaches using the multi agent-based behavioral economic landscape (mabel) model.' PhD Thesis. Purdue University.United States of America.

Almutairia, A., Collierb, Z. A., Hendricksonc, D., Palma-Oliveirad, J. M. and Polmateere, T. L. (2019) 'Stakeholder mapping and disruption scenarios with application to resilience of a container port', *Reliability Engineering and System Safety*, 182 (C), pp. 219–232. doi: https://pdf.sciencedirectassets.com/271430/1-s2.0-S0951832018X00118/1-s2.0-S0951832017311602/main.pdf?

APICS (2017) 'SCOR Framework.' (Online). Available at: http://www.apics.org/apics-for-business/products-and-services/apics-scc-frameworks/scor (Accessed: 28 August 2017).

Arnold, R. D. and Wade, J. P. (2015) 'A Definition of Systems Thinking : A Systems Approach', *Procedia Computer Science*, 44 (2), pp. 669–678. doi: 10.1016/j.procs.2015.03.050.

Ashayeri, J. and Kampstra, R. . (2005) Demand Driven Distribution:The Logistical challenges and opportunities. *Proceedings of International Trade and Logistics, Corporate Strategies and Global Economy*. Le Havre: University of Le Havre, France.

Ayers, J. (2006) 'Demand-Driven Supply Chain Implementation', *Chemical Engineering Progress*, 102(12), p. 21.

Ayers, J. B. and Malmberg, D. M. (2002) 'Supply Chain Systems: Are You Ready?', *Information Strategy: The Executive journal*, 19(1), pp. 18–27.

Babbie, E. . (2010) *The Practice of Social Research*. Cengage Learning.Pearson Education

Bajpai, N. (2011) *Business Research Methods*. India, Pearson Education.

Barratt, M. (2004) 'Understanding the meaning of collaboration in the supply chain', *Supply Chain Management: An International Journal*, 9(1), pp. 30–42. doi: 10.1108/13598540410517566.

Barratt, M. and Oke, A. (2007) 'Antecedents of supply chain visibility in retail supply chains: A resource-based theory perspective', *Journal of Operations Management*, 25(6), pp. 1217–1233. doi: 10.1016/j.jom.2007.01.003.

Barrett, J. (2007) ‘Demand-Driven is an Operational Strategy’, *Industrial Management Management*, 49(6), pp. 1–14.

Bartlett, P., Julien, D. and Baines, T. (2007) ‘Improving supply chain performance through improved visibility’, *International Journal of Logistics Management*, 18(2), pp. 294–313. doi: 10.1108/09574090710816986.

Battista, C., Fumi, A. and Schiraldi, M. M. (2012) ‘The Logistic Maturity Model: guidelines for logistic processes continuous improvement’, *Proceedings of the POMS 23rd Annual Conference. Chicago, Illinois, USA*.

Becker, J., Knackstedt, R. and Pöppelbuß, J. (2009) ‘Developing Maturity Models for IT Management’, *Business & Information Systems Engineering*, 1(3), pp. 213–222. doi: 10.1007/s12599-009-0044-5.

Berger, J., Hofmeester, N., Makhadho, M., Miot, J., Moller, H., Pharasi, B., Phillips, D., Raubenheimer, T., Sallet, J. and Suleman, F. (2010) Republic of South Africa Medicines Procurement Reform in the Public Sector.Pretoria, Department of Health Republic of South Africa.

Bidzha, L., Greyling, T. and Mahabir, J. (2017) Has South Africa’s Investment in Public Health Care Improved Health Outcomes? Working paper on Economic Research Africa. Pretoria, National Treasury of South Africa. Available at: https://econrsa.org/system/files/publications/working_papers/working_paper_663.pdf.

Bjartnes, R., Strandhagen, J. O., Dreyer, H. and Solem, K. (2008) ‘Intelligent and demand driven manufacturing network control concepts’, *Third World Conference on Production and Operations Management*. JOMSA.Tokyo,Japan. pp. 1–15.

Black, I. G. and Halatsis, A. (2001) ‘A demand driven freight transport system for the supply chain’, in *ITSC 2001. 2001 IEEE Intelligent Transportation Systems. Proceedings (Cat. No.01TH8585)*, pp. 954–958. doi: 10.1109/ITSC.2001.948789.

Bonney, M. C., Zhang, Z., Head, M. A., Tien, C. C. and Barson, R. J. (1999a) ‘Are push and pull systems really so different?’, *International Journal of Production Economics*, 59(1), pp. 53–64. doi: 10.1016/S0925-5273(98)00094-2.

Bonomi, J. and Antone, S. D. (2014) ‘Industrial Marketing Management Reinventing the wheel ? A critical view of demand-chain management’, *Industrial Marketing Management*. 43(6), pp. 1012–1025. doi: 10.1016/j.indmarman.2014.05.014.

Botha, L. (2016) ‘Stock Visibility Solution Stock Visibility Solution – An Overview’. (Online), Available at: https://www.mezzanineware.com/svs. Accessed on 27 January 2018.

Brooks, P., El-Gayar, O. and Sarnikar, S. (2013) ‘Towards a business intelligence maturity model for healthcare’, in *Proceedings of the Annual Hawaii International Conference on System Sciences*, pp. 3807–3816. Hawaii, United States of America. doi: 10.1109/HICSS.2013.560.

Bryman, Bell, Hirschsohn, Santos, D., DuToit, Masenge, Van Aardt and Wagner (2014) 'Research Methodology: Business and Management Contexts.' South Africa, Oxford University Press.

Budd, J., Knizek, C. and Tevelson, B. (2012) 'The Demand-Driven Supply Chain: Making it work and delivering results.'

Boston, Boston Consulting Group.(online). Available at https://www.bcg.com/documents/file 106861.pdf. (accessed on 12 January 2017)

Buijs, P., Vis, I. F. A. and Carlo, H. J. (2014) ‘Synchronization in cross-docking networks: A research classification and framework’, *European Journal of Operational Research*. Elsevier B.V., 239(3), pp. 593–608. doi: 10.1016/j.ejor.2014.03.012.

Burns, L.R., DeGraaff, R.A., Danzon, P.M., Kimberly, J.R., Kissick, W.L. and Pauly, M.V. (2002) 'The Wharton School study of the health care value chain.' *The health care value chain: producers, purchasers and providers.* San Francisco: Jossey-Bass, pp.3-26.

Byrnes, J. (2004) ‘Fixing the Healthcare Supply Chain’, *Harvard Business School*, pp. 1–4: Working Knowledge.

Callender, C. and Grasman, S. E. (2010) ‘Barriers and Best Practices for Material Management in the Healthcare Sector’, *Engineering Management Journal*, 22(4), pp. 11–19. doi: 10.1080/10429247.2010.11431875.

Canever, M. D., Trijp, H. C. M. Van and Beers, G. (2008) ‘The emergent demand chain management: key features and illustration from the beef business’, *Supply Chain Management: An International Journal*, 13(2), pp. 104–115. doi: 10.1108/13598540810860949.

Cao, M., Vonderembse, M. A., Zhang, Q. Y. and Ragu-Nathan, T. S. (2010) ‘Supply chain collaboration: conceptualisation and instrument development’, *International Journal of Production Research*, 48(22), pp. 6613–6635. doi: 10.1080/00207540903349039.

Caridi, M. (2013) ‘Measuring supply chain visibility in the apparel industry’, *Benchmarking: An International Journal*, 20(1), pp. 25–44. doi: 10.1108/14635771311299470.

Caridi, M., Moretto, A., Perego, A. and Tumino, A. (2014) ‘The benefits of supply chain visibility: A value assessment model’, *International Journal of Production Economics*, 151, pp. 1–19. doi: 10.1016/j.ijpe.2013.12.025.

Caro, F. and Gallien, J. (2010) ‘Inventory Management of a Fast-Fashion Retail Network’, *Operations Research*, 58(2), pp. 257–273. doi: 10.1287/opre.1090.0698.

Carvalho, H., Cruz-Machado, V. and Tavares, J. G. (2012) ‘A mapping framework for assessing Supply Chain resilience.' *International Journal of Logistics Systems and Management*, 12(3), pp. 354–373.

Cecere L (2016). Is a customer-centric strategy the same as demand driven? Outside-In? (online). Available: http://www.supplychainshaman.com/demand/is-a-customer-centric-strategy-the-same-as-demand-driven-outside-in/. Accessed 11 January 2020.

Cecere L (2013). Concepts of Demand Management (online). Available: https://www.supplychain247.com/article/concepts_of_demand_management. Accessed 11 January 2020.

Charmaz, K. (1996) ‘The Search for Meanings- Grounded Theory: *Rethinking Methods in Psychology*, pp. 27–49. London, United Kingdon:Sage. doi: 10.1016/B978-0-08-044894-7.01581-5.

Chakravarty, A.K. (2014) Transforming the Contemporary Supply Chain. Springer Texts.

Childerhouse, P., Aitken, J. and Towill, D. R. (2002) 'Analysis and design of focused demand chains', *Journal of Operations Management*, 20(6), pp. 675–689. doi: 10.1016/S0272-6963(02)00034-7.

Christopher, M., Gattorna, J. and Christopher, M. (2005) 'Supply chain cost management and value-based pricing', *Industrial Marketing Management*, 34(2), pp. 115–121.

Christopher, M. and Lee, H. (2004) 'Mitigating Supply Chain Risk Through Improved Confidence.', *International Journal of Physical Distribution & Logistics Management*, 34(5), pp. 388–396. doi: 10.1108/09600030410545436.

Christopher, M. and Towill, D. (2001) 'An integrated model for the design of agile supply chains', *International Journal of Physical Distribution & Logistics Management*, 31(4), pp. 235–246. doi: 10.1108/09600030110394914.

Chopra, S., Meindl, P (2016). Supply Chain Management: Strategy, Planning and Operation.Sixth Edition. London, Pearson.

Clark, T. and Jones, R. (1999) 'Organisational interoperability maturity model for C2', in *Proceedings of the 1999 Command and Control Research and Technology Symposium* (pp. 1-13).

Cooper, M. C., Lambert, D. M. and Pagh, J. D. (1997) 'Supply Chain Management: More Than a New Name for Logistics', *The International Journal of Logistics Management*, 8(1), pp. 1–14. doi: 10.1108/09574099710805556.

Crosby (1979) *Quality is Free*. New York: McGraw-Hill.

Croxton, K. L., Garcia-Dastugue, S. J., Lambert, D. M. and Rogers, D. S. (2001) 'The Supply Chain Management Processes', *The International Journal of Logistics Management*, 12(2), pp. 13–36. doi: 10.1108/09574090110806271.

Croxton, K. L., Lambert, D. M., García-Dastugue, S. J. and Rogers, D. S. (2002) 'The Demand Management Process', *The International Journal of Logistics Management*, 13(2), pp. 51–66. doi: 10.1108/09574090210806423.

CSCMP (2013) *CSCMP Supply Chain Management Definitions and Glossary*. (Online), Available at: http://cscmp.org/cscmp/educate/scm_definitions_and_glossary_of_terms/cscmp/educate/scm_definitions_and_glossary_of_terms.aspx? (Accessed: 28 August 2017).

DeAsi, G (2020). Ten powerful behavioural segmentation methods to understand your customers (online): Available: https://www.pointillist.com/blog/behavioral-segmentation/. (Accessed on 4 January 2020).

Deloitte, (2019). How digital healthcare can give provider an edge: Building a digital supply chain. (online). Available: https://www2.deloitte.com/us/en/pages/operations/articles/health-care-building-a-digital-supply-chain-examples.html. Accessed on 8 January 2020.

Diaz N.D (2015). Preliminaries on Demand Driven Value Networks: Implications of Information Technology. A master's thesis, Texas State University. United States.

Dreyer, H. C., Strandhagen, J. O., Romsdal, A. and Hoff, A. (2010) 'Principles for real-time, integrated supply chain control: An example from distribution of pharmaceuticals', in *IFIP Advances in Information and Communication Technology*. Springer, Berlin, Heidelberg. doi: 10.1007/978-3-642-16358-6_24.

Dudovskiy, J. (2018) The Ultimate Guide to Writing a Dissertation in Business Studies: A Step-by-Step Assistance.(Online).Available at: https://research-methodology.net/about-us/ebook/.Accessed on 4 August 2019.

Van Dyk, L. (2013) 'The Development of a Telemedicine Service Maturity Model.' PhD thesis, Stellenbosch University, Stellenbosch.

Eagle, S. (2017) Demand-Driven Supply Chain Management: Transformational Performance Improvement. 1st Edition. UK, CPI Group Ltd.

Van Eeden, J. (2018) A model for the translation of South African economic activity into shipping container demand. PhD thesis, University of Stellenbosch, Stellenbosch.

Elmuti, D., Khoury, G., Omran, O. and Abou-Zaid, A. S. (2013) 'Challenges and Opportunities of Health Care Supply Chain Management in the United States', *Health Marketing Quarterly*, 30(2), pp. 128–143. doi: 10.1080/07359683.2013.787885.

Esper, T. L., Ellinger, A. E., Stank, T. P., Flint, D. J. and Moon, M. (2010) 'Demand and supply integration: A conceptual framework of value creation through knowledge management', *Journal of the Academy of Marketing Science*, 38(1), pp. 5–18. doi: 10.1007/s11747-009-0135-3.

Farris, M. T. (2012) 'Solutions to strategic supply chain mapping issues', *International journal of physical Distribution & Logistics Management*, 40(3), pp. 164–180. doi: 10.1108/09600031011035074.

Fawcett, S. E., Wallin, C., Allred, C. and Magnan, G. (2009) 'Supply chain information-sharing: benchmarking a proven path', *Benchmarking: An International Journal*, 16(2), pp. 222–246. doi: 10.1108/14635770910948231.

Firouzi, F. (2012) 'Design and Analysis of a Health Care Supply Chain Management', *Advanced materials research*, 43(3), pp. 2128–2134. doi: 10.4028/www.scientific.net/AMR.433-440.2128.

Fischer, J.-H., Thomé, A. M. T., Scavarda, L. F., Hellingrath, B. and Martins, R. (2016) 'Development and Application of a Maturity Measurement Framework for Supply Chain Flexibility', *Procedia CIRP*, 41, pp. 514–519. doi: 10.1016/j.procir.2015.12.107.

Fisher, M. (1997) 'What is the Right Supply Chain for Your Product?', *Harvard Business Review*, 75(2), pp. 105–116.

Fleischmann, B. and Meyr, H. (2003) 'Planning Hierarchy, Modeling and Advanced Planning Systems', *Handbooks in operations research and management science*, 11, pp. 457–523.

Fliedner, G. and Fliedner, G. (2007) 'CPFR : An emerging supply chain tool'. *Industrial Management and data systems, 103(1),* pp.14-21. doi: 10.1108/02635570310456850.

Forrester (2019). The best of times and worst of times for segmentation: Overthrow traditional customer segmentation in the personalization revolution (online). Available: https://www.forrester.com/report/The Best Of Times And The Worst

Of Times For Segmentation/-/E-RES150375 (Accessed: 4 January 2020)

Francis, V. (2008) ‘Supply chain visibility: lost in translation?’, *Supply Chain Management: An International Journal*, 13(3), pp. 180–184. doi: 10.1108/13598540810871226.

Fraser, P., Moultrie, J. and Gregory, M. (2002) ‘The use of maturity models/grids as a tool in assessing product development capability’, *IEEE International Engineering Management Conference*, 1, pp. 244–249. IEEE. doi: 10.1109/IEMC.2002.1038431.

Frazelle, E. (2002) *Supply chain strategy*. 1st Edition. Newyork, McGraw-Hill.

Frohlich, M. T. and Westbrook, R. (2002) ‘Demand chain management in manufacturing and services: Web-based integration, drivers and performance’, *Journal of Operations Management*, 20(6), pp. 729–745. doi: 10.1016/S0272-6963(02)00037-2.

Garcia, H. (2008) '*A Capability Maturity Model to Assess Supply Chain Performamce*', PhD thesis, Florida International University, United States of America. Available at: http://digitalcommons.fiu.edu/etd/191/.

Garcia Reyes, H. and Giachetti, R. (2010) ‘Using experts to develop a supply chain maturity model in Mexico’, *Supply Chain Management: An International Journal*, 15(6), pp. 415–424. doi: 10.1108/13598541011080400.

Gardner, J. T. and Cooper, M. C. (2003) ‘Strategic Supply Chain Mapping Approaches'. *Journal of Business Logistics, 24(2).*

Gastaldi, L., Pietrosi, A. and Corso, M. (2017) ‘Measuring the Maturity of Business Intelligence in Healthcare : Supporting the Development of a Roadmap Towards Precision Medicine’, in *Technological Forecasting and Social Change 128*, pp. 84-103. doi: 10.13140/2.1.3558.0169.

Gattorna (2010) "Dynamic supply chains: delivering value through people". 2nd Edition, Prentice Hall,Great Britain.

Gattorna (2006) "Living supply chains:How to mobilise the enterprise around delivering what your customers want". 1st Edition, Prentice Hall,Great Britain.

Gibbert, M., Ruigrok, W. and Wicki, B. (2008) ‘Whay passes as rigorous case study?’, *Strategic Management Journal*, 29(13), pp. 1465–1474. doi: 10.1002/smj.722.

Goddard, W. and Melville, S. (2004) *Research Methodology: An Introduction*. 2nd edition. New Jersey, Blackwell Publishing.

Goh, M., De Souza, R., Zhang, A. N., He, W. and Tan, P. S. (2009) ‘Supply chain visibility: A decision making perspective’, in *2009 4th IEEE Conference on Industrial Electronics and Applications, ICIEA 2009*, pp. 2546–2551. doi: 10.1109/ICIEA.2009.5138666.

Goor, A. R. Van (2001) ‘Demand & Supply Chain Management : A Logistical Challenge’, in *17th International Logistics Congress, Thessaloniki*, pp. 1–15.

Grabis, J. and Bērziša, S. (2015) A Reference Model Based Design of Supply Chain Management Capabilities.(Online). Available at: http://ceur-ws.org/Vol-1408/paper1-cobi.pdf. Accessed on: 6 March 2018.

Gulati, P . (2009) Research Management: Fundamental and Applied Research. India: Global India Publications.

Gunasekaran, A., Patel, C. and McGaughey, R. E. (2004) 'A framework for supply chain performance measurement', *International Journal of Production Economics*, 87(3), pp. 333–347. doi: 10.1016/j.ijpe.2003.08.003.

Haavik, S. (2000) 'Building a Demand driven, Vendor-Managed Supply Chain', Healthcare Financial Management, 54(2), pp. 56–61.

Hadaya, P. and Cassivi, L. (2007) 'The role of joint collaboration planning actions in a demand-driven supply chain', *Industrial Management & Data Systems*, 107(7), pp. 954–978. doi: 10.1108/02635570710816694.

Heaney, B. (2013) Supply Chain Visibility Supply Chain Visibility : A Critical Strategy to optimise cost and service. *Aberdeen Group*, 20 (1).

Heikkilä, J. (2002) 'From supply to demand chain management: Efficiency and customer satisfaction', *Journal of Operations Management*, 20(6), pp. 747–767. doi: 10.1016/S0272-6963(02)00038-4.

Hilletofth, P. (2011) 'Demand-supply chain management: industrial survival recipe for new decade', *Industrial Management & Data Systems*, 111(2), pp. 184–211. doi: 10.1108/02635571111115137.

Hilletofth, P., Ericsson, D. and Christopher, M. (2009) 'Demand chain management: a Swedish industrial case study', *Industrial Management & Data Systems*, 109(9), pp. 1179–1196. doi: 10.1108/02635570911002261.

Hines, T. (2004) *Supply Chain Strategies: Customer-driven and customer-focused*. 1st Edition. Oxford: Elsevier Butterworth-Heinemann.

Hjort, Lantz, Ericsson, Gattorna, (2013). "Customer segmentation based on buying and returning behaviour" International Journal of Physical Distribution and logistics Management, 43 (10). DOI 10.1108/IJPDLM-02-2013-0020

Ho, D., Kumar, A. and Shiwakoti, N. (2016) 'Maturity model for supply chain collaboration: CMMI approach', in *IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*, pp. 845–849. doi: 10.1109/IEEM.2016.7797996.

Hofman (2014). Leading in the Digital Future: Insights from the Gartner Keynote at the 2014 Supply Chain Conference. Gartner.

Hopp, W. J. and Spearman, M. L. (2004) 'To Pull or Not to Pull: What Is the Question?', *Manufacturing & Service Operations Management*, 6(2), pp. 133–148. doi: 10.1287/msom.1030.0028.

Hsu, C.-C., Kannan, V. R., Tan, K.-C. and Leong, G. K. (2008) 'Information sharing, buyer-supplier relationships, and firm performance:A multi-region analysis', *International Journal of Physical Distribution&Logistics Management*, 38(4), pp. 296–310. doi: http://dx.doi.org/10.1108/MRR-09-2015-0216.

Hübner, A. H., Kuhn, H., Sternbeck, M. G. and Hu, A. H. (2014) 'Demand and supply chain planning in grocery retail : an operations planning framework', *International Journal of Retail & Distribution Management*, 41(7), pp. 512–530. doi: 10.1108/IJRDM-05-2013-0104.

Hull, B. Z. (2005) 'Are supply (driven) chains forgotten?', *The International Journal of Logistics Management*, 16(2), pp. 218–236. doi: 10.1108/09574090510634520.

IBM (2007) *Follow the leaders: Scoring high on the supply chain maturity model*. *China, Mainland*. doi: Academico/Material Didatico/Bibliografia Global/Logística.

(Impact forHealth, 2019) https://impactforhealth.com/wp-content/uploads/2019/09/2019.09_Innovations-in-health-product-distribution_Overview.pdf

Imran, M., Kang, C. and Babar, M. (2018) 'Medicine supply chain model for an integrated healthcare system with uncertain product complaints', *Journal of Manufacturing Systems*, 46, pp. 13–28. doi: 10.1016/j.jmsy.2017.10.006.

Juttner, U., Christopher, M. and Baker, S. (2007) 'Demand chain management-integrating marketing and supply chain management', *Industrial Marketing Management*, 36(3), pp. 377–392. doi: 10.1016/j.indmarman.2005.10.003.

Jabareen, Y. (2009) 'Building a Conceptual Framework: Philosophy, Definitions, and Procedure', *International Journal of Qualitative Methods*, 8(4), pp. 49–62. doi: 10.1177/160940690900800406.

Jackson, N. C. (2004) 'Background to Systematic Reviews', in *Handbook - systematic review of health promotion and public health interventions*. Cochrane, pp. 5–8.

Jacobs, D. (2006) 'Journal of Fashion Marketing and Management : An International Article information ':, *Journal of Fashion Marketing and Management: An International Journal*, 10(1), pp. 363–382. doi: 10.1108/13612021111151941.

Janvier-James, A. M. (2011) 'A New Introduction to Supply Chains and Supply Chain Management: Definitions and Theories Perspective', *International Business Research*, 5(1), pp. 194–207. doi: 10.5539/ibr.v5n1p194.

JSI (2017) *The supply chain manager ' s handbook the supply chain manager ' s handbook*.Arlington, John Snow Inc.

Kaipia, R. and Hartiala, H. (2006) 'Information-sharing in supply chains: five proposals on how to proceed', *The International Journal of Logistics Management*, 17(3), pp. 377–393. doi: 10.1108/EL-01-2014-0022.

Keele and Staffs (2007) 'Guidelines for performing systematic literature reviews in software engineering: EBSE Technical Report. (Online). Available at: https://www.elsevier.com/__data/promis_misc/525444systematicreviewsguide.pdf. Accessed on: 17 July 2017.

Kelle, P., Woosley, J. and Schneider, H. (2012) 'Pharmaceutical supply chain specifics and inventory solutions for a hospital case', *Operations Research for Health Care*, 1(2), pp. 54–63. doi: 10.1016/j.orhc.2012.07.001.

Khan, N., Silva, S., Kandl, T. and Ag, F. H. R. (2012) 'A Software Based Solution to Facilitate End to End Information Supply Chain Visibility', in *Service Systems and Service Management (ICSSSM) international conference on IEEE*, pp. 850–855.

Kim, S.-H. and Kwon, I.-W. G. (2015) ‘The Study of Healthcare Supply Chain Management in United States: Literature Review’, *Management Review: An International Journal Management Review An International Journal* , 10(2), pp. 34–57.

Kokilam, M. B., Joshi, H. G. and Kamath, V. G. (2016) ‘Strengthening the Pharmaceutical Supply Chain Management with Information Communication Technology Intervention: A Windfall to the Indian Rural Public Healthcare System’, *Journal of Health Management*, 18(2), pp. 274–289. doi: 10.1177/0972063416637719.

Korhonen, P., Huttunen, K. and Eloranta, E. (1998) ‘Demand chain management in a global enterprise- information management view Demand chain management in a global enterpriseÐ information management view’, *Production Planning and Control*, 9(6), pp. 526–531. doi: 10.1080/095372898233777.

Kortabarria, A., Apaolaza, U., Lizarralde, A. and Amorrortu, I. (2018) ‘Material Management without Forecasting : From MRP to Demand Driven MRP’, *Journal of Industrial Engineering and Management*, 11(4), pp. 632–650.

Kritchanchai, D. (2012) ‘A Framework for Healthcare Supply Chain Improvement in Thailand’, *Operations and Supply Chain Management*, 5(2), pp. 103–113.

Kumar, M., Srai, J., Pattinson, L. and Gregory, M. (2013) ‘Mapping of the UK food supply chains : capturing trends and structural changes’, *Journal of Advances in Management*, 10(2), pp. 299–326. doi: 10.1108/JAMR-05-2013-0034.

Kwon, I. W. G., Kim, S. H. and Martin, D. G. (2016) ‘Healthcare supply chain management; strategic areas for quality and financial improvement’, *Technological Forecasting and Social Change*., 113(1), pp. 422–428. doi: 10.1016/j.techfore.2016.07.014.

Lahti, M., Shamsuzzoha, A. H. M. and Helo, P. (2009) ‘Developing a maturity model for Supply Chain Management’, *International Journal of Logistics Systems and Management*, 5(6), p. 654. doi: 10.1504/ijlsm.2009.024796.

Lambert, D. and Cooper, M. (2000) ‘Issues in Supply Chain Management’, *Industrial Marketing Management*, 29(1), pp. 65–83. doi: 10.1016/S0019-8501(99)00113-3.

Lambert, D. M. and Enz, M. G. (2017) ‘Issues in Supply Chain Management: Progress and potential’, *Industrial Marketing Management*, 62, pp. 1–16. doi: 10.1016/j.indmarman.2016.12.002.

Lans, I. van der (2008) 'Description of the theoretical framework for a ‘Consumer driven and responsive supply chain’.ISAfruit.

Lapide, L. (2006) ‘Demand Management Revisited’, *The Journal of Business Forecasting*, 25(3), pp. 17–19. Available at: http://search.proquest.com.ezp.waldenulibrary.org/docview/226916674/abstract?accountid=14872.

Lebovitz, R. and Graban, M. (2001) ‘The journey toward demand driven manufacturing’, in *Proceedings - 2nd International Workshop on Engineering Management for Applied Technology, EMAT*, pp. 29–35. doi: 10.1109/EMAT.2001.991308.

Lee, H. L. (2002) ‘Aligning Supply Chain Strategies with Product Uncertainties’, *Carlifornia Management Review*, 44(3), pp. 105–119.

Lee, H. L., Padmanabhan, V. and Whang, S. (1997) 'The Bullwhip Effect In Supply Chains', *Sloan Management Review*, 38(3), pp. 93–102.

Levenger, M., Ongeri, B., Wolde, A. and Kagoya, H. R. (2013) 'Namibia National Supply Chain Assessment', Submitted to the US Agency for International Development by the Supply Chain Management System. Online. Available at: https://www.medbox.org/namibia-national-supply-chain-assessment-results/download.pdf. Accessed on: 13 October 2018.

Lewis, C.D. (1997). Demand forecasting and inventory control: A control aided learning approach. Woodhead publishing limited, Abington Hall, Abington, Cambridge, England.

Llewellyn, E. (2016) 'National Strategy for Improved Availability and Access: Visibility and Analytics Network', pp. 1–12.Unpublished report.

Lockamy, A. and McCormack, K. (2004) 'The development of a supply chain management process maturity model using the concepts of business process orientation', *Supply Chain Management: An International Journal*, 9(4), pp. 272–278. doi: 10.1108/13598540410550019.

Lotfi, Z., Mukhtar, M., Sahran, S. and Zadeh, A. T. (2013) 'Information Sharing in Supply Chain Management', *Procedia Technology*, 11(Iceei), pp. 298–304. doi: 10.1016/j.protcy.2013.12.194.

Louw, J. J. (2006) Advanced supply chain planning processes large-scale petrochemical companies. PhD thesis, Stellenbosch University,Stellenbosch.

Lummus, R. R. and Vokurka, R. J. (1999) 'Managing the Demand Chain Through Managing the Information Flow: Capturing "moments of Information"', *Production & Inventory Management Journal*, 40(1), pp. 16–20. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=11934248&site=ehost-live&scope=cite.

Mahadevan, K. (2010) 'Supply Chain Visibility and Integration – The current directions in organisations: A comprehensive literature review and research questions', in *The 2nd International Conference on Computer and Automation Engineering (ICCAE)*, pp. 226–229. doi: 10.1109/ICCAE.2010.5451465.

Mialki, S (2019). Defining behavioural segmentaion with seven examples from marketing campaigns (online). Available: https://instapage.com/blog/behavioral-segmentation. Accessed on 4 January 2020.

Mapowo, N., Kock, I. De and Eeden, J. Van (2018) 'Incorporating product categorization to improve the performance of SA ' s public healthcare supply chain : A research agenda', in *SAIIE29 Proceedings, 24th - 26th of October 2018*, pp. 391–404.

Marais, A. (2018) A management tool towards the development of healthcare innovation platforms. Masters thesis, Stellenbosch University,Stellenbosch.

Maree, K. (2011) *First Steps in Research*. 8th Edition. South Africa, Van Schaik Publishers.

Marques, L., Martins, M., & Araújo,C., (2019): The healthcare supply network: current state of the literature and research opportunities, *Production Planning & Control*, (Online), Available at: DOI: 10.1080/09537287.2019.1663451. Accessed, 16 October 2019.

Martilla, J. A. and James, J. C. (1977) 'Importance-Performance Analysis', *Journal of Marketing*, 41(1), p. 77. doi: 10.2307/1250495.

Martin, P. Y. and Turner, B. A. (1986) 'Grounded Theory and Organisational Research', *Applied Behavioral Science*, 22(2), pp. 141–157.

Mbhele, T. P. (2016) 'Decoupling paradigm of push-pull theory of oscillation in the FMCG industry', *South African Journal of Business Management*, 47(2), pp. 53–66.

McLaren, T. S. (2006) 'A Measurement Model for Web-enabled Supply Chain Integration', in *19th Bled eConference eValues. June, 5.-7. 2006*, pp. 1–13.

Medicines Sans Frontiers, Rural health advocacy project, treatment action campaign, Rudasa and +Section27 (2014) Stock Outs in South Africa, Second Annual Report.

Mendes, P., Leal, J. E. and Thome, A. M. T. (2016) 'A maturity model for demand-driven supply chains in the consumer product goods industry', *International Journal of Production Economics*, 179 (1), pp. 153–165. doi: 10.1016/j.ijpe.2016.06.004.

Meng, X., Sun, M. and Jones, M. (2011) 'Maturity Model for Supply Chain Relationships in Construction', *Journal of Management*, 27(1), pp. 97–105. doi: 10.1061/(ASCE)ME.1943-5479.0000035.

Mentzer, J. T., Keebler, J. S., Nix, N. W., Smith, C. D. and Zacharia, Z. G. (2001) 'Defining supplychain management', *Journal of Business Logistics*, 22(2), pp. 1–25.

Mettler, T. (2011) 'Maturity assessment models: a design science research approach', *Int. J. Society Systems Science*, 3(12), pp. 81–98. doi: 10.1504/IJSSS.2011.038934.

Mezzanine Health Solutions (2017) *Health Solutions _ Mezzanine Ware*. Available at: http://www.mezzanineware.com/health-solutions/ (Accessed: 4 April 2017).

Miclo, R., Fontanili, F., Lauras, M., Lamothe, J. and Milian, B. (2016) 'An empirical study of Demand-Driven MRP', in *Proceedings of Information systems logistics and supply chain*, pp. 1–7.

Miclo, R., Lauras, M., Fontanili, F., Lamothe, J., Melnyk, A., Miclo, R., Lauras, M., Fontanili, F. and Lamothe, J. (2019) 'Demand Driven MRP : assessment of a new approach to materials management', *International Journal of Production Research*. Taylor & Francis, 57(1), pp. 1–16. doi: 10.1080/00207543.2018.1464230.

Min, H (2015). The Essentials of Supply Chain Management: New Business Concepts and Applications. Pearson Education, United states.

Mokheseng, M., Horn, G. S. and Klopper, A. G. (2016) 'ScienceDirect Supply chain solutions to improve the distribution of antiretroviral drugs (ARVs) to clinics in rural areas : A case study of the QwaQwa district’, *Health SA Gesondheid*. 22(1), pp. 93–104. doi: 10.1016/j.hsag.2016.11.001.

Mouton, J. (2012) *How to succeed in your Master’s & Doctoral Studies:A South African Guide and Resource Book*. Van Schaik Publishers.

Mustaffa, N. H. and Potter, A. (2009) ‘Healthcare supply chain management in Malaysia: a case study’, *Supply Chain Management: An International Journal*, 14(3), pp. 234–243. doi: 10.1108/13598540910954575.

Narayana, S. A., Kumar Pati, R. and Vrat, P. (2014) ‘Managerial research on the pharmaceutical supply chain - A critical review and some insights for future directions’, *Journal of Purchasing and Supply Management*. Elsevier, 20(1), pp. 18–40. doi: 10.1016/j.pursup.2013.09.001.

Ncube, M. A. (2015) *Understanding and Mitigating the Pharmaceutical Supply Chain Management Challenges in Cape Town’s Khayelitsha and Eastern Sub-structure*. Management College of Southern Africa.Masters thesis,Management College of Southern Africa.

Nemzoff, C; Rosen D; Chalkidou, K (2019). Entrepreneurship on the rise in the medical supply chain in Africa: A tale of four Pharmacy disruptors (online). Available: https://www.cgdev.org/blog/entrepreneurship-rise-medical-supply-chain-africa-tale-four-pharmacy-disruptors. Accessed 8 January 2020.

Netland, T. and Alfnes, E. (2008) ‘A practical tool for supply chain improvement-experiences with the supply chain maturity assessment test (SCMAT)’, *: Necessity and Sufficiency, proceedings of the 3rd …*, pp. 1–14. Available at: https://www.sintef.no/upload/Teknologi_og_samfunn/intrans/Netland and Alfnes (2008) A practical tool for supply chain improvement_submitted to POM Tokyo%5B1%5D.pdf.

Newcombe, R. (2010) ‘From client to project stakeholders : a stakeholder mapping approach From client to project stakeholders : a stakeholder mapping approach’, *Construction and Economics*, 21(8), pp. 841–848. doi: 10.1080/0144619032000072137.

O’Marah, K. (2005) ‘It ’ s all about the Customer’, *Industrial Management*, 47(2), pp. 1–8.

Oracle, (2015). Oracle Value Chain Planning: Demantra Advanced Forecasting (online): Available: http://www.oracle.com/us/products/applications/057019.pdf. Accessed 11 January 2020.

One Network Enterprises, (2015). Demand Sensing Much More Than a Demand Management Evolution (online). Available :http://www.supplychain247.com/paper/demand_sensing_in_supply_chain/news.Accessed on 11 January 2020.

Papert, M., Rimpler, P. and Pflaum, A. (2016) ‘Enhancing supply chain visibility in a pharmaceutical supply chain’, *International Journal of Physical Distribution & Logistics Management*, 46(9), pp. 859–884. doi: 10.1108/IJPDLM-06-2016-0151.

Pati, D., and Lorusso, L.N. (2018) "How to Write a Systematic Review of the Literature", *Health Environments Research and Design Journal*, 11(1), p15-30

Paulk, M. C., Curtis, B., Chrissis, M. B. and Weber, C. V (1993) 'Capability Maturity Model for Software , Version 1 . 1', *Carnegie Melon University*, p. 82.

Payne, T. and Peters, M. J. (2004) 'What Is the Right Supply Chain For Your Products?', *The International Journal of Logistics Management*, 15(2), pp. 77–92. doi: 10.1108/09574090410700310.

Payne, T (2010). Aligning AMR's DDVN and Garner's Chaos Tolerant Supply Chain Maturity Frameworks. Gartner.

Pérez-arroyave, H. D. and Rodríguez-ramírez, L. A. (2013) 'Supply chain strategies: Which one hits the mark. CSCMP's Supply Chain Quarterly, 2013(1), 30', *Supply Chain Quarterly Review*, 30(1).

Petticrew, Mark, Roberts and Helen (2006) 'Systematic Reviews in the Social Sciences: A Practical Guide'. Washington, Blackwell Publishing.

Pillay, J. (2015) *Development of a warehouse management maturity model framework for use by third party logistics service providers in south africa*. Masters thesis, Stellenbosch University, Stellenbosch.

Pöppelbuß, J. and Röglinger, M. (2011) 'What makes a useful maturity model? A framework of general design principles for maturity models and its demonstration in business process management', *Ecis (p*28). Available at: http://aisel.aisnet.org/ecis2011/28/.

Priem, R.L. and Swink, M., 2012. A demand-side perspective on supply chain management. *Journal of Supply Chain Management*, *48*(2), pp.7-13.

Privett, N. and Gonsalvez, D. (2014) 'The top ten global health supply chain issues: Perspectives from the field', *Operations Research for Health Care*, 3(1), pp. 226–230.

Ptak, C. and Smith, C. (2011) 'Lean and Demand Driven MRP: Lean Finds a Friend in Demand Driven MRP. (Online). Available at https://www.semanticscholar.org/paper/Topic%3A-Lean-and-Demand-Driven-MRP-Lean-Finds-a-in/b3b3cd56f66bc86cff8812378bb47b67a064549b. Accessed on 27 February 2019.

Ptak, C. and Smith, C. (2019) *Demand Driven Material Requirement Planning*. (Online). Available at: https://www.demanddriveninstitute.com/ddmrp (Accessed: 27 February 2019).

Purchase, C (2016), The 2016 Supply Chain Top 25: Lessons from Leaders, (Online). Available: https://www.mmh.com/article/the_2016_supply_chain_top_25_lessons_from_leaders. Accessed on 5 January 2020.

Rahman, S. (2012) 'The Theory of Constraints: A Management Philosophy', *The Theory of Constraints*. 1st Editi. RMIT University, Australia, pp. 136–138. doi: 10.4018/978-1-60960-768-5.ch009.

Rainbird, M. (2004a) 'Demand and supply chains : the value catalyst', *International Journal of Physical Distribution & Logistics Management*, 34(4), pp. 230–250. doi: 10.1108/09600030410533565.

Ravikumar, K_, Saroop A, Narahari,H.K, Dayama, P (2005). Demand sensing in e-busines. Sadhana 30 (2),pg 311-345

Rexhausen, D., Pibernik, R. and Kaiser, G. (2012) 'Customer-facing supply chain practices - The impact of demand and distribution management on supply chain success', *Journal of Operations Management*., 30(4), pp. 269–281. doi: 10.1016/j.jom.2012.02.001.

Reyes, H. G. and Giachetti, R. (2010) 'Using experts to develop a supply chain maturity model in Mexico', *Supply Chain Management: An International Journal*, 15(6), pp. 415–424. doi: 10.1108/13598541011080400.

Ridwan, M. and Norzamani, M. (2014) 'Best Practices in Healthcare Supply Chain Management to Improve the Performance of Healthcare Services', pp. 2–8.(Online). Available at: https://www.academia.edu/11622662/Best_Practices_in_Healthcare_Supply_Chain_Management_to_Improve_the_Performance_of_Healthcare_Services,.Accessed on: 3 March 2017.

Rosemann, M. and Bruin, T. De (2005) 'Towards a Business Process Mangement Maturity Model', in *ECIS 2005 Proceedings of the Thirteenth European Conference on Information Systems*, pp. 26–28. doi: 10.1109/EUROMICRO.2007.35.

Sahay, B. S. (2003) 'Supply chain collaboration: the key to value creation', *Work Study*, 52(3), pp. 76–83. doi: 10.1108/00438020310462872.

Santos, J. B. and D'Antone, S. (2014) 'Reinventing the wheel? A critical view of demand-chain management', *Industrial Marketing Management*., 43(6), pp. 1012–1025. doi: 10.1016/j.indmarman.2014.05.014.

Sarley, D., Mahmud, M., Idris, J., Osunkiyesi, M., Dibosa-osadolor, O., Okebukola, P. and Wiwa, O. (2017) 'Transforming vaccines supply chains in Nigeria', *Vaccine*. 35(17), pp. 2167–2174. doi: 10.1016/j.vaccine.2016.11.068.

Saunders, M., Lewis, P. and Thornhill, A. (2007) *Research Methods for business students*. Fourth Edition. London: Prentice Hall.

SAS (2018). Demand shaping: Achieving and maintaining optimal supply and demand alignment (online). Available: https://www.sas.com/content/dam/SAS/en_us/doc/whitepaper1/demand-shaping-107018.pdf. Accessed 11 January 2020.

Saunders, M., Lewis, P. and Thornhill, A. (2012) *Research methods for business students*. 6th edition. Pearson Education.

Seethamraju, R. (2014) 'Enterprise systems and demand chain management: A cross-sectional field study', *Information Technology and Management*, 15(3), pp. 151–161. doi: 10.1007/s10799-014-0178-0.

Selen, W. and Soliman, F. (2002) 'Operations in today ' s demand chain management framework', *Journal of Operations Management*, 20(6), pp. 667–673. doi: 10.1016/S0272-6963(02)00032-3.

Serbout, M. A., Berrado, A. and Benabbou, L. (2016) 'Pharmaceutical Products Supply Chain', in *Logistics Operations Management (GOL), 3rd International Conference on. IEEE*, pp. 1–6.

Srai, J. S. and Gregory, M. (2008) 'A supply network configuration perspective on international supply chain development', *International Journal of Operations & Production Management*, 28(5), pp. 386–411. doi: 10.1108/01443570810867178.

Stadtler, H. (2005) 'Supply chain management and advanced planning — basics , overview and challenges', *European Journal of Operational Research*, 163(1), pp. 575–588. doi: 10.1016/j.ejor.2004.03.001.

Steenbergen, M. Van (2011) Maturity and Effectiveness of Enterprise Architecture. PhD thesis, Utrecht University.

Stevens, G. C. (1989) 'Integrating the Supply Chain', *International Journal of Physical Distribution & Materials Management*, 19(8), pp. 3–8. doi: 10.1108/EUM0000000000329.

Stewart, G. (1997) 'Supply-chain operations reference model (SCOR): the first cross-industry framework for integrated supply-chain management', *Logistics Information Management*, 10(2), pp. 62–67. doi: 10.1108/09576059710815716.

Stonich, M. and Moncrieff, B. (2001) 'Supply - chain practice maturity model and performance assessment. ' *Recuperado el*, 6 (5).

Strauss, A. and Corbin, J. (1994) 'Grounded theory methodology', *Handbook of qualitative research*, pp. 273–285. Sage. doi: 10.1007/BF00988593.

Taylor, D. H. (2005) 'Value chain analysis : an approach to supply chain improvement in agri-food chains', *International Journal of Physical Distribution & Logistics Management*, 35(10), pp. 744–761. doi: 10.1108/09600030510634599.

Thierry, C., Bel, G. and Thomas, A. (2010) 'The Role of Modeling and Simulation in Supply Chain Management', *SCS M&S Magazine*, 4(1), pp. 1–8.

Toba, S., Tomasini, M. and Yang, Y. H. (2008b) 'Supply Chain Management in Hospital : A Case Study', *California Journal of Operations Management*, 6(1), pp. 49–55. Available at: http://www.csupom.org/publications/2008/08-7.pdf.

Du Toit, D. and Vlok, P. J. (2014) 'Supply chain management: A framework of understating', *South African Journal of Industrial Engineering*, 25(3), pp. 25–38. doi: 10.1007/s13398-014-0173-7.2.

Tongco, M. D. C. (2007) 'Purposive Sampling as a Tool for Informant Selection. *A Journal for Plant, People and Applied Research, Ethnobotany Research and applications*, 5, pp. 147–158. doi: 10.17348/era.5.0.147-158.

ToolsGroup (2015). Demand sensing: The changing landscapeof forecasting (online). Available: http://www.aricia.ltd.uk/Temp/150430_Demand_Sensing_Final.pdf. Accessed on 11 January 2020.

Treville, S., Shapiro, R. D. and Hameri, A. P. (2004) 'From supply chain to demand chain: The role of lead time reduction in improving demand chain performance', *Journal of Operations Management*, 21(6), pp. 613–627. doi: 10.1016/j.jom.2003.10.001.

Tsiakis, P (2014). Powering the new supply chain: Demand sensing for small and medium-sized businesses (online).Available: https://docplayer.net/15687966-Powering-the-new-supply-chain-demand-sensing-for-small-and-medium-sized-businesses.html. Accessed 11 January 2020.

Ulrich, W. and Kuehn, W. (2015) 'Business architecture : setting the record business architecture : setting the record', *Business and Dynamic Change*, 2(1), pp. 1–19.

USAID (2010) 'Reengineering Public Health Supply Chains for Improved Performance Guide for Applying Supply Chain Segmentation Framework', USA, USAID.

USAID (2011) 'Supply Chain Evolution: Introduction to a Framework for Supply Chain Strengthening of a Developing Country Public Health Programs, Deliver project, Task order 4.' (Online). Available at: http://deliver.jsi.com/dhome/search?p_search_tok=Supply Chain Evolution Introduction to a Framework for Supply Chain Strengthening of Developing Country Public Health Programs & btn Gsearch. Accessed on: 5 May 2017.

Vaidyanathan, K. and Howell, G. (2007) 'Construction Supply Chain Maturity Model - Conceptual Framework', in *15th Annual Conference of the International Group for Lean Construction*, pp. 170–180. Available at: http://www.iglc.net/papers/details/469.

Vargas Bustamante, A. and Shimoga, S. V (2017) 'Comparing the Income Elasticity of Health Spending in Middle-Income and High-Income Countries: The Role of Financial Protection', *Kerman University of Medical Sciences*, 7(73), pp. 255–263. doi: 10.15171/ijhpm.2017.83.

Verdouw, C. N., Beulens, A. J. M., Trienekens, J. H. and Van Der Vorst, J. G. A. J. (2011) 'A framework for modelling business processes in demand-driven supply chains', *Production Planning and Control*, 22(4), pp. 365–388. doi: 10.1080/09537287.2010.486384.

Vollmann, T. E., Cordon, C. and Heikkila, J. (2000) 'Teaching supply chain management to business executives', *Production and Operations Management*, 9(1), pp. 81–90.

Vos, A., Strydom, H. and Delport, C. (2012) *Research at Grass Roots*. 4th Edition. South Africa, Van Schaik Publishers.

Walters, D. (2006) 'Effectiveness and efficiency: the role of demand chain management', *The International Journal of Logistics Management*, 17(1), pp. 75–94. doi: 10.1108/09574090610663446.

Walters, D. and Rainbird, M. (2004) 'The demand chain as an integral component of the value chain', *Journal of Consumer Marketing*, 21(7), pp. 465–475. doi: 10.1108/07363760410568680.

Wei, H. L. and Wang, E. T. G. (2007) 'Creating strategic value from supply chain visibility- The dynamic capabilities view', in *Proceedings of the Annual Hawaii International Conference on System Sciences*, Hawaii, United States of America. pp. 1–10. doi: 10.1109/HICSS.2007.157.

Wilson, J. (2010) *Essentials of Business Research: A guide to doing your research project*. Sage Publications.

World Bank (2016) *Death rate, crude (per 1,000 people) | (Online)* Available at: http://data.worldbank.org/indicator/sp.dyn.cdrt.in?end=2014&start=1960 (Accessed: 10 August 2019).

World Health Organisation (2018) *Global Tuberculosis*.(Online).Available at https://www.who.int/tb/publications/global_report/en/.Accessed on: 6 June 2018.

World Health Organisation (2018) Sustainable Development Goals. (Online). Available at: http://www.who.int/sdg/en/ (Accessed: 6 June 2018).

Wu, Y., Gao, J. J. and Yu, L. R. (2009) 'Demand Chain Management — the New Source of Profit Increase', in *16th International Conference on Industrial Engineering and Engineering Management*, pp. 1483–1487.

Yadav, P. (2015) 'Health Product Supply Chains in Developing Countries: Diagnosis of the Root Causes of Underperformance and an Agenda for Reform', *Health Systems & Reform*, 1(2), pp. 142–154. doi: 10.4161/23288604.2014.968005.

Yadav, P. ; Glassman. A (2019): Harnessing the power of private distribution channels for Universal Health Coverage. Available: www.cgdev.org. Accessed on 8 January 2020.

Yin, R. (2009) Case study research: Design and methods, Case Study Research: Design and Methods. Washington, Sage. doi: 10.1016/S0022-3913(12)00047-9.

Yu-Chun, P., Tang, Y. and Gulliver, S. (2013) Mutual dependency grid for stakeholder mapping: a component-based approach to supply chain participant analysis. Unpublished paper, pp 72-81.

Zhang, N., He, W. and Lee, E. W. (2008) 'Address supply chain visibility from knowledge management perspective', in *IEEE International Conference on Industrial Informatics (INDIN)*. Daejeon, Korea, pp. 865–870. doi: 10.1109/INDIN.2008.4618222.

Zhou, H. and Benton, W. C. (2007) 'Supply chain practice and information sharing', *Journal of Operations Management*, 25(6), pp. 1348–1365. doi: 10.1016/j.jom.2007.01.009.

Zipline, (2019): LifeSaving Deliveries by Drone (online). Available on: https://flyzipline.com/. Accessed on 8 January 2020.

Appendices:

Appendix 1: Ethical considerations

Ethics clearance to conduct the study was obtained from both the Stellenbosch University Research Ethics Committee and the DoH ethics committee.

Western Cape Government
Health

HEALTH IMPACT ASSESSMENT
HEALTH RESEARCH SUB-DIRECTORATE
Health.Research@westerncape.gov.za
tel: +27 21 483 0866: fax: +27 21 483 9895
5th Floor, Norton Rose House,, 8 Riebeek Street, Cape Town, 8001
www.capegateway.gov.za)

REFERENCE: WC_201902_018
ENQUIRIES: Dr Sabela Petros

Stellenbosch University

Private Bag X1

Matieland

7602

For attention: Mr Munyaradzi Bvuchete, Prof Sara Grobbelaar

Re: **A maturity model for demand driven supply chain management in public healthcare sector**

Thank you for submitting your proposal to undertake the above-mentioned study. We are pleased to inform you that the department has granted you approval for your research.

Please contact **Dr Richard Davids on 021 808 6173** to assist you with any further enquiries in accessing the following sites:

Idas Valley Clinic

Kayamandi Clinic

Stellenbosch Hospital

Kindly ensure that the following are adhered to:

1. Arrangements can be made with managers, providing that normal activities at requested facilities are not interrupted.
2. By being granted access to provincial health facilities, you are expressing consent to provide the department with an electronic copy of the final feedback (**annexure 9**) within six months of completion of your project. This can be submitted to the provincial Research Co-ordinator (Health.Research@westerncape.gov.za).

Figure 1: Ethical clearance

Appendix 2: Maturity model ranking interview guideline

The second phase of validation of the DDSCM model involved semi-structured interviews with experts working in healthcare supply chains. Table 1 outlines the questions that were asked to subject matter experts. Experts were supposed to rank the importance of the concepts as related to the public healthcare supply chain. This enabled the test for reliability and usefulness of the maturity model in the healthcare supply chain context.

Table 1 : Interview Protocol Guide for maturity ranking interviews

QUESTIONS	**1 – Strongly Disagree**	**2 - Disagree**	**3 - Neutral**	**4 - Agree**	**5 – Strongly Agree**
1. Demand planning, supply planning, distribution planning, warehouse management, expiry management, order management, warehouse automation, transport flexibility, cross docking and deliveries is important in healthcare supply chains					
2. Demand visibility, inventory visibility, data accessibility, data accuracy, data timeliness, data relevance, process visibility, order visibility is important in healthcare supply chains					
3. IT architecture, systems interoperability, data capturing, data storage and analysis and data reporting is important in healthcare supply chains					
4. Supply chain relationships & partnerships, resource sharing, collaborative decision making, trust and mutual interdependence, joint knowledge creation & sharing, joint collaborative planning, organisational design, goal congruency, systems and structures is important in healthcare supply chains					
5. Human resources skills , training, clear roles, innovation, incentives, working environment, culture and behaviour, policies and plans is important in healthcare supply chains					
6. Cost management, alignment of objectives, strategic inventory positioning, streamlined processes, segmentation, product classification, management support and organisation vision is important in healthcare supply chain					
7. Reliability & Sustainability, responsiveness & speed of response, agility & service, supply chain cost, product availability & standards, inventory turns, working capital, customer satisfaction is important in healthcare supply chains					

Appendix 3: Papers used in the systematic literature review

The extraction of the dataset that was used for a systematic literature review is shown in the Table 2 below. The following search terms were used to search for journal articles, conference papers and reports in the databases such as Scopus, Web of Science and Science Direct.

- ((demand driven) AND (supply chain) AND ((visibility) OR (information sharing)))
- ((customer driven) AND (supply chain) AND ((visibility) OR (information sharing)))
- ((pull) AND (supply chain) AND ((visibility) OR (information sharing)))

Papers were screened based on relevance of title and abstract, language and accessibility of the paper.

Table 2: Papers used in the systematic literature review

Paper ID	Authors	Title	Methodology	Field of research	Type of publication
1	(Bjartnes et al., 2008)	Intelligent and demand driven manufacturing network control concepts	-Case study, Literature review	Food industry	Conference proceedings
2	Dreyer et al., (2009)	Principles for Real-Time, Integrated Supply Chain Control: An Example from Distribution of Pharmaceuticals	-Case study, literature review	Pharmaceuticals	Conference proceedings
3	Christopher et al., (2001)	An integrated model for the design of agile supply chains	Literature review	Manufacturing	International Journal of Physical Distribution & Logistics Management
4	Black et al., (2001)	A Demand Driven Freight Transport System for the Supply Chain	Case study, literature review	Transport	Conference proceedings
5	Croxton et al., (2001)	The demand management process	Literature review	Not specified	The International Journal of Logistics Management
6	Verdouwa et al., (2010)	Process modelling in demand-driven supply chains: A reference model for the fruit industry	Simulation	Fruit Industry	Journal of Computers and Electronics in Agriculture
7	Cao et al., (2017)	A study of the bullwhip effect in supply- and demand-driven supply	Simulation	Manufacturing	Journal of Industrial and Production Engineering
8	Juttner et al., (2006)	Demand chain alignment competence :delivering value through product life cycle management	Conceptual & case study	Marketing	Journal of Industrial Marketing Management
9	Juttner et al., (2007)	Demand chain management-integrating marketing and supply chain management	Conceptual & case study	Marketing	Journal of Industrial and Marketing Management
10	Frohlich et al., (2002)	Demand chain management in manufacturing and services: web-based integration, drivers and performance	Survey	Manufacturing	Journal of operations management
11	Hilletofth (2011)	Demand-supply chain management: industrial survival recipe for new decade	Conceptual & Case study	Manufacturing	Industrial Management & Data Systems
12	Agrawal (2012)	Demand Chain Management: Factors Enhancing Market Responsiveness Capabilities	Survey & Conceptual	Manufacturing	Journal of Marketing Channels
13	Hadaya et al.,(2007)	The role of joint collaboration planning actions in a demand-driven supply chain	Survey	Manufacturing	Industrial management and data systems

Paper ID	Authors	Title	Methodology	Field of research	Type of publication
14	Wu et al., (2009)	Demand Chain Management :the New Source of Profit Increase	Conceptual	Not specified	Conference proceedings
15	Goor (2001)	Demand & Supply Chain Management: a Logistical challenge	Conceptual & case study	Not specified	Conference proceedings
16	Korhonen, Huttunen and Eloranta, (1998)	Demand chain management in a global enterprise information management view	Conceptual	Not specified	Production Planning and Control
17	Heikkilä (2002)	From supply to demand chain management: efficiency and customer satisfaction	Case study	Telecommunications	Journal of operations management
18	Jacobs (2006)	The promise of demand chain management in fashion	Conceptual	Fashion Industry	Journal of Fashion Marketing and Management
19	Santos et al (2014)	Reinventing the wheel? A critical view of demand-chain management	Conceptual	Not specified	Industrial Marketing Management
20	Seethamraju (2014)	Enterprise systems and demand chain management: a cross-sectional field study	Cross-sectional qualitative field study	Not specified	Information Technology and Management
21	Mbhele (2016)	Decoupling paradigm of push-pull theory of oscillation in the FMCG industry	Survey	Manufacturing	South African Journal of Business Management
22	Selen and Soliman (2002)	Operations in today ' s demand chain management framework	Conceptual	Not specified	Journal of Operations Management
23	Esper et al.(2010)	Demand and supply integration: a conceptual framework of value creation through knowledge management	Conceptual	Not specified	Journal of the Academy of Marketing Science
24	Treville, Shapiro and Hameri (2004)	From supply chain to demand chain: the role of lead time reduction in improving demand chain performance	Conceptual	Manufacturing	Journal of operations management
25	Mendes, Leal and Thome (2016)	A maturity model for demand-driven supply chains in the consumer product goods industry	Case study	Manufacturing	International Journal of Production Economics
26	Canever, Trijp and Beers (2008)	The emergent demand chain management: key features and illustration from the beef business	Case study	Beef Industry	International journal in supply chain management
27	Walters (2006)	Effectiveness and efficiency: the role of demand chain management	Conceptual	Fashion	The International Journal of Logistics Management
28	Lapide (2006)	Demand Management Revisited	Conceptual	Not specified	The Journal of Business Forecasting
29	Hilletofth, Ericsson and Christopher (2009)	Demand chain management: a Swedish industrial case study	Case study	Manufacturing	Industrial Management & Data Systems

Paper ID	Authors	Title	Methodology	Field of research	Type of publication
30	Haavik (2000)	Building a Demand driven, Vendor-Managed Supply Chain	Case study	Not specified	Healthcare Financial Management
31	Rainbird (2004)	Demand and supply chains: the value catalyst	Conceptual	Not specified	International Journal of Physical Distribution & Logistics Management
32	Hull (2005)	Are supply (driven) chains forgotten?	Conceptual	Not specified	The International Journal of Logistics Management
32	Bonney et al. (1999)	Are push and pull systems really so different?	Conceptual	Manufacturing	International Journal of Production Economics
34	Hopp and Spearman (2004)	To Pull or Not to Pull: What Is the Question?	Conceptual	Manufacturing	Manufacturing & Service Operations Management
35	Rexhausen, Pibernik and Kaiser (2012)	Customer-facing supply chain practices - The impact of demand and distribution management on supply chain success	In-depth interviews, Survey	Not specific	Journal of Operations Management
36	Verdouw et al.(2011)	A framework for modelling business processes in demand-driven supply chains	Simulation	Flowers industry	Production Planning and Control
37	Lebovitz and Graban (2001)	The journey toward demand driven manufacturing	Conceptual	Manufacturing	Conference proceedings
38	Ashayeri and Kampstra (2005)	Demand Driven Distribution: The Logistical challenges and opportunities	Case study	Flowers industry	Conference proceedings
39	O'Marah (2005)	It ' s all about the Customer	Conceptual	Manufacturing	Industrial Management
40	Budd, Knizek and Tevelson (2012)	The Demand-Driven Supply Chain: Making it work and delivering results	Not specified	Manufacturing	Report
41	Barrett (2007)	Demand-Driven is an Operational Strategy	Not specified	Manufacturing	Industrial Management
42	Jim Ayers (2006)	Demand-Driven Supply Chain Implementation	Not specified	Manufacturing	American Institute of Chemical Engineers
43	Ayers and Malmberg (2002)	Supply Chain Systems: Are You Ready?	Not specified	Manufacturing	Information Strategy: The Executive journal

Appendix 4: Evaluated supply chain maturity models

Comparative analysis of supply chain maturity models to extract common themes and components that can be synthesized in the DDSCM maturity model. The papers used for this analysis were searched using "*supply chain management" AND "maturity models*". The Table 3 below illustrates the concepts extracted from the supply chain maturity models and how they are classified under the seven key DDSCM dimensions.

Table 3: Supply Chain Concepts

References	Distribution Management	Visibility	Technology	Collaboration	Human Resources	Organisational alignment	Performance Management
Ho et al., (2016)	N/A	Information Sharing	N/A	Relationship Building Decision Synchronisation Goal Congruence Resource Sharing Collaborative Communication Joint knowledge Information system integration Rationalisation Formalisation Resource Investment Alignment	N/A	Managerial Support	Incentive Alignment
Fischer et al., (2016)	Logistics Flexibility	Information flow Inventory visibility Demand Visibility Planning information exchange Integration of internal and external information	IT system fully integrated along the SC	Long term development of partners	N/A	N/A	PM for planning, control and improvement
Mendes et al., (2016)	Warehouse Management Distribution	Product Tracking and Visibility	VMI CPFR	N/A	N/A	Senior Management Support	N/A
Reyes and Giachetti (2010)	Inventory management and control	Standardisation of data collection process	RFID	Integration, collaboration and development of suppliers	Training	Identifying customer needs	Defining Organisational KPI
	Implementing quality assurance in transportation and delivery system		Information systems and technology management processes	Policies to select and develop suppliers	Development of work culture	Attending the customers complains	Defining the periodicity of information analysis

References	Distribution Management	Visibility	Technology	Collaboration	Human Resources	Organisational alignment	Performance Management
	WMS			Defining collaborative strategies with suppliers	Actions to reduce employees turnover	Implementing projects to reduce the down times in the information systems	Communicating to employees the meaning of each KPI and how to calculate it
	Automated equipment			Contracts and Agreements	Development of rewarding strategies		Standardise the presentation of KPIs
Lahti et al., (2009)	Planning strategy	N/A	N/A	N/A	N/A	N/A	Overall chain metrics
	Demand planning						
	Supply Planning						
	Demand/Supply balancing and decision making						
	Warehouse management and delivery						
Ayers (2002)	JIT delivery	Inventory visibility		Partner system integration	Skills	Customer focused organisation	N/A
	N/A	Demand visibility	Web-based technology for information exchange	N/A	Discipline	Segment strategies	N/A
	Lead-time reduction	Data timeliness and accuracy					
Moncrieff and Stonich (2001)	Real time planning and decision making	Data sharing		Alignment of organisational objectives with partners objectives		Identify strategic partners	Define, monitor performance metrics

Appendix 5: Investigation on the relationships between DDSCM Dimensions

The DDSCM framework that was used to map the relationships between DDSCM dimensions relationships through a survey is shown in Figure 2.

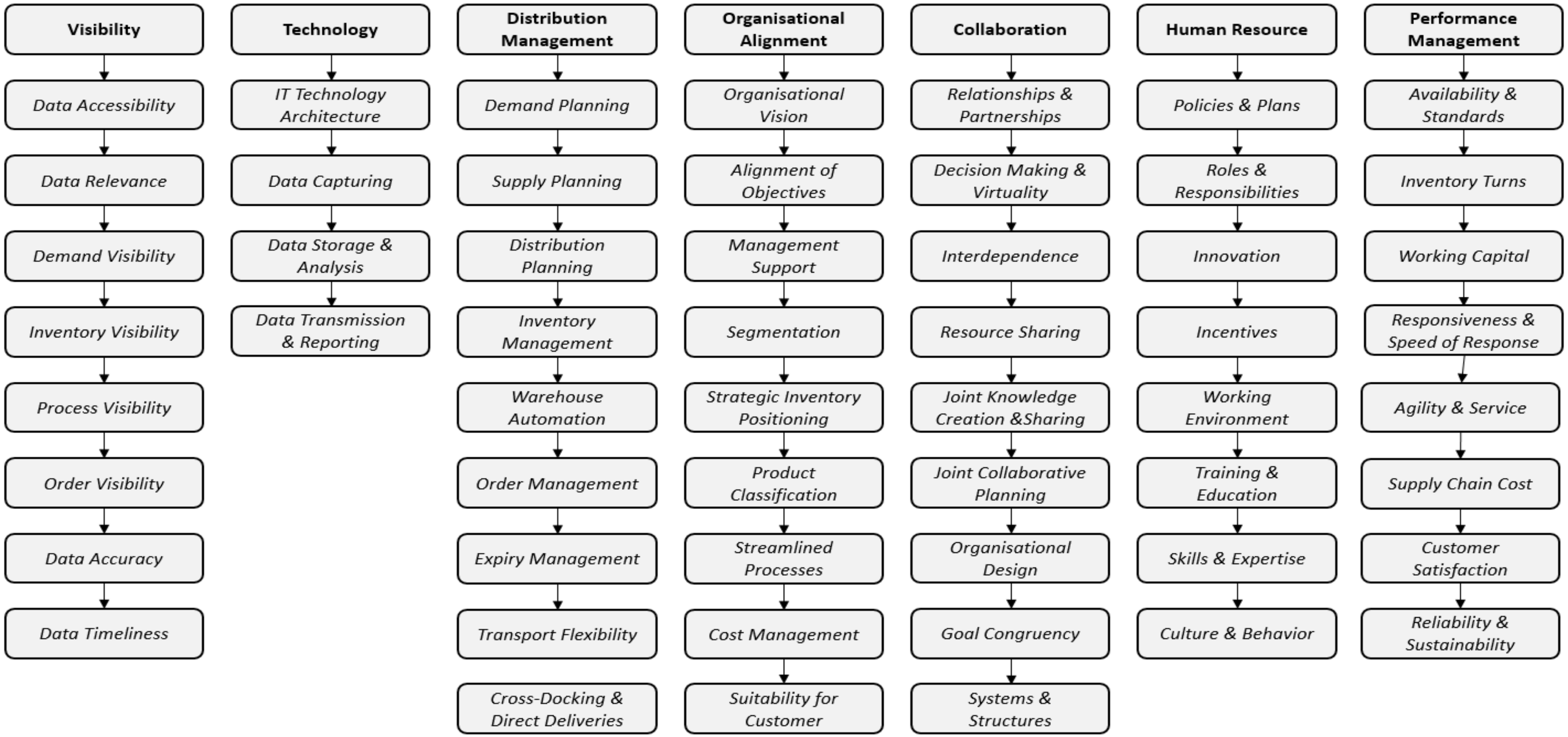


Figure 2: DDSCM Framework

Appendix 6: Survey Questions

Using the DDSCM Framework in Figure 2, Participants responded to the following Questions in Table 4.

Table 4: Survey questions for DDSCM Dimensions relationship mapping

Survey Question		To a greater extent	To a moderate extent	To some extent	To a smaller extent	Not at all	**Participants remarks**
		Number of responses					
Q1	To what extent does Technology enhance Supply Chain Visibility?	64	11	3	0	0	Technology is key to supply chain
Q2	To what extent does Supply Chain Visibility enhance Collaboration?	48	23	5	2	0	Engaging customers and suppliers in the supply chain increases visibility
Q3	To what extent does human resources enhance supply chain visibility?	19	21	24	11	3	
Q4	To what extent does Supply Chain Visibility enhance Distribution Management?	40	31	7	0	0	
Q5	To what extent does Supply Chain visibility enhance Performance Management?	35	30	13	0	0	Visibility across the entire supply chain improves performance
Q6	To what extent does Organisational Alignment influence Supply Chain Visibility?	22	24	29	3	0	
Q7	To what extent does Technology enhance Distribution Management?	45	26	7	0	0	4th industrial revolution technologies are the main link in the supply chain
Q8	To what extent does Human Resources influence Distribution Management?	16	28	24	8	2	
Q9	To what extent does Technology enhance collaborative activities?	32	28	13	4	1	Any technology development and utilisation must be in support of enhancing a collaborative environment between suppliers and customers
Q10	To what extent does Technology enhance Performance Management?	34	35	8	1	0	There is no doubt that latest technologies can support and improve supply chain performance
Q11	To what extent does Technology support Organisational Alignment?	16	31	24	7	0	
Q12	To what extent does Collaboration support Organisational Alignment?	31	31	13	3	0	
Q13	To what extent does Organisational Alignment support Distribution Management?	13	14	31	15	5	The supply chain is integrated and is controlled by multiple and linked methods and decision rules. These methods and decision rules influence the flow of products in the supply chain
Q14	To what extent does Organisational Alignment support Human Resources?	38	28	7	4	1	People are the most critical aspect of organisational alignment and associated business processes.

Q15	To what extent does Collaboration enhance Performance Management?	30	28	18	2	0	A collaborative environment between suppliers and customers facilitates organisational agility, responsiveness and competitiveness
Q16	To what extend do Human Resources influence Technology?	17	17	14	13	17	Technology can only serve that which the human resource intends to automate for process effectiveness and efficiency.
Q17	To what extent does Collaboration support Distribution Management?	10	25	12	14	17	Supply chain must have an effective flow of products from point of origin to the end user
Q18	To what extent do Collaboration influence Human Resources?	15	16	13	19	15	
Q19	To what extent does Distribution Management influence Performance Management?	19	8	18	15	18	
Q20	To what extent does Organisation Alignment enhance performance management?	19	12	15	14	18	
Q21	To what extent does Human Resources influence Performance Management?	24	18	10	12	14	

Appendix 7: Capabilities mapping

Table 5 shows the interview protocol used as a guideline in doing capabilities mapping at different supply chain nodes (clinics, hospitals, central medicines stores, manufacturing and distributors). This assist in matching DDSCM capabilities to supply chain nodes.

Table 5: Interview protocol (capabilities mapping)

Dimension	Capabilities	Interview Questions
Distribution management	Risk Management	How do you manage supply chain risk?
	Planning	Can you explain your demand planning, supply planning and distribution planning processes?
	Inventory Positioning	What influences the positioning of your decoupling points to serve markets effectively?
		Do you protect your inventory positions with buffer sizes and profiles that are dynamically adjustable based on Events and seasonality?
	Warehouse Operations	Give me an overview of your core warehouse processes and functions?
		Can you describe your inventory management process?
	Warehouse Visibility & Automation	What technologies do you use to improve warehouse operations and what are these technologies used for...i.e...Barcodes for inventory visibility?
	Order Management	How do you manage customer orders?
	Logistics and Transport Flexibility	Describe how you optimise and ensure transport and logistics to ensure that you meet customer needs?
	Expiry Management	How do you manage expired healthcare products?
Visibility	Information sharing & Information Quality	How do you ensure that you have access to information quality (accuracy, timeliness, transparency) and share relevant information with other supply chain partners?
	Demand and Inventory Visibility	Do you have access to downstream demand and inventory information in real-time?
	Order Visibility	How do you ensure that you have customer order visibility along the supply chain pipeline?
Technology	Information Technology Infrastructure	What technologies do you use to ensure supply chain visibility?

Dimension	Capabilities	Interview Questions
	Data Transmission and Reporting	What are the capabilities of these technologies?
	Data Capturing	Is data capturing and reporting on actual medicines consumptions and inventory status prioritised and shared and how is it captured?
Collaboration	Relationships	How do you build good relationships with supply chain partners?
	Interdependence and Resource Sharing	How do you collaborate with supply chain partners?
	Decision Making	Is decision making collaborative with other supply chain partners based on elements such as inventory and actual demand?
Performance Management	Key Performance Indicators	Do you have key performance indicators for inventory management, order fulfilment, stock management?
	Metrics	What metrics do you use to measure supply chain performance?
Human Resources	Policies and plans	Do you have policies and plans that you use when you do placement for human resources in inventory management/stock management?
	Clear roles & responsibilities	Are roles and responsibilities for the staff that work in stock management clearly defined?
	Innovation	How do you support innovation to solve supply chain problems?
	Incentives and working environment	Do you make use of incentives and rewarding strategies for good inventory management and accurate data collection?
	Training & Education	Is there training of staff dealing with inventory management and supply chain planning to enhance their skills and expertise?
Organisational Alignment	Management Support	What management support initiatives are in place for supply chain improvement?
	Organisational Vision	Does your organisation vision address customer orientation as a key element for supply chain success?
	Streamlined Processes	Do you have SOPs for all supply chain processes and functions?
	Alignment of Objectives	Are your organisational supply chain objectives aligned with other supply chain partner's objectives?
	Cost Management	Do you measure (quantify), track and report supply chain costs regarding stock management/inventory management?
	Product Classification	What basis do you use to categorise and classify healthcare products?
	Segmentation	What basis do you use to segment your customers?

Appendix 8: Capabilities mapping outcomes

Table 6 shows the capabilities for key supply chain nodes and outlines processes of achieving the capabilities from an organisational perspective (clinics, hospitals, central medicines stores, manufacturing and distributors).

Table 6: Capabilities mapping profiles

Capabilities	Clinics	Hospitals	Central Medicines Stores	Manufacturing	Distributors
Risk Management	•CMD sends reports on potential stock-out of products •Pre-emptively identifying risks then identifying and executing an approach to limit the likelihood and impact of the risk •Contingency plans for stock-outs include redistribution of products across the entire network of facilities in the sub-district (network reorganises)	•Stock-out risks due to no supply by CMD or Supplier are cushioned by safe keeping stock buffers for 2-6 weeks(depending on the size of the medication) •Contingency planning for product stock-outs include borrowing stock from nearby facilities	•Redistribution of inventory to other provinces •CMD develops and sends the "DUES" report highlighting stock availability and potential stock-out items to facilities then a follow up meeting with district managers •Taking into considering of space availability, the maximum and minimum stock kept is 3 months and 2 months depending on item type. (Ordering up to a level) •Apportionment of stock available at the deport to all facilities in need •Orders for facilities above observable previous patterns are cut • Stock buffering of 3 months of any of the 1299 lines	•Management of Risk via a monthly risk management process: •Identify, classify and quantify risk (risk teams assign probabilities to identified risks) •Mitigation and risk-acceptance is in place for risks that cannot be fixed •Risk management framework focusing on risk acceptance aligned with the impacted/affected stakeholders	X
Demand Planning	X	X	X	•Demand forecasting •Demand influencers, historical demand affect demand forecast	X
Supply Planning	X	X	•Replenishment based on actual orders from downstream • Printing purchase orders (PAs) once a week and the MEDSAS advices what to order (quantities)	•Supply planning takes the agreed demand forecast and converts it into a weekly supply plan (horizon is 0-36 months) : taking into account the Net requirements, required inventory policies and demonstrated capacity	X
Distribution Planning	X	X	•Schedules created based on orders from demanders	X	X

Capabilities	Clinics	Hospitals	Central Medicines Stores	Manufacturing	Distributors
Warehouse Operations (Inventory management)	•Inventory accuracy > 90% based on actual and validated data •Cycle counting •5S & house keeping	•Stock maintenance (issuing stock, and replenishment of stock) •Stock take / spot check •Cycle counting •Stock take (inventory accuracy to ensure that there is a tally between what is in the system and what is on the shelf) • layout designed in a way that segment, fast moving items from slow moving items from ARVs •5S & house keeping	•**Day 0:**Print date (Analysing what has been ordered by the facilities by importing orders from the RDM system) •**Day 1:** Pick, pack and check quality and quantity products •**Day 2**: Cut-off for dispatch and handover to 3PL) •**Day 3**: delivery day by 3PL to facilities and liability transfer to 3PL •Proof of deliveries signed and returned to warehouse •Service level agreements with distributors clearly defined in the contract •Cycle counting and stock take •5S in place (dedicated places for all stock and use of racking structures)	•Warehouse operations are outsourced to 3PL with whom we sign a KPI driven contract •Replenishment to a pre-determined stock level	X
Warehouse Visibility & Automation	•60% of the inventory locatable via the inventory system	• Product visibility in the storehouse is ensured by writing the name of product item on the boxes •The inventory locatable via the inventory system	•Warehouse management system MEDSAS •Inventory Control Number •Use of stock cards when issuing stock •No bin location used, (printed pictures of items and descriptions used to identify the type of product in the warehouse)	•Barcoding, scanning, and formal WMS used •Picking is done manually	X
Order Management	•Orders created based on actual demand and predicted demand •JAC system gives an update on what demand was using a 6 month average , the system generates a prepopulated order that is then reviewed before release	•Frequency of ordering products at CMD is once a week and the lead-time gap is 5 days •Frequency of ward ordering is twice a week based on actual consumption •SOPs in place for actual ordering •Based on the past consumption and usage, the CMD does not allow you to order more (the restriction has been placed in the JAC system)	•Allocated order print date and fulfilment of orders based on SOPs for fulfilment •Systems used to recommend orders based on past consumption and max/min levels taking into consideration type of item, space available, usage, short dated stock/normal, cold chain (8-12 weeks)	•Order processing by 3PL/LSP •Customer orders are taken via email, telephone & EDI by a 3PL call centre •This is then passed onto the distribution centre for fulfilment	X
Logistics and Transport Flexibility	X	• Only go to collect from the CMD if it's an emergency order	Delivery liability transferred to the 3PL on handover (third day)	•Use 3PL (use multiple principle loads OR single drop-points.	•Actual consolidation of PODs

Capabilities	Clinics	Hospitals	Central Medicines Stores	Manufacturing	Distributors
				Loads are either delivered to stores or customer distribution centers	
Expiry Management	•Tracking of expiry products risk weekly and monthly •KPIs in place to measure expired products	•Medicines nearing their expiry dates are either exchanged with other health facilities that are willing to buy or switch with another product • The JAC system does not capture expiry dates of medicines, the personnel check manually mainly during stock takes	•SOPs in place for expired medicines management •A dedicated quarantine room and cages for expired stock •No returns policy (only allowed if its short dated stock) Stock within the 6 month stock expiry range not sent to facilities •FEFO,FIFO,LIFO (stock rotation)	•Stock is incinerated by a certified company	X
Information sharing & Information Quality	•Upstream visibility only achievable through reports send by CMD on what's is available, the current threats, and future threats and this guides how the orders will be placed •CMD can't see the products in the shelf of the facility	•Information sharing with CMD on orders and CMD shares information to facilities on potential stock-out of a particular products	•No upstream visibility but information available to track the 3PL •Reports visibility, ("dues report", operations report, facilities ordering patterns) •Purchase Advices send to manufacturers once a week and then manufacturer delivers on order •Through the help desk, the depot can notify the facilities (demanders) when order fulfilment will be late	•Various ERP systems interface between LSP, manufacturer, and in some cases back to the customers	X
Demand and Inventory Visibility	•Consumption of stock by patients collecting medicines at dispensing points	•Stock issued to different wards based on consumption (demand) •Consumption of stock at wards (ward stock usage Manual reports)	•Ability to see downstream on what inventory sits at facilities and no visibility of supplier inventory levels • Visibility of inventory at the depot send to facilities every week • Give suppliers outstanding orders report every week • Share consumption/usage data with the NDoH for future tendering purposes	•No access to downstream demand information •Demand is forecasted (predicted demand) based on previous consumptions and replenished periodically	X
Order Visibility	•JAC system is live and allows order status and tracking and visibility	•Order tracking - checking what is own order and visibility of previous orders •Captures incomplete orders	•Visibility to orders placed by facilities •Orders send via email and fax to manufacturer	•Customer orders processed near real time as orders are being captured and stock is being allocated	X

Capabilities	Clinics	Hospitals	Central Medicines Stores	Manufacturing	Distributors
Information Technology Infrastructure	•JAC pharmacy system for dispensing and inventory control connected to all facilities in the district supply network	•A JAC stock control and dispensing platform for western cape region used to place orders, generates automatic orders based on usage and consumption (if a product item falls under set minimum, the JAC automatically generates an order) and responsible personnel authorises only • Predictive analytics of JAC using weighting based on past months consumption (suggest the amount that you need to order) •JAC is connected to all other hospitals in the region and the stock manager is able to check the status of inventory of other hospitals) •Analysis capability of consumption trends	•Electronic ordering system •Inventory management system MEDSAS • WINRDM	•Combination of analytics reports by external companies (reports visibility •Internal standard reports and user developed in house tools(excel and power BI based)	X
Data Transmission and Reporting	• Multiple software platforms used, Facility uses JAC and RDM is used by CMD •There is an interface created that links JAC and RDM	•Use an RDM platform to convert a JAC file into RDM file that can be viewed and seen by the CMD (CMD can't see a JAC files , the systems are not connected)	•Reports sent via email and fax	•Ability to login into distributor system and check order status (3pls,lsp)	X
Data Capturing	•Data captured manually (no stock visibility solution used)	•Data is captured manually	•Stock cards used to capture data when issuing stock •Orders captured in MEDSAS	•Aggregated consumption data	X
Relationships	•Transactional relationship with the CMD (Ordering and receiving stock)	•Helpline available that links the hospital with the central medicines store in case of queries •Communication between the hospital and the CMD is only when an order is not delivered that is not on the "out of stock list"	•Collaboration through communication with 3PLs (working relationship) •Notification by 3PL when they can't deliver or when delayed due to disruptions such as strikes, robberies • Information exchange and communication • Meetings with suppliers sales reps to discuss outstanding orders	• Use of contracts that define scope and agreements for business partners. •Important to have formal SLAs shared and aligned •KPIs shared and aligned •Close relationship with supply chain partner(3pl), manufacturer can go into the system of the supply chain partner and check what orders are placed, who are the customers and what are the value of the products	X

Capabilities	Clinics	Hospitals	Central Medicines Stores	Manufacturing	Distributors
			• Skills development committee collaborating with HR on training needs • Collaborating with other depots and tertiary hospitals		
Decision Making	•Decision making is collaborative	•Collaborative decision making	•Communications with other department for instance between operation and procurement (Provisional advices highlighting how much should be ordered considering the space available at operations (warehouse)) •Collaboration in teams	•Collaborative Decision making (need to factor in available space before having seasonal stock-build)	X
Key Performance Indicators	•KPIs aligned and shared with supply chain partners				
Metrics	X	X	•Annual performance plan measuring (1) Finalisation (order cycle time - benchmark 80%), (2) service delivery measured by order fulfilment of the right quality and quantity to facilities (Measured by the number of help-desk calls/reports from facilities) (3) Stock availability (benchmark of 97%)	•Internal and external fulfilment (reliability) •Forecast accuracy Inventory value •End to end costs	X
Policies and plans	• Workforce plans reviewed bi-annually •insufficient staffing •limited financial resources		X	X	X
Innovation	•Innovation in the context of the legislative space •Pharmacist roles assumed to have the capability of supply chain roles	•Innovation - randomly performing cycle counting on a location in the stores and check expired for expired stock	•Collaborative problem solving and consultation • Inputs to improve operations from staff through workshops	X	X
Incentives and working environment			• Performance based incentives (financial) • Appraisals on good performance (acknowledgements through emails)		

Capabilities	Clinics	Hospitals	Central Medicines Stores	Manufacturing	Distributors
Training & Education	X	X	•Skills development committee develop training framework and coordinate training (ordering, issuing and training on warehouse operations) •Training and workshops help once every 6 months •Mentoring of staff by qualified staff •Identification of staff that need skills and development by mentoring staff •Existence of staff performance plans and individual improvement plans	X	X
Streamlined Processes	•SOPs clearly defined	•SOPs for stock management	SOPs in place	•SOPS cleared defined	
Cost Management	•Month budget tracking tools •Financial statement to measure supply chain costs	Variance analysis (checking if cost falls within budget)	•Monitoring of budget, what is ordered, and writing off of stock (Quarterly review), receiving stock within usable dates, no overstocking, cutting off facilities that are over-ordering •Visibility of cost valuable on a higher level for cost control •Control cost through managing the quantity that is ordered, the amount of stock that is written off, minimizing over-stocking, and controlling demanders (facilities) ordering patterns	•Supply chain cost measurement, tracking and reporting (yes, very robustly (both Profit and loss and balance sheet)	X
Inventory positioning	X	X		Strategic decoupling points	

Capabilities	Clinics	Hospitals	Central Medicines Stores	Manufacturing	Distributors
Product classification	X	•Normal product items (paracetamol, ARVs...etc.) •Cold chain products (vaccines and eye drops for the eye clinic) •DDB orders (products that are not kept by the CMD, the CMD place the order with the supplier and the supplier directly delivers to the hospital – lead-time of 1/2 month)	X	• ABC analysis (categorisation of products by margin/sales) •Classification of product in terms of types (brands) With respect to distribution (to determine distribution) •Value (high, medium, low) •Volume (high, medium, low) •Variety (Over The Counter (OTC) & behind the counter for medical products) •Lead-time •Duration life cycle •Variability (stable and variable demand)	X
Segmentation	X	X	X	Customer Segmentation •Profitability •Net sales •Strategic alignment • Geographic location and demand profile	X

Appendix 9: DDSCM Network Mapping Tool (Assessment tool)

To test the applicability and validity of the network-maturity mapping tool, the guideline below is utilised.

Key

Extent of utilising a Capability			Effort required to achieve capability			Impact of a Capability	
0	not at all		1	No effort		1	No impact
1	to a smaller extent		2	Some effort		2	Some impact
2	to some extent		3	Moderate effort		3	Moderate impact
3	to a moderate extent		4	Most effort		4	Most impact
4	To a larger extent		5	Extremely more effort		5	Extremely largest impact

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Risk Management***	•Supply chain risk assessment mechanism in place			
		•Potential supply chain risks identified			
		•Risk Analysis (weight factors applied to identified risks)			
		•Contingency plans to mitigate supply chain risks and supply chain disruptions in place			
		•Dedicated supply chain systems and Predictive analytics tools utilised to timely identify & monitor & mitigate supply chain risk & contingency plans			
Manufacturing **Central Medicines Stores** **NDoH**	***Distribution Planning***	•Location of facilities is documented • Synchronisation: Visibility of transport capability across the number of supply chain links			
		•Route planning completed using planning tool to assign transport requests •Delivery scheduling			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		•3PL Service Levels Agreements defined and their performance is measured			
		•Data on replenishment orders, transport reliability, and costs of transport in current/future network scenarios, used to create a distribution plan.			
		•Strategic capacity planning (warehouse, labour and transport capacity)			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Inventory Management***	•Medicines Stock Storeroom layout is formally reviewed on a regular basis •Systematic processes followed to ensure reliable and accurate records of information			
		•Good inventory accuracy-greater than 99% •There is a performance management process implemented to coach staff handling medicine stock on continuous improvement processes •Full housekeeping in place •Dynamic policy on how much inventory should be kept at the facility with defined min/max levels • Inventory audits (cycle counting)			
		•Lean practices (5S) implemented and owned by all •Medicines stock management staff are well trained with all skills required to excel in the job and deliver the expected customer service, keep good product integrity, high picking accuracy, low cycle time and low operational costs. •Healthcare supply chain staff is adequate and is equipped to perform medicine stock keeping and supply chain planning work			
		• Medicine stock storeroom is designed to provide flexibility, high density and speed to cope with customer demand. • Innovation through skilled supply chain workforce •Standard operating procedures in place for inventory management •On-time and in-full [delivery] (OITF) of medicines stock			
		• Orders created based on actual demand			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Warehouse (Inventory) Visibility & Automation***	•Technologies & Data is leveraged to improve operations such as the ability to locate specific product within the store room			
		•Basic automation using barcodes to ensure visibility of incoming and outgoing inventory			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		•Advanced warehouse automation and mechanisation leveraged (RFID, GS1)			
		•Track and trace inventory identity, status, quantity, location. •Real-time exception management through alert messaging.			
		•Medicines Stock Management system integrated with the standardised digital supply chain platform that connect with other supply chain partners			
Manufacturing **Central Medicines Stores**	*Order Management*	•Formal standards for order management			
		•Procedures in place to review, process & prioritise customer orders •Customer order accuracy with specific customer requirements			
		•Integrating customer order management with supply chain planning and execution processes			
		•Providing holistic, real-time order process support with value-added functions like manufacturing capacity reservation or order configuration based on a collaborative design and execution portal			
		•Automated order management by supply chain platform			
Manufacturing **Central Medicines Stores** **Hospital, Clinics**	*Expiry Management*	•Policy in place for expired healthcare products management followed and audited			
		•Norms and standards for healthcare products wastage are defined			
		•Tracking of expiry dates for medicines and wastage risk			
		•Established policy for systematic picking of expired medicines (FEFO) •Quarantine area in facilities			
		•Expired medicines quantity is measured, managed and reported on the digital supply chain platform			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
Third Party Logistics (3PLs)	*Logistics and transport Flexibility*	•Distribution operation is customer driven (oriented on customer service i.e... On time and In full delivery) • Routing optimisation tool to optimise distribution •Track and trace solution to manage the distribution operation •Basic delivery mechanism in place •Bundling of goods to utilise available truck capacity efficiently as possible to meet replenishment plan			
		•Distribution operation is well executed with dynamic dispatching based on customer orders received. •Distribution Fleet policy in place •Planned and Scheduled delivery routes documented •Tailoring transportation to meet segmentation needs			
		•Manual delivery tracking tool •Information from the tool is used to identify variances and root causes and define action plans to adjust plan or execution, depending on the root cause variance & root cause analysis •Formal returns management •Dynamic routing based on actual demand needs •Flexibility to change the content of delivery and routes through full "truck loads" & full "pallet loads"			
		• Real time track and trace tool is implemented and allows managing and acting to solve distribution problems during the delivery route. •There is a closed loop process that feedback actual information to the route optimization planning tool to improve compliance to plan of the distribution route. • Estimated time of arrival (ETA) is provided to all customers before delivery of products •Transport arrives on time for warehouse/facilities appointments with defined service level agreements that are measured and managed •Optimisation of scheduling routing based on actual demand data			
		•ETA is dynamically updated as the route is executed and communicated to customers to ensure right delivery •Proof of Delivery (POD) used and returned to the warehouse •Coordinated replenishment programs •Optimisation of transport modes and routes continuously			
	Information sharing & Information Quality	•Accurate demand and inventory data from downstream (facilities) available in real time and this data is integrated into the demand planning process • Upstream (manufacturing) Inventory data is available			
Manufacturing Central Medicines stores		•An integrated decision support system exist and provide customer data between supply chain partners •Transparency on demand, inventory & capacity information amongst supply chain stakeholders			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
Hospitals, Clinics **Third Party Logistics**		•Full access to and use of supply chain partners information driving joint planning •Information availability, accessibility, and usability from all actors on appropriately aggregated levels at the right time at the right place			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Demand and Inventory Visibility***	•Demand signals are considered in the forecast process. •Forecasts are communicated to other supply chain partners			
		•Access to Minimum Order Quantity (MOQ) & Economic Batch Quantity (EBQ) •Information for planning & controlling functions readily available at depots and facilities where it is used			
		•Lead-time visibility of all suppliers and partners			
		•Demand-driven tools like CPFR and VMI provide actual demand and inventory information between customers and suppliers •Inventory and demand information is shared across the supply chain to provide visibility to all echelons			
		•Master data accuracy and availability & timeliness to relevant supply chain partners available on a standardised digital supply chain platform that is accessible to relevant supply chain stakeholders			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Order Visibility***	•Order transaction and movement is visible to supply chain partners and customers			
		•Online real-time order configuration and updates through the supply chain platform			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Information Technology Infrastructure***	•Basic integration of Information Management systems and database systems with analytical tools to facilitate ease of information sharing and analysis			
		•Advanced supply chain systems and technologies (e.g., web based application) provide information seamlessly between supply chain partners to enable collaborative planning, monitoring, evaluation, and execution			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		•IT architecture keeps tracks of plans and monitors stock buffers and triggers alerts in case of unexpected deviations •Efficient information management system that produce management reports on stock levels, usage patterns and expenditure trends			
		•Technology architecture that links interlocking roles and responsibilities between the supplier, national, provinces, districts, healthcare facilities & 3PLs and monitors end-to-end performance and alert exceptions, analytical tools and modelling capabilities for advanced decision support			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	*Data Transmission and Reporting*	•Information Technology architecture produces static reports and the reports are distributed in paper format			
		•Information Technology supports static reports with graphical data & reports are distributed digitally			
		•Information Technology architecture supports dynamic data navigation and reports are distributed automatically and digitally			
		•Information Technology architecture supports dynamic statistical analysis and reports are directly and constantly available to relevant supply chain partners			
		•Information Technology architecture support dynamic scenario analysis and reports are directly and constantly available to relevant supply chain partners			
	Data Capturing	•Procedures and pharmaceutical data management standards exist to guide capturing and reporting of medicines supply and consumption data			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**		•Electronic solutions to strengthen data collection and reporting ie the SVS			
		•Data (master data/information) consistently defined and harmonised throughout the organisation			
		Clear, institutionalised policies for capturing and reporting of supply and inventory usage			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		•Data (master data/information) consistently defined and harmonised throughout the supply chain •Automated processes for data aggregation analysis & sharing			
Manufacturing Central Medicines Stores Hospitals, Clinics	*Relationships*	•Supply chain actors value collaboration			
		•Basic collaboration in cross functional teams			
		•Inter-organisation collaboration. •Great efforts made on building good relationships with suppliers to ensure the supply chain is aligned to their capabilities & customer expectations •(Supplier Relationship Management)			
		•Partnerships and advanced relationships with suppliers •Risk and benefits sharing			
		•Supplier development and long term contracts with suppliers •Supply chain actors trust & collaborate with each other			
	Decision Making	•Joint knowledge creation and innovation with supply chain partners			
Manufacturing Central Medicines Stores Hospitals, Clinics		•Collaborative setting & alignment of KPIs with other supply chain partners			
		•Data is used as an input to decision making			
		•Collaborative decision making & problem solving with other supply chain partners driven by available data			
		•Technology supports automated decision making for all supply chain partners			
Manufacturing Central Medicines Stores Hospitals, Clinics	*Key Performance Indicators*	•Performance Indicators imbedded in the organisation			
		•Regular reporting of KPIs through a KPI Dashboard/Scorecard accessible by all partners in the medicines supply chain			
		•Regular monitoring and tracking of KPIs against goals & there is transparency			
		•Metrics can support managers to assess the overall supply chain health, diagnose problems and plan actions progressively			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		•Root cause analysis & corrective actions consistently taken into consideration to improve performance based on monitoring and evaluation results			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Policies and plans***	•A strategic plan that addresses human resource requirements for supply chain functions and personnel is authored			
		•Supply chain organisation structure adequately supports supply chain functions			
		•Clear & detailed human resource policies, norms, standards are available and fully implemented and adhered to at all levels , guiding and supporting the management of human resources in the supply chain			
		•Distinct and permanent budget line exists for supply chain human resource strengthening activities (i.e. training, incentives, coaching, performance management) and has actual funding allocated to it			
		•Workforce plans are updated annually and used to inform supply chain staff recruiting and other staffing decisions			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Roles and responsibilities***	•SOPs for supply chain tasks are available and utilised at all levels			
		•Job tasks are based on applicable competency model			
		•Roles & responsibilities are clarified & documented			
		•Suitable qualified SC Official observing SOPs to ensure staff is motivated and receives continuous training			
		•High performing teams are formed & supply chain managers are empowered			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Innovation***	•Basic approaches to supply chain problem solving			
		•Innovative ideas tolerated and utilised to solve supply chain issues			
		•Supply chain personnel have expertise, qualified and are able to define and solve complex problems			
		•Skilled staff with proactive approach to evidence-based quality improvements			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		•Supply chain staff has Systematic thinking capabilities •Strategies in place to promote innovation and creativity among supply chain staff			
Manufacturing Central Medicines Stores Hospitals, Clinics	*Incentives and working environment*	•Incentives and rewarding strategies in place and utilised for reaching goals & targets			
		•Motivation to supply chain staff for proper and accurate demand and inventory data collection, reporting and analysis			
		•Good working environment and working conditions support performance			
		•Workers have good work culture and have a sense of ownership for their roles and are motivated to do their jobs			
		•Supply chain staff has high accountability, engagement and empowerment			
Manufacturing Central Medicines Stores Hospitals, Clinics	*Training & Education*	•Resources to train supply chain staff to manage planning (demand, supply, distribution planning) and ordering of stock based on actual demand			
		• Education development framework & Programme in place which directs & coordinates the delivery of a learning environment & continuous training for staff			
		• Material management personnel have adequate training for recording and reporting supply and inventory usage			
		•Personnel with supply chain expertise guide and inform supply chain-related strategic policy, programmes, and funding decisions.			
		•Senior level champions for human resource supply chain management with sufficient budget, tools, and authority actively and fully empower the development of supply chain personnel.			
Manufacturing Central Medicines Stores Hospitals, Clinics	*Streamlined Processes*	•Procedures exist for most supply chain and stock management processes			
		•Innovation excellence is a key to successful processes & is infused into all supply chain processes			
		•Standard operating procedures for Supply chain and stock management processes			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		•Standard operating procedures are aligned to/with other supply chain partners and are accredited (i.e. ISO)			
		•Standard operating procedures for Supply chain and stock management processes are optimised & continuously improved			
Manufacturing Central Medicines Stores Hospitals, Clinics	*Cost Management*	•Basic tracking of supply chain costs			
		•Supply chain costs are measured and quantified			
		•Developed and dedicated systems and tools to measure, quantify and track supply chain costs			
		•Financial deviations from target are actively managed			
		•Full visibility of supply chain costs amongst supply chain partners through the digitalised supply chain platform			
Manufacturing NDoH	*Product Classification*	•Developed Holistic demand driven supply chain strategy that identifies all customer segments			
		•Specific products and their related service levels are identified and tailored to segments with emphasis on prioritisation of service, quality, cost & lead-time •A product classification framework is available to categorise products into classes			
		•Categorisation of products into clusters with similar characteristics using the different decision rules related to replenishment accomplished (DWV3) demand variability, volume, variety, life cycle maturity, delivery lead-time, value, delivery channels costs, cold/cool chain requirements			
		•Clear definition of requirements for each demand channels along with specific objectives to maximize competitiveness (service delivery) in each segment •Supply chain strategy differentiate functional and innovative products (stable demand products and unpredictable demand products)			
		•Supply chain strategy is defined, and tailored segments aligning the customer needs and product characteristics while maximising the use of resources with supply chain functions: i.e. Functional products for the Physical efficient supply chain and innovative products for a Responsiveness supply chain (ways of responding to stable and unpredictable demand for products)			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
Manufacturing NDoH	*Segmentation*	•Key strategic suppliers identified			
		•Segmentation analysis specifying supply chain goals, scope and the leader for the process •Defined "status" (i.e. preferred, key, strategic) supplier/customer using explicit criteria			
		•Customer segments identified and clearly defined for optimal channel selection using data on seasonality accessibility, order size, timing of resupply, service requirements, product information (number of SKUs), supply sources, storage location, transportation and routing resources and inventory policies •Suppliers segmented and expectations communicated to the suppliers (service level agreements) •Service objectives and standard operating procedures for each segment •Internal stakeholders aligned with segmentation			
		•Customer segmentation based on geographic focus and demand profiles •SOPs developed for managing the segments may quickly and easily applied to new product reducing the need for system design and redesign for new product			
		•Supplier/Customer segmentation strategy reviewed yearly and supplier/customer segments updated •Segments are flexible and adaptable			
Manufacturing NDoH	*Demand Planning*	•Demand plan is based on statistical forecasts, historical data and trends •Forecasts are reconciled & communicated with other organisational functions			
		•Judgements and experience of demand planners included in the demand plan •What if-scenarios, constraints (i.e. budget) integrated into the demand plan			
		•Synchronised joint demand planning with other external supply chain partners utilising inventory and consumption patterns data •Demand plans are aligned with customers and supply plans are aligned with key suppliers to ensure product availability and reduce variability through information sharing. •Demand plan is tracked for accuracy			
		•Demand plan created based on harmonised master and transactional data using a planning software •Demand planners have the right skills set (quantitative, computer, interpersonal and process management)			
		•Demand driven planning using actual demand information. •Inventory strategies are clearly formulated & monitored by all stakeholders periodically •Demand plan included in the standardised digital supply chain platform that is accessible to relevant supply chain partners			

<table>
<tr><th>Relevant to Node</th><th>Capabilities</th><th>Capability Statements</th><th>Extent of use</th><th>Effort</th><th>Impact</th></tr>
<tr><td rowspan="5">Central Medicines Stores
Manufacturing
NDoH</td><td rowspan="5">Supply Planning</td><td>•Supply plan created based on inventory policies of downstream supply chain partners</td><td></td><td rowspan="5"></td><td rowspan="5"></td></tr>
<tr><td>•Supply plan is created from basic demand plan</td><td></td></tr>
<tr><td>•Integrated organisational supply planning created that is based on data within the whole organisation (lead-time, supplier constraints and stock-holding)
•Supply chain planners have visibility to stock on hand and consumption data</td><td></td></tr>
<tr><td>•Supply plan is included in the standardised digital supply chain platform that is accessible to relevant supply chain partners</td><td></td></tr>
<tr><td>•Automatic supply order generation and supply chain staff just authorise</td><td></td></tr>
<tr><td rowspan="3">Central Medicines Stores
Manufacturing</td><td rowspan="3">Warehouse Operations (Inventory Management)</td><td>•There are service customer oriented KPIs (fill rate, perfect order etc.) in place
•Product prioritization in the order processing system
•Basic storage rack structures in place to maximise warehouse density
•Warehouse density is prioritised to increase asset utilisation
•Warehouse layout is formally reviewed on a regular basis to increase warehouse productivity and reduce safety risks
•Single forklifts are used most of the time to perform product put-away, retrieval and truck loading
•Inventory management system is entirely manual</td><td></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td>•Warehouse operations are well executed with good operational performance (Good inventory accuracy-greater than 99%, increased warehouse productivity, downward trend on warehouse cost)
•Racking structures are implemented and increased warehouse density (e.g., more than 10%), maximizing asset utilization.
•Double forklifts are used most of the time (greater than 50% of the time) to perform product put-away, retrieval and truck loading.
•There is a performance management process implemented that increased productivity
•Front line supervisors can lead, and coach the warehouse team towards a continuous improvement process
•Full housekeeping in place
•Dynamic policy on how much inventory should be kept at the warehouse with defined min/max levels</td><td></td></tr>
<tr><td>•Lean practices (5S, KAIZEN) implemented and owned by all, to ensure clean, safe and efficient workplace in the warehouse
•Warehouse employees are well trained with all skills required to excel in the job and deliver the expected customer service, keep good product integrity, high picking accuracy, low cycle time and low operational costs.</td><td></td></tr>
</table>

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		•Warehouse is fully oriented towards customer service, meeting expected perfect order goals (greater than 99%) based on actual customer orders. • Warehouse layout is designed to provide flexibility, high density and speed to cope with customer demand. •Simulation tool is regularly used to review layout and labour requirements aligned with demand • Triples or Quad forklifts are used most of the time (greater than 50%) to perform product put-away, retrieval and truck loading. • Innovation through skilled workforce, standard operating procedures and multifunctional teams.			
		•KPIs included in Service Level Agreements •Segments Out of stock monitoring & Product Out-of-Stock in the segments (not OOS in the warehouse) is a key performance indicator in the warehouse metrics. •Demand driven replenishment (replenishment/fulfilment based on actual demand as opposed to forecasts)			
Manufacturing	***Interdependence & resource sharing***	•Commitment by supply chain partners with respect to collaborative resource investment and resource pooling			
		•Pooling & sharing resources together with other supply chain partners to reduce the supply chain risk due to supply chain disruptions			
		•Commitment agreements signed for collaborative resource investment and sharing with supply chain partners			
		•Sharing of relevant information, risks & benefits with all supply chain partners			
		•Resource sharing and pooling included in organisational strategy			
Manufacturing **Central Medicines Stores** **Hospitals, Clinics**	***Metrics***	•On Time In Full (OTIF) Tracking. •Supply chain RELIABILITY and STABILITY levels defined in organisational strategy •Supply chain AGILITY levels and SPEED/VELOCITY defined in organisational strategy •Supply chain RESPONSIVENESS level defined in organisational strategy			
		•Customer order fulfilment and on-time deliveries are (<100%) and high customer satisfaction, •On time delivery & percentage of returned goods established against well-defined targets •Supply chain RELIABILITY and STABILITY measured and quantified •Supply chain AGILITY and SPEED/ VELOCITY measured and quantified •Supply chain RESPONSIVENESS measured and quantified			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		•Controls in place to improve supply chain reliability, Agility, Speed, Responsiveness, & Stability •Controls in place to improve supply chain RELIABILITY, AGILITY, STABILITY, SPEED/VELOCITY and RESPONSIVENESS			
Manufacturing **Central Medicines Stores**	*Management Support*	•Upper Management support for supply chain and stock management processes			
		•Top management supporting resource allocation and partnering strategies			
		•Top management strongly understand and support the demand driven supply chain management approach and also support the building of adaptive demand based networks			
		•Appointed supply chain director who sits on the organisational board			
Manufacturing **Central Medicines Stores**	*Organisational Vision*	•Understanding of actual customer demand and translation of that into strategies and plans to satisfy the actual demand			
		•Organisational vision does clearly define customer orientation & demand-pull replenishment as a core competency			
		•Customer-pull-driven fulfilment as well as outsourcing all non-core supply chain activities to third -party logistics			
		•Customer -focused, collaborative culture is firmly in place. •Supply chain scope encompasses multi-echelon supply network (end to end supply chain configuration)			
Manufacturing **Central Medicines Stores**	*Alignment of Objectives*	•Consensus on supply chain strategy			
		•A demand-driven supply chain strategy is developed			
		•A comprehensive demand-driven supply chain strategy is defined & implemented			
		•Alignment of organisational KPIs with end-to-end supply chain goals & objectives.			
		•Continuous review & update of the demand-driven supply chain strategy			
Manufacturing **NDoH**	*Inventory Positioning*	Cross docking & direct deliveries to achieve delivery efficiencies			
		Strategic decoupling points			

Relevant to Node	Capabilities	Capability Statements	Extent of use	Effort	Impact
		Strategic decoupling points protected by buffer profiles and sizes			
		Dynamic adjustment of buffer profiles and sizes based on events and seasonality			

Appendix 10: Health facilities

Nineteen (19) DDSCM capabilities are relevant to the three (3) health facilities included in this study. These capabilities were assessed using semi-structured interviews based on the network-mapping tool. The assessment outcomes are shown in Table 7.

Key

3	Risk Management	21	Decision Making
8	Inventory Management	22	Key Performance Indicators
9	Storeroom Visibility & Automation	24	Policies and plans
12	Expiry Management	25	Clear roles & responsibilities
14	Demand and Inventory Visibility	26	Innovation
15	Order Visibility	27	Incentives and working environment
16	Information Technology Infrastructure	28	Training & Education
17	Data Transmission and Reporting	31	Streamlined Processes
18	Data Capturing	33	Cost Management
19	Relationships		

Table 7: Health Facilities Assessment Outcomes

	Health Facility 1			Health Facility 2			Health Facility 3			Average	STD	Average	STD	Average	STD
ID	Maturity	Effort	Impact	Maturity	Effort	Impact	Maturity	Effort	Impact	Maturity		Effort		Impact	
3	80%	1	4	35%	1	4	60%	3	3	58%	23%	1,7	1,15	3,67	0,58
8	65%	2	4	80%	4	5	90%	4	5	78%	13%	3,3	1,15	4,67	0,58
9	35%	5	5	0%	1	5	35%	4	1	23%	20%	3,3	2,08	3,67	2,31
12	100%	3	5	95%	2	4	100%	3	4	98%	3%	2,7	0,58	4,33	0,58
14	100%	1	2	50%	4	4	88%	1	2	79%	26%	2,0	1,73	2,67	1,15
15	100%	1	1	0%	1	1	100%	1	3	67%	58%	1,0	0,00	1,67	1,15
16	75%	2	5	0%	1	5	81%	3	4	52%	45%	2,0	1,00	4,67	0,58
17	70%	3	4	0%	1	5	95%	3	4	55%	49%	2,3	1,15	4,33	0,58
18	75%	2	5	40%	4	5	80%	3	5	65%	22%	3,0	1,00	5,00	0,00
19	63%	4	5	75%	5	5	94%	3	4	77%	16%	4,0	1,00	4,67	0,58
21	44%	3	5	81%	1	5	90%	3	4	72%	25%	2,3	1,15	4,67	0,58
22	55%	2	4	60%	3	5	95%	3	4	70%	22%	2,7	0,58	4,33	0,58
24	75%	2	5	95%	4	5	95%	3	5	88%	12%	3,0	1,00	5,00	0,00
25	90%	2	5	100%	3	3	100%	3	4	97%	6%	2,7	0,58	4,00	1,00
26	55%	3	4	85%	3	3	100%	3	5	80%	23%	3,0	0,00	4,00	1,00
27	60%	4	5	70%	5	5	95%	3	4	75%	18%	4,0	1,00	4,67	0,58
28	20%	5	4	95%	4	4	100%	3	5	72%	45%	4,0	1,00	4,33	0,58
31	80%	3	2	95%	4	5	95%	2	4	90%	9%	3,0	1,00	3,67	1,53
33	90%	2	2	75%	1	5	95%	2	5	87%	10%	1,7	0,58	4,00	1,73

Table 7 outlines that health facility 3 has more mature DDSCM capabilities, followed by health facility 1, and health facility 2 is the least mature facility. Health facility 2 does not have an IT infrastructure to use when managing inventory and processing orders. This has a ripple effect on the capabilities such as order visibility, data capturing, data transmission and reporting as witnessed by the immature state of these capabilities. Health facility 2 also has issues on risk management. Furthermore, it can be observed in Table 7 that all the three (3) facilities still struggle with warehouse visibility (inventory visibility in the pharmacy) due to lack of technologies such as RFID and barcodes. RFID and barcodes require a lot of effort in terms of investment in setting up the infrastructure in the health facilities. However, despite the low maturity of warehouse visibility in the health facilities, it was perceived to have high impact on the operations of health facilities. Figure 3 and Figure 4 helps in outlining priorities for supply chain managers at the three (3) facilities.

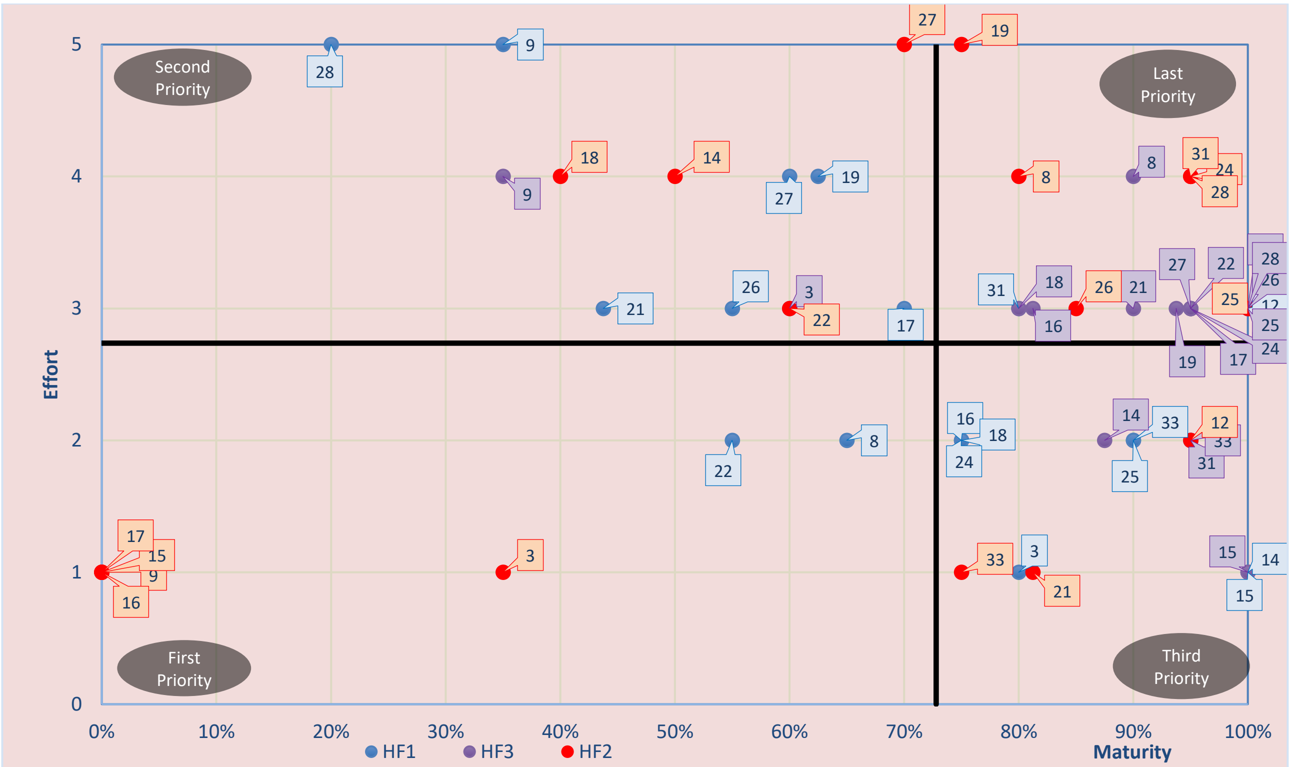


Figure 3: Maturity - Effort Mapping

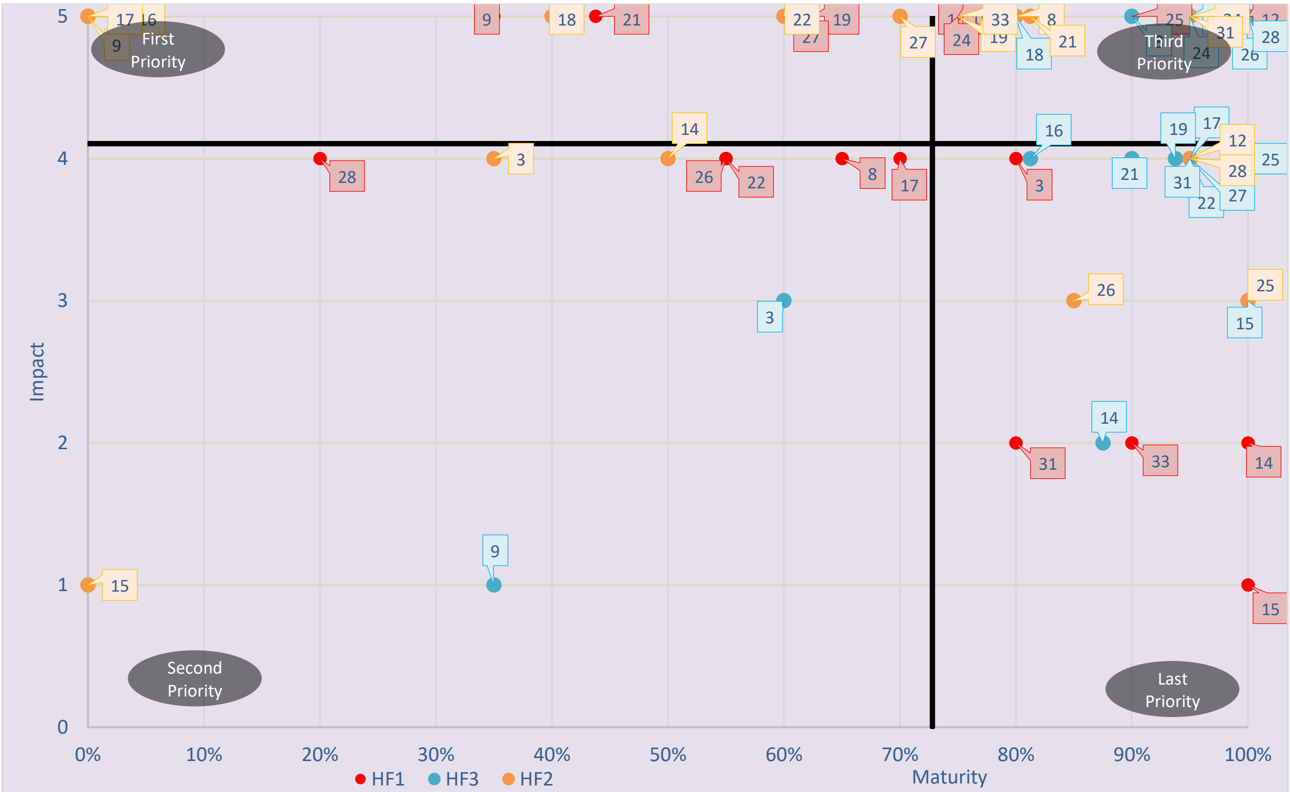


Figure 4: Maturity – Impact Mapping

Appendix 11: Distribution

The distribution node entails the receiving of medicines from manufactures, storage and distribution of medicines to hospitals and health facilities. Different lens of analysis were considered in this section. Firstly, the applicability of the tool within Western Cape Province in South Africa and secondly, the tool was tested within another context, which is a Gauteng Province in South Africa and lastly it was tested at the central distribution of medicines in Kenya. The reason for doing this was to test the applicability of the tool within a province context, and then another developing country context. Different provinces and countries have different rules and policies for public healthcare supply chain design and management. Table 8 outlines the distribution assessment outcomes.

Table 8 Distribution Assessment Outcomes

	CMS 1			CMS 2			CMS 3			Average	STD	Average	STD	Average	STD
ID#	Maturity	Effort	Impact	Maturity	Effort	Impact	Maturity	Effort	Impact	Maturity		Effort		Impact	
3	75%	3	5	65%	2	3	0%	5	3	47%	41%	3,33	1,53	3,67	1,15
6	80%	2	5	65%	3	3	55%	3	5	67%	13%	2,67	0,58	4,33	1,15
7	100%	2	5	75%	3	3	75%	3	4	83%	14%	2,67	0,58	4,00	1,00
8	100%	2	5	60%	3	3	75%	3	4	78%	20%	2,67	0,58	4,00	1,00
9	0%	5	5	50%	3	3	25%	4	4	25%	25%	4,00	1,00	4,00	1,00
10	80%	2	5	65%	3	3	90%	3	4	78%	13%	2,67	0,58	4,00	1,00
11	100%	2	5	70%	3	3	95%	3	5	88%	16%	2,67	0,58	4,33	1,15
12	100%	2	5	75%	3	3	60%	4	4	78%	20%	3,00	1,00	4,00	1,00
13	17%	3	5	67%	3	3	75%	3	4	53%	32%	3,00	0,00	4,00	1,00
14	50%	3	5	50%	3	3	50%	4	5	50%	0%	3,33	0,58	4,33	1,15
15	0%	1	1	50%	3	3	50%	4	4	33%	29%	2,67	1,53	2,67	1,53
16	50%	5	5	50%	3	3	81%	3	4	60%	18%	3,67	1,15	4,00	1,00
17	81%	2	0	50%	3	3	88%	3	0	73%	20%	2,67	0,58	1,00	1,73
18	90%	3	4	55%	3	3	50%	3	4	65%	22%	3,00	0,00	3,67	0,58
19	55%	2	3	50%	3	3	92%	3	4	66%	23%	2,67	0,58	3,33	0,58
21	65%	1	2	65%	3	3	80%	3	4	70%	9%	2,33	1,15	3,00	1,00
22	100%	2	5	75%	3	3	70%	3	5	82%	16%	2,67	0,58	4,33	1,15
23	100%	2	5	67%	3	3	42%	4	4	70%	29%	3,00	1,00	4,00	1,00
24	100%	2	5	70%	3	3	75%	3	4	82%	16%	2,67	0,58	4,00	1,00
25	90%	3	5	75%	3	3	90%	2	4	85%	9%	2,67	0,58	4,00	1,00
26	95%	3	4	70%	3	3	90%	2	4	85%	13%	2,67	0,58	3,67	0,58
27	100%	4	1	60%	3	3	70%	4	5	77%	21%	3,67	0,58	3,00	2,00
28	90%	4	5	65%	3	3	55%	4	4	70%	18%	3,67	0,58	4,00	1,00
29	100%	2	5	75%	3	3	100%	3	5	92%	14%	2,67	0,58	4,33	1,15
30	100%	2	5	75%	3	3	63%	3	5	79%	19%	2,67	0,58	4,33	1,15
31	80%	2	5	70%	3	3	95%	3	4	82%	13%	2,67	0,58	4,00	1,00
32	100%	2	5	70%	3	3	75%	3	4	82%	16%	2,67	0,58	4,00	1,00
33	80%	2	5	70%	3	3	80%	3	5	77%	6%	2,67	0,58	4,33	1,15

Table 8 show that, Central Medicines Stores 3 has a low maturity score on risk management. The stores currently struggle with pre-emptively identifying, assessing and controlling threats and potential disruptions to the public healthcare supply chain. These threats could stem from a variety of sources such as potential disruptions to the medicines supply, product loss due to expiry, theft and damage. Furthermore, it can be observed that, Central Medicines Stores 1, Central Medicines Stores 2 and Central Medicines Stores 3 are still faced with a challenge of ensuring warehouse visibility and automation.

Furthermore, the exchange of quality information between the manufacturers, hospitals, health facilities and Central Medicines Stores 1 is still manual or hardly exist. This reflects the lack of integrated IT infrastructure and the “will” to share the information. This has resulted in failure to track orders across the demand-supply network. Figure 5 and Figure 6 helps the supply chain managers in outlining priorities and subsequent intervention mechanisms for the three (3) central medicines stores.

Key

1	Product Classification		20	Interdependence and resource sharing
2	Segmentation		21	Decision making
4	Demand Planning		22	Key performance indicators
5	Inventory Positioning		23	Metrics
6	Supply Planning		24	Policies and plans
7	Distribution Planning		25	Clear roles and responsibilities
8	Inventory Management		26	Innovation
9	Storeroom Visibility & Automation		27	Incentives and working environment
10	Order management		28	Training and education
11	Logistics flexibility		29	Management support
12	Expiry Management		30	Organisational vision
13	Information sharing and Information quality		31	Streamlined processes
14	Demand and Inventory Visibility		32	Alignment of objectives
15	Order Visibility		33	Cost management
16	Information Technology Infrastructure			
17	Data Transmission and Reporting			
18	Data Capturing			
19	Relationships			

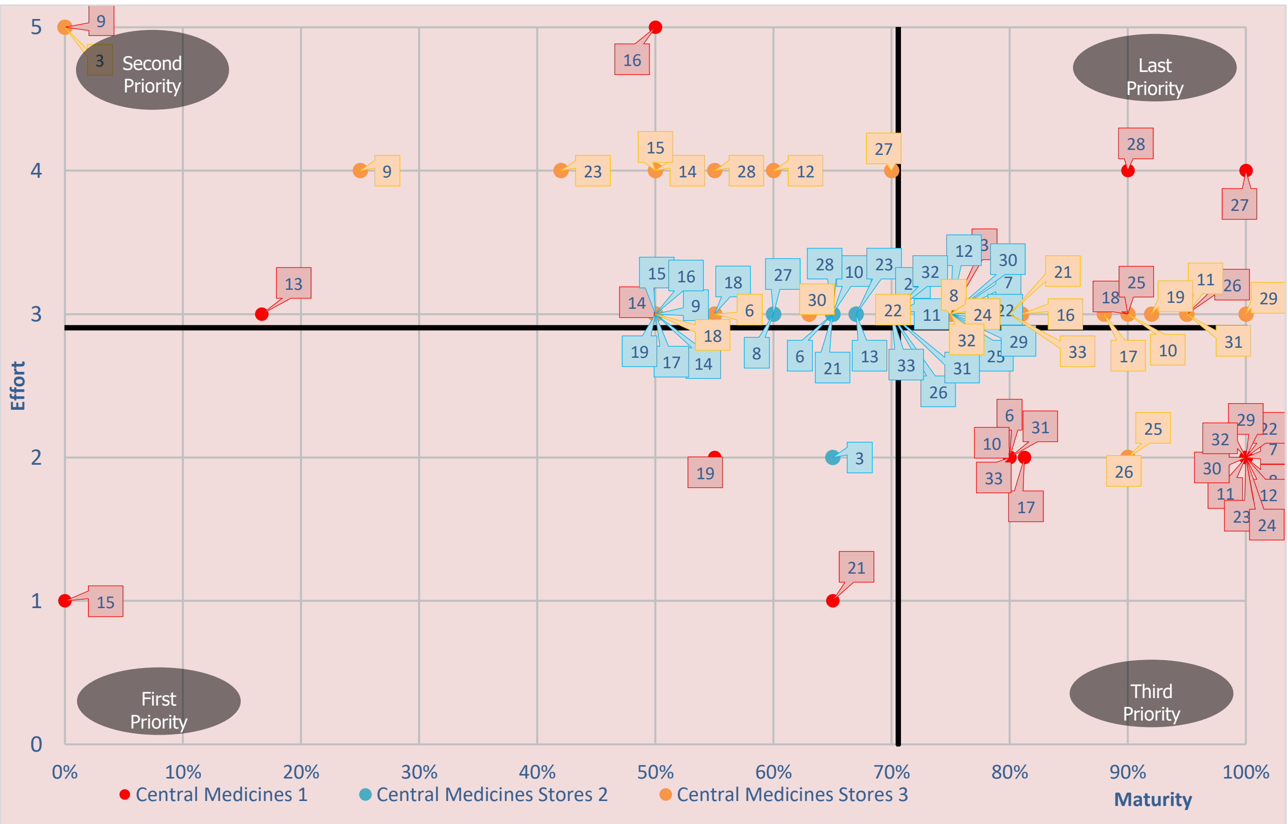


Figure 5: Maturity – Effort Mappings

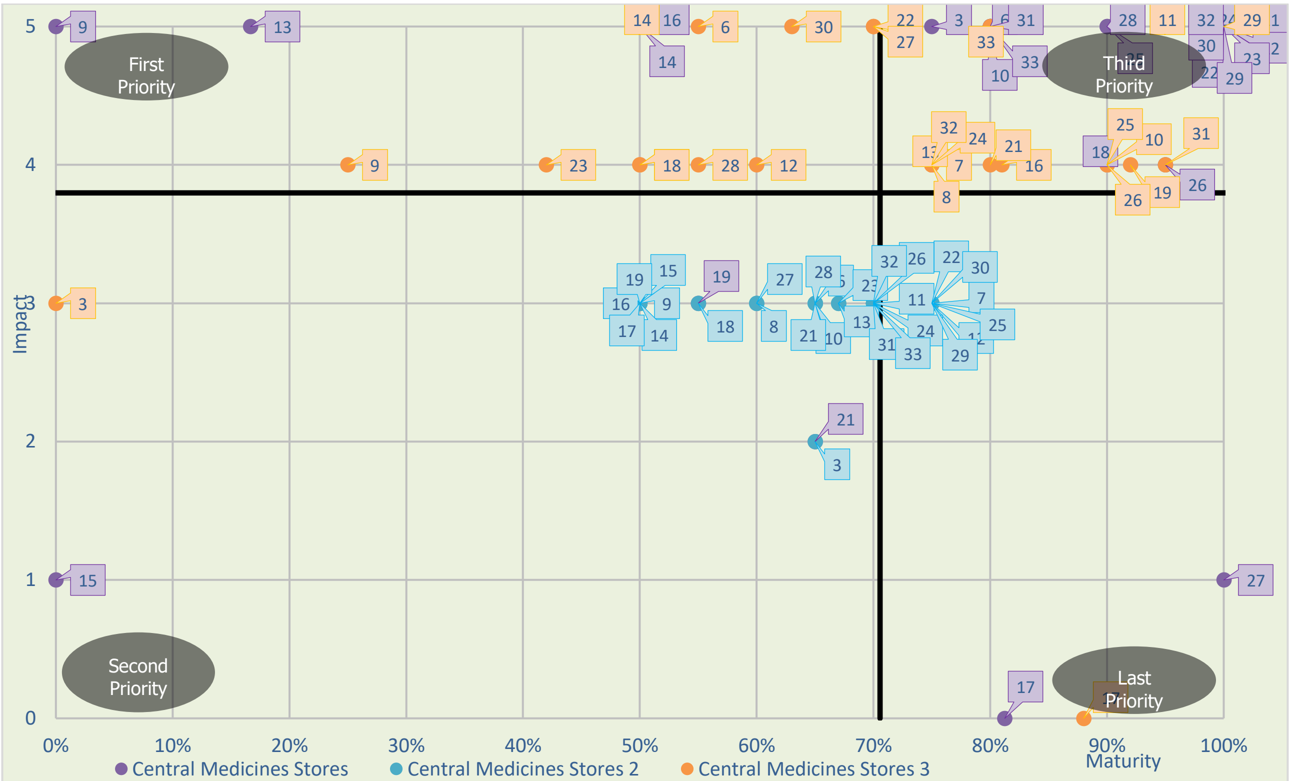


Figure 6: Maturity – Impact Mappings

Appendix 12: Manufacturing

Capabilities mapping profile reveal that thirty-three (33) DDSCM capabilities are relevant to pharmaceutical manufacturing companies. These capabilities were assessed using semi-structured interviews based on the network-mapping tool. The assessment outcomes for pharmaceutical manufacturing organisations are shown in Table 9.

Table 9: Manufacturing Assessment Outcomes

	Manufacturer 1			Manufacturer 2			Manufacturer 3			Average	STD	Average	STD	Average	STD
ID	Maturity	Effort	Impact	Maturity	Effort	Impact	Maturity	Effort	Impact	Maturity		Effort		Impact	
1	100%	1	4	75%	3	3	90%	1	4	88%	13%	1,67	1,15	3,67	0,58
2	100%	2	4	65%	3	4	75%	2	4	80%	18%	2,33	0,58	4,00	0,00
3	85%	4	3	65%	3	4	50%	4	3	67%	18%	3,67	0,58	3,33	0,58
4	100%	2	5	100%	4	4	50%	2	5	83%	29%	2,67	1,15	4,67	0,58
5	81%	4	1	88%	4	5	0%	0	0	84%	4%	4,00	0,00	3,00	2,83
6	90%	2	5	75%	3	3	60%	2	5	75%	15%	2,33	0,58	4,33	1,15
7	65%	2	3	90%	3	4	0%	0	0	78%	18%	2,50	0,71	3,50	0,71
8	50%	2	2	55%	3	4	0%	0	0	53%	4%	2,50	0,71	3,00	2,00
9	70%	3	3	90%	3	4	0%	0	0	80%	47%	3,00	0,00	3,50	0,71
10	75%	3	4	80%	3	3	70%	3	4	75%	5%	3,00	0,00	3,67	0,58
11	50%	1	2	100%	4	5	100%	1	2	83%	29%	2,00	1,73	3,00	1,73
12	75%	3	2	75%	4	4	0%	0	0	75%	0%	3,50	0,71	3,00	1,41
13	100%	5	3	92%	5	5	33%	5	3	75%	36%	5,00	0,00	3,67	1,15
14	100%	5	2	95%	3	5	75%	5	2	90%	13%	4,33	1,15	3,00	1,73
15	100%	4	2	63%	4	4	75%	4	2	79%	19%	4,00	0,00	2,67	1,15
16	94%	3	2	88%	3	4	56%	3	2	79%	20%	3,00	0,00	2,67	1,15
17	70%	2	3	75%	3	5	45%	2	3	63%	16%	2,33	0,58	3,67	1,15
18	100%	2	5	90%	2	4	60%	2	5	83%	21%	2,00	0,00	4,67	0,58
19	100%	5	5	100%	3	5	45%	5	5	82%	32%	4,33	1,15	5,00	0,00
20	50%	3	5	55%	2	3	0%	0	0	53%	4%	2,50	0,71	4,00	1,41
21	100%	4	4	45%	3	4	50%	4	4	65%	30%	3,67	0,58	4,00	0,00
22	85%	2	5	100%	4	4	90%	2	5	92%	8%	2,67	1,15	4,67	0,58
23	100%	1	2	67%	3	3	83%	1	3	83%	17%	1,67	1,15	2,67	0,58
24	90%	5	5	60%	3	3	50%	5	5	67%	21%	4,33	1,15	4,33	1,15
25	80%	1	2	95%	3	4	88%	1	2	88%	8%	1,67	1,15	2,67	1,15
26	90%	4	2	80%	4	4	50%	4	2	73%	21%	4,00	0,00	2,67	1,15
27	90%	3	2	95%	4	5	65%	3	2	83%	16%	3,33	0,58	3,00	1,73
28	90%	3	4	100%	3	4	80%	3	4	90%	10%	3,00	0,00	4,00	0,00
29	75%	2	4	94%	3	5	100%	2	4	90%	13%	2,33	0,58	4,33	0,58
30	100%	5	4	75%	3	4	69%	5	4	81%	17%	4,33	1,15	4,00	0,00
31	100%	5	3	100%	4	5	100%	5	3	100%	0%	4,67	0,58	3,67	1,15
32	100%	5	4	70%	3	5	70%	5	4	80%	17%	4,33	1,15	4,33	0,58
33	100%	1	4	95%	3	5	100%	1	4	98%	3%	1,67	1,15	4,33	0,58

The empirical investigation regarding DDSCM in three (3) pharmaceutical manufacturing organisations reveal that the DDSCM approach is recognised as a competitive advantage and has significant impact on satisfying customer demand cost effectively. However, supply chain managers at these organisations perceived that some capabilities of DDSCM require high effort to implement and sustain as shown in Table 9.

Across all the pharmaceutical companies involved in this empirical investigation, it can be observed that, Manufacturer 3 outsource its warehouse operations and focuses on its competence area, which is manufacturing. Both Manufacturer 1 and Manufacturer 2 have a low maturity concerning inventory management and control despite the high impact that this DDSCM capability has on the satisfaction of customer demand.

Manufacturer 3 struggle with a couple of DDSCM capabilities as evidenced by the low maturity of the DDSCM capabilities. Firstly, both demand and supply planning need attention. There is need for the integration of statistical forecasting techniques, experience, judgement of planners and consumption patterns when designing the demand plan that will be fulfilled by the supply plan. Secondly, the non-existence of an integrated supply chain platform connecting relevant supply chain partners has resulted in the organisation facing challenges in accessing quality information and subsequently struggle to transmit data and share relevant reports to other supply chain partners in real-time. These challenges can be addressed by fostering, leveraging and managing upstream and downstream supply chain relationships and partnerships for the purposes of integrating information systems. This will enable the sharing of information that lead to the creation of customer value, collaborative decision-making and process innovation.

At Manufacturer 2, human resources plans and policies have a low maturity despite having a higher impact on the organisation. The argument is that they require a moderate effort to achieve and sustain. Manufacturer 1 also has expiry management processes that have low maturity. Finally, to develop strategic and operational priorities, Figure 7 and Figure 8 outline that the capabilities to be addressed first, which are the ones that have a low maturity, have high impact on the organisation but require minimum effort to achieve.

Key

1	Product Classification		20	Interdependence and resource sharing
2	Segmentation		21	Decision making
4	Demand Planning		22	Key performance indicators
5	Inventory Positioning		23	Metrics
6	Supply Planning		24	Policies and plans
7	Distribution Planning		25	Clear roles and responsibilities
8	Inventory Management		26	Innovation
9	Storeroom Visibility & Automation		27	Incentives and working environment
10	Order management		28	Training and education
11	Logistics flexibility		29	Management support
12	Expiry Management		30	Organisational vision
13	Information sharing and Information quality		31	Streamlined processes
14	Demand and Inventory Visibility		32	Alignment of objectives
15	Order Visibility		33	Cost management
16	Information Technology Infrastructure			
17	Data Transmission and Reporting			
18	Data Capturing			
19	Relationships			

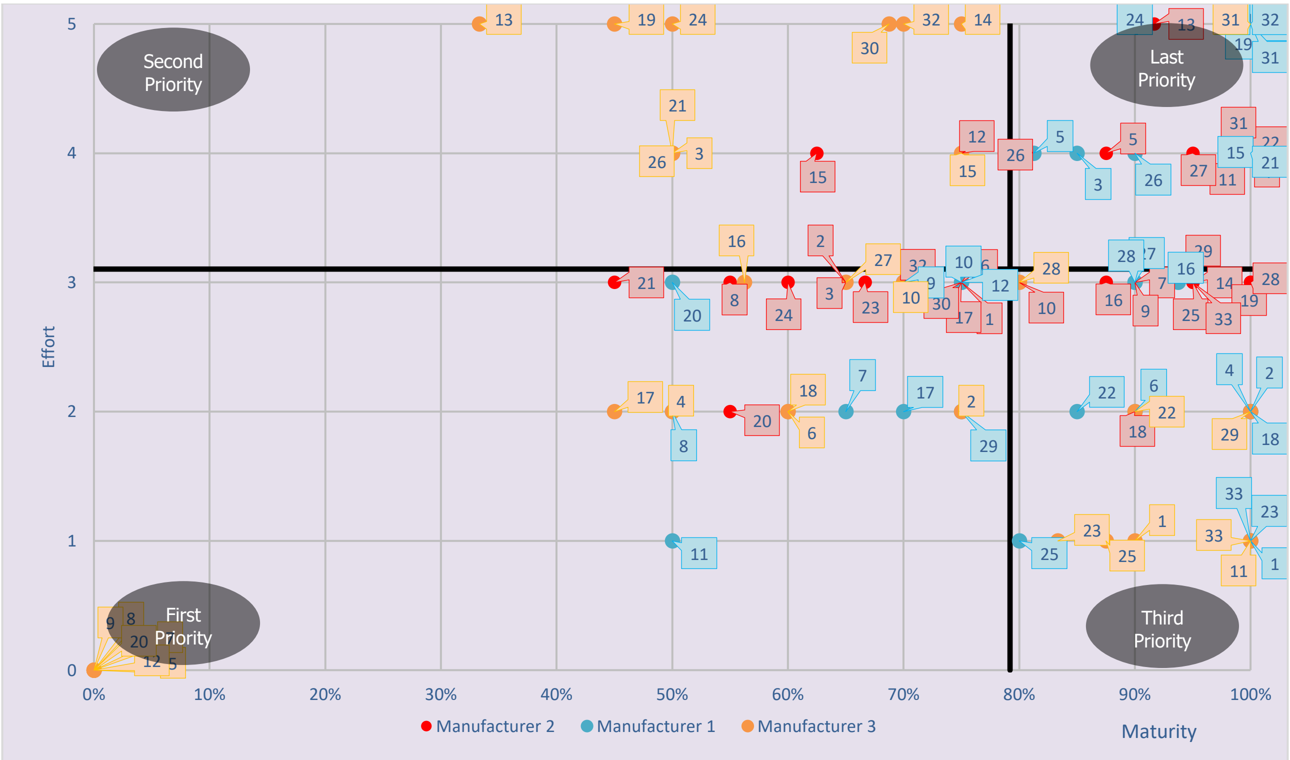


Figure 7: Maturity –Effort Mapping

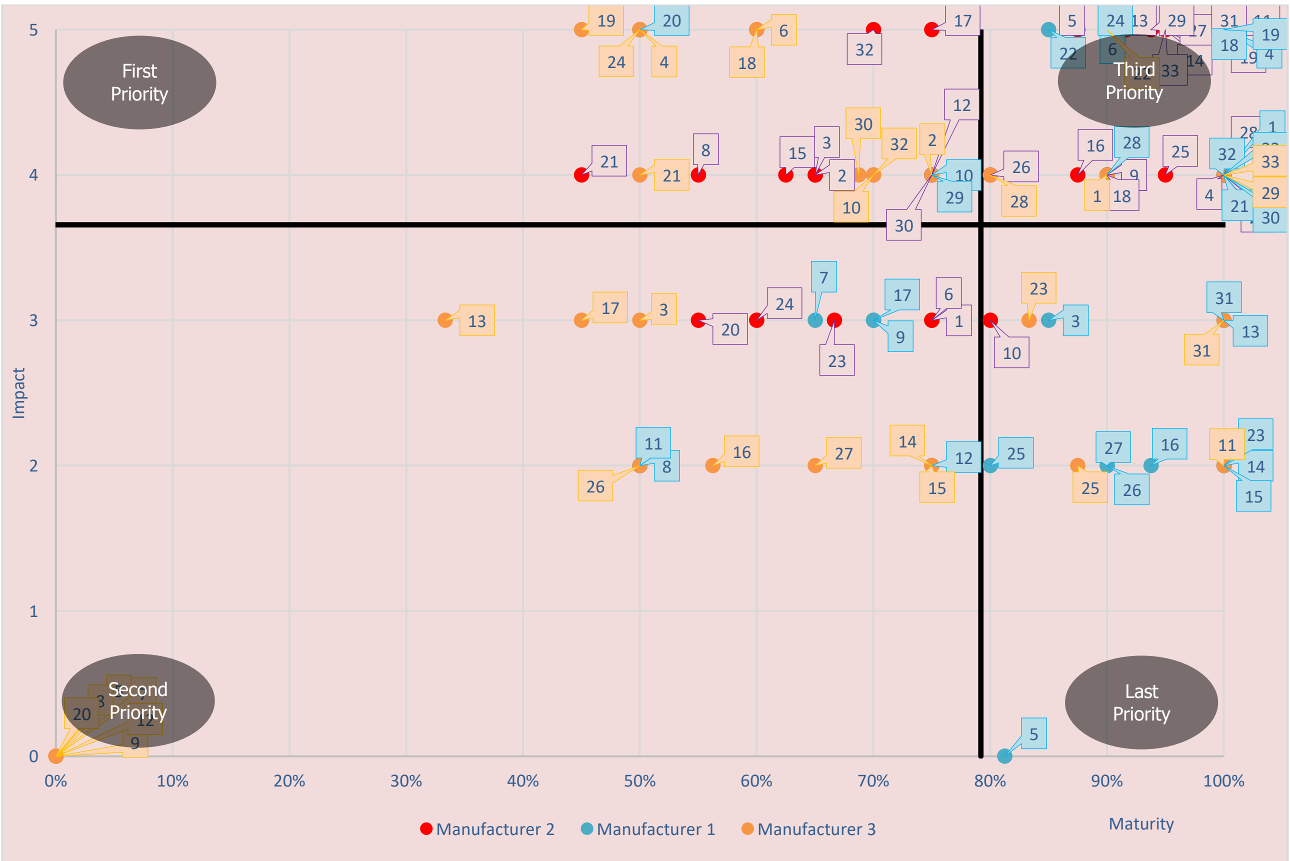


Figure 8: Maturity – Impact Mapping

Appendix 13: Capabilities Maturity Mappings Outcomes

The assessment outcomes from the theoretical network-mapping tool are embedded into Tableau Software Platform to give a visual representation of the state of DDSCM at the different SCN links. This enhances informed decision making by provincial managers, district managers and facility managers. The tool allows managers to page through visual representations of the state of DDSCM for different manufacturers, distribution centers, hospitals and health facilities. In particular, the tool supports the managers to determine the weakest link in the network. After identifying a weak link in the network and associated immature DDSCM capabilities in the whole network, the managers can strategically prioritise capabilities to address by implementing interventions. The tool also supports the monitoring and evaluation of the effectiveness and impact of the interventions over a timeframe.

To illustrate that the tool can be used as a monitoring and evaluation tool of interventions that are put in place to address DDSCM capabilities that are immature, have high impact and require low effort to achieve and sustain, data is randomly generated for 2020 (which will be the second assessment a year later after putting interventions into place). This data is compared with the actual assessment data of 2019.

Supply chain managers are able to view status of DDSCM capabilities and their associated maturity scores. The visual representation of successive years allow the tracking of any improvements on DDSCM capabilities resulting from interventions.

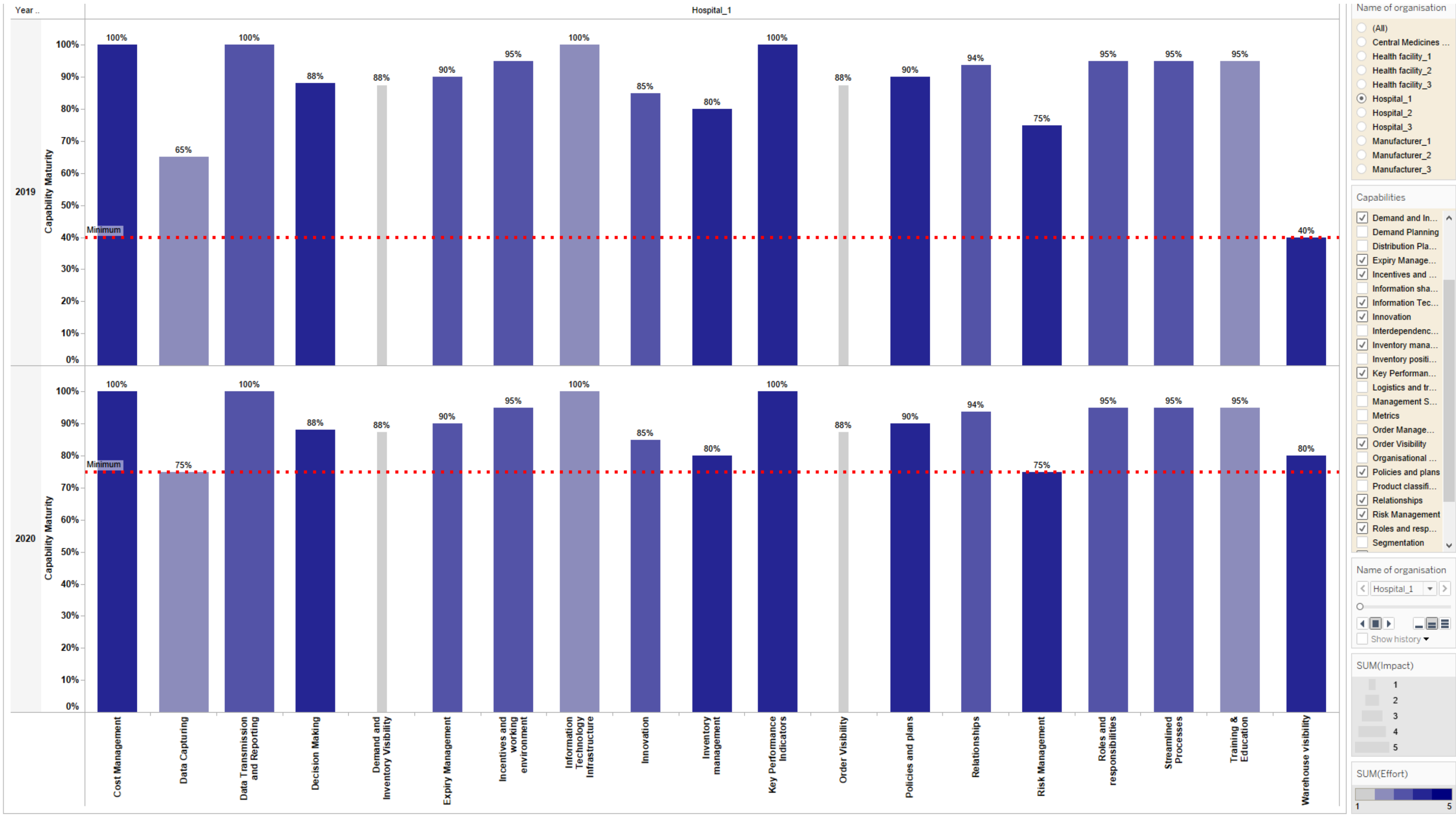


Figure 9 : Capabilities Maturity Mapping (Hospital 1)

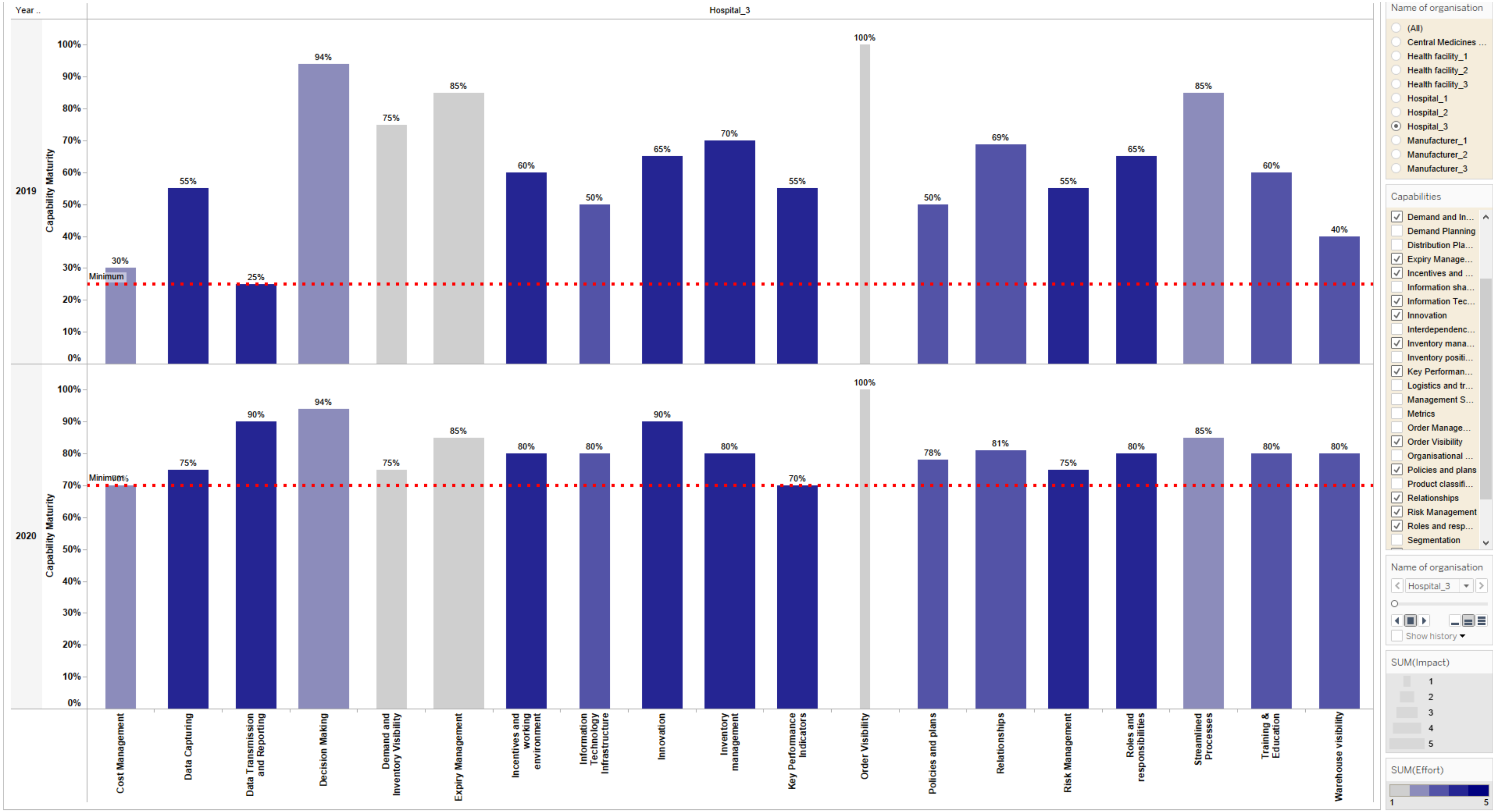


Figure 10: Capabilities Maturity Mappings (Hospital 3)

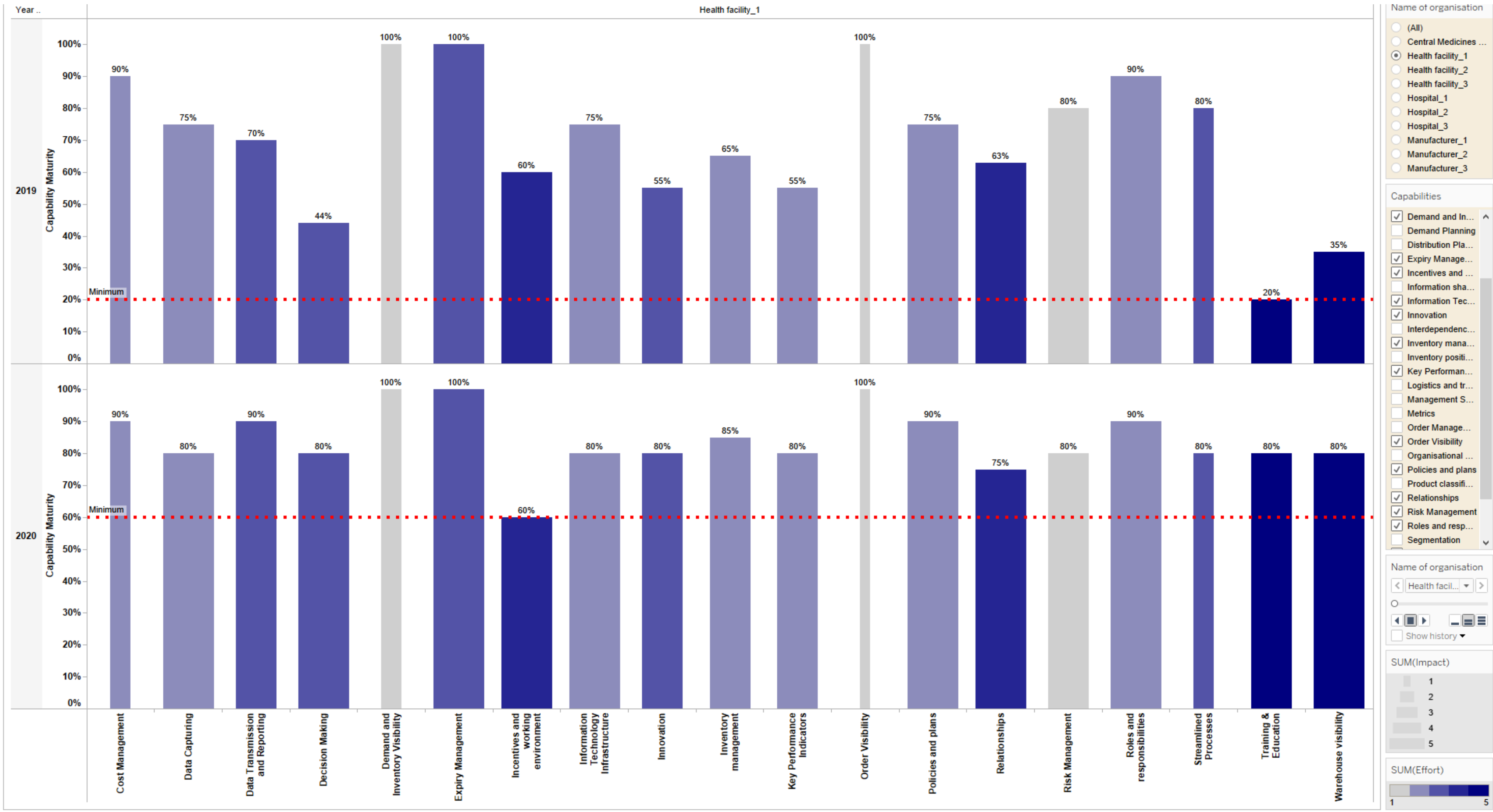


Figure 11: Capabilities Maturity Mapping (Health Facility 1)

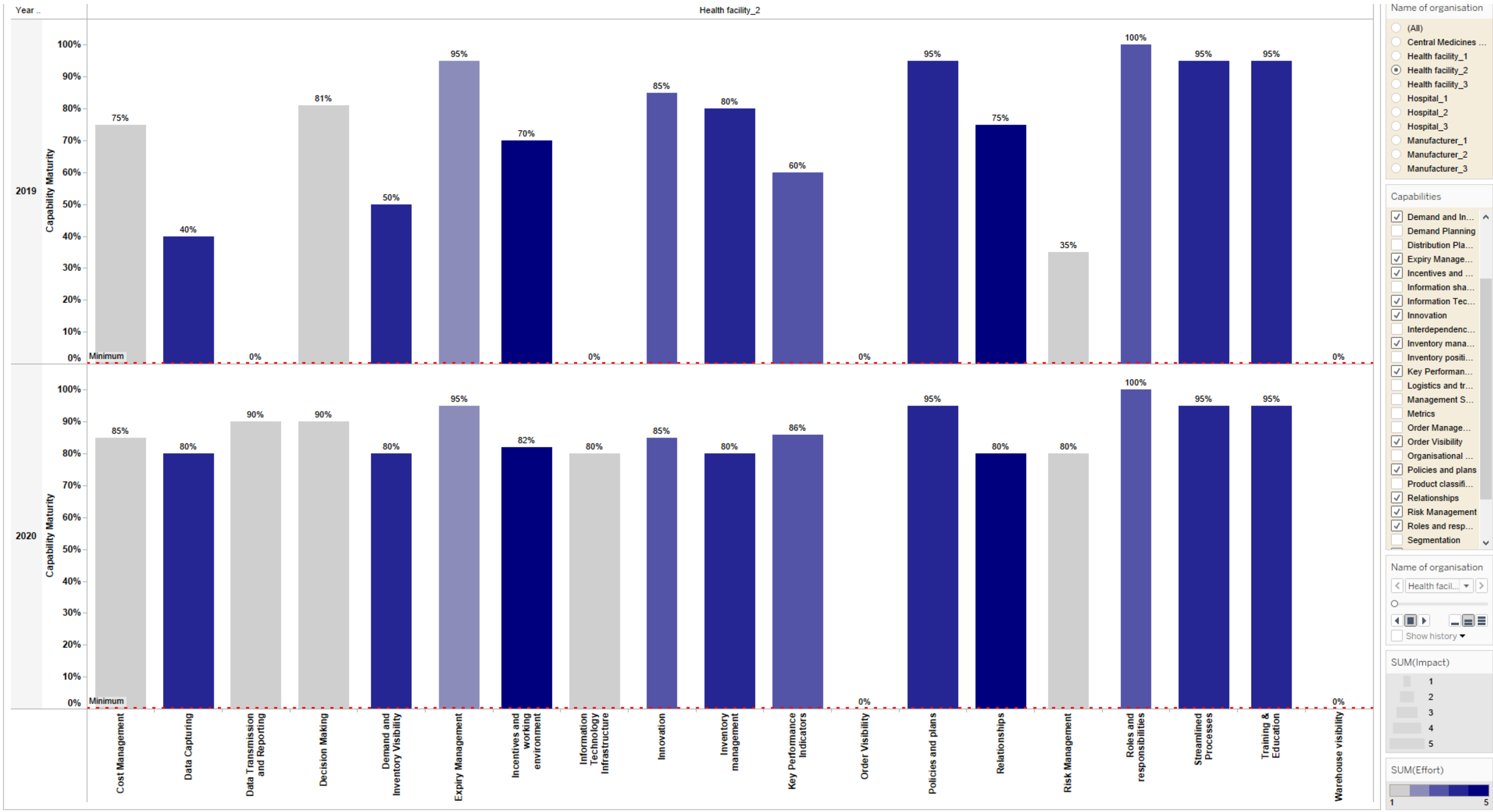


Figure 12: Capabilities Maturity Mapping (Health Facility 2)

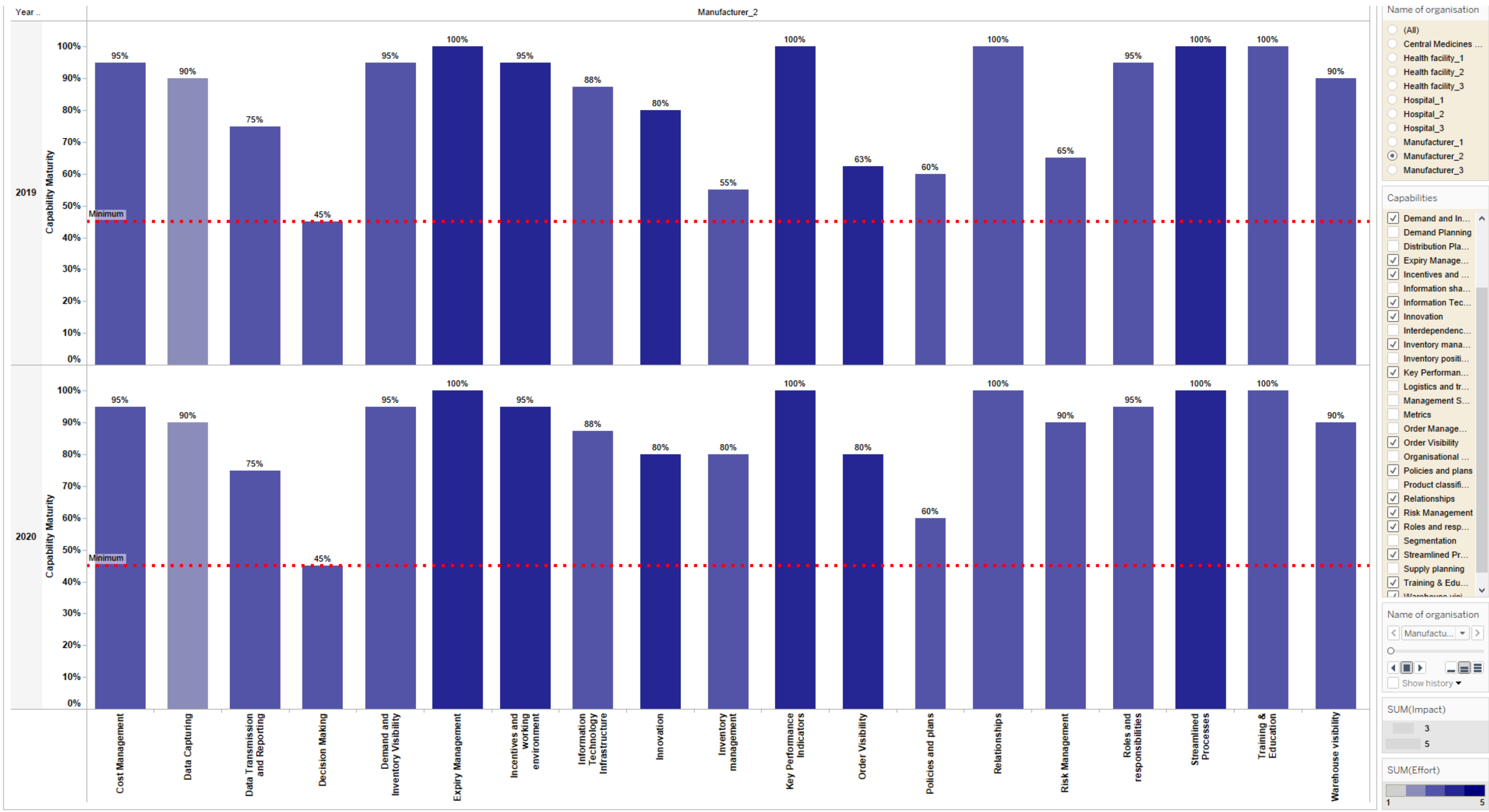


Figure 13: Capabilities Maturity Mapping (Manufacturer 2)

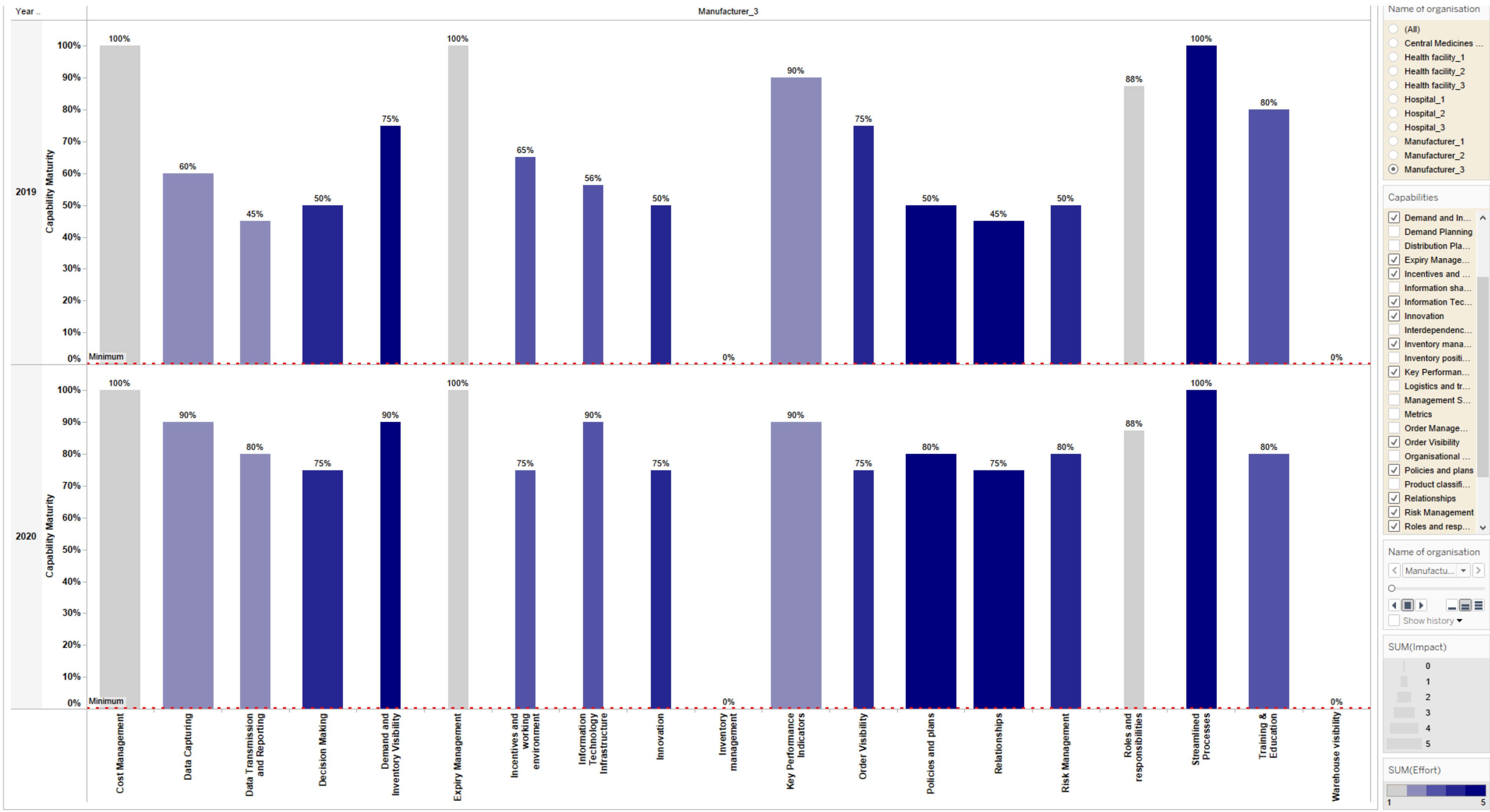


Figure 14: Capabilities Maturity Mapping (Manufacturer 3)

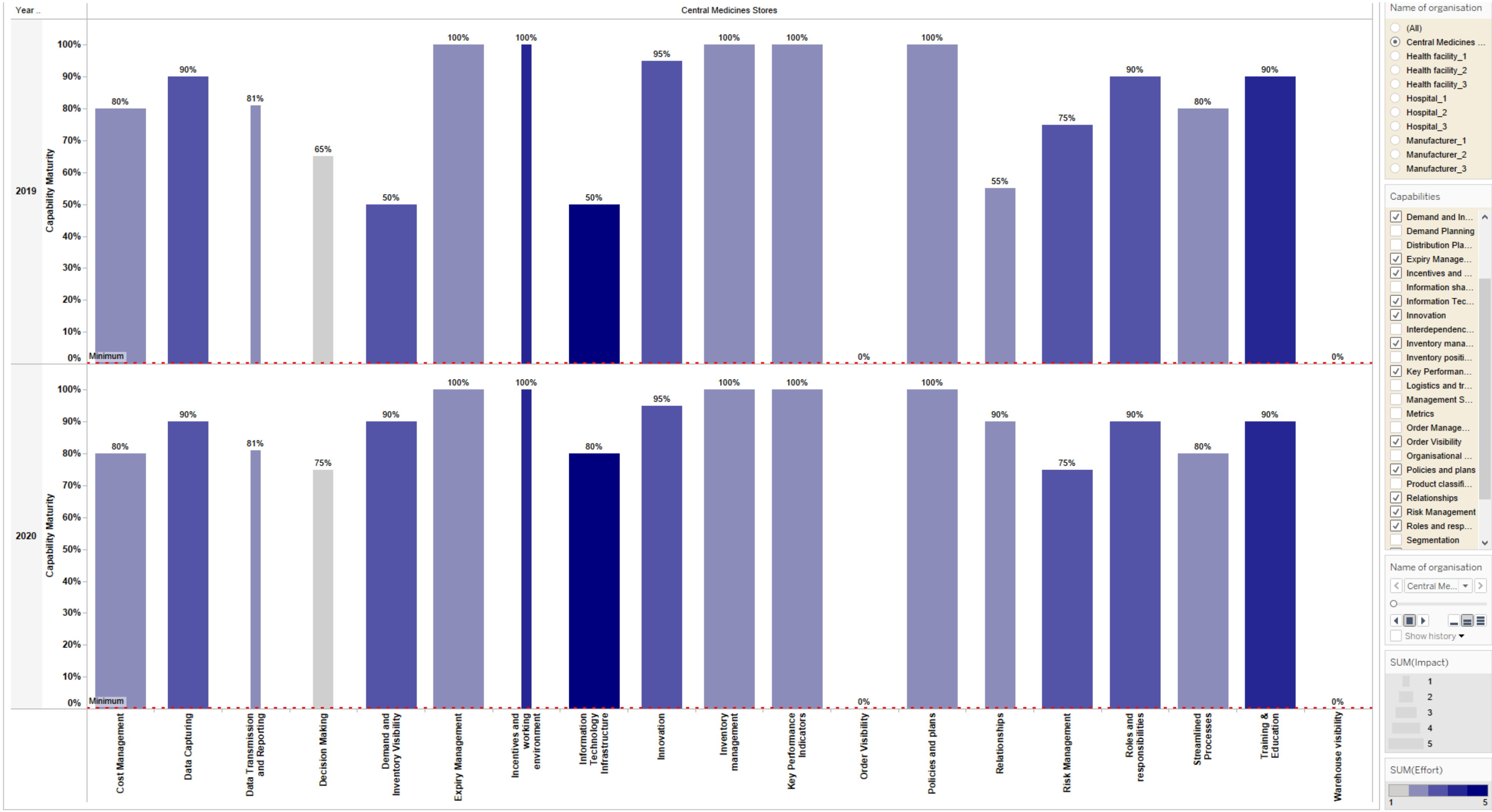


Figure 15: Capabilities Maturity Mapping (Central Medicines Stores 1)

Appendix 14: Assessment Outcomes (Sample of Raw data)

This section provides an outline of the raw data sets collected from unique supply chain nodes.

Table 10: Hospital 2 - (Assessment Tool for the Hospital Node)

Sub-dimension	Capabilities	Extent	Weight	Average weighting	Effort	Impact
Risk Management	•Stock management risk assessment mechanism in place	3	0,15	0,85	3	5
	•Potential stock management risks identified	3	0,15			
	•Risk Analysis (weight factors applied to identified risks)	3	0,15			
	•Contingency plans to mitigate stock management risks and stock supply disruptions in place	4	0,2			
	•Dedicated stock management systems and Predictive analytics tools utilised to timely identify & monitor & mitigate stock management risk	4	0,2			
Inventory Management	•Medicines Stock Storeroom layout is formally reviewed on a regular basis •Systematic processes followed to ensure reliable and accurate records of information	4	0,2	0,95	1	2
	•Good inventory accuracy-greater than 99% •There is a performance management process implemented to coach staff handling medicine stock on continuous improvement processes •Full housekeeping in place •Dynamic policy on how much inventory should be kept at the facility with defined min/max levels • Inventory audits (cycle counting)	4	0,2			
	•Lean practices (5S) implemented and owned by all •Medicines stock management staff are well trained with all skills required to excel in the job and deliver the expected customer service, keep good product integrity, high picking accuracy, low cycle time and low operational costs. •Stock management staff is adequate and is equipped to perform medicine stock keeping and supply chain planning work	3	0,15			
	• Medicine stock store room is designed to provide flexibility, high density and speed to cope with customer demand. • Innovation through skilled supply chain workforce •Standard operating procedures in place for inventory management •On-time and in-full [delivery] (OITF) of medicines stock	4	0,2			
	• Orders created based on actual demand	4	0,2			
Storeroom Visibility & Automation	•Technologies & Data is leveraged to improve operations such as the ability to locate specific product within the store room	0	0	0	5	5
	•Basic automation using barcodes to ensure visibility of incoming and outgoing inventory	0	0			
	•Advanced warehouse automation and mechanisation leveraged (RFID, GS1)	0	0			
	•Track and trace inventory identity, status, quantity, location. •Real-time exception management through alert messaging.	0	0			
	•Medicines Stock Management system integrated with the standardised digital supply chain platform that connect with other supply chain partners	0	0			
Expiry Management	•Policy in place for expired healthcare products management followed and audited	4	0,2	1	1	1

Sub-dimension	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Norms and standards for healthcare products wastage are defined	4	0,2			
	•Tracking of expiry dates for medicines and wastage risk	4	0,2			
	•Established policy for systematic picking of expired medicines (FEFO) •Quarantine area in facilities	4	0,2			
	•Expired medicines quantity is measured, managed and reported on the digital supply chain platform	4	0,2			
Demand and Inventory Visibility	•Visibility on inventory consumption (percentage of demand and inventory visibility)	4	0,5	1	1	1
	•Good communication and collaboration with central medicines stores	4	0,5			
Order Visibility	•Order transaction and movement is visible to supply chain partners (percentage of order visibility)	0	0	0	5	4
	•Online real-time order configuration and updates	0	0			
Information Technology Infrastructure	•Basic integration of Information Management systems and database systems with analytical tools to facilitate ease of information sharing and analysis	0	0	0,1875	4	4
	•Advanced stock management systems and technologies (e.g., web based application) provide information seamlessly between supply chain partners (other facilities, CMD) to enable collaborative planning, monitoring, evaluation, and execution	0	0			
	•IT architecture keeps tracks of plans and monitors stock buffers and triggers alerts in case of unexpected deviations •Efficient information management system that produce management reports on stock levels, usage patterns and expenditure trends	3	0,188			
	•Technology architecture that links interlocking roles and responsibilities between the supplier, national, provinces, districts, healthcare facilities & 3PLs and monitors end-to-end performance and alert exceptions, analytical tools and modelling capabilities for advanced decision support	0	0			
Data Transmission and Reporting	•Information Technology architecture produces static reports and the reports are distributed in paper format	0	0	0,2	3	4
	•Information Technology supports static reports with graphical data & reports are distributed digitally	2	0,1			
	•Information Technology architecture supports dynamic data navigation and reports are distributed automatically and digitally	2	0,1			
	•Information Technology architecture supports dynamic statistical analysis and reports are directly and constantly available to relevant supply chain partners (Other facilities, CMD, Manufacturers)	0	0			
	•Information Technology architecture support dynamic scenario analysis and reports are directly and constantly available to relevant supply chain partners (other facilities, CMD, manufacturers)	0	0			
Data Capturing	•Procedures and pharmaceutical data management standards exist to guide capturing and reporting of medicines supply and consumption data	3	0,15	0,75	3	3
	•Electronic solutions to strengthen data collection and reporting	3	0,15			
	•Data (master data/information) consistently defined and harmonised throughout the organisation	3	0,15			
	Clear, institutionalised policies for capturing and reporting of supply and inventory usage	3	0,15			
	•Data (master data/information) consistently defined and harmonised •Automated processes for data aggregation analysis & sharing	3	0,15			
Relationships	•Supply chain actors value collaboration	2	0,125	0,6875	3	5
	•Basic collaboration in cross functional teams	3	0,188			
	•Inter-organisation (facilities) collaboration.	3	0,188			

Sub-dimension	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Sharing of risk and benefits with other supply chain partners (ie sharing of stock when there are stock-outs situations)	3	0,188			
Decision Making	•Joint knowledge creation and innovation with supply chain partners (other facilities, CMD, manufacturers)	1	0,063	0,6875	3	5
	•Collaborative setting & alignment of KPIs with other supply chain partners (other facilities, CMD, manufacturers)	1	0,063			
	•Data is used as an input to decision making	4	0,25			
	•Collaborative decision making & problem solving with other supply chain partners (Other facilities, CMD, manufacturers) driven by available data	3	0,188			
	•Technology supports automated decision making for all stock management staff	2	0,125			
Key Performance Indicators	•Performance Indicators imbedded in the organisation	2	0,1	0,2	3	4
	•Regular reporting of KPIs through a KPI Dashboard/Scorecard accessible by all partners in the medicines supply chain (other facilities, CMD, manufacturers)	0	0			
	•Regular monitoring and tracking of KPIs against goals & there is transparency	0	0			
	•Metrics can support managers to assess the overall stock management process & diagnose problems and plan actions progressively	1	0,05			
	•Root cause analysis & corrective actions consistently taken into consideration to improve performance based on monitoring and evaluation results	1	0,05			
Policies and plans	•A strategic plan that addresses human resource requirements for stock management functions and personnel is authored	0	0	0,1	5	5
	•Organisation structure adequately supports stock management functions	2	0,1			
	•Clear & detailed human resource policies, norms, standards are available and fully implemented and adhered to at all levels , guiding and supporting the management of human resources in the stock management	0	0			
	•Distinct and permanent budget line exists for stock management human resource strengthening activities (i.e. training, incentives, coaching, performance management) and has actual funding allocated to it	0	0			
	•Workforce plans are updated annually and used to inform recruiting and other staffing decisions for stock management	0	0			
Clear roles & responsibilities	•SOPs for stock management tasks are available and utilised at all levels	4	0,2	0,8	2	2
	•Job tasks are based on applicable competency model	3	0,15			
	•Roles & responsibilities are clarified & documented	4	0,2			
	•Suitable qualified stock management official with SC training available who observes SOPs to ensure staff is motivated and receives continuous training	2	0,1			
	•High performing teams are formed & stock management leaders are empowered	3	0,15			
Innovation	•Basic approaches to stock management problem solving	3	0,15	0,75	3	3
	•Innovative ideas tolerated and utilised to solve stock management issues	4	0,2			
	•Stock management personnel have expertise , qualified and are able to define and solve complex problems	3	0,15			
	•Skilled staff with proactive approach to evidence-based quality improvements	3	0,15			
	•Systematic thinking capabilities stock management staff, •Strategies to promote innovation and creativity among stock management staff	2	0,1			
Incentives and working environment	•Incentives and rewarding strategies in place and utilised for reaching goals & targets	1	0,05	0,55	3	5
	•Motivation to stock management staff for proper and accurate demand and inventory data collection, reporting and analysis	1	0,05			
	•Good working environment and working conditions support performance	3	0,15			

Sub-dimension	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Workers have good work culture and have a sense of ownership for their roles and are motivated to do their jobs	3	0,15			
	•Stock management staff has high accountability, engagement and empowerment	3	0,15			
Training & Education	•Resources available to train facility staff to manage planning and ordering of stock based on actual demand	4	0,2	0,55	4	4
	• Education & development framework & Programme in place which directs & coordinates the delivery of a learning environment & continuous training for staff	1	0,05			
	• Material management personnel have training for recording and reporting supply and inventory usage	1	0,05			
	•Personnel with supply chain expertise guide and inform supply chain-related strategic policy, programmatic, and funding decisions.	4	0,2			
	•Senior level champions for human resource stock management with sufficient budget, tools, and authority actively and fully empower the development of stock management personnel.	1	0,05			
Streamlined Processes	•Procedures exist for most stock management processes	4	0,2	0,75	3	4
	•Innovation excellence is a key to successful processes & is infused into all stock management processes	3	0,15			
	•Standard operating procedures for stock management processes	4	0,2			
	•Standard operating procedures aligned to other facilities and are accredited	1	0,05			
	•Standard operating procedures for Stock management processes are optimised & continuously improved	3	0,15			
Cost Management	•Basic tracking of stock management costs	4	0,2	0,65	3	2
	•Stock management costs are measured and quantified	3	0,15			
	•Developed and dedicated systems and tools to measure, quantify and track stock management costs	3	0,15			
	•Financial deviations from target are actively managed	3	0,15			
	•Full visibility of stock management costs through the digitalised supply chain platform accessible to relevant partners	0	0			

Table 11: Health facility 2 - (Assessment Tool for the Health facility Node)

Sub-dimension	Capabilities	Extent	Weight	Average weighting	Effort	Impact
Risk Management	•Supply chain risk assessment mechanism in place	2	0,1	0,35	1	4
	•Potential supply chain risks identified	2	0,1			
	•Risk Analysis (weight factors applied to identified risks)	1	0,05			
	•Contingency plans to mitigate supply chain risks and supply chain disruptions in place	2	0,1			
	•Dedicated supply chain systems and Predictive analytics tools utilised to timely identify & monitor & mitigate supply chain risk & contingency plans	0	0			
Inventory Management	•Medicines Stock Storeroom layout is formally reviewed on a regular basis •Systematic processes followed to ensure reliable and accurate records of information	1	0,05	0,8	4	5
	•Good inventory accuracy-greater than 99% •There is a performance management process implemented to coach staff handling medicine stock on continuous improvement processes •Full housekeeping in place	4	0,2			

Sub-dimension	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Dynamic policy on how much inventory should be kept at the facility with defined min/max levels • Inventory audits (cycle counting)					
	•Lean practices (5S) implemented and owned by all •Medicines stock management staff are well trained with all skills required to excel in the job and deliver the expected customer service, keep good product integrity, high picking accuracy, low cycle time and low operational costs. •Healthcare supply chain staff is adequate and is equipped to perform medicine stock keeping and supply chain planning work	3	0,15			
	• Medicine stock store room is designed to provide flexibility, high density and speed to cope with customer demand. • Innovation through skilled supply chain workforce •Standard operating procedures in place for inventory management •On-time and in-full [delivery] (OITF) of medicines stock	4	0,2			
	• Orders created based on actual demand	4	0,2			
Storeroom Visibility & Automation	•Technologies & Data is leveraged to improve operations such as the ability to locate specific product within the store room	0	0	0	1	5
	•Basic automation using barcodes to ensure visibility of incoming and outgoing inventory	0	0			
	•Advanced warehouse automation and mechanisation leveraged (RFID, GS1)	0	0			
	•Track and trace inventory identity, status, quantity, location. •Real-time exception management through alert messaging.	0	0			
	•Medicines Stock Management system integrated with the standardised digital supply chain platform that connect with other supply chain partners	0	0			
Expiry Management	•Policy in place for expired healthcare products management followed and audited	3	0,15	0,95	2	4
	•Norms and standards for healthcare products wastage are defined	4	0,2			
	•Tracking of expiry dates for medicines and wastage risk	4	0,2			
	•Established policy for systematic picking of expired medicines (FEFO) •Quarantine area in facilities	4	0,2			
	•Expired medicines quantity is measured, managed and reported on the digital supply chain platform	4	0,2			
Demand and Inventory Visibility	•Visibility on inventory consumption (percentage of demand and inventory visibility)	4	0,5	0,5	4	5
	•Good communication and collaboration with central medicines stores	0	0			
Order Visibility	•Order transaction and movement is visible to supply chain partners (percentage of order visibility)	0	0	0	1	5
	•Online real-time order configuration and updates	0	0			
Information Technology Infrastructure	•Basic integration of Information Management systems and database systems with analytical tools to facilitate ease of information sharing and analysis	0	0	0	1	5
	•Advanced supply chain systems and technologies (e.g., web based application) provide information seamlessly between supply chain partners to enable collaborative planning, monitoring, evaluation, and execution	0	0			
	•IT architecture keeps tracks of plans and monitors stock buffers and triggers alerts in case of unexpected deviations •Efficient information management system that produce management reports on stock levels, usage patterns and expenditure trends	0	0			
	•Technology architecture that links interlocking roles and responsibilities between the supplier, national, provinces, districts, healthcare facilities & 3PLs and monitors end-to-end performance and alert exceptions, analytical tools and modelling capabilities for advanced decision support	0	0			
Data Transmission and Reporting	•Information Technology architecture produces static reports and the reports are distributed in paper format	0	0	0	1	5
	•Information Technology supports static reports with graphical data & reports are distributed digitally	0	0			

Sub-dimension	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Information Technology architecture supports dynamic data navigation and reports are distributed automatically and digitally	0	0			
	•Information Technology architecture supports dynamic statistical analysis and reports are directly and constantly available to relevant supply chain partners	0	0			
	•Information Technology architecture support dynamic scenario analysis and reports are directly and constantly available to relevant supply chain partners	0	0			
Data Capturing	•Procedures and pharmaceutical data management standards exist to guide capturing and reporting of medicines supply and consumption data	4	0,2	0,4	4	5
	•Electronic solutions to strengthen data collection and reporting	0	0			
	•Data (master data/information) consistently defined and harmonised throughout the organisation	0	0			
	Clear, institutionalised policies for capturing and reporting of supply and inventory usage	4	0,2			
	•Data (master data/information) consistently defined and harmonised throughout the supply chain •Automated processes for data aggregation analysis & sharing	0	0			
Relationships	•Supply chain actors value collaboration	4	0,25	0,75	5	5
	•Basic collaboration in cross functional teams	0	0			
	•Inter-organisation (facilities) collaboration.	4	0,25			
	•Sharing of risk and benefits with other supply chain partners (ie sharing of stock when there are stock-outs situations)	4	0,25			
Decision Making	•Joint knowledge creation and innovation with supply chain partners	4	0,25	0,81 25	1	5
	•Collaborative setting & alignment of KPIs with other supply chain partners	3	0,18 75			
	•Data is used as an input to decision making	3	0,18 75			
	•Collaborative decision making & problem solving with other supply chain partners driven by available data	3	0,18 75			
	•Technology supports automated decision making for all supply chain partners	0	0			
Key Performance Indicators	•Performance Indicators imbedded in the organisation	4	0,2	0,6	3	5
	•Regular reporting of KPIs through a KPI Dashboard/Scorecard accessible by all partners in the medicines supply chain	0	0			
	•Regular monitoring and tracking of KPIs against goals & there is transparency	0	0			
	•Metrics can support managers to assess the overall supply chain health, diagnose problems and plan actions progressively	4	0,2			
	•Root cause analysis & corrective actions consistently taken into consideration to improve performance based on monitoring and evaluation results	4	0,2			
Policies and plans	•A strategic plan that addresses human resource requirements for supply chain functions and personnel is authored	3	0,15	0,95	4	5
	•Supply chain organisation structure adequately supports supply chain functions	4	0,2			
	•Clear & detailed human resource policies, norms, standards are available and fully implemented and adhered to at all levels , guiding and supporting the management of human resources in the supply chain	4	0,2			
	•Distinct and permanent budget line exists for supply chain human resource strengthening activities (i.e. training, incentives, coaching, performance management) and has actual funding allocated to it	4	0,2			
	•Workforce plans are updated annually and used to inform supply chain staff recruiting and other staffing decisions	4	0,2			
Clear roles & responsibilities	•SOPs for supply chain tasks are available and utilised at all levels	4	0,2	1	3	3

Sub-dimension	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Job tasks are based on applicable competency model	4	0,2			
	•Roles & responsibilities are clarified & documented	4	0,2			
	•Suitable qualified SC Official observing SOPs to ensure staff is motivated and receives continuous training	4	0,2			
	•High performing teams are formed & supply chain managers are empowered	4	0,2			
Innovation	•Basic approaches to supply chain problem solving	3	0,15	0,85	3	3
	•Innovative ideas tolerated and utilised to solve supply chain issues	3	0,15			
	•Supply chain personnel have expertise , qualified and are able to define and solve complex problems	3	0,15			
	•Skilled staff with proactive approach to evidence-based quality improvements	4	0,2			
	•Systematic thinking capabilities supply chain staff, strategies to promote innovation and creativity among supply chain staff	4	0,2			
Incentives and working environment	•Incentives and rewarding strategies in place and utilised for reaching goals & targets	0	0	0,7	5	5
	•Motivation to supply chain staff for proper and accurate demand and inventory data collection, reporting and analysis	3	0,15			
	•Good working environment and working conditions support performance	4	0,2			
	•Workers have good work culture and have a sense of ownership for their roles and are motivated to do their jobs	3	0,15			
	•Supply chain staff has high accountability, engagement and empowerment	4	0,2			
Training & Education	•Resources available to train facility staff to manage planning and ordering of stock based on actual demand	4	0,2	0,95	4	4
	•Education & development framework & Programme in place which directs & coordinates the delivery of a learning environment & continuous training for staff	4	0,2			
	• Material management personnel have training for recording and reporting supply and inventory usage	4	0,2			
	•Personnel with supply chain expertise guide and inform supply chain-related strategic policy, programmatic, and funding decisions.	3	0,15			
	•Senior level champions for human resource supply chain management with sufficient budget, tools, and authority actively and fully empower the development of supply chain personnel.	4	0,2			
Streamlined Processes	•Procedures exist for most supply chain and stock management processes	3	0,15	0,95	4	5
	•Innovation excellence is a key to successful processes & is infused into all supply chain processes	4	0,2			
	•Standard operating procedures for Supply chain and stock management processes	4	0,2			
	•Standard operating procedures aligned to other facilities and other supply chain partners and are accredited	4	0,2			
	•Standard operating procedures for Supply chain and Stock management processes are optimised & continuously improved	4	0,2			
Cost Management	•Basic tracking of supply chain costs	4	0,2	0,75	1	5
	•Supply chain costs are measured and quantified	4	0,2			
	•Developed and dedicated systems and tools to measure, quantify and track supply chain costs	4	0,2			
	•Financial deviations from target are actively managed	3	0,15			
	•Full visibility of supply chain costs amongst supply chain partners through the digitalised supply chain platform	0	0			

Table 12: Central Medicines Stores - (Assessment Tool for the CMS Node)

Sub-dimensions	Capabilities	Extent	Weight	Average weighting	Effort	Impact
Risk Management	•Risk assessment Framework in place	4	0,20			
	•Potential risks identified	4	0,20			
	•Risk Analysis (weight factors applied to identified risks - considering the risks with high impact)	3	0,15			
	•Contingency plans to mitigate risks and disruptions in place	4	0,20			
	•Dedicated Systems and Predictive Analytics (Data Analytics) utilised to timely identify & monitor & mitigate risk	0	0,00	0,75	3	5
Supply Planning	•Replenishment plan created based on inventory policies	4	0,20			
	•Replenishment plan is created from actual customer orders	4	0,20			
	•Integrated organisational replenishment plan created that is based on data (visibility to stock on hand & consumption data) within the whole organisation (lead-time, supplier constraints and stock-holding)	4	0,20			
	•Replenishment plan is included in a standardised digital IT platform that is accessible to relevant supply chain partners (connecting all partners)	0	0,00			
	•Automatic replenishment order execution via the standardised IT platform and operations staff just authorise	4	0,20	0,80	2	5
Distribution Planning	•Location of facilities is documented •Synchronisation: Visibility of transport capabilities	4	0,20			
	•Delivery scheduling	4	0,20			
	•3PL Service Levels Agreements defined and their performance is measured	4	0,20			
	•Data on replenishment orders, transport reliability, and costs of transport in current/future network scenarios, used to create a distribution plan.	4	0,20			
	•Strategic capacity planning (warehouse, labour and transport capacity)	4	0,20	1,00	2	5
Warehouse Operations (Inventory Management)	•There are service customer(ie clinics, hospitals) oriented KPIs (fill rate , perfect order..etc) in place •Product prioritization in the order processing system •Basic storage rack structures in place to maximise warehouse density •Warehouse density is prioritised to increase asset utilisation •Warehouse layout is formally reviewed on a regular basis to increase warehouse productivity and reduce safety risks •Single forklifts are used most of the time to perform product put-away, retrieval and truck loading	4	0,20			
	•Warehouse operations are well executed with good operational performance (Good inventory accuracy-greater than 99%, increased warehouse productivity, downward trend on warehouse cost) •Double forklifts are used most of the time (greater than 50% of the time) to perform product put-away, retrieval and truck loading •Front line supervisors can lead, and coach the warehouse team towards a continuous improvement process •Dynamic policy on how much inventory should be kept at the warehouse with defined min/max levels	4	0,20	1,00	2	5

Sub-dimensions	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Lean practices (5S, KAIZEN) (full house keeping in place) implemented and owned by all, to ensure clean, safe and efficient workplace in the warehouse •Warehouse employees are well trained with all skills required to excel in the job and deliver the expected customer service, keep good product integrity, high picking accuracy, low cycle time and low operational costs.	4	0,20			
	• Triples or Quad forklifts are used most of the time (greater than 50%) to perform product put-away, retrieval and truck loading. • Innovation through skilled workforce, standard operating procedures and multifunctional teams.	4	0,20			
	•Segments (ie clinics, hospitals) Out of stock monitoring & Product Out-of-Stock in the segments (not OOS in the warehouse) is a key performance indicator in the warehouse metrics	4	0,20			
Warehouse Visibility & Automation	•Technologies & Data is leveraged to improve operations such as the ability to locate specific product within the warehouse	0	0,00			
	•Basic automation using barcodes to ensure visibility of incoming and outgoing inventory	0	0,00			
	•Advanced warehouse automation and mechanisation leveraged (RFID, GS1)	0	0,00			
	•Real-time exception management through alert messaging for low inventory levels in the warehouse	0	0,00			
	•Warehouse Management System integrated with the standardised digital IT platform that connect with other supply chain partners (manufacturers, health facilities)	0	0,00	0,00	5	5
Order Management	•Formal standards for order management	4	0,20			
	•Procedures in place to review, process & prioritise customer orders •Customer order accuracy with specific customer requirements	4	0,20			
	•Integrating customer order management with procurement processes	4	0,20			
	•Providing holistic, real-time order process support with value-added functions like inventory status in the warehouse to facilities and manufacturers through an IT platform	0	0,00			
	•Automated order management by IT platform	4	0,20	0,80	2	5
Expiry Management	•Policy in place for expired healthcare products management followed and audited	4	0,20			
	•Norms and standards for healthcare products wastage are defined	4	0,20			
	•Tracking of expiry dates for medicines and wastage risk	4	0,20			
	•Established policy for systematic picking of expired medicines (FEFO) •Quarantine area in facilities	4	0,20			
	•Expired medicines quantity is measured, managed and reported on the digital supply chain platform	4	0,20	1,00	2	5
Logistics and transport Flexibility	•Distribution operation is customer driven (oriented on customer service i.e.. On time and In full delivery) • Routing optimisation tool to optimise distribution •Track and trace solution to manage the distribution operation •Basic delivery mechanism in place •Bundling of goods to utilise available truck capacity efficiently as possible to meet replenishment plan	4	0,20	1,00	2	5

Sub-dimensions	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Distribution operation is well executed with dynamic dispatching based on customer orders received. •Distribution Fleet policy in place •Planned and Scheduled delivery routes documented •Tailoring transportation to meet segmentation needs	4	0,20			
	•Information from the tracking tool is used to identify variances and root causes and define action plans to adjust plan or execution, depending on the root cause variance & root cause analysis •Formal returns management process •Dynamic routing based on actual demand needs •Flexibility to change the content of delivery and routes through full "truck loads" & full "pallet loads"	4	0,20			
	• Real time track and trace tool is implemented and allows managing and acting to solve distribution problems during the delivery route. •There is a closed loop process that feedback actual information to the route optimization planning tool to improve compliance to plan of the distribution route. • Estimated time of arrival (ETA) is provided to all customers before delivery of products •Transport arrives on time for warehouse/facilities appointments with defined service level agreements that are measured and managed •Optimisation of scheduling routing based on actual demand data	4	0,20			
	•ETA is dynamically updated as the route is executed and communicated to customers to ensure right delivery •Proof of Delivery (POD) used and returned to the warehouse •Coordinated replenishment programs •Optimisation of transport modes and routes continuously	4	0,20			
Information sharing & Information Quality	•Accurate demand and inventory data from downstream (facilities) available in real time and this data is integrated into the demand planning process • Upstream (manufacturing) Inventory data is available	2	0,17			
	•An integrated decision support system exist and provide customer data between supply chain partners •Transparency on demand, inventory & capacity information amongst supply chain stakeholders	0	0,00			
	•Full access to and use of supply chain partners information replenishment •Information availability, accessibility, and usability from all actors on appropriately aggregated levels at the right time at the right place	0	0,00	0,17	3	5
Demand and Inventory Visibility	•Lead-time visibility of all suppliers and partners	4	0,33			
	•Inventory and demand information is shared across the supply chain to provide visibility to all echelons	2	0,17			
	•Master data accuracy and availability & timeliness to relevant supply chain partners available on a standardised digital supply chain platform that is accessible to relevant supply chain stakeholders	0	0,00	0,50	3	5
Order Visibility	•Order transaction and movement is visible to supply chain partners and customers (upstream and downstream)	0	0,00			
	•Online real-time order configuration and updates through the IT platform	0	0,00	0,00	1	1

Sub-dimensions	Capabilities	Extent	Weight	Average weighting	Effort	Impact
Information Technology Infrastructure	•Basic integration of Information Technology Systems with Data Analytical tools to facilitate ease of information analysis	4	0,25			
	•Advanced supply chain systems and technologies provide information seamlessly between supply chain partners to enable collaborative planning, monitoring, evaluation, and execution (integrate IT platform connecting all partners)	1	0,06			
	•IT architecture keeps tracks of plans and monitors stock buffers and triggers alerts in case of unexpected deviations	2	0,13			
	•Technology architecture with modelling capabilities for advanced decision support	1	0,06	0,50	5	5
Data transmission and reporting	•Information Technology supports static reports with graphical data & reports are distributed digitally	4	0,25			
	•Information Technology architecture supports dynamic data navigation and reports are distributed automatically and digitally	4	0,25			
	•Information Technology architecture supports dynamic statistical analysis and reports are directly and constantly available to relevant supply chain partners	4	0,25			
	•Information Technology architecture support dynamic scenario analysis and reports are directly and constantly available to relevant supply chain partners	1	0,06	0,81	2	4
Data Capturing	•Procedures and pharmaceutical data management standards exist to guide capturing and reporting of medicines supply and consumption data	4	0,20			
	•Electronic solutions to strengthen data collection and reporting	4	0,20			
	•Data (master data/information) consistently defined and harmonised throughout the organisation	3	0,15			
	Clear, institutionalised policies for capturing and reporting of supply and inventory usage	4	0,20			
	•Data (master data/information) consistently defined and harmonised throughout the supply chain •Automated processes for data aggregation analysis & sharing	3	0,15	0,90	3	5
Relationships	•Supply chain actors value collaboration	4	0,20			
	•Basic collaboration in cross functional teams	4	0,20			
	•Inter-organisation collaboration	3	0,15	0,55	2	3
Decision Making	•Joint knowledge creation and innovation with supply chain partners	3	0,15			
	•Collaborative setting & alignment of KPIs with other supply chain partners	0	0,00			
	•Data is used as an input to decision making	4	0,20			
	•Collaborative decision making & problem solving with other supply chain partners driven by available data	3	0,15			
	•Technology supports automated decision making for all supply chain partners	3	0,15	0,65	1	2
Key Performance Indicators	•Performance Indicators imbedded in the organisation	4	0,20			
	•Regular reporting of KPIs through a KPI Dashboard/Scorecard accessible by all partners in the medicines supply chain	4	0,20			
	•Regular monitoring and tracking of KPIs against goals & there is transparency	4	0,20			
	•Metrics can support managers to assess the overall supply chain health, diagnose problems and plan actions progressively	4	0,20	1,00	2	5

Sub-dimensions	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Root cause analysis & corrective actions consistently taken into consideration to improve performance based on monitoring and evaluation results	4	0,20			
Metrics	•On Time In Full (OTIF) Tracking. •Supply chain RELIABILITY and STABILITY levels defined in organisational strategy •Supply chain AGILITY levels and SPEED/VELOCITY defined in organisational strategy •Supply chain RESPONSIVENESS level defined in organisational strategy	4	0,33			
	•Customer order fulfilment and on-time deliveries are (<100%) and high customer satisfaction, •Ontime delivery & percentage of returned goods established against well defined targets •Supply chain RELIABILITY and STABILITY measured and quantified •Supply chain AGILITY and SPEED/ VELOCITY measured and quantified •Supply chain RESPONSIVENESS measured and quantified	4	0,33			
	•Controls in place to improve supply chain reliability, Agility, Speed, Responsiveness, & Stability •Controls in place to improve supply chain RELIABILITY, AGILITY, STABILITY, SPEED/VELOCITY and RESPONSIVENESS	4	0,33	1,00	1	4
Policies and plans	•A strategic plan that addresses human resource requirements for operations functions and personnel is authored (adequate staff for warehouse operations)	4	0,20			
	•Organisational structure adequately supports operations functions	4	0,20			
	Human resource policies guide and support the management of human resources in operations	4	0,20			
	•Distinct and permanent budget line exists for human resource strengthening activities in operations (i.e. training, incentives, coaching, performance management)	4	0,20			
	•Workforce plans are updated annually and used to inform operations recruiting and other staffing decisions	4	0,20	1,00	2	5
Roles and responsibilities	•SOPs for operations tasks are available and utilised at all levels	4	0,20			
	•Job tasks are based on applicable competency model	4	0,20			
	•Roles & responsibilities are clarified & documented	3	0,15			
	•Suitable qualified operations Official observing SOPs to ensure staff is motivated and receives continuous training	4	0,20			
	•High performing teams are formed & operations managers are empowered	3	0,15	0,90	3	5
Innovation	•Basic approaches to supply chain problem solving	4	0,20			
	•Innovative ideas tolerated and utilised to solve operations issues	4	0,20			
	•Operations personnel have expertise, qualified and are able to define and solve complex problems	4	0,20			
	•Skilled staff with proactive approach to evidence-based quality improvements	4	0,20			
	•Operations staff has Systematic thinking capabilities •Strategies in place to promote innovation and creativity among operations staff	3	0,15	0,95	3	4
Incentives and working environment	•Incentives and rewarding strategies in place and utilised for reaching goals & targets	4	0,20			
	•Motivation to operations staff for proper and accurate demand and inventory data collection, reporting and analysis	4	0,20	1,00	4	1

Sub-dimensions	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Good working environment and working conditions support performance	4	0,20			
	•Workers have good work culture and have a sense of ownership for their roles and are motivated to do their jobs	4	0,20			
	•Operations staff has high accountability, engagement and empowerment	4	0,20			
Training & Education	•Resources to train operations staff to manage replenishment of stock based on actual demand	4	0,20			
	• Education development framework & Programme in place which directs & coordinates the delivery of a learning environment & continuous training for staff	3	0,15			
	• Material management personnel have adequate training for recording and reporting supply and inventory usage	4	0,20			
	•Personnel with supply chain expertise guide and inform supply chain-related strategic policy, programmes, and funding decisions.	4	0,20			
	•Senior level champions for human resource management in operations are equipped with tools and enough budget to actively and fully empower the development of operations personnel.	3	0,15	0,90	4	5
Management Support	•Upper Management support for operations processes	4	0,25			
	•Top management supporting resource allocation and partnering strategies	4	0,25			
	•Top management strongly understand support the building of adaptive demand based networks	4	0,25			
	•Appointed operations director (with supply chain experience) who sits on the organisational board	4	0,25	1,00	2	5
Organisational Vision	•Understanding of actual customer demand and translation of that into strategies and plans to satisfy the actual demand	4	0,25			
	•Organisational vision does clearly define customer orientation & demand-pull replenishment as a core competency	4	0,25			
	•Customer-pull-driven fulfilment as well as outsourcing all non-core supply chain activities to third -party logistics	4	0,25			
	•Customer -focused, collaborative culture is firmly in place. •Supply chain scope encompasses multi-echelon supply network (end to end supply chain configuration)	4	0,25	1,00	2	5
Streamlined Processes	•Procedures exist for most operations processes	4	0,20			
	•Innovation excellence is a key to successful processes & is infused into all operations processes	4	0,20			
	•Standard operating procedures for operations processes	4	0,20			
	•Standard operating procedures are aligned to/with other supply chain partners and are accredited (ie ISO)	0	0,00			
	•Standard operating procedures for operations management processes are optimised & continuously improved	4	0,20	0,80	2	5
Alignment of Objectives	•Consensus on supply chain strategy	4	0,20			
	•A demand-driven supply chain strategy is developed (replenishment based on actual demand not forecasted demand)	4	0,20			
	•A comprehensive demand-driven supply chain strategy is defined & implemented	4	0,20			
	•Alignment of organisational KPIs with end-to-end supply chain goals & objectives.	4	0,20	1,00	2	5

Sub-dimensions	Capabilities	Extent	Weight	Average weighting	Effort	Impact
	•Continuous review & update of the demand-driven supply chain strategy	4	0,20			
Cost Management	•Basic tracking of operations costs	4	0,20			
	•Operations costs are measured and quantified	4	0,20			
	•Developed and dedicated systems and tools to measure, quantify and track operations costs	4	0,20			
	•Financial deviations from target are actively managed	4	0,20			
	•Full visibility of operations costs amongst relevant supply chain partners through the digitalised IT platform	0	0,00	0,80	2	5

Appendix 15: Experiences of supply chain leaders

Supply Chain Top 25, identifying supply chain leaders and highlighting their best practices.

Table 13: Gartner Supply Chain Rankings of the 2016 Supply Chain Top 25

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
Unilever	Consumer products	•willingness to share best practices with the broader supply chain community. •platform to crowdsource innovations for sustainable products as part of its "sustainable living" plan.	•significant investments in regional operational centers that support all facets of the customer order-to-cash process. This work is yielding cost savings through economies of scale and common processes, as well as the ability to better support customer needs by applying analytics to a common CRM system. •Improvement of product life cycle management through global reuse initiatives, product platform thinking for scalable global growth and a segmentation-based approach.	•achieving zero waste through its "four R approach" — reducing, reusing, recovering or recycling — and treating waste as a resource with alternate uses, such as converting factory waste to building materials or composting food waste from staff cafeterias. Longer term, it aspires to be "carbon-positive" by 2030.
McDonald's	Restaurant	•Orchestrating the upstream supply chain through promoting and acting as the conduit between outsourced vendors, suppliers, corporate stores and franchise partners •uses council meetings to collaborate with suppliers on new product innovation and technology, as well as on plant safety •Base expectations with suppliers are managed through a standard supplier performance index, but the differentiator is more cultural and behavioral, as partners tend to put the McDonald's system. first	x	x

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
		when sharing product and process innovations and staffing support teams with top talent. •Working closely with suppliers •broad-scale effort to retool restaurants previously configured for a more traditional daily menu schedule. •McDonald's supply chain actively participates on both product and menu category teams to help shape the portfolio and better plan for new initiatives.		
Amazon	Retailer	•leader when it comes to innovation in its products and supply chain •same day delivery service •to reduce dependency on third-party freighter services, Amazon is building its own logistics network to keep up with customer demand •testing drone aircraft, with the ultimate goal of creating a 30-minute order-to-delivery service	X	•a lack of transparency on supply chain sustainability and governance performance measures
Intel	Technology	•Growth opportunities through acquisition of chipmaker Altera in 2015 •entirely new ecosystem of China-based technology providers to support the ramp up of new tablet products in 2014	•Intel's supply chain is also acting as a test bed for new products offered by its IoT group, using this technology to improve the visibility and coordination of complex inbound capital equipment deliveries and outbound product shipments to customers.	•longtime focus on running an ethical and sustainable supply chain •largest U.S. purchaser of renewable energy certificates and when combined with in-house sources, gets 100% of the 3.1 billion kilowatt-hours of electricity its operations consumes annually from green sources

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
H&M	Fast fashion retailer	•part of a recent coalition of top clothing companies that called on governments to agree to a strong climate change deal based on concerns that long-term climate effects could harm production of one if its major inputs, cotton •operates its supply chains tailored by product type, with 80% of volume built to plan at standard, cost-efficient lead times and the remaining 20% that is agile and can respond to fashion trends by going from design to hanger in as little as 20 days.	•digital efforts are moving less quickly, as it grapples with the added shipping, handling and price deterioration associated with online returns.	•strong record in sustainability and workers' rights. •fashion industry innovation accelerator for sustainable clothing.
Inditex (Zara)	Fashion retail group	•Organisational culture is very team-oriented and focused on having talented practitioners run the business using best-in-class processes versus the personality driven cultures often found at fashion houses. •A dedicated team converts voice of the customer feedback gathered from the store and district network into prescriptive advice for the design teams	•E-commerce •A planning and analytics team that sorts through real-time sales trends to inform future design and production.	•set a goal to run 100% eco-efficient stores by 2020. •Tracks sustainability measures across all of its processes and will consume 30% less energy and 50% less water compared to a conventional store.

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
Cisco Systems	Networking	•created a new role managing both supply chain operations and the IT group, reflecting the high use of technology in managing supply chains.	•leveraged technology along with process improvement in supplier collaboration dimension. •A cloud-based partnering platform with suppliers that serves as a single source of truth for data, eliminating the bullwhip effect between Cisco, contract manufacturers and suppliers. •Full demand visibility, and suppliers can address shortages through alerts in a more automated way, removing Cisco as the potential bottleneck to the resolution process. •digitizing the logistics function. This includes connecting logistics to the broader supply chain with data, standards, automated event management and machine agents •new technologies to bear in its warehouses, including augmented reality, telematics and video analytics. This is part of a broader effort to digitize its supply chain. It is leveraging in-house Internet of Everything (IoE) technology to improve product quality, gain energy efficiency in operations and reach universal order visibility.	x
Samsung Electronics	Electronics	•supply chain has enabled a move into business-based products and solutions tailored for industry-specific uses across retail, education, hospitality, healthcare,	•gaining insight into consumer behaviors through connected devices	•use of sustainable materials in the Samsung Galaxy S6 and its long-term commitment to the proper disposal and recycling of e-waste

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
		finance and transportation. •innovate its products, with the most recent push being in virtual reality (VR), by offering a lower-cost device that converts its latest Galaxy smartphones into a full-on mobile VR headset. •The supply chain team continues to focus on improving customer collaboration		
The Coca Cola.Co	Food and Beverage	•Supply chain, in partnership with the business, is taking a value-based approach to product and packaging portfolio management. •Use its Freestyle smart delivery systems to tailor supply chain solutions by market and segment.	•full-service dispensing machine that can offer a myriad of choices by combining 100+ different sodas and juices	•set out ambitious sustainability goals for 2020 that include improving water and emissions efficiency by more than 20%,. •Empowering five million women across its value chain and several programs to improve nutritional content and reporting.
Nestlé	Consumer food	•supply chain has consistent priorities around fresh product availability, customer collaboration, capital efficiency, data-driven decision making, complexity management and people development. •focused on optimizing end-to-end process flows and rethinking quality across its broader value chain	•investing in predictive analytics for demand planning and enabling growth in its e-commerce business, which includes packaging tailored more for delivery than display in a store.	•use of "zero water" factories and conversion of bio-waste into renewable energy
Nike	Footwear and apparel	•Nike entered into an innovation and manufacturing partnership with outsource provider Flex that is expected to add value in terms of new manufacturing technologies and shorter cycle times.	•ramping new technologies •extended visibility to outsourced factory production and compliance, as well as to how stores are executing on merchandising, inventory and operations plans.	x

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
		•invested significantly in supply network design and PLM capabilities		
Starbucks	Coffee retailer	• Emphasis for the need for supply chain to have a seat at the boardroom table •Strong supply chain capability towards speedy delivery	•rolled out a click-and-collect feature through its online app that allows consumers to place and pay for orders that are routed to the nearest store for fast-lane pick up	•socially conscious company as evidenced by its program to reimburse employee college costs and the use of marketing to promote harmony in the community. It recently announced that it plans to donate all its leftover food at U.S. stores to charity
Colgate-Palmolive	Consumer products	•Continuous improvement and the concept of economic value-add are embedded in the supply chain and broader company's DNA. •Disciplined governance process.	•partnered with its enterprise software provider to co-develop supply chain control tower capabilities, including better demand sensing, inventory optimization and supply network planning. This has improved daily responsiveness and reduced inventory levels, while minimizing out of stock impacts	x
3M	Manufacturer	•regionalizing supply chains to reduce complexity, enhance operational impact and improve customer service	•accelerating disruptive technology to leverage innovation and deliver higher quality, lower-cost and even-more innovative products. •harmonizing global processes in alignment with a global ERP platform to deliver world-class productivity, inventory management and capital efficiency.	•aggressive 10-year sustainability goals that include reducing global water usage by 10%, improving energy efficiency by 30%, achieving "zero landfill" status for more than 30% of manufacturing sites and helping customers reduce CO2 emissions by 250 million tons

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
PepsiCo	Food and beverage	•tailored assortments and perimeter displays at the right store and time to drive sales.	•leveraging its near-real-time direct store delivery network visibility to support hyperlocal marketing, •global rollout of a standardized demand and supply planning platform that delivers base capabilities to emerging markets and a larger menu of capabilities for complex, mature markets. •partnering with commercial teams to deploy a total portfolio optimization governance process and tool that allows for data-driven assessment of portfolio health, detailed analysis relative to evaluation criteria and targets, and a process for final portfolio decisions •using tools and models to perform advanced inventory analysis and decision making. This includes self-service dashboards that allow users to drill into root causes for problem areas and to simulate the quantitative impact of corrective actions.	x
Walmart	Retailer	•stocking product centrally	•E-commerce •set up large, dedicated online fulfillment centers	•Global Women's Economic Empowerment Initiative, which provides training, access to markets and career opportunities to nearly 1 million women, many on farms and in factories. As part of that effort, the retailer is increasing its sourcing from women-owned businesses.

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
HP	computing	•improving customer experience through perfect order fulfillment	•visibility and data analytics platform that is now leveraged for improved demand forecasting, among other areas •developed a quality cloud environment to better track the quality life cycle. •enabling artificial intelligence (AI) software routines to identify problems in the order to fulfillment process and upstream supply chain.	•focused on combatting human trafficking in its supply chains and focused on improving sustainability and workers' rights across its entire value chain.
Schneider Electric	Energy management and automation	•moving from decentralized supply chains supporting its extremely diverse customer base to one that is tailored to align with customer requirements, in a scalable way, through a small number of differentiated end-to-end flows through ordering, planning, sourcing, manufacturing and delivery. •efforts to significantly reduce end-to-end customer lead times, improve time to market for new capabilities and improve customer satisfaction through special care units and focused on-time-deliver •focused on maturing its sales and inventory operations planning process, deploying network optimization and leaning out warehousing and transportation functions. •team is driving continuous improvements in its engineer-to-order and field services supply chains.	x	x

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
L'Oréal	Cosmetics Company	•Its supply chain has focused on improving demand forecasting and supply and demand matching capabilities. The results have been impressive, as it has been able to improve service levels by more than 2%, while holding inventory constant. •In the area of product innovation, the supply chain organization closely coordinates with R&D on new product introduction (NPI). •Strategic sourcing team members are engaged in the early stages of the product life cycle to coordinate development and eventual launch with supplier partners.	•The supply chain team is also continuing to develop and deploy its supplier management program on a best-of-breed platform.	x
BASF	Chemical Company	•differentiation in supply chain services, which moves the group from proportionally spreading costs to business units to charging for services rendered. This shift has put better visibility on the true cost-to-serve of each business and presented opportunities to reduce expensive, complex offers where they are not needed. Through its focus, this effort has also improved service delivery for customers and identified value-based pricing opportunities for special services. The last major focus area for	•to digitize supply chain management, in line with Industry 4.0 standards. This includes digitization of its logistics function and horizontal digital integration from its customers, through its internal operations and upstream to suppliers. Prescriptive analytics are being built to aid in daily decision making and strategy planning.	x

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
		supply chain is on delivery reliability excellence.		
Johnson & Johnson	Healthcare	•defined an end-to-end operating system that defines a standard way of working across all internal functions with external partners and between segments. •improving customer experience and creating joint value delivered through customer focus teams staffed by dedicated supply chain professionals. •supply chain team has improved supplier collaboration through tighter integration,	•Created digital visibility through serialization and track and trace, and deployed control towers for supply chain planning (SCP) and analytics to sense and respond to issues. •Factory 4.0 is another priority for its advanced manufacturing group, which is experimenting and implementing disruptive technologies such as robotics, 3D printing and data analytics.	x
BMW	Automobile	•implemented a risk filter for suppliers that takes into account location-specific and product-specific risks •supplier self-assessments and audits	•significant investments in supply network visibility and digital manufacturing in line with Industry 4.0 objectives. Innovative robotic systems used in manufacturing	•reduced the volume of resources utilized and the emissions per vehicle produced by an average of 45% since 2006 through a variety of projects
GlaxoSmithKline	Pharmaceutical	•improve coordination across each stage of production from sourcing and manufacturing to more efficient delivery of its products to patients and consumers. •The GSK Production System (GPS) introduced is a standard way of working that identifies and eliminates the root causes of accidents, defects and waste. •More recent initiatives and capabilities	• End-to-end logistics coordination and visibility.	•set up a new information exchange for its suppliers to share best practices on energy efficiency and reducing environmental impacts •GSK expects to cut value chain emissions by 25% by 2020

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
		include product portfolio complexity analysis		
Kimberly-Clark	Personal care and paper company	•created a new chief supply chain officer (CSCO) position with global responsibilities for procurement, transportation, continuous improvement, sustainability, quality, safety and regulatory operations •improvements in on-shelf availability, e-commerce fulfillment capabilities and continued refinement of its world class Supply Chain Efficiency Fund (SCEF) program. Its on-shelf availability work involves further improvements in demand forecasts based on point-of-sale data, near-term customer demand signals and promotional forecasting tools. Other considerations include product portfolio and packaging decisions. •innovating packaging to make it more direct-ship friendly and realigning its network to ensure wide coverage for quick delivery windows. Its SCEF program centers on a cost-to-serve model that identifies a range of logistics services from most to least efficient and provides incentives through trade promotion fund transfers for	E-commerce	x

Company	Focus	Customer driven partner integration	Adoption of Advanced Analytics	Corporate Social Responsibility
		customers to choose more efficient models, where it is a net positive for the company.		
Lenovo	High tech company	•a detailed network design analysis that led to a decision to merge acquired product production into Lenovo's existing in-house manufacturing network. Overall, the company runs a hybrid ownership model for all of its manufacturing. At the same time, the supply chain team ran programs to enhance customer experience and operational excellence	•One program that has improved customer satisfaction is the creation of a customer social/digital platform for key global accounts with content that is tailored to each customer's preference in terms of order status, new product information and technical support information.	x