Development of a pharmaceutical product categorization framework taxonomy for the South African public healthcare pharmaceutical supply chain—VAN enabled

by

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Declaration

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Abstract

Many of the challenges in supply chains have been traced to emanate from a misalignment between the type of product, together with its attributes, and the strategy according to which the supply chain of the product is managed. Several frameworks, incorporating a diverse set of product attributes, have been recommended to enable this alignment between product attributes and supply chain strategies in various sectors. The priorities that are typically pursued in public healthcare pharmaceutical supply chains, differ from those that are typically pursued in the commercial sector in a number of ways. Despite this, a structured search of literature did not uncover any framework that incorporates the distinct critical attributes to be used in describing product categorization in public healthcare pharmaceutical supply chains specifically.

A review of literature on product categorization as it has been applied in various industries, indicates that it is reasonable to conclude that tailoring supply chain management practices and policies to the attributes of the products being supplied in the public healthcare pharmaceutical supply chain sector is likely to be beneficial. The South African National Department of Health is in the process of rolling out the Visibility and Analytics Network reference framework, with the aim of ensuring the sustained availability of and access to medicine. At present, the Visibility and Analytics Network strategy does not incorporate the product categorization concept. In this study, a product categorization framework is developed specifically for use in the contemporary South African public healthcare pharmaceutical supply chain. The framework is intended to provide guidance to supply chain managers on aligning pharmaceutical products with appropriate supply chain strategies, thereby formulating different supply pipelines in line with the relevant attributes of the products.

It is envisioned that the framework will be used by the provincial supply chain managers in the Visibility and Analytics Network strategy informed push model as they: analyze and optimize complex links in the public healthcare pharmaceutical supply chain; and make inventory planning and management recommendations to primary healthcare facilities. The product categorization framework that is developed in this research is expected to aid in enhancing sustainable availability and access to medicines in the South African public healthcare supply chain.

Opsomming

‘n Groot aantal van die uitdagings in voorsieningskettings ontstaan vanweë ‘n wanbelyning tussen die tipe produk, tesame met die eienskappe daarvan, en die strategie waarvolgens die voorsieningsketting van die produk bestuur word. Verskeie raamwerke, wat 'n uiteenlopende reeks produkeienskappe insluit, word aanbeveel om hierdie belyning tussen produkeienskappe en voorsieningskettingstrategieë in verskillende sektore te bewerkstellig. Die prioriteite wat tipies in farmaseutiese voorsieningskettings vir openbare gesondheidsorg nagestreef word, verskil van dié wat tipies in die kommersiële sektor nagestreef word. Ten spyte hiervan het 'n gestruktureerde literatuursoektog geen raamwerk ontbloot wat die onderskeie kritieke eienskappe bevat wat gebruik moet word om, spesifiek in openbare gesondheidsorgvoorsieningskettings vir farmaseutiese produkte, die kategorisering van produkte te bewerkstellig nie.

'n Oorsig van die literatuur wat handel oor die toepassing van produk-kategorisering in verskillende industrieë, dui aan dat dit redelik is om tot die gevolgtrekking te kom dat hierdie praktyk ook in openbare gesondheidsorgvoorsieningskettings vir farmaseutiese produkte voordeel sal inhou. Die Suid-Afrikaanse Nasionale Departement van Gesondheid implementeer tans ‘n verwysingsraamwerk, naamlik die Sigbaarheid- en Analitiese Netwerk, wat ten doel het om volgehoue beskikbaarheid van- en toegang tot medisyne te verseker. Die produkkategorisering konsep word nie tans in hierdie verwysingsraamwerk ingesluit nie. In hierdie navorsing word 'n raamwerk vir produkkategorisering spesifiek ontwikkel vir gebruik in die kontemporêre Suid-Afrikaanse openbare gesondheidsorgvoorsieningsketting vir farmaseutiese produkte. Die raamwerk is ontwerp om aan bestuurders in die voorsieningsketting leiding te gee oor hoe om toepaslike voorsieningskettingstrategieë, vir verskillende farmaseutiese produkte te identifiseer om sodoende verskillende aanbodpyplyne daar te stel, in ooreenstemming met die toepaslike eienskappe van die produkte.

Daar word voorsien dat, binne die konteks van die Sigbaarheid- en Analitiese Netwerk, provinsiale voorsieningskettingbestuurders die raamwerk sal gebruik soos wat hul: komplekse skakels in die farmaseutiese voorsieningsketting vir openbare gesondheidsorg analiseer en optimeer; en aanbevelings rakende voorraadbeplanning en -bestuur by primêre gesondheidsorgfasiliteite maak. Die raamwerk vir produkkategorisering wat in hierdie navorsing ontwikkel is, sal na verwagting bydra tot volhoubare beskikbaarheid van- en toegang tot medisyne in die Suid-Afrikaanse openbare gesondheidsorgvoorsieningsketting.

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- ✓ Last but not least, the individuals and organizations that agreed to partake in the validation of my study.

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Nomenclature

Acronyms and abbreviations

NDoH	National Department of Health
VAN	Visibility and Analytics Network reference framework
PHCFs	Primary healthcare facilities
PSSCs	Product Service Supply Chains
SOSCs	Service Only Supply Chains
SCM	Supply Chain Management
KPI	Key Performance Indicator
OTC	Over-the-counter medicine
STGs	Standard Treatment Guidelines
EML	Essential Medicine List
AMD	Affordable Medicines Directorate
EDP	Essential Drugs Program
NEMLC	National Essential Medicines List Committee
PTC	Pharmaceutical Therapeutic Committees
PMPU	Provincial Medicine Procurement Units
SCOR	Supply Chain Operations Reference model

Chapter 1

Introduction

Supply chains incorporate the end-to-end streaming of information, products, and money (Perez, 2013) and supply chain management (SCM) has been defined as: *"The management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole"* (Christopher, 2011). This definition describes supply chain management as a function that incorporates a wide variety of activities, and a function that has a far-reaching impact on an organization. Consequently, how supply chains are managed has significant implications for an organization's product cost, working capital requirements, lead time to market, and service delivery, amongst others.

In an influential paper that pioneered the concept of product categorization, Fisher (1997) proposed that the reason why supply chains do not perform as expected despite increased investments in effort and resources, is an improper alignment of product attributes and supply chain strategies. Similarly, Harris, Componation, & Farrington (2010) stated that a product with steady demand and dependable supply cannot be managed similarly as a product with unpredictable demand and inconsistent supply.

Applying the concept of product categorization in the healthcare sector is expected to offer benefits in terms of the sustainable availability of medicines and a reduction in healthcare expenditure (Mapowo, Bam, de Kock, & van Eeden, 2018). Researchers have highlighted that product categorization makes a vital contribution to business attributes such as spend analysis, financial analysis, strategic sourcing, tendering, enterprise resource planning, and merchandising in healthcare (Fisher, 1997; Harris et al., 2010). The concept of product categorization has been employed in conjunction with robust Information Technology (IT) systems for better use in scientific warehousing and inventory management, transparent integrated procurement, real-time stock monitoring, and decentralized distribution methodologies (Prinja, Bahuguna, Tripathy, & Kumar, 2015).

This research project is concerned with developing a framework for incorporating the principle of product categorization into the management of the public healthcare pharmaceutical supply chain in South Africa. This first chapter provides background on the research problem before formally defining the aim and objectives of the research. The scope of the study is also defined, and key assumptions, limitations, and delimitations are articulated. The research design and validation

strategy are also described before the chapter concludes with an overview of the content of each chapter of the thesis.

1.1. Background

The South African National Department of Health (NDoH) is in the process of rolling out the Visibility and Analytics Network (VAN) reference framework, with the aim of ensuring the sustained availability of and access to medicines (Llewellyn, 2017). One of the objectives of the VAN strategy is to transform South Africa's public healthcare pharmaceutical supply chain from an 'uninformed pull' system to an 'informed push' system (Llewellyn, 2017). The distinction between these two systems being that specialized supply chain management professionals will be utilized in each province. These professionals will analyze and optimize complex links in the public healthcare pharmaceutical supply chain and make inventory planning and management recommendations to primary healthcare facilities (PHCFs), rather than the PHCFs doing so on their own (Llewellyn, 2016). An informed push model will relieve the PHCFs' staff of sophisticated and time-consuming supply chain planning work and enable them to focus more exclusively on healthcare delivery.

At present, the VAN strategy does not incorporate product categorization—which entails the organization of products into categories according to shared attributes; more specifically, when supply chains are considered, attributes that are related to or could influence the best supply chain management strategy for respective products (Qi, Boyer, & Zhao, 2009). Simchi-Levi, Clayton, and Raven (2013) reasoned that *"one size does not fit all"* in the formulation of a supply chain strategy, highlighting the fact that different supply chain management strategies may be needed for products that differ in terms of attributes such as variability, volume, lead-time, lifecycle, etc.

Findings from a nationwide survey conducted by the Stop Stock-outs Projects (SSP)[1] stated that in 2013, 21% of South African public healthcare facilities experienced a stock out or shortage of a Tuberculosis (TB) or Human Immunodeficiency Virus (HIV) medicine within three months prior to SSP conducting the survey (Stop Stock-outs Projects, 2013). In 2014, a second national SSP survey exposed that the abovementioned metric further increased to 25%, meaning that a quarter of PHCFs in South Africa experienced HIV and TB medicine stock-outs at least once in the year prior to the SSP survey. In 2015, the status quo remained unchanged at 25% (2015 Stock Outs National Survey

[1] SSP is a consortium made up of six civil society organizations established in 2013 to monitor the availability of: medicines for TB; antiretroviral (ARV) medicines for HIV; and childhood vaccines; amongst others.

Third Annual Report – South Africa, 2016). Medicine stock-outs pose a danger to people's health by leading to interrupted treatment, the taking of partial doses, or defaulting on treatment. In turn, these eventualities lead to increased cost, loss of confidence in the health system, decreased immunity of patients, drug resistance, and increased risk of opportunistic infections leading to more illness, new infections and ultimately death (2015 Stock Outs National Survey Third Annual Report – South Africa, 2016). It can be reasoned that, due to differences in the therapeutic nature of pharmaceuticals and differences in performance of these products in the supply chain, various pharmaceutical products (e.g. anti-hypertensive, anti-viral, thrombolytic, and anti-cancer medicines) require different supply chain management strategies (e.g. continuous-flow, efficient, fast, and agile supply chains) depending on the product attributes (e.g. demand volume, lead-time, uncertainty, and lifecycle). Such an approach of managing the supply chain of pharmaceutical products in line with the product attributes is expected to improve the performance of the supply chain, thereby decreasing the occurrence of stock-outs.

Product categorization has been conceptualized in diverse ways and has been envisioned to be substantial in effective supply chain strategies for improving performance efficiency in a wide range of sectors (Harris et al., 2010; Mapowo et al., 2018; Sullivan, Harris, Farrington, & Componation, 2007). In the South African public healthcare pharmaceutical supply chain, segmenting products into clusters according to shared attributes and oriented management ideologies is potentially a valuable strategy for improving performance. Ways in which the management approaches for various categories can differ include: what and how key performance indicators (KPIs) and performance levels are defined; applied inventory management policies; and how and why replenishment and procurement decisions are taken.

This research focuses on proposing an approach for applying the principle of product categorization to the South African public healthcare pharmaceutical supply chain. The research is provided within the reference framework of the VAN strategy of the South African public healthcare pharmaceutical supply chain.

1.2. **Research aim and objectives**

In order to propose an approach for applying the principle of product categorization in the South African public healthcare pharmaceutical supply chain, the main question which guided the research is: What is the best approach to match pharmaceutical products and their attributes with supply chain strategies in the South African public healthcare pharmaceutical supply chain to enhance sustainable

availability of medicines based on the VAN strategy? Thus, the following research aim and objectives are pursued.

1.2.1. Research aim

The aim of this research inquiry is to contribute towards improving the sustainable availability of medicines in the South African public healthcare pharmaceutical supply chain by proposing a suitable framework for the application of the concept of product categorization under the VAN strategy.

1.2.2. Research objectives

In order to pursue the stated research aim, four research objectives, as well as a number of sub-objectives, are defined:

- ✓ Research objective 1: To develop the rationale for the research by investigating the expected benefit of incorporating product categorization into the South African public healthcare pharmaceutical supply chain. The sub-objectives associated with research objective 1 are:
  a) Provide an overview of the concept of product categorization based on literature;
  b) Provide an overview of the contemporary application of product categorization to various industries, including a summary of the impact of product categorization in these industries, based on a systematic literature review;
  c) Provide an overview of the operation and management of the South African public healthcare pharmaceutical supply chain;
  d) Provide an overview of supply planning in line with the VAN principles in the South African public healthcare pharmaceutical supply chain; and
  e) Articulate the rationale for expecting product categorization to hold benefit for the South African public healthcare pharmaceutical supply chain.
- ✓ Research objective 2: To investigate a number of operational aspects that are critical to informing the development of the framework design requirements. The sub-objectives associated with research objective 2 are:
  a) Determine and identify a set of product attributes critical for matching pharmaceutical product categories with supply chain strategies in public healthcare pharmaceutical supply chains using a triangulation method;
  b) Identify pharmaceutical product bundles based on existing classification and nomenclature systems used in healthcare;

c) Provide an understanding of supply chain focus points which product categorization can target;

d) Examine supply chain strategies and contextualize the product categorization framework development consistent with: the VAN supply chain; VAN service supply planning; and the South African public healthcare pharmaceutical supply chain; and

e) Determine and tailor to the VAN strategy, the specific levers to control in product categorization and supply chain strategy implementation in the South African public healthcare pharmaceutical supply chain.

✓ Research objective 3: To develop a framework, drawing from the findings of the first and second objectives, for the incorporation of product categorization into the South African public healthcare pharmaceutical supply chain, providing detail on:

a) The basis for categorization—i.e. aligning and matching pharmaceutical product categories with appropriate supply chain strategies coupled with respective decoupling points and thus formulate different supply pipelines for different products; and

b) The implication of categorization—i.e. what aspects of the South African public healthcare pharmaceutical supply chain would be implicated based on the product categorization framework.

✓ Research objective 4: To verify and validate the framework using subject matter experts (SMEs) validation interviews and a case study application. The sub-objectives associated with research objective 4 are:

a) Validation interviews and iterative improvement of the framework—from preliminary to final product categorization framework—based on subject matter expert (SME) feedback; and

b) To validate the final framework using a case study application and establish recommendations for future research.

1.3. **Scope of study**

In SCM, the term ‘planning’ can be used to refer to supply planning, demand planning or distribution planning (Harris et al., 2010; Llewellyn, 2017). The focus of this research is limited to product categorization for supply planning in the South African public healthcare pharmaceutical supply chain under the context of the VAN reference framework. Thus, product categorization for demand and distribution planning is outside the scope of this project, except in cases of overlaps with supply planning. Furthermore, only supply planning activities that occur at the national and provincial levels

of the South African healthcare system will be considered, thus supply planning activities that relate to the actual manufacturing of pharmaceuticals is outside of the scope of the study.

The motivation for focusing on supply planning specifically is that, under the VAN strategy, supply planning will be used to develop sourcing and replenishment plans within the supply chain, which is considered to have a significant, direct impact on product categorization for sustainable availability of medicines (Llewellyn, 2017). Therefore, the output of this research inquiry (i.e. the product categorization framework) will be used to facilitate decision making in sourcing and replenishment of pharmaceuticals in a bid to ensure sustainable availability of medicines to end-users.

The US Department of Health and Human Services (2017) defined drugs as "*articles intended for use in the diagnosis, cure, mitigation, treatment, or prevention of disease in man or other animals*" and a device as "*an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar or related article, including any component, part, or accessory*" used in achieving the same purpose as a drug. The scope of this study is limited to the categorization of drugs or pharmaceuticals and excludes devices.

1.4. **Assumptions, limitations, and delimitations**

This thesis is limited to the pharmaceutical supply chain in the South African public healthcare sector. The focus will be on developing product-driven supply chain sourcing and replenishment strategies for VAN in the context of supply planning (thus excluding demand or distribution planning) and will be limited to two tiers, namely national and provincial supply planning.

Service SCM has two categories of supply chain systems, i.e. Product Service Supply Chains (PSSCs) and the Service Only Supply Chains (SOSCs) (Wang, Wallace, Shen, & Choi, 2015). PSSCs have both physical products and services, for example, restaurants and food retail supply chains, while in SOSCs the 'products' offered are pure services for example financial consultancy and psychology advice (Wang, Wallace, Shen, & Choi, 2015). This research, however, will be limited to the PSSCs as this goes along with the South African public healthcare supply chain in that the delivery of healthcare by practitioners is deemed to be the service while the medication/pharmaceuticals are the products.

1.5. **Research design and methodology**

According to Bryman and Bell (2014), a quantitative research approach tends to adopt the norms and practices of a model and extensively emphasizes deduction and quantification when collecting and analyzing data. In contrast, Bryman and Bell (2014) posited that a qualitative research approach is

principally inductive in the linkage of theory and research, with the emphasis being placed on generation rather than testing of theory. Qualitative and quantitative research approaches can also be combined to aid the researcher in capitalizing on the strengths and counterbalancing the weaknesses of each method, using a mixed-method research approach (Bryman & Bell, 2014).

For this thesis, a mixed-method research approach will be employed where secondary quantified data sources on the South African public healthcare pharmaceutical supply chain are utilized to determine and resolve the research problem. To address the multifaceted research problem, an inductive approach—where theory is an outcome of the research—is used and systems thinking is applied to analyze and synthesize literature and determine the multiple variables and parameters in developing a strategic input-output framework. The proposed framework is verified and validated to confirm the solution. The basic systems engineering approach which will be employed is shown in Figure 1.1.

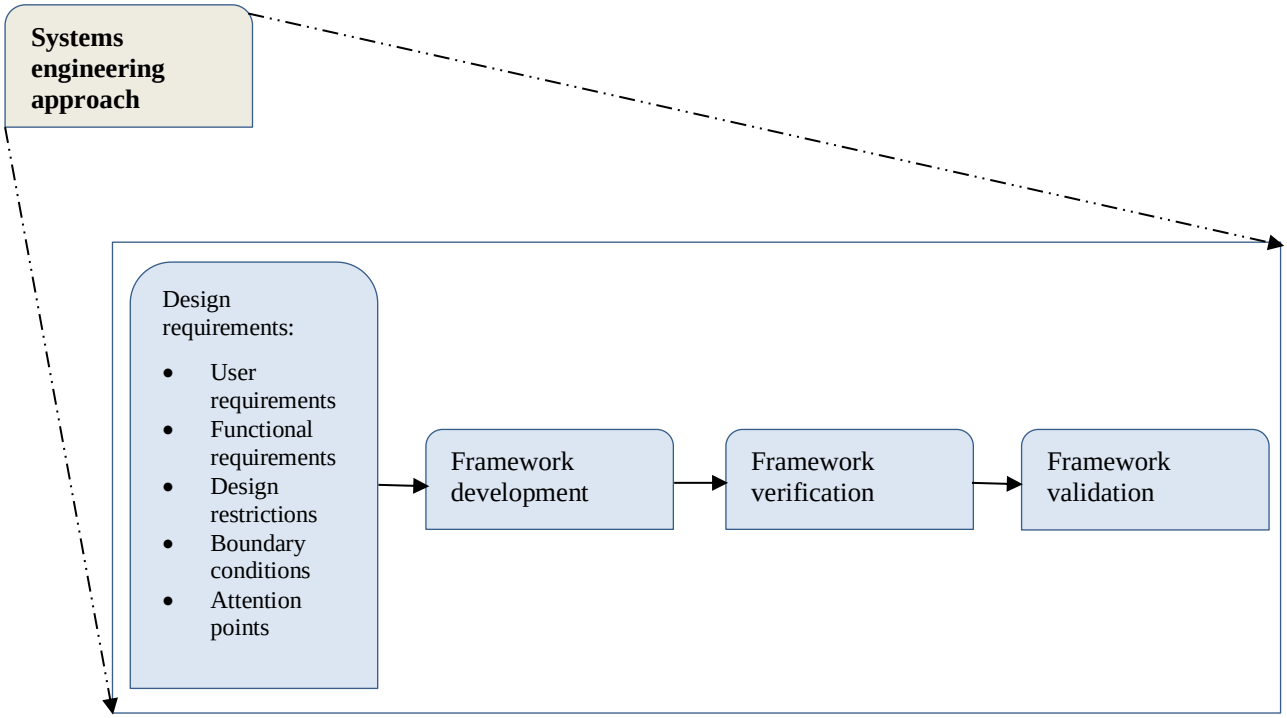

Figure 1.1: A basic systems engineering approach for framework development (adapted from Mouton (2013) and van Aken, Berends, and van der Bij (2007))

Van Aken et al. (2007) posited five categories of requirements to enable a balanced approach in the design and development of a framework, namely: user requirements (U); functional requirements (F); design restrictions (R); boundary conditions (B); and attention points (A). In line with this recommendation, the ‘design requirements’ element in Figure 1.1 will consist of these five categories of requirements. Van Aken et al. (2007) definition of each of the five categories of requirements is given in Table 1.1.

Table 1.1: Framework design requirement categories employed in this research (adapted from van Aken et al. (2007))

Framework design requirement category	The generic definition of the requirement category
User requirements (U)	These are the critical and distinct requirements, as deemed by the framework user, which are used to define the constraints in framework development.
Functional requirements (F)	These are the fundamental enablers which facilitate the functionality, performance or result of the framework's design and use.
Design restrictions (R)	These are the scope, exclusions, limits, and elements of the framework design's preferred solution space.
Boundary conditions (B)	These are the categorical design requirements or rules that cannot be altered and must be met e.g. ethics, code of conduct and legislation
Attention points (A)	These are the desirable and relevant requirements of the framework design though they are not binding nor restrictive.

The synthesis of these requirements to develop the framework will follow a basic input-output categorization process, as in Figure 1.2:

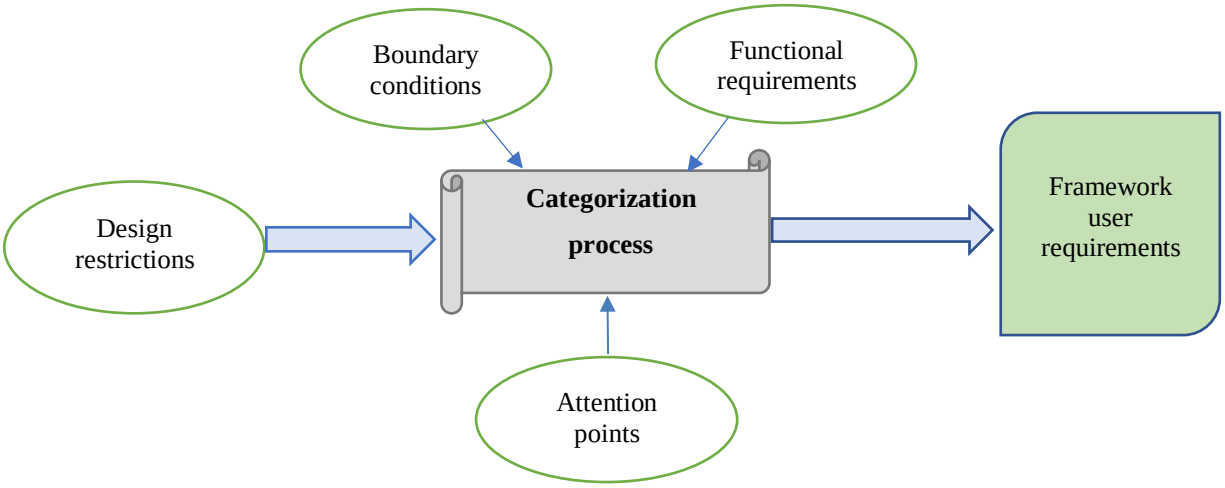

Figure 1.2: Input-output transformation process (adapted from The US Department of Defense Systems Management College (2001))

1.6. **Validation strategy**

The product categorization framework intended to aid the VAN supply chain professionals, the South African NDoH, and ultimately the government in enhancing sustainable availability of medicines, is expected to be useful as a decision tool for VAN professionals to decide on 'what' product categories can be appropriately matched to 'which' supply chain strategies by considering 'which' product attributes. In establishing such a framework, it follows that principles of validity and reliability are fundamental in ensuring that the research product is valuable and useful (Jabareen, 2009).

Reliability is considered to be the extent to which the results of a study are consistent over time and whether they are an accurate representation of the total population under study (Bryman & Bell, 2014). Reliability of the findings is evaluated by verification of the study which entails the assessment

of whether the solution was developed in the correct manner. Verification refers to mechanisms that are employed in the framework development process to incrementally contribute to reliability and validity, and thus, demonstrate the thoroughness of the study (Srai, Alinaghian, & Kirkwood, 2013). Srai et al. (2013) further assert that verification will aid in determining whether the solution is of a high quality and complete, though it will not necessarily ensure that the solution is useful in addressing the original problem.

Validity addresses the aforementioned gap by demonstrating the integrity of the solutions from the study and ensuring that the research output truly addresses the investigated concept, providing the appropriate answers (Kothari, 2004). Srai et al. (2013) posited that the focus of validation is on the link between the purpose and the context of the research study and conclusions, thus assessing whether the developed solution addresses the defined problem. Kothari (2004) defines two forms of validity, namely external validity, which focuses on the extent to which a solution can be generalized from the view of its relevance to a larger population, and internal validation, which comprises the following three distinct concepts:

- Criterion validity—which evaluates the extent to which applicable features of the solution can be precisely forecasted by the theoretical concept;
- Face validity (also referred to as content validity)—which assesses the extent to which a solution provides adequate coverage of the topic under study; and
- Construct validity—which tests whether the solution addresses what it claims to solve and that the solution does not assess irrelevant attributes.

1.6.1. Applicable validation routes

Validation is commonly achieved via three main approaches, namely: 1) interviews with subject matter experts (SMEs); 2) implementation and 3) case study application (Mouton, 2001). Each of these approaches has its own advantages and disadvantages as given below, based on Mouton (2001):

- **Interviews with SMEs**

Definition:	These are interviews where the interviewer gathers knowledge from the interviewee to disprove or validate claims made by the researcher. These interviews can be structured, semi-structured or unstructured interviews.
Advantages:	It provides a platform for obtaining knowledge from experts who can either contest or support the research findings.

Disadvantages: The interviewees can only respond within their circumstances based on their personal experiences and knowledge hence the need for special consideration in interviewee selection.

- **Implementation**

Definition: This denotes the full practical application of a framework in a given setting to review and validate its correctness.

Advantages: The results of the implementation are definitive and holistic.

Disadvantages: The full implementation of the framework is resource-intensive and time-consuming.

- **Case studies**

Definition: This is a detailed examination of an already existing case with the aim of providing descriptive, explanatory and exploratory findings.

Advantages: It provides a different perspective from which practical challenges and requirements are better understood due to similarities between case studies and reality.

Disadvantages: It is susceptible to manipulation and strongly rooted in the setting/context in which it is applied.

This study will employ interviews with SMEs—using semi-structured interviews and Likert scale rankings—followed by a case study to obtain detailed and practical insight into the validity of the framework. An overview of the validation process and roadmap is provided in the succeeding section.

1.6.2. Validation roadmap overview

A summary of the validation strategy that will be employed in this research is provided in Figure 1.3. As discussed, this study will take a mixed methods research approach and semi-structured interviews with SMEs and a case study application will be employed as validation methods.

A triangulation approach based on three sourced of input, namely findings based on a systematic literature review, SME inputs, and the application of logical arguments and reasoning based on an understanding of SCM in public healthcare, will be used to determine the product attributes taxonomy. Using the same findings and inputs, a supply chain strategies taxonomy will be developed.

Framework design requirements specifications which describe user requirements, functional requirements, design restrictions, boundary conditions and attention points, will be identified based

on the literature reviews and SME inputs (derived from semi-structured interviews) presented in Chapters 2 and 3.

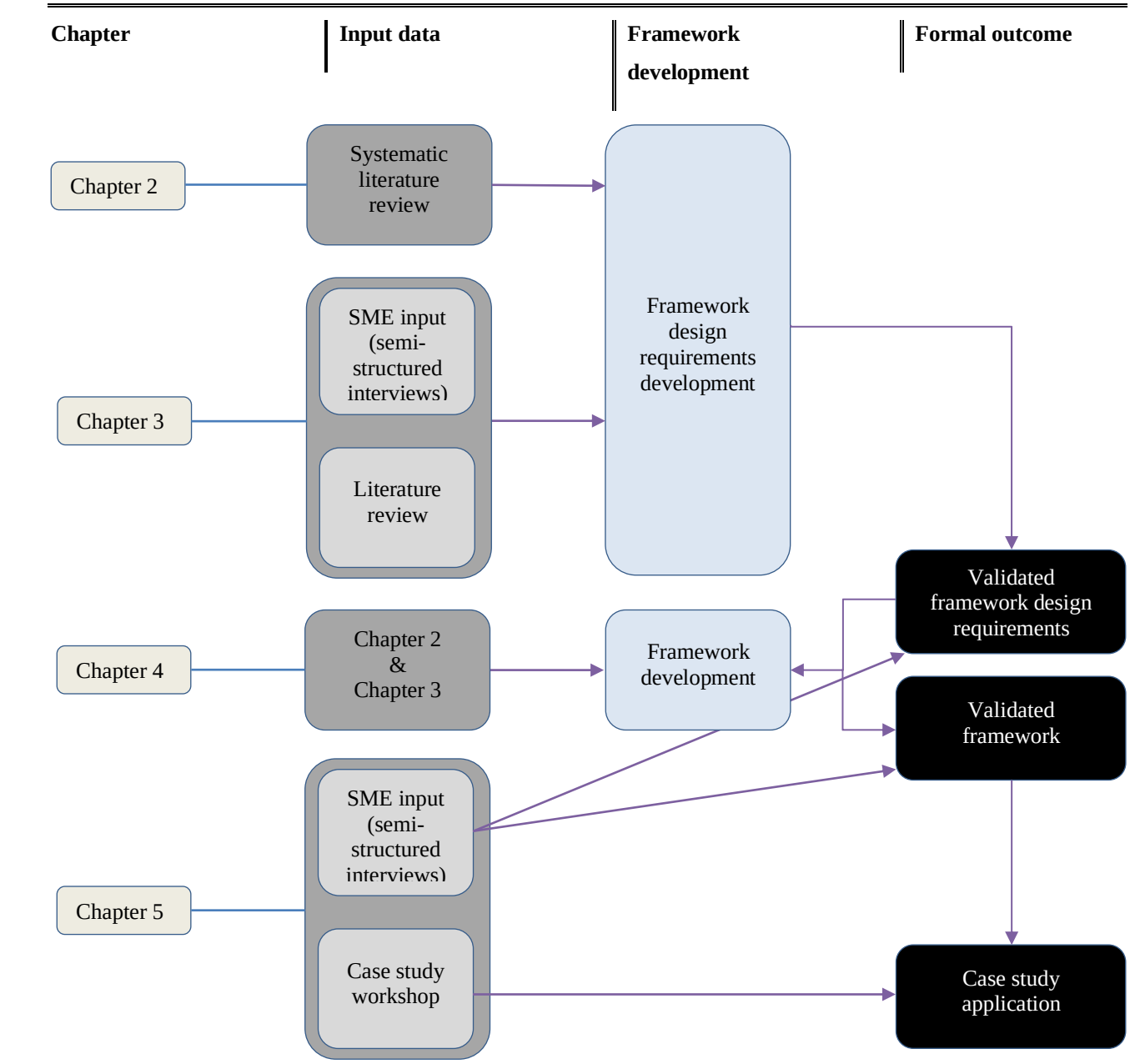

Figure 1.3: Validation process overview

The *preliminary* product categorization framework will be developed based on this set of design requirements. Feedback on both the set of design requirements and the *preliminary* product categorization framework will then be gathered from SMEs using semi-structured interviews. This feedback will be incorporated to develop the *final* product categorization framework. For the purpose of maintaining the flow of the narrative and not duplicating the framework within the main document, the *preliminary* framework is given in Appendix D while the validated *final* framework (with SME feedback incorporated) is given in the main body of the thesis in Chapter 4.

The *final* product categorization framework presented in Chapter 4 will then be used to conduct a case study workshop with the main purpose of evaluating the applicability and operability of the framework.

1.7. **Thesis outline**

The outline and sequence of this study is summarized in Figure 1.4.

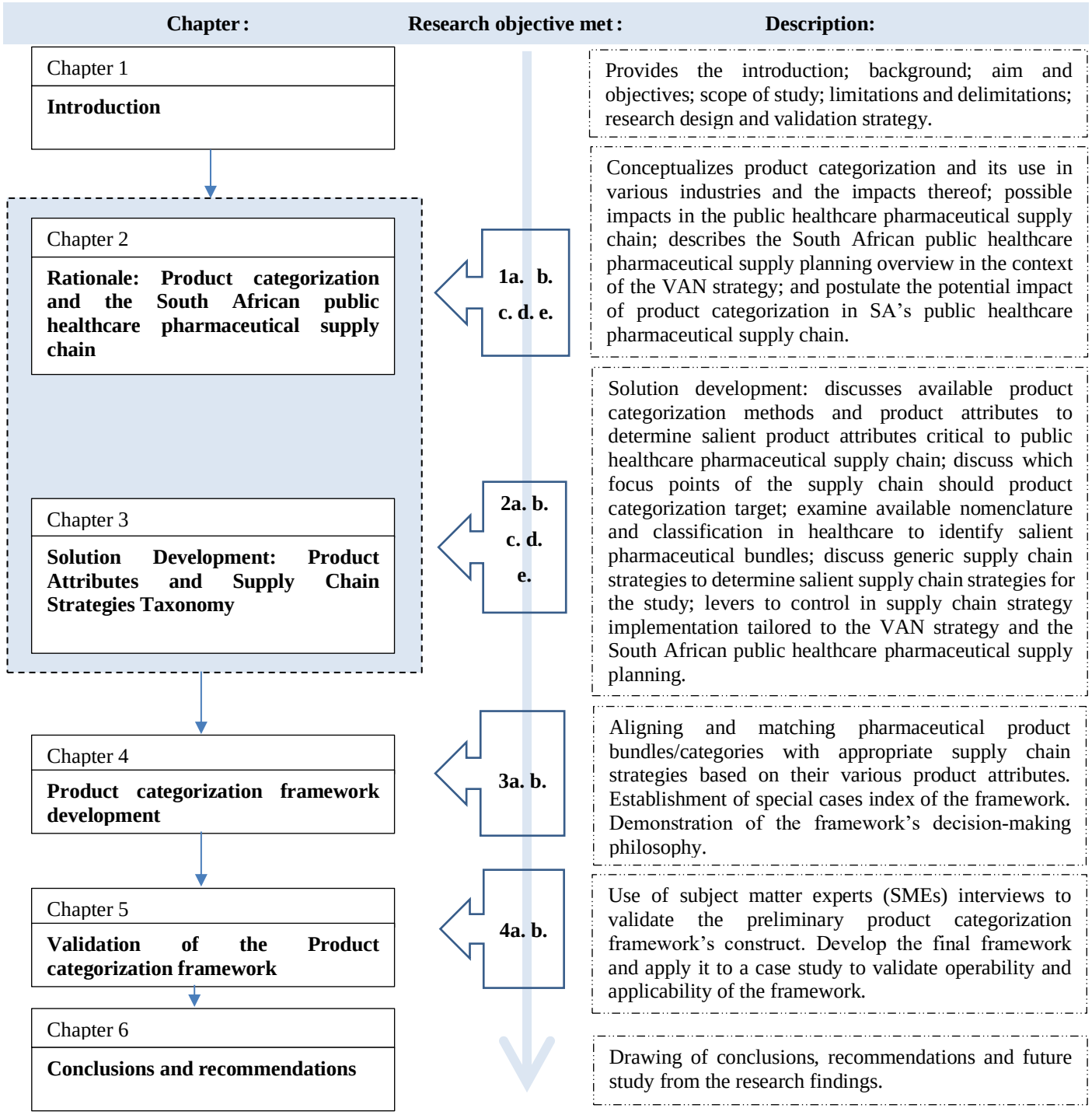

Figure 1.4: Thesis overview

Chapter 2

Rationale: Product categorization and the South African public healthcare pharmaceutical supply chain[2]

2.1. Introduction to literature

This chapter presents relevant literature on the concept of product categorization—its application in various industries, evidence on its impact, and concepts used in its application. The chapter further investigates the product categorization methods that have been used in relation to SCM in the various industries. This chapter seeks to address the first objective of this thesis:

Research objective 1: To develop the rationale for the research by investigating the expected benefit of incorporating product categorization into the South African public healthcare pharmaceutical supply chain. The sub-objectives associated with research objective 1 are:

a) Provide an overview of the concept of product categorization based on literature;

b) Provide an overview of the contemporary application of product categorization to various industries, including a summary of the impact of product categorization in these industries, based on a systematic literature review;

c) Provide an overview of the operation and management of the South African public healthcare pharmaceutical supply chain;

d) Provide an overview of supply planning in line with the VAN principles in the South African public healthcare pharmaceutical supply chain; and

e) Articulate the rationale for expecting product categorization to hold benefit for the South African public healthcare pharmaceutical supply chain.

[2] A significant portion of the text in Sections 2.2 and 2.3 has been reproduced from a conference article that was published as part of this research. The article citation is: Mapowo, N., Bam, L., de Kock, I., & van Eeden, J. (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, Spier, Stellenbosch, South Africa* (pp. 391–404).

The intended outcome of this chapter is to derive concepts from the literature that potentially drive the feasibility and applicability of the product categorization dimensions in the South African public healthcare pharmaceutical supply chain. The chapter ends with a summary of the set of framework design requirements that are derived from the work presented.

2.2. The concept of product categorization

Fisher (1997), an acknowledged pioneer of the concept of product categorization, proposed that if products are classified based on their demand configurations, they fall into one of two categories: they are either primarily functional or primarily innovative. Furthermore, Fisher (1997) proposed that supply chains can either be physically efficient or market responsive based on the stated product distinction. He then posited a generic framework to match the product type to the appropriate supply chain strategy with functional products being matched to efficient supply chains and innovative products matched to responsive supply chains, while the converse results in a mismatch as shown in Figure 2.1

	Functional Products	**Innovative Products**
Efficient Supply Chain	**Match**	**Mismatch**
Responsive Supply Chain	**Mismatch**	**Match**

Figure 2.1: Fisher's framework, matching supply chains with products. (adapted from Fisher (1997))

Fisher (1997) asserted that functional products are the widely available products which satisfy basic needs. They are characterized by a relatively extensive lifecycle, with little change over time and little variance in their offerings. Demand for functional products is typically predictable and stable, and they tend to possess low-profit margins because of the many competitors in the market (Christopher, 2011). Inventory is used to buffer demand because the cost of functional products obsolescence is low (Harris et al., 2010).

Sullivan, Harris, Farrington, and Componation (2007) underlined that innovative products are typically distinguished as trendy and have highly volatile demand that is difficult to predict. They are associated with significantly more uncertainty than functional products. Innovative products have larger product variety and short life-cycles, but the profit margin is high, therefore lost sales (opportunity cost) exert a significant effect on company performance (Harris et al., 2010). Table 2.1 shows the demand aspects for the classification of products as either functional or innovative.

Table 2.1: Product demand aspects versus functional or innovative (adapted from Fisher (1997))

Demand Aspects	Functional (Predictable Demand)	Innovative (Unpredictable Demand)
Average stock-out rate	1% to 2%	10% to 40%
Product Variety	Low (10 to 20 variants per category)	High (often millions of variants per category)
Contribution to Margin	5% to 20%	20% to 60%
Product Life Cycle	More than 2 years	3 months to 1 year

If products are not aligned with their appropriate supply chain strategies, this can result in overserving and overcharging functional products' customers, and underserving and undercharging innovative products' customers (Sullivan et al., 2007). Translating this to the public healthcare pharmaceutical supply chain, various products from the pharmaceutical product portfolio can probably be determined and categorized according to either being functional or innovative. This, as established by Fisher (1997) in Table 2.1, would be dependent on the pharmaceuticals demand aspects (e.g. average stock-out rates, product life cycle, and product variety, etc.) of each product. It can then be reasoned that chronic medication which, in the South African pharmaceutical supply chain, has been exposed to have a stock-out rate of 25% as established in Section 1.1, will possibly not be considered the same as other medication with little or no stock-outs. Chronic medication stock-outs can probably be argued to be in the innovative products category since their stock-out rate is between 10% and 40% as identified in Table 2.1. However, it can contrarily be argued that since normally chronic patients are registered and known, then chronic medication should have predictable demand and thus should be categorized as functional. This uncertainty in categorization brings the need to consider all product attributes and determine which ones are critical for matching product categories to appropriate supply chain strategies, and this is the partial aim of this thesis.

2.3. **Applications of product categorization**

A systematic literature review was conducted to determine previous applications of product categorization as well as the documented impacts of product categorization.

2.3.1. Literature analysis approach

To understand the trends in research, the current applications of product categorization, and how product categorization relates to supply chain strategies, a systematic literature review was conducted. Tranfield, Denyer, and Smart (2003) posited that a systematic literature review is a scientific, transparent and replicable approach "that aims to minimize bias through exhaustive literature searches of published and unpublished studies by providing an audit trail of the reviewer's decisions, procedures, and conclusions". Tranfield et al. (2003) further highlighted that a systematic literature review process involves three main steps, namely: i) identifying the research questions and planning

the review, ii) conducting the review, and iii) reporting and dissemination. The procedure is shown in Figure 2.2:

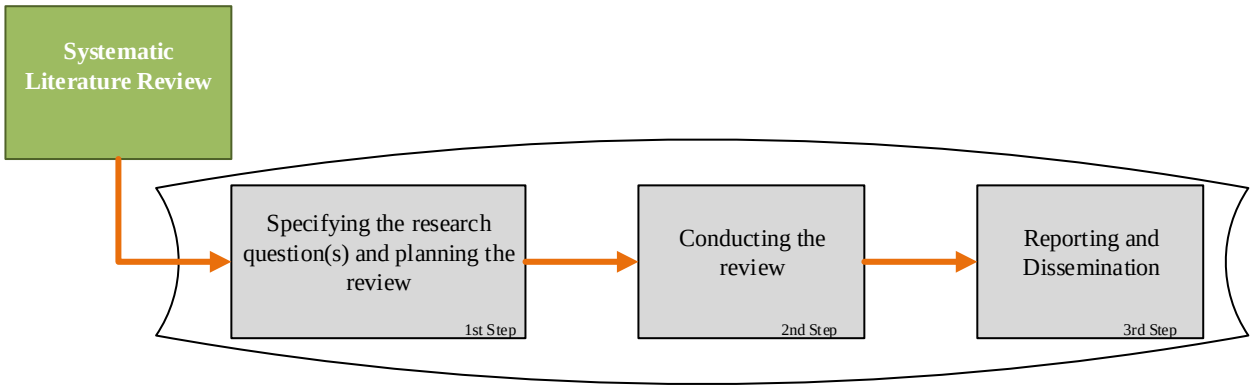

Figure 2.2: Systematic literature review procedure (adapted from Tranfield et al. (2003))

2.3.2. Step 1: Specifying and planning the review

The systematic literature review consisted of firstly gathering and then analyzing research studies and publications concerning product categorization and supply chain strategies that incorporated the practice of product categorization. An overview of the application of product categorization dimensions across industries and more specifically the healthcare sector is subsequently provided.

The literature review was conducted using the Scopus[3] database to identify the application trends of product categorization. The literature review thus sought to address the following two research questions (RQ):

- RQ 1: For the past decade (2007 to 2017), what have been the trends and concepts employed in applying the product categorization dimensions?
- RQ 2: What are the impacts of incorporating product categorization in the various industries?

Both research questions are considered within the SCM context. Keywords from the research questions were derived and the following search line was developed:

(((categori* OR segment* OR classif*) W/5 (demand* OR supply* OR distrib*)) AND ("supply chain" OR "value chain")).

[3] Scopus is a large abstract and citation database of peer-reviewed literature: books, scientific journals and conference proceedings.

The search line took word variations into consideration, for instance, the terms product categorization, segmentation or classification are used interchangeably in the literature. The search line also catered for variations between American English and British English. Since the aim is to consider product categorization within the context of SCM, the terms supply chain and value chain are also included as search terms as well as demand, supply, and distribution. Supply chain and value chain do not necessarily mean the same in literature, but the two terms encompass various aspects that intersect, hence both terms were incorporated into the search line.

2.3.3. Step 2: Conducting the review

The search field included title, abstract, and keywords of items in the Scopus database and the initial search yielded 792 documents. Since the focus of the structured literature review is on contemporary applications of the concept of product categorization, the results were filtered to include only literature published over the past decade (2007-2017). This reduced the number of documents to 636.

The abstracts of the 636 documents were screened for relevancy based on the following two criteria:

i. Documents that addressed the development of frameworks and models of product categorization dimensions and/or supply chain strategies were accepted; and

ii. Documents that did not describe the development of a framework or model but that did detail how and why product categorization should be applied in any setting were included too.

The screening yielded 61 documents that were concerned with detailing and/or development of frameworks, models, and impacts of product categorization and/or supply chain strategies. Care was taken not to overly filter documents during the screening phase, lest important documents might be left out.

Of the 61 documents identified through the screening process, four documents were found to be inaccessible, thus reducing the number of documents included in the dataset for analysis to 57. A further seven documents were added to the dataset for analysis, based on serendipitous discovery. These documents all satisfied the screening criteria. The final dataset for analysis, therefore, consisted of 64 relevant documents. A summary of the approach followed is provided in Figure 2.3.

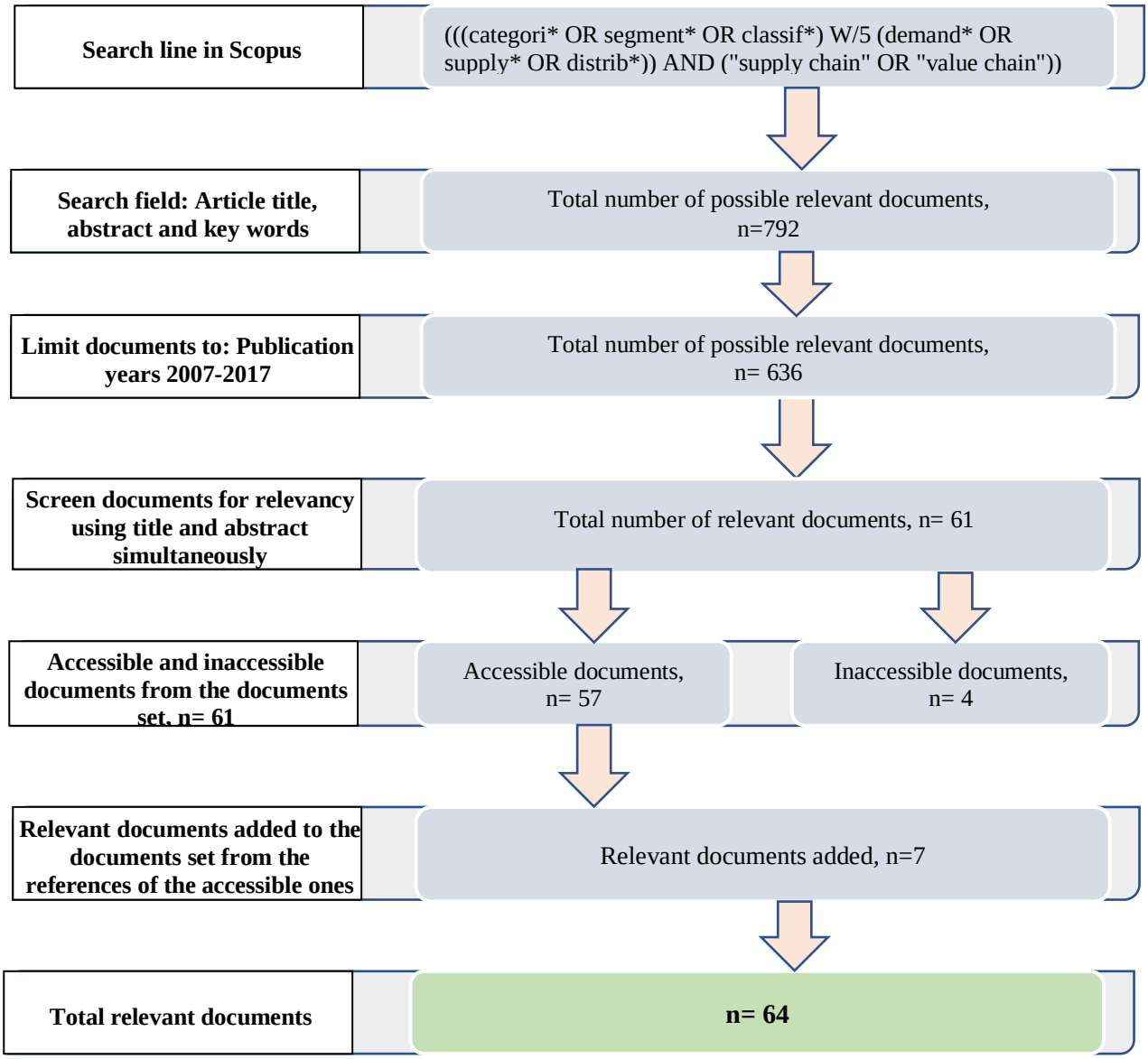

Figure 2.3: Scopus database search methodology (reproduced from Mapowo et al. (2018))

2.3.4. Step 3: Reporting and dissemination of the systematic review

This section provides an overview from the systematic literature review of the application of the product categorization concept, firstly in other industries which are not healthcare (18 documents in the dataset document instances of industry application in general), then secondly in the healthcare industry itself (three documents in the dataset document instances of application to the healthcare industry specifically).

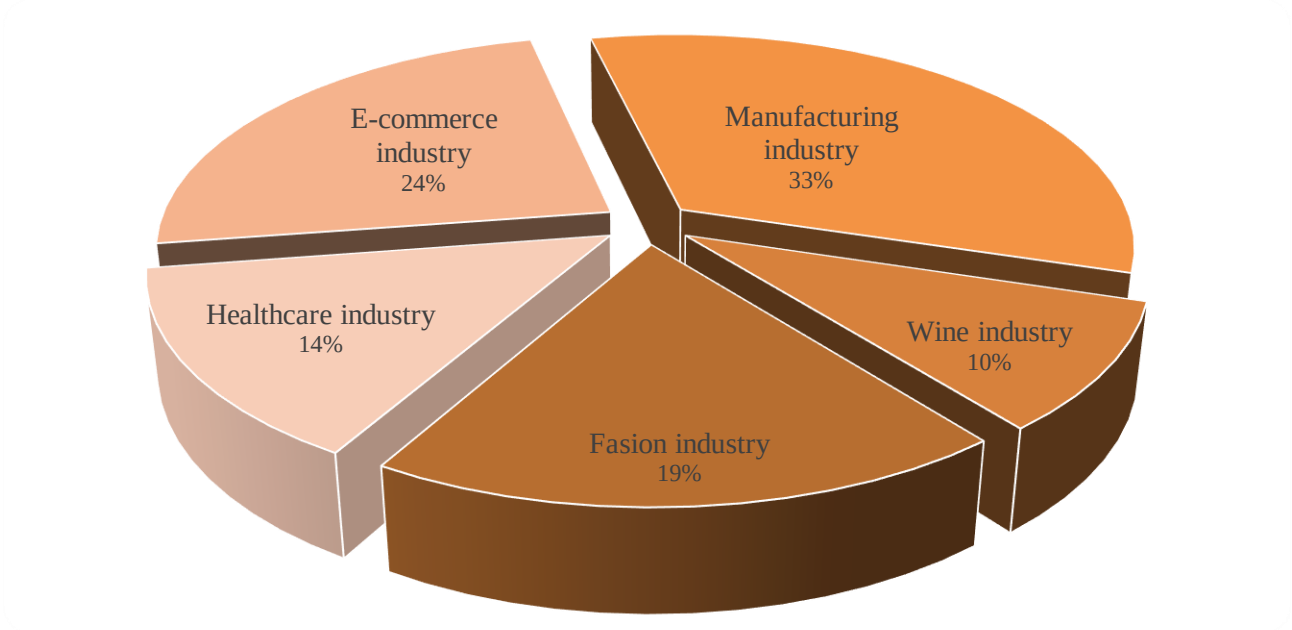

Figure 2.4: Percentage distribution of industry-specific documents pool

The industries that are covered in the dataset are summarized in Figure 2.4. As shown, the majority of industry-specific research has been directed at the manufacturing industry (33%) followed by e-commerce (24%). Healthcare is one of the five industries that are explicitly included in the dataset.

2.3.4.1. Application of product categorization in other industries (excluding healthcare)

The four industries (excluding healthcare) to which concept of product categorization has been applied in that dataset, share certain characteristics with the healthcare supply chain, including:

- ✓ Agility to seasonal and demographic variations, in the case of the fashion and retail industry;
- ✓ The visibility, variability, analytics and categorization of a large innovative product portfolio and how they are supplied that underscores the need for continuous improvement, in the case of the e-commerce industry;
- ✓ Responsiveness to high demand, especially in the case of the wine industry; and
- ✓ Combination of lean and agile principles, in the manufacturing industry.

Table 2.2 below details the concepts of product categorization application in the industries and the impacts thereof. As summarized in the table, product categorization has been applied to demand planning, distribution planning, and supply planning functions in the supply chain. As stated in Section 1.3, the scope of this research is specifically focused on supply planning. The aspects of the supply chain that have been impacted include product availability, product shelf space, order cycle time, lead time to delivery, and demand variability.

Table 2.2: Impacts of application of product categorization in industries (reproduced from Mapowo et al. (2018))

Industry	Literature	Concepts in application	Impacts
Wine industry	Wen, Tong, and Yao (2010)	Quality Function Deployment (QFD)	Optimal determination of delivery frequencies and minimum lot sizes. Improved product and packaging management. Enhanced marketing and responsiveness to high demand peaks.
Manufacturing industry	Nagashima, Wehrle, Kerbache, and Lassagne (2015)	Ordered feature evaluation analysis (OFEA); and Collaboration intensity	Enhanced demand forecasting accuracy.
	Naim and Gosling (2011)	Lean and agile ('Leagile') manufacturing paradigms	Optimal determination of decoupling point.
	Ramkumar, Subramanian, Narendran, and Ganesh (2013)	Vendor Managed Inventory (VMI)	Reduction in lead time and demand variability. Optimal stocking quantities at warehouses.
	Ervolina, Ettl, Lee, and Peters (2009)	Available-To-Sell (ATS)	Optimal demand forecasting. Profitable demand response. Profitable product portfolio.
	Hiremath, Sahu, and Tiwari (2013)	Outbound logistics network (OLN). Multi-objective genetic algorithm (MOGA)	Minimize the total network cost. Maximize resource utilization.
	Taylor, Gan, Grunow, Gan, and Grunow (2015)	concurrent product and supply chain design (CP-SCD)	Provide managerial insights in design trade-off analysis.
	Fichtinger, Chan, and Yates (2017)	Two-Echelon Dual-Channel Supply Chain	Development of profitable market segments.
	Micieta, Lieskovsky, and Binasova (2016)	Group technology	Improvement in quality, productivity and inventory management. Increase costing accuracy. Increase customer service. A gain in sustainable competitive advantage.
	Rajan and Wang (2016)	Hierarchical clustering	Obsolescence reduction.
Fashion and retail industry	Şen (2008)	Efficient supply chain management practices	Production of a variety of sizes, styles, and colors in shorter lead-time. Agility to changing demand requirements. Ability to better forecast and plan future production needs.
	Roscoe and Baker (2014)	Supply chain segmentation	Aligning of demand planning, marketing, sales, and supply chain functions.
	Martínez, Errasti, and Rudberg (2015)	Pronto Moda or Rapid-Fire Fulfilment	Reduction of variety and a wide range of garments per collection. Standardizing fabrics and product platforms. Introduction of mini collections.
	Sardar, Lee, and Memon (2016)	Outsourcing strategies. Goal programming	Cost-saving. Capacity flexibility.
E-commerce industry	Rofin and Mahanty (2017)	Cournot model	Determination of product categories' optimal dual-channel supply chain configuration for different customer online channels preference.
	Hofbauer, Withalm, and Wölfel (2007)	Ontology	Derivation of web ontologies. Efficient and reliable electronic product data exchange across organizations.
	Liao, Chen, and Yang (2013); Murray, Agard, and Barajas (2015); Cooke (2014); and	Two-step data mining approach	Mining customer knowledge on online channels and product segments preferred. Better market segmentation.
	Li and Huang (2012)	Two-Echelon Dual-Channel Supply Chain	Development of profitable market segments.

Considering the literature on the wine industry specifically, the incorporation of product categorization facilitates responsiveness to high demand peaks. Product categorization in the wine industry has also shown that, with delivery frequencies and minimum lot sizes determined, the cost of inbound and outbound transportation can potentially be reduced (Wen et al., 2010).

Examples from the manufacturing industry show that potential impacts of the incorporation of product categorization include determining the optimal decoupling point, reducing lead time and demand variability, optimizing stock quantities at depots, and improving the accuracy of demand forecasting. As seen in the fashion industry, a reduction of variety and a wide range of garments per delivery as well as standardizing product platforms is potentially possible through the incorporation of product categorization. The E-commerce industry shows that visibility, analytics, and categorization of a large product portfolio is likely feasible through the incorporation of product categorization. Determination of product categories' optimal multi-channel supply chain configuration for products is potentially possible too.

As discussed previously, there are shared characteristics between the four industries discussed here and the healthcare industry. It is therefore plausible that some of the same impacts that have been discussed here can potentially be reaped from incorporating product categorization in the healthcare supply chain. The expected benefit of applying product categorization to the South African public healthcare pharmaceutical supply chain is discussed in Section 2.6.

2.3.4.2. Application of product categorization in healthcare

Unlike in the commercial sector where the focus is largely on profit and competitive advantage, the focus in the public healthcare sector is on effective and sustainable availability and administration of healthcare (Abdulsalam, Gopalakrishnan, Maltz, & Schneller, 2015). The dimensions of product categorization have been used in the healthcare sector by Yadav, Lydon, Oswald, Dicko, and Zaffran (2014) in developing a framework for decision making in the integration of vaccine supply chains with other health commodity supply chains. The framework enabled the optimization of immunization supply chains as vaccines were delivered to the end recipients efficiently, effectively and sustainably. Optimal product categories which aided in aligning of demand planning and supply chain functions were determined. Hua, Tang, and Wu (2016) employed the product categorization dimensions in developing an integrated reverse supply chain model. The model was meant to investigate the impact of various unwanted medications categories and government’s publicity and penalty investment on the reverse supply chain profit as well as the collection rate of expired medications. The findings showed that as the percentage of unexpired medications grew, the rate of expired medications collection remained the same, but the profit of the whole reverse supply chain

increased (Hua et al., 2016). Finally, Kritchanchai and Meesamut (2015) employed the dimensions of product categorization in developing an inventory management model for a hospital in Thailand. They argued that a single inventory management system cannot be used on all medicines effectively. The inventory management system they developed enabled the hospital to minimize the total inventory costs while maintaining patient drug administration safety levels. Provision for demand forecasting accuracy was made as well as a reduction in demand variability (Kritchanchai & Meesamut, 2015). The application of product categorization in healthcare according to the systematic literature review is summarized in Table 2.3.

Table 2.3: Impacts of application of product categorization in healthcare (reproduced from Mapowo et al. (2018))

Industry	Literature	Concepts in application	Impacts
Healthcare	(Yadav et al., 2014)	Vaccines supply chain generic map.	Efficient, effective and sustainable delivery of vaccines to end recipients.
	(Hua et al., 2016)	Integrated reverse supply chain model.	Increase in percentage of unexpired medications grew, the rate of expired medications collection remained the same, but the profit of the whole reverse supply chain increased. Cost reduction.
	(Kritchanchai & Meesamut, 2015)	Inventory management model.	Minimized total inventory costs while maintaining drug administration safety levels. Reduction in demand variability. Increase in demand forecasting accuracy.

Similar to the comment made at the end of the previous section, the examples of previous applications of product categorization to the healthcare industry, as well as the documented benefits from these applications, can be used to determine potential applications of product categorization to the South African public healthcare pharmaceutical supply chain. In the two sections that follow, a general introduction to the South African public healthcare pharmaceutical supply chain (Section 2.4) as well as an overview of supply planning in this supply chain (Section 2.5) is presented. This is followed by a discussion of the expected benefit of applying product categorization to the South African public healthcare pharmaceutical supply chain in Section 2.6.

2.4. The South African public healthcare pharmaceutical supply chain

Raja and Mohammad (2004) asserted that a public healthcare pharmaceutical supply chain mainly comprises of four operational functions, namely product selection; quantification and procurement; inventory and distribution; and product use. They further posited that these operational functions exist within an enabling environment of policy and legal framework which governs the core management supporting elements. There is limited literature available on the description of exact operations within

the South African public healthcare pharmaceutical supply chain system, however, the work of Zuma (2016) will be largely referred to, coupled with some available additional contemporary resources.

As shown in the pharmaceutical logistics framework in Figure 2.5, the South African public healthcare pharmaceutical supply chain can be conceptualized as consisting of four operational functions, supportive elements, and an enabling environment. Each of these components will be discussed in the succeeding sections.

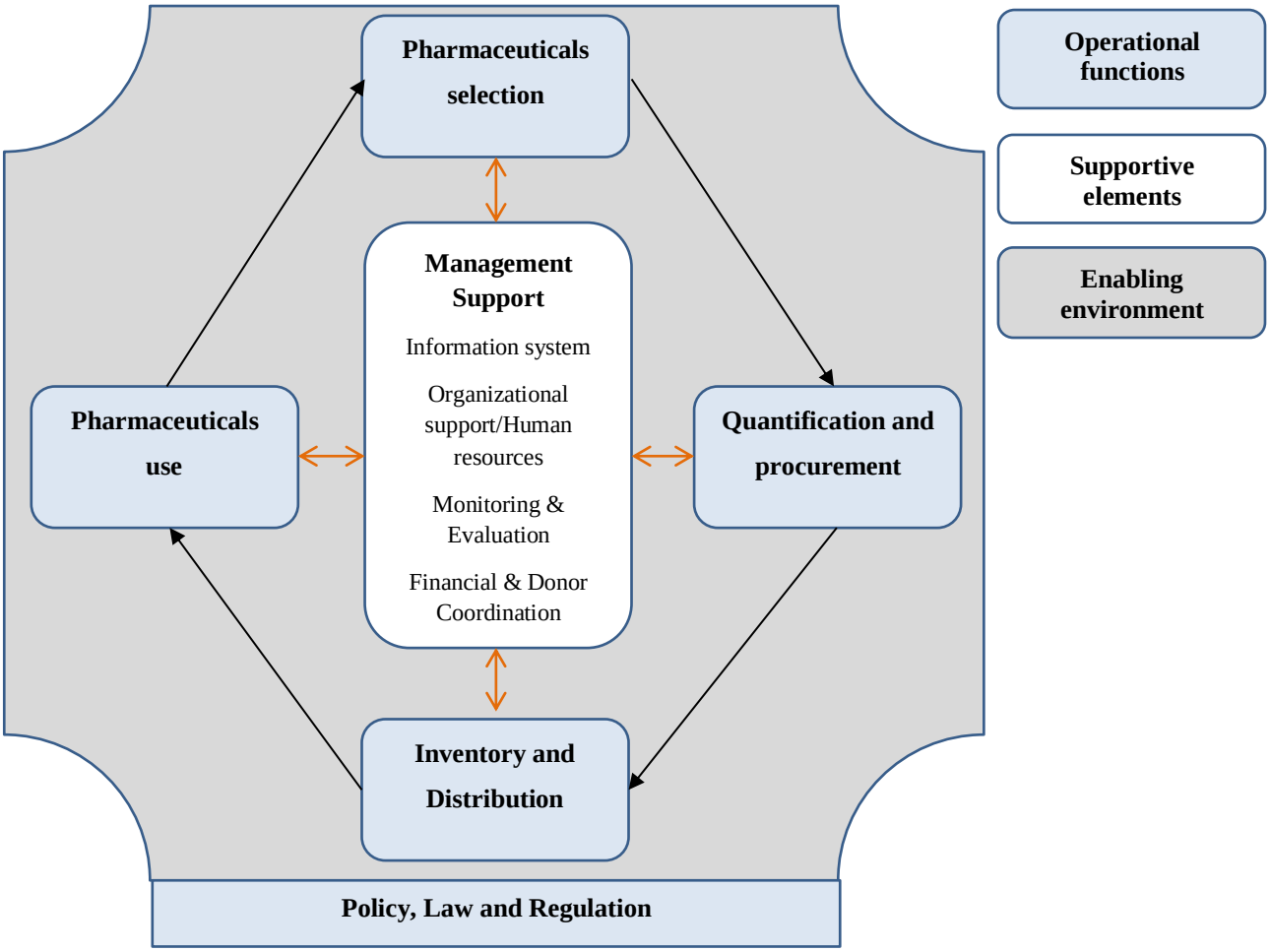

Figure 2.5: Pharmaceutical logistics framework (adapted from Raja and Mohammad (2004))

2.4.1. Operational functions

Each of the four operational elements depicted in Figure 2.5 is briefly discussed in the following subsections.

2.4.1.1. Pharmaceuticals selection

The public healthcare pharmaceutical supply chain sector consists of three levels of care i.e. PHCFs, secondary hospital, and tertiary/quaternary hospital (Perumal-Pillay & Suleman, 2017). The South African NDoH in particular, comprises of a sector-wide Procurement Division mainly responsible for

the essential medicines selection; the standard treatment guidelines (STGs) and essential medicines lists (EMLs) development for each health system level; the administration of health tenders and contracts; and finally, the licensing of the individuals and facilities involved in the pharmaceutical products delivery (Perumal-Pillay & Suleman, 2017).

The South African NDoH has the responsibility for ensuring safe, affordable and equitable access to medicines. The Affordable Medicines Directorate (AMD), a subset of the NDoH, is also responsible for "getting pharmaceuticals to the point of need" (Llewellyn, 2016). The AMD governs, from the national level, the operations and processes of the public healthcare pharmaceutical supply chain to ensure medicine availability across all tiers. The NDoH stipulates the AMD to focus on the Essential Drugs Program (EDP)[4], tender and contract management, and pharmacists' and pharmacies' licensing (Zuma, 2016).

The national EML is utilized by all provinces, with a National Essential Medicines List Committee (NEMLC) and provincial, district and facility-based Pharmaceutical Therapeutic Committees (PTCs) facilitating medicine selection (Zuma, 2016). Zuma (2016) further states that the provincial PTCs known as (PPTCs) have the self-governance to select medicines appropriate for their provincial EML needs, though they are guided by the national EML and funded by the provincial budgets. Literature describing the medicine selection processes in South Africa is not readily available in the public domain, but what is known is that the decisions of the NEMLC guide and drive the procurement of medicines in the public healthcare pharmaceutical supply chain and form the basis for medicine tender processes (National Department of Health, 2017). The NEMLC's decisions at the provincial level are binding even in donor-funded programs such as the ARV program (Pharasi & Miot, 2012). According to Perumal-Pillay and Suleman (2017), the NEMLC often select medicine based on cost and efficacy oblivious of the product availability for procurement. This lack of alignment between the medicine selection and procurement processes is therefore potentially a contributing factor to stock-outs at the facility level.

2.4.1.2. Essential medicines procurement

The South African public healthcare pharmaceutical supply chain uses a closed system for medicine procurement where the central national tier superintends procurement processes with the active

[4] Essential Drugs Program (EDP) promotes the establishment of the Standard Treatment Guidelines (STGs) and Essential Medicines List (EML) for PHCFs at hospital level to ensure the availability of safe, affordable and quality medicines (Gray & Vawda, 2018)

involvement of various provinces (Zuma, 2016). Once the national tier awards the tenders to selected suppliers, provinces are informed and will procure pharmaceuticals from these specific suppliers. Provinces have the mandate of quantifying their pharmaceutical requirements advised by the EML including other pharmaceuticals as per need (Patel, Norris, Gauld, & Rades, 2009). Most of the pharmaceuticals in the public healthcare pharmaceutical supply chain are procured via national tenders and are managed by the AMD in conjunction with the provisions of the National Treasury allocations (Patel et al., 2009).

However, Zuma (2016) argued that provinces do not entirely depend on national contracts since in some cases suppliers fail to meet the service levels, and in such cases, provinces use buy-outs to ensure continuous replenishment of stock. A quotation system where quotes are requested from pre-qualified suppliers before contracting them is used to procure pharmaceuticals that are not on contract—this is termed buyouts. The NDoH pays the deficit from the buy-outs and policy dictates that buy-outs should not exceed 10% of the budget (Berger et al., 2010).

2.4.1.3. Essential medicines inventory and distribution management

The South African pharmaceutical distribution network involves the central medicine stores, regional depots, hospital facilities and PHCFs (Berger et al., 2010; Zuma, 2016). Zuma (2016) posited that provinces employ various distribution methods with third-party logistics (3PL) services being mostly used between the regional/district depots and PHCFs. Figure 2.6 provides a representation of the pharmaceutical distribution network.

Some provinces, for example, the Free State province, pay contractors based on weight consignment so that deliveries cannot take place until the accumulation of stock reaches a certain threshold for dispatch (Berger et al., 2010). Few of the provinces employ a direct delivery system where medicines are directly distributed from the depots to the PHCFs, whereas with the rest of the provinces, stock flows through all the levels downstream (Zuma, 2016).

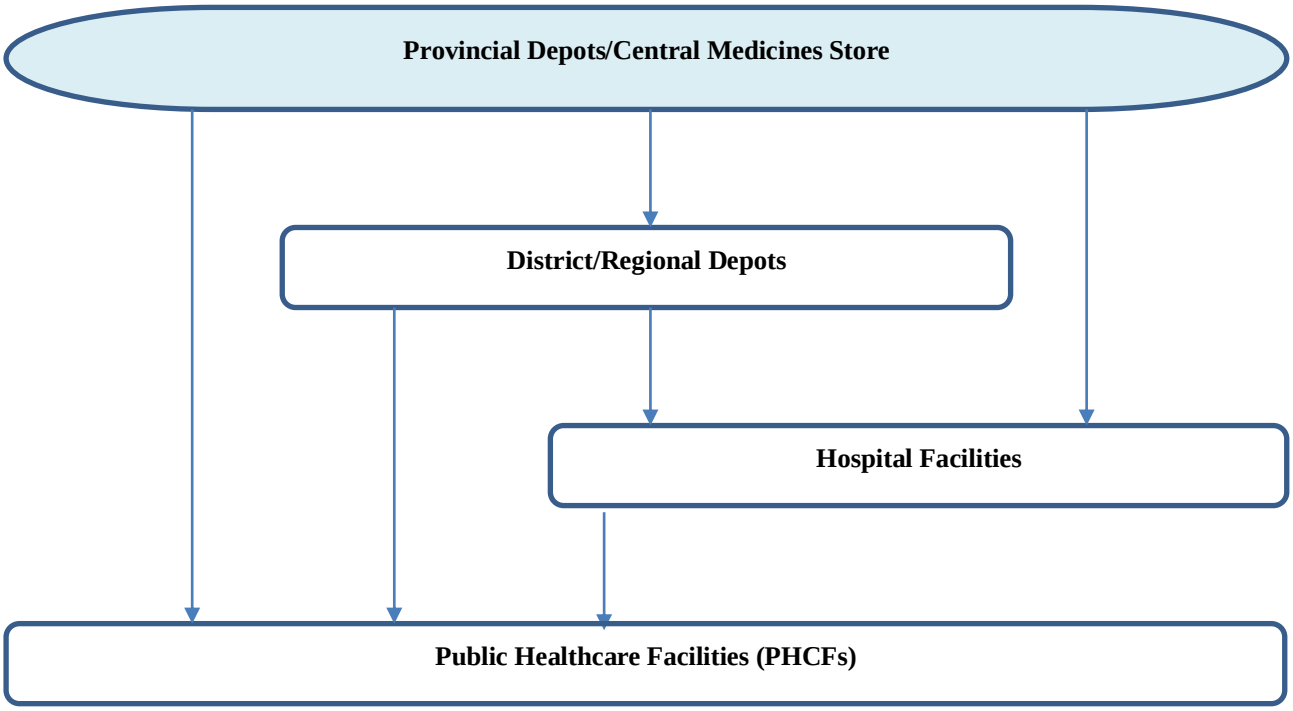

Figure 2.6: Product flows in the South African public healthcare pharmaceutical distribution network (adapted from Zuma (2016))

The distribution of medicine downstream through all the levels, i.e. from provincial depot to district depot to hospital facilities to PHCFs, can affect the lead-times to deliver pharmaceuticals which consequently may shorten medicine lifecycle (shelf life and lifetime). Furthermore, this can complicate the tracking of medicine expiry dates and makes stock prone to being lost in transit between the levels (Zuma, 2016).

2.4.1.4. Pharmaceuticals use

Provinces utilize different approaches to promote rational use of different medicines, with some using the activity-based costing (ABC) analysis—a method used to classify items according to their relative importance—to determine any irrational use of medicine within the province. Other provinces use district pharmacists to conduct training sessions to equip health professionals and inhibit the irrational use of medicines (Zuma, 2016). Zuma (2016) concluded from his study that there is limited capacity building in the South African public healthcare sector for the rational use of medicine.

2.4.2. Management support

As shown in Figure 2.5, Raja & Mohammad (2004) define four supportive elements, namely the information system, organizational support/human resources, monitoring and evaluation, and

financial and donor coordination. These are grouped together and collectively labeled management support. Each of the four elements of management support is subsequently discussed.

2.4.2.1. Information systems

Technological systems like the Stock Visibility System (SVS) and the RxSolution software implementation are underway across provinces' PHCFs to enhance the visibility of stock within the supply chain (Berger et al., 2010). The NDoH is currently using the Contract Management System to manage tenders; administering tender item specification and tender lifecycle in conjunction with the MEDSAS system which manages storage and distribution of products at depots. The National Treasury uses the Rfx system to administer tender processes at the provincial level and the Western Cape province uses the Sourcelink system instead (Berger et al., 2010). Information on what other provinces use is not readily available. This fragmentation of the information landscape possibly complicates medicine stock visibility across the pharmaceutical supply chain.

2.4.2.2. Organizational support/human resources

The NDoH's AMD manages tenders in collaboration with the National Treasury, with three responsibilities (Berger et al., 2010): (i) identifying and selecting medicines for the EML and promoting rational use; (ii) facilitating and coordinating operations and processes for procurement and distribution of pharmaceuticals; and (iii) licensing pharmacy infrastructure and issuing licenses to dispense medicines.

2.4.2.3. Financial coordination

Government financing, e.g. taxes, donor financing, and health insurance schemes, are the primary source of funds for public healthcare pharmaceutical supply chains (Patel et al., 2009; Zuma, 2016). Various provinces and local governments are accountable and responsible for the management of the allocated funds and oversee how these funds are spent on healthcare provision within the province/local government (Berger et al., 2010).

2.4.2.4. Monitoring and evaluation

Within the monitoring and evaluation component, all supporting elements of the operational elements are interlinked with the aim of ensuring that activities and processes adhere to SOPs and best practices within the public healthcare pharmaceutical supply chain (Berger et al., 2010).

2.4.3. Law, policy and legal framework

As shown in Figure 2.5, the enabling environment within which the South African public healthcare pharmaceutical supply chain operates is governed by a legal framework consisting of policies, legislations, guidelines, and SOPs.

The National Department of Health (1996) defined the South African national drug policy to consist of: (i) medicine selection; (ii) traditional medicines; (iii) medicine pricing; (iv) procurement and distribution; (v) rational use of medicines; (vi) human resource management; (vii) research and development; (viii) technical cooperation; (ix) monitoring and evaluation; and (x) regulations and legislations. These elements govern the legislation relevant to medicine supply within the South African public healthcare pharmaceutical supply chain (Zuma, 2016).

In summary of the discussed elements in this section, it is clear that the bundling up of pharmaceuticals is potentially important for monitoring and evaluation of the pharmaceutical supply chain as consumption data and demand trend analysis of pharmaceuticals can be analyzed. This can potentially enhance the rational use of medicines cost-effectively. Provinces can possibly analyze these trends within their specific context i.e. market environment, ease of doing business, demographics, etc. Analyzing service supply planning and service provision in the South African public healthcare pharmaceutical supply chain in the context of VAN—which the NDoH is rolling out—will provide a further understanding of the gaps in the supply chain, and this is discussed in the succeeding section.

2.5. **The VAN strategy in the South African public healthcare pharmaceutical supply chain**

In a typical supply chain system, there exists a ‘product’ that is processed and delivered from a point of origin to a point of consumption. Wang et.al (2015) posit that the ‘product’ can be either a tangible physical product or an intangible service product. As stated in Section 1.4, Wang et.al (2015) further suggest that in the context of service supply chain management, two categories of supply chain systems exist, namely PSSCs and SOSCs. PSSCs have both physical products and services, for example, restaurants and food retail supply chains, while in SOSCs the ‘products’ offered are pure services for example financial consultancy and psychology advice (Wang et al., 2015). As discussed in Section 1.4, this study is limited to PSSCs.

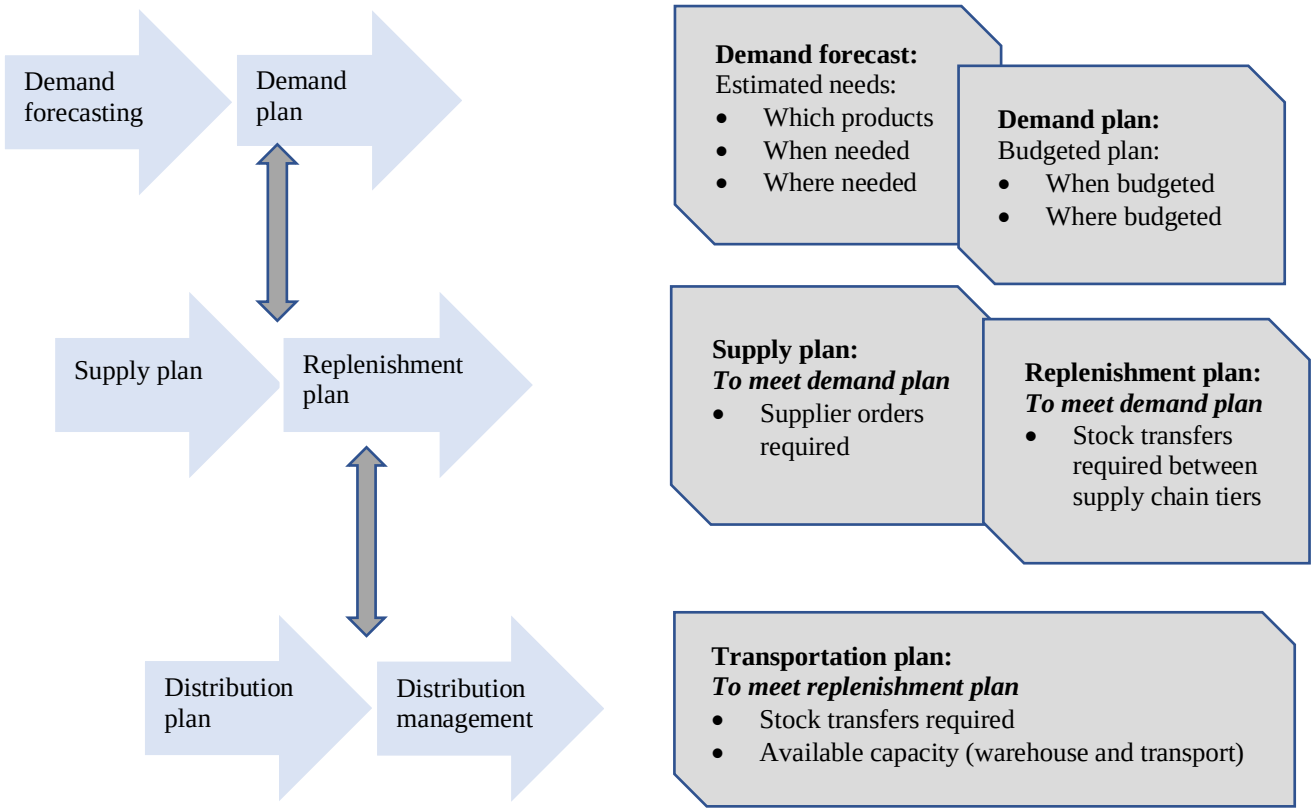

Figure 2.7: Service supply chain planning in VAN (adapted from Llewellyn (2017))

PSSCs entail various overlapping phenomena, which include demand planning, supply planning, and distribution planning as shown in Figure 2.7, which have been defined by Llewellyn (2017), in the context of VAN, as:

1. Demand planning: A combination of statistical forecasting techniques using historical data (e.g. consumption data, historical campaigns, availability to consumers and epidemiology) and, anticipated trends and constraints (e.g. available supply, budget and product changes) to develop demand estimates for products and/or services in order to meet patients' demand (Llewellyn, 2016).

2. Supply planning: The coordination of inventory and orders to optimize the delivery of products to meet the patients' needs—i.e. to provide sufficient products at the right place and at the right time in order to fulfill the demand plan. The outputs from a supply plan are replenishment orders and purchase orders with supply planning variables such as lead time, safety stock, stock on hand, minimum order quantities and delivery channel costs (Llewellyn, 2017).

3. Distribution planning: This is a schedule of shipments of products between warehouse/depots, sub-depots and PHCFs in order to fulfill a supply plan. A distribution plan takes into consideration the constraints of transport capacity and storage capacity in order to determine bottlenecks and optimize asset utilization (Llewellyn, 2017).

As stated in Section 1.3, this study is limited to supply planning.

2.5.1. Transitioning to an 'informed push' approach

The South African public healthcare pharmaceutical supply chain intends to transition from the use of an 'uninformed pull system'—where stock orders are placed as per need by healthcare staff—to an 'informed push system' by the implementation of the VAN initiative (briefly introduced in Section 1.1) (Llewellyn, 2017). The difference being that specialized supply chain management professionals will be utilized in each province and will make recommendations to PHCFs, rather than PHCFs doing their own ordering (Llewellyn, 2017). Llewellyn (2017) highlighted that the VAN model has been established based on the key features of:

- **Visibility**: Specialized supply chain planners will make use of visibility on the consumption data and stock on hand.
- **Analytics**: Analytical processes and Information Technology (IT) will be used to make ordering recommendations and optimization decisions
- **Network**: The network of interlocking roles and responsibilities will link at national, provincial, district and PHCF level, offering clear definitions on what individuals are responsible for, and what technology links support them.

An informed push model, which the VAN advocates for, will relieve the facility staff of supply chain planning and management, which they do not necessarily possess the expertise to perform (Llewellyn, 2017). Specialists who have received the necessary training and have access to the required information technology tools and visibility will perform this work instead. The approach pursues an economy of skill. The transitioning of the supply chain will proceed in four stages, as depicted in Figure 2.8. Stage 3 represents the status quo when VAN is fully operationalized and Stage 4 represents the ideal futuristic state (Llewellyn, 2017):

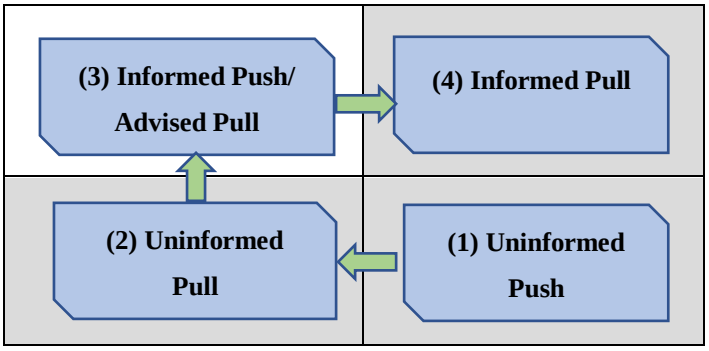

Figure 2.8: The scope of VAN (adapted from Llewellyn (2017))

Stage 1 represents the status quo prior to the implementation of VAN, where the stock is sent to PHCFs based on assumptions and rough calculations from the higher levels of the supply chain. This stage utilizes no supply chain training. Stage 2 is when recipients make orders on their own. Demanders (recipients) are trained to calculate orders, though there is no analysis and upstream visibility. Stage 3 utilizes trained and informed planners. The planners use technology to make order recommendations based on visible sock levels and consumption data. Stage 4 employs a highly automated ordering. In this final stage, technology is used to make order recommendations to demanders who will only be required to authorize spend (Llewellyn, 2017).

2.6. **The potential impact of product categorization in the South African public healthcare pharmaceutical supply chain**

As mentioned previously, it is reasonable to expect that some of the benefits that have been derived from implementing the concept of product categorization in other industries or in the healthcare sector outside of South Africa, could also be achieved if product categorization is applied to the South African public healthcare pharmaceutical supply chain. This section starts with a generalized discussion on the potential positive impact of implementing product categorization in this supply chain before proceeding to a discussion of the potential benefit within the context of the VAN service supply planning approach specifically.

2.6.1. General comments on potential benefits

Based on the findings presented in Section 2.3.4.1 and 2.3.4.2, product categorization can be postulated to potentially enable determination of optimal lot sizes for various pharmaceutical products, as well as replenishment frequency and safety stock levels for different product categories. Literature has suggested the possibility that the lower the replenishment lead time from the provincial depots, as an example, the lower the amount of safety stock that needs to be held by the PHCFs (Kritchanchai & Meesamut, 2015; Yadav, 2015).

Within the South African public healthcare pharmaceutical supply chain, some products are highly sensitive to shortages and stock-outs and, as described in Chapter 1, these pose a high cost to both the healthcare system and its patients. In the wake of the extensive stock outs reported in South Africa, the Health Minister Aaron Motsoaledi in 2013 announced that: “A decision has been taken to implement a **direct delivery system** to certain categories of hospitals…” (Brand South Africa, 2013). The Minister mentioned this in a bid to curb stock-outs, enhance stock supply to hospitals, and free up depots so that deliveries can be made from suppliers directly to district hospitals and PHCFs more efficiently. However, it can be argued that not all pharmaceuticals need a direct delivery system nor

the conventional approach that has been there—the depot system because different products require different supply chain strategies since they have different products attributes and 'one size does not fit all' in terms of supply chain strategy. Therefore, it can be reasoned that a supply/replenishment plan should be developed to facilitate determination of replenishment and purchase orders required as well as stock transfers required where products in the product portfolio will have different supply chain pipelines/strategies according to their attributes e.g. demand, lead time to delivery and cost, etc. By incorporating product categorization, an on-time performance which also affects the variability of lead time has the potential to be optimized. Furthermore, literature has suggested that product categorization in a public healthcare pharmaceutical supply chain has the capability of increasing supply flexibility of various pharmaceuticals—the more flexible the supply is; the less lead time variability will potentially be displayed in order quantities. Product categorization based on product attributes (demand, value volatility, etc.) will possibly enable a better match between demanded products and supply chain strategies (continuous-flow, efficient, fast, and agile supply chains, etc.) which will potentially aid in enhancing the sustainable availability of medicines and a better performing public healthcare supply chain.

2.6.2. Potential benefits within the VAN service supply planning approach specifically

As discussed, the focus of this research is specifically on supply planning. Demand planning and distribution planning are generally well understood and well defined, but it can be less clear what supply planning comprises because it can have many overlaps with demand and distribution planning. Llewellyn (2017) posited that for VAN, supply planning is distinctly considered to pursue the following arithmetic:

$$
\begin{aligned}
&Demand\ plan\ (forecast\ consumption\ for\ the\ month)\\
&\quad - Beginning\ of\ the\ month\ stock\ on\ hand\ (inclusive\ of\ safety\ stock)\\
&\quad + safety\ stock\ (function\ of\ demand\ forecast\ accuracy)\\
&\quad = \boldsymbol{Required\ stock\ for\ the\ month}\\
&\quad - inbound\ orders\ already\ expected\ in\ the\ month\\
&\quad = \boldsymbol{New\ supplier\ or\ replenishment\ orders\ required}
\end{aligned}
$$

It, therefore, implies that to determine the new supplier or replenishment orders required, constraints and decision points to be taken into account are: combined order and delivery lead time, stock on hand at the depot, delivery channel costs and the minimum order quantity (Llewellyn, 2017). After taking into consideration these constraints and decision points, the outputs are: a supply plan (i.e. supplier **orders** required) and a replenishment plan (i.e. stock **transfers** required), which all endeavor

to meet a demand plan (Llewellyn, 2016). With reference to the concept of product categorization, these outputs can be best determined upon selection of the appropriate supply chain strategy for each product category, cognizant of the product attributes.

This study, as highlighted in Section 1.3, focuses on product categorization from the view of the two tiers of administration of the South African public healthcare pharmaceutical supply chain i.e. the national and provincial levels. The current national role in planning involves: coordinating product selection and demand forecasting for cross contracting; and overseeing in-contract compliance of demanders and suppliers with stock availability and ordering guidelines (Llewellyn, 2016). However, the new activities in the context of VAN will be: establishing and coordinating nationwide planning processes to ease communication along the supply chain; promoting the optimization and continuous improvement; and managing national health budget allocation and resolving supplier issues (Llewellyn, 2017). It follows that, with the establishment of a framework that enables the appropriate matching of product attributes and supply chain strategies, the national level will potentially be able to facilitate sufficient health budget allocation to assist and enable the various supply chain strategies. Moreover, the national level will likely be able to resolve and optimize supplier tendering and contracting issues, including upholding legislation and guidelines, to ensure various supply chain strategies offer the 'right' products at the 'right' time in the 'right' quantities. This will potentially pave the way for an improved pharmaceutical supply chain and enhance the sustainable availability of medicines.

Consequently, a product categorization framework that matches product bundles, attributes and supply chain strategies will potentially smooth the supply-demand malfunctions and mitigate bullwhip effects. Moreover, product-driven supply chain sourcing and replenishment strategies i.e. supply chain strategies developed from the framework, will likely aid in stock (pharmaceuticals) availability and potentially contribute as input to the development of an appropriate distribution plan. Continuous improvement in national aggregation, issue resolution, and budget alignment can thus potentially be facilitated from the provincial level to the national level and vice versa. The Provincial Medicine Procurement Units (PMPUs) will thus likely be capacitated, through VAN, to create plans for their provincial districts and facilities. Such capacity building seeks to pursue the enactment of the Affordable Medicines Directorate (AMD) strategy where the short-term focus (1-3 years) is on three pillars—i.e. contracting, supply chain and contract management—in order to 'get the right pharmaceuticals to the point of need' and beyond three years the focus will be on 'selecting the right pharmaceuticals' (Llewellyn, 2017).

2.7. **Framework design requirements identified in Chapter 2**

Aspects discussed in this chapter can be used to deduce design requirements as defined by van Aken et al. (2007) which are detailed in Table 2.4. The table format will be used in the succeeding chapters to identify and describe design requirements discussed in each chapter. The table details the selected design requirement as discussed in the chapter and the corresponding requirement ID.

Table 2.4: Framework design requirements identified in Chapter 2

Requirement	Req. ID
User requirements (U)	
Not applicable (none identified)	
Functional requirements (F)	
Not applicable (none identified)	
Design restrictions (R)	
Not applicable (none identified)	
Boundary conditions (B)	
The framework's output, in the form of recommendations for managing the public healthcare pharmaceutical supply chain, must align with the principles that underpin the Visibility and Analytics Network strategy, most importantly the concept of informed push.	**B1**
The framework's output, in the form of recommendations for determining supply planning's sourcing and replenishment plans, must contribute to the determination of supplier collaboration constraints (contracts and tenders) within the funding limitations.	**B2**
The framework's output, in the form of recommendations for managing the public healthcare pharmaceutical supply chain, must align with the principles that underpin the South African Constitution.	**B3**
Attention points (A)	
The framework's recommendation for managing supply chain strategies should ideally incorporate the direct delivery and depot system that are already operational in the South African public healthcare pharmaceutical supply chain	**A1**

2.8. **Conclusion**

In this chapter, consistent with Objective 1 of this research, a rationale for the research has been developed and Sections 2.3.4.1; 2.3.4.2; and 2.6 have detailed the impacts of the concept of product categorization when applied in various industries including the potential benefits product categorization can have in the South African public healthcare pharmaceutical supply chain. An overview of the operation and management of the South African public healthcare pharmaceutical supply chain was detailed together with an overview of supply planning in line with the VAN principles in the South African public healthcare pharmaceutical supply chain.

Chapter 3 will conceptualize product categorization methods together with generic product attributes to ensure the determination of critical product attributes specific for public healthcare pharmaceutical supply chains. Pharmaceutical product bundles will be identified as an essential element of the product categorization framework development. Supply chain strategies in SCM will be

conceptualized and contextualized to the South African public healthcare pharmaceutical supply chain in the scope of the VAN. To provide perspective, the supply chain goals which product categorization can target will also be discussed. Levers to control in supply chain strategy implementation, enabled through the VAN strategy, will also be established.

Chapter 3

Solution development: Product attributes and supply chain strategies taxonomy

3.1. Introduction

The findings of literature reviews as well as information gathered from SMEs, on a number of topics that are relevant to the development of a framework are presented in this chapter. Information is also synthesized in order to formulate interim solutions that are necessary inputs to the framework development presented in the following chapter. This chapter is consistent with this study's second objective:

Research objective 2: To investigate a number of operational aspects that are critical to informing the development of the framework design requirements. The sub-objectives associated with research objective 2 are:

a) Determine and identify a set of product attributes critical for matching pharmaceutical product categories with supply chain strategies in public healthcare pharmaceutical supply chains using a triangulation method;

b) Identify pharmaceutical product bundles based on existing classification and nomenclature systems used in healthcare;

c) Provide an understanding of supply chain focus points which product categorization can target;

d) Examine supply chain strategies and contextualize the product categorization framework development consistent with: the VAN supply chain; VAN service supply planning; and the South African public healthcare pharmaceutical supply chain; and

e) Determine and tailor to the VAN strategy, the specific levers to control in product categorization and supply chain strategy implementation in the South African public healthcare pharmaceutical supply chain.

The chapter ends with a summary of the set of framework design requirements that are derived from the work presented.

A significant portion of the text in Sections 3.2 and 3.3 has been reproduced from a conference article that was presented as part of this research. The full article citation is as follows: Mapowo, N., Bam, L., de Kock, I., & van Eeden, J. (2019). "Enabling product categorisation in a public healthcare pharmaceutical supply chain by underscoring the product attributes taxonomy". Accepted for publication in: Proceedings of the *25th ICE/IEEE International Technology Management Conference, 17th – 19th of June 2019, Sophia Antipolis, Nice, France*. © 2019 IEEE.

3.2. **Product categorization methods**

This section details the generic product categorization methods that have been established in the literature. The product attributes that are identified for use in matching product categories with appropriate supply chain strategies in these established categorization methods are presented. Finally, the most salient characteristics that differentiate public healthcare supply chains from commercial supply chains, in general, are briefly discussed.

As briefly introduced in Section 2.2 and as a reminder to the reader, Fisher (1997) proposed that if products are classified based on their demand configurations, they fall into one of two categories: they are either primarily functional or primarily innovative—with functional products being characterized by the low profit-margins and predictable demand whereas innovative products are characterized by short lifecycles, high-profit margins, and volatile demand. Furthermore, Fisher (1997) posited that these product categories can be matched to supply chains which can either be physically efficient or market responsive. According to Fisher (1997), functional products are matched to efficient supply chains and mismatched to responsive supply chains, while the opposite holds true for innovative products. If products are not aligned with their appropriate supply chain strategies, this can result in overserving and overcharging functional products' customers and underserving and undercharging innovative products' customers.

Various researchers have premised on Fisher's pioneering framework to develop product categorization methods using diverse product attributes. Three such well-documented methods that can address SCM product categorization selection are: the DWV³ by Christopher and Towill (2000), the three-dimensional global classification system by Christopher and Towill (2002) and the Product Supply Characterization (PSC) model by Payne and Peters (2004).

3.2.1. The DWV^3 classification

The DWV^3 classification system utilizes five product attributes, namely the **D**uration of the product lifecycle, the time **W**indow for delivery, the **V**olume, the **V**ariety, and the **V**ariability, which build the acronym DWV^3. This classification method is mainly used to develop focused demand chains where processes are prioritized as a sequence of events with the end view of serving the ultimate consumer (Christopher & Towill, 2000).

3.2.2. The three-dimensional global classification system

The three-dimensional global classification system utilizes three product attributes, namely: product, demand, and lead-times. Each attribute is classified as one of two gradations (Christopher & Towill, 2002):

- Product (standard or special);
- Demand (stable or volatile); and
- Lead-time (short or long).

The three-dimensional global classification system was developed with a focus on linking the supply chain strategy with the product lifecycle management, signifying that the most suitable supply chain strategy of a product differs depending on its stage in the product lifecycle (Christopher & Towill, 2002).

3.2.3. The Product Supply Characterization (PSC) model

Payne and Peters (2004) asserted that the PSC's focus is on addressing total supply chain costs and service performance to the customer. The PSC model utilizes seven (7) product attributes which are:

- Volume,
- Volatility,
- Order line value,
- The frequency of order lines,
- Order line weight,
- Substitutability of a product and
- Number of customers buying each product

The DWV^3 and the PSC can potentially suit a public healthcare pharmaceutical supply chain, largely because the DWV^3 has been employed in developing a focused demand supply chain, which in this case the end goal will be to serve the patient. Furthermore, the PSC focuses on service performance for the customer, which in the case of the healthcare pharmaceutical supply chain would be the healthcare delivery to the patients. However, the three-dimensional global classification system takes into consideration the order qualifiers and order winners in a supply chain and could, therefore, be beneficial to a public healthcare pharmaceutical supply chain in the reduction of costs and increase in performance.

It is evident that the three prominent categorization methods that have been presented here differ in terms of the product attributes on which categorization decisions are based. A consolidated set of product attributes that have been developed in literature is presented in the following section and consequently, salient supply chain-driving product attributes for public healthcare supply chains are determined.

3.3. Salient supply chain-driving product attributes

Harris, Sullivan, Componation, and Farrington (2006) conducted an extensive systematic literature review of post-2000 product attributes employable in matching product categories with appropriate supply chain strategies, which were not focused on one particular company or industry. The study yielded a compilation of 15 generic product attributes. Consequently, Sullivan et al. (2007) premised on these product attributes and defined the respective measurable characteristics of these product attributes. The complete set of product attributes defined by Harris et al. (2006) together with the measurable characteristics by Sullivan et al. (2007) are presented in Table 3.1.

Table 3.1: Product attributes and their measurable characteristics (reproduced from Mapowo, Bam, de Kock, and van Eeden (2019) © 2019 IEEE)

Product attributes	Examples of measurable characteristics	DWV[3]	The three-dimensional global classification system	PSC
Cost	Supply chain, inventory, and manufacturing			
Demand	Variability, predictability, volatility, and volume	✖	✖	✖
Quality	Defects and yield percentage			
Financial	Profit margin per part			
Product	Physical characteristics		✖	✖
Lifecycle	Phase and length of time in phase	✖		
Design	Manufacturability of the product			
Standardization	Few customized features of the product			
Customer	Responsiveness in service			✖
Uncertainty	Customer demand and market environment			
Delivery	On-time or on-schedule	✖		
Flexibility	Handling of change in demand, design, and delivery			✖
Inventory	Product held in Kanban/JIT inventory			
Lead time	Response time to deliver the product		✖	
Production	Capability and capacity to produce in a lean environment			

The table provides an indication of which of these product attributes are utilized in each of the three product categorization methods discussed in the previous section. The product attributes compilation by Harris et al. (2006) confirms the work done by Christopher and Towill (2000), (2002) and Payne and Peters (2004) in coming up with the three product categorization methods discussed in Section 3.2. However, as an example, product attributes such as volume, volatility, and variability utilized in

the DWV[3] method represent different dimensions of the expanded form of the 'demand' attribute identified by Harris et al. (2006).

The product categorization methods discussed in this section were developed for use in the commercial sector. The product attributes established from literature are generic and research has not yet considered determining critical product attributes in the public healthcare pharmaceutical supply chain sector specifically. However, while there are certainly many commonalities between the dynamics of commercial sector supply chains and public healthcare supply chains, there are also distinct differences which would need to be taken into consideration when selecting appropriate product attributes for product categorization in a public healthcare supply chain. Several salient characteristics that distinguish public healthcare supply chains from commercial supply chains are briefly discussed in the following discussion.

Lingervelder, Bam, and Bam (2016) systematically compared and highlighted differences between donor-funded supply chains with commercial supply chains. In their findings, characteristics of public healthcare pharmaceutical supply chains were discussed under the donor-funded supply chains grouping. Six of the 12 characteristics which Lingervelder et al. (2016) describe as having distinctions between the two types of supply chains are relevant to supply planning within the public healthcare pharmaceutical supply chain, namely:

i) The goals and objectives of a commercial supply chain typically focus on competitive advantage, revenue generation and profit maximization, whereas the public healthcare pharmaceutical supply chain typically aims at efficiently and cost-effectively ensuring sustainable availability of medication (Christopher et al., 2009; Harris et al., 2010; Kritchanchai & Meesamut, 2015; Yadav et al., 2014).

ii) Supply chains comprise of an upstream segment with activities such as manufacturing, financing, warehousing, and forecasting, etc., and a downstream segment with activities such as stock storage and distribution to retailers and consumers. Commercial supply chains primarily manage the two segments coupled together while public healthcare supply chains ordinarily decouple the segments from one another (Nicholson, English, Guenther, & Claiborne, 2013).

iii) In a public healthcare pharmaceutical supply chain, finances come from government funding and/or charitable donations from organizations and the recipients of the products and services often pay very little or nothing at mostly insignificant profit

margins. However, in commercial supply chains, revenue generated from the sale of goods and services is largely the source of finance (Beamon & Balcik, 2008).

iv) For public healthcare supply chains, especially at the national tier level, demand is largely characterized by unpredictability due to differences in the impact of the situation, demographic variations, and social and economic structures of the area. However, in commercial supply chains, there is considerable consistency in demand elasticity, demand patterns and forecasting abilities (Beamon & Balcik, 2008).

v) The majority of public healthcare pharmaceutical supply chains have purchasing decisions that are made from competitive bidding processes, tenders, and short-term contracts or agreements, while commercial supply chains tend to pursue lasting relationships with partners to come up with long-term contracts and agreements (Schliephake, Stevens, & Clay, 2009).

vi) Transport and logistics in public healthcare pharmaceutical supply chains have different orientations as opposed to commercial supply chains due to the complexity of conditions they must operate in. For example, commercial areas can opt not to target areas where there is poor transportation infrastructure but public healthcare pharmaceutical supply chains do not have that option as they have to address the population's needs regardless of the operating conditions (Wassenhove, 2006).

From the description of the six characteristics where public healthcare supply chains differ from commercial supply chains, it is evident that the product attributes deemed to be critical for product categorization in a commercial supply chain are not necessarily directly applicable to the public healthcare pharmaceutical supply chain without scrutiny and undergoing necessary adaptations or modifications. Thus, the triangulation approach is used to achieve strengthened construct validity and internal validity. The triangulation method is applied by firstly taking into account the understanding of the supply chain-driving product categorization methods as applied in various industries' supply chains and subsequent product attributes as provided in the literature and already discussed in Section 3.2 and this section. Secondly, subject matter experts (SMEs) are consulted to cross-check what literature provided, interpolating these provisions to public healthcare pharmaceutical supply chains. Finally, provisions from literature and inputs from SMEs are synthesized and a final list of proposed product attributes for use in public healthcare pharmaceutical supply chains are developed through the application of logical arguments and reasoning. Thus, as part of the triangulation method, the following section describes how inputs from SMEs were gathered as a second source of input for

determining the product attributes that are relevant in a public healthcare pharmaceutical supply chain.

3.3.1. SME input incorporation methodology

In order to determine appropriate supply chain-driving product attributes critical to the public healthcare pharmaceutical supply chain, a semi-structured interview was set up as shown in Appendix A. The compilation of product attributes by Harris et al. (2006) in Table 3.1 was used in the semi-structured interview and the description of measurable characteristics of the product attributes by Sullivan et al. (2007) was provided in order to minimize ambiguity. A 5-point Likert-type scale was used to measure responses as this provided a greater degree of nuance than a simple 'yes/no' and gave granular feedback through a wide range of answer options. The Likert scale ranged from 'strongly unimportant' to 'strongly important'.

Two open-ended questions were also included in the semi-structured interview, the first of these required that the respondents comment on the product attributes employed in the three generic product categorization methods established in this study. The responses indicated whether SMEs deemed the set of product attributes defined in any of the three established product categorization methods to be directly applicable to public healthcare pharmaceutical supply chains. The second open-ended question probed respondents to indicate whether apart from the 15 product attributes included in Table 3.1, there were any other product attributes which the respondent deemed critical. When interpreting these responses, care was taken to discern differences in wording but similarities in essence of the suggested product attributes compared to those already provided. Care was also taken in noting that research recommends that the number of product attributes to be used should strike a balance between too many and too few as it is neither desirable nor economically feasible to establish an extensive number of discrete supply chain pipelines as this would escalate operations management overheads (Christopher et al., 2009; Godsell et al., 2011; Harris et al., 2010).

Since this study concerns SCM within the healthcare sector, individuals that are considered to be SMEs in either SCM or management of healthcare systems were selected as respondents and their backgrounds are detailed in Appendix B. Based on the different expertise of the SMEs and their various areas of specialty, the survey was designed to have a comprehensive base with views of the study from various critical expertise standpoints. These include the business analysis and improvement perspective, the VAN perspective, policy analysis perspective, maturity models analysis perspective, informed push model analysis perspective, strategic and operational supply

chain management perspective and the healthcare supply chain governance perspective. The input provided by these SMEs formed the second component of the triangulation method used in this study.

3.3.2. SMEs feedback findings and analysis

This section starts with a presentation of the results of the SME survey. Thereafter, a set of product attributes that have been selected based on the results of the SME survey are discussed in more detail. The discussion incorporates feedback received from the SMEs together with logical arguments. Specific emphasis is placed on arguments that are based on the characteristics that differentiate public healthcare pharmaceutical supply chains from commercial supply chains in general. In conclusion, a set of product attributes to be used for product categorization in public healthcare pharmaceutical supply chains is proposed.

The first question of the survey required the SMEs to evaluate the importance of 15 product attributes for product categorization decision in public healthcare pharmaceutical supply chains. Additionally, respondents were requested to suggest additional product attributes that should also be taken into consideration. The feedback provided by the seven SMEs is summarized in Table 3.2

If more than 50% ($4^{+}/7$) of the respondents considered a product attribute to be either important or strongly important, then such a product attribute was deemed worthy of further consideration. Using this criterion, 12 of the 15 product attributes remained, namely: demand (7/7); lead time (7/7); delivery (6/7); quality (6/7); cost (6/7); life cycle (6/7); standardization (6/7); customer (6/7); uncertainty (6/7); flexibility (6/7); product (5/7); and financial (4/7).

In response to an open-ended question, SMEs suggested four additional product attributes which they deem to be applicable, namely: shelf life; substitutability of the product; seasonality of the product; and a therapeutic group of the product.

Each of the 12 product attributes that were indicated as being either strongly important or important by at least 50% of the respondents, as well as the four additional product attributes proposed by the respondents are considered in the discussion that follows. As per the triangulation method employed in this research, the discussion synthesizes inputs from literature, the inputs received from the SMEs as well as logical reasoning to ascertain the most critical product attributes for use in public healthcare pharmaceutical supply chains.

Table 3.2: SME's responses to literature compilation of product attributes, and other suggested product attributes (reproduced from Mapowo et al. (2019) © 2019 IEEE)

			Frequency of Occurrence				
Source	**Product Attributes**	**Examples of Measurable Characteristics**	*Strongly unimportant*	*Unimportant*	*Neutral*	*Important*	*Strongly important*
Provisions from literature	Cost	Supply chain, inventory, and manufacturing			1	5	1
	Demand	Variability, predictability, volatility, and volume				1	6
	Quality	Defects and yield percentage			1	3	3
	Financial	Profit margin per part	1		2	3	1
	Product	Physical characteristics			2	3	2
	Life cycle	Phase and length of time in phase			1	3	3
	Design	Manufacturability of the product		2	2	3	
	Standardization	Few customized features of the product		1		5	1
	Customer	Responsiveness in service			1	2	4
	Uncertainty	Customer demand and market environment			1	1	5
	Delivery	On-time or on-schedule			1	2	4
	Flexibility	Handling of change in demand, design, and delivery			1	5	1
	Inventory	Product held in Kanban/JIT inventory			4	2	1
	Lead time	Response time to deliver product				2	5
	Production	Capability and capacity to produce in a lean environment		1	3	2	1
SMEs additions/suggestions	Shelf life	Expiry dates and obsolescence					2
	Substitutability of a product	Alternatives of the same drug				1	
	Seasonality of a product	Change in demand with relation to seasons				1	
	Therapeutic group	Product physical characteristics, product class				1	

3.3.2.1. Cost and financial product attributes

According to Payne and Peters (2004), when matching product categories with the appropriate supply chain strategies, the categorization should be based on balancing required customer service levels with the total costs of supplying that service level. Such considerations are the same for both commercial supply chains and public healthcare supply chains. Costing approaches that are driven by activity-based methods in a public healthcare pharmaceutical supply chain, which is mainly

financed by the government and/or donors, enable supply chain managers to make better-informed decisions pertaining to the customer, product, and channel cost/profitability by providing the true cost of sending a particular product via a certain supply chain pipeline (Abdulsalam et al., 2015; van der Veeken & Rutten, 1998).

At the operational level, the true cost in under-resourced public healthcare pharmaceutical supply chains is driven by factors such as the number of orders placed and order line weight which translates to lot sizes and replenishment frequency (Payne & Peters, 2004). Finances as a product attribute entail measurable characteristics, such as 'profit margin per part', 'cost of procurement', 'holding cost', 'cost of obsolescence' and 'cost of distribution'. These measurable characteristics aid in decisions such as: determining the threshold between products that are deemed affordable and those that are not; and choosing a certain supply chain strategy over another, thus directing the number of orders placed and the order line weight which impacts lot sizes and replenishment frequency. While these characteristics are extensively defined in the commercial supply chains (where the focus, as established before, is largely on competitive advantage, revenue generation, and profit maximization) they are most likely less commonly defined in public healthcare pharmaceutical supply chains (where the primary aim is the sustainable and cost-effective availability of medicines), even though they are equally relevant in this context (Abdulsalam et al., 2015; Birhanu, Lanka, & Neelakanteswara Rao, 2014; Kim, Fowler, Shunk, & Pfund, 2012).

As public healthcare pharmaceutical supply chains in developing countries in general, and in South Africa in particular, operate on restricted budgets and are mostly under-resourced, the 'cost to the supply chain' characteristic is considered a significant concern as this has a direct impact on the ability to fulfill the aim of ensuring sustainable and cost-effective availability of medicines. Thus, consistent with literature provisions and the recommendations from SMEs, **'cost to the supply chain'** is deemed to be a critical product attribute to the public healthcare pharmaceutical supply chain product categorization.

3.3.2.2. Demand, customer and uncertainty product attributes

Lee (2002) asserts that products with a dependable source of supply and stable demand should not be managed in the same way as those with unreliable supply and unpredictable demand. Fisher (1997) added that the demand for functional products can be forecasted with ease, while it is complex to forecast demand for innovative products due to the unpredictability of demand. As established before, some public healthcare pharmaceutical supply chains are characterized by unpredictability in demand due to demographic variations, as well as the social and economic characteristics of the area being

served. Therefore, dynamics in demand need closer scrutiny in such supply chains. Some products also have stable demand in certain circumstances and unstable in other, for example, seasonal products and those that spike in demand during certain circumstances e.g. disease outbreaks. Hence, within the public healthcare pharmaceutical supply chain, products that have predictable, circumstantial or unpredictable demand cannot use the same supply chain strategy (Harris et al., 2010; Lee, 2002).

Based on this reasoning, the 'customer responsiveness in service' and 'uncertainty of demand' attributes as well as the 'seasonality of a product' attribute proposed by the SMEs, will be merged and considered under demand. Demand is considered as a primary attribute in the three-dimensional global classification system with gradations: volatile or stable; however, the secondary attributes of demand—i.e. volume, volatility, and variability—have been used in the DWV^3 classification system and these secondary attributes have been further expanded to formulate all seven of the PSC's product attributes. This suggests that the consideration of demand as a product attribute is a priority to both commercial supply chains and public healthcare pharmaceutical supply chains. The use of the stated secondary and expanded attributes results in strategies which are highly sensitive to slight changes in the product portfolio and are needful of frequent review (Kritchanchai & Meesamut, 2015). Hence, such forms of the demand attribute are not the most appropriate for use on a national or global scale of the public healthcare pharmaceutical supply chain which is susceptible to extensive unpredictability (Aitken, Childerhouse, Christopher, & Towill, 2005; Godsell et al., 2011). The forms of the demand attribute should, however, be used as pointers in defining the threshold between demand that is considered volatile versus demand that is considered stable. Moreover, use of the secondary and expanded product attributes would result in an extensive number of differentiated pipelines which makes the supply chain unnecessarily complex as alluded to before. Based on the literature findings and SME input, **demand** should be considered as a critical product attribute in the public healthcare pharmaceutical supply chain since it embeds the secondary attributes and will make the supply chain strategies less sensitive to slight changes in the pharmaceutical product portfolio.

3.3.2.3. Quality and life cycle product attributes

From the perspective of production and operations management, quality is a product attribute with measurable characteristics such as defects and yield percentage that can be used for product categorization (Roscoe & Baker, 2014). In the context of a public healthcare pharmaceutical supply chain specifically, quality can be considered with measurable characteristics such as obsolescence and shelf life which pertain to inventory management (Musa, Gunasekaran, & Yusuf, 2014). This is potentially an important consideration as, unlike commercial supply chains which can choose to forgo

areas with unfavorable conditions, public healthcare pharmaceutical supply chains have a mandate to reach all populations regardless of the ease of accessibility, and hence inventory management has to be aligned to product life cycle to keep service levels high. Moreover, life cycle, which is derived from the shelf life (defined as the recommended time that products can be stored while maintaining acceptable quality under specified conditions of distribution, storage, and display) and from lifetime (defined as the first date of use until the product expires/stops working), can be merged together with the consideration of quality (Christopher, 2011).

Life cycle consideration is vital for products within the pharmaceutical product portfolio as this metric can vary significantly between products. Products with short life cycles require both a short end-to-end pipeline and rapid time to market to facilitate continuous replenishment in relation to demand during the product life cycle (Aitken et al., 2005). This is applicable particularly to pharmaceutical products which need a cold chain. Products with short life cycles also potentially pose a greater risk of obsolescence. Examples of measurable characteristics for life cycle such as quality, lifetime, shelf life and obsolescence will thus be used to define the threshold between temporal and lasting life cycles. Based on these provisions from literature and how quality and life cycle were ranked by the SMEs, **life cycle** should be considered as a highly critical product attribute to a public healthcare pharmaceutical supply chain.

3.3.2.4. Product and standardization product attributes

The consideration of the physical characteristics of the product, which can be conceptualized as a binary gradation of either being standard or special according to Christopher and Towill (2002), appears to be vital in the selection of supply chain strategies. In terms of the level of standardization of products, Fisher's (1997) distinction between functional products (which satisfy basic needs with no significant change over time, and have longer life cycles with predictable demand and low profit margins) and innovative products (which are defined as having more volatile demand, shorter life cycles, and high profit margins) is relevant.

The product's physical characteristics and standardization considerations are potentially important considerations for both commercial supply chains and public healthcare pharmaceutical supply chains. SMEs highlighted the need to consider 'therapeutic group' and 'substitutability of the product' as product attributes, these can be merged into this discussion of the product's physical characteristics and standardization of the product. In public healthcare pharmaceutical supply chains specifically, different products in the pharmaceutical product portfolio address different therapeutic needs and have different demand trends. Therefore, considering which products perform in what manner is

deemed critical in the selection of an appropriate supply chain strategy for a group of products which perform similarly. Furthermore, decisions on the positioning of inventory and capacity flexibility can be facilitated by information on the product's physical characteristics and standardization of the product, in order to cost-effectively hedge against volatile demand (Harris et al., 2010).

In terms of information to use when categorizing products according to physical and standardization attributes, end-to-end signals for the various products can be obtained and crucial flows of information can occur not only within the supply chain but also from the marketplace to the supply chain (Godsell et al., 2011).

Thus, the therapeutic nature, substitutability of the product, criticality of the product, standardization of the product category and the physical characteristics of the product are deemed critical aspects. These **product**'s characteristics should be taken into consideration in making a distinction between 'standard' and 'special' products and consequently identifying appropriate supply chain strategies in the public healthcare pharmaceutical supply chain. A more entailing distinction between 'standard' and 'special' pharmaceutical products based on the therapeutic nature, criticality of the product, and standardization of the product category will be given in Section 3.4.

3.3.2.5. Delivery and lead time product attributes

The consideration of delivery lead time has been an essential aspect in the development of focused demand chains where processes are prioritized as a sequence of events with the end goal of serving the ultimate consumer (Childerhouse, Aitken, & Towill, 2002). The time window for delivery is an appropriate consideration in 'leagile' strategies—where both lean and agile paradigms are involved—with products that either require rapid replenishment soon after an order is placed or products expected to have a short life cycle in the market (Aitken et al., 2005). The lead time consideration is potentially important for both commercial supply chains and public healthcare pharmaceutical supply chains. A failure in service levels of time-to-market results in lost sales and opportunity costs, implying that lead time to resupply a market drives the organization's capability to respond quickly to demand even when there is a bullwhip effect (Qi et al., 2009). Moreover, too long a lead time results in stock-outs and obsolescence, leading to market mediation costs and penalties as per stipulated regulations in contracts, tenders or constitution (Christopher, Peck, & Towill, 2006; Christopher & Ryals, 2014). Based on these considerations and the input from the SMEs on the **delivery lead time**, the attribute is deemed essential in enhancing the sustainable availability of medicines in public healthcare pharmaceutical supply chains. This is because pharmaceutical products are needed at different times, at different primary healthcare facilities in different volumes

and at different costs to the supply chain. The ability of delivery lead time to be lean when there is a need to deliver to stock, and the ability of delivery lead time to be agile when there is a need to deliver to demand, will potentially drive decision-making on whether to utilize on-time or on-schedule deliveries. This is likely particularly applicable for pharmaceutical categories such as epidemic medication where there is low and fairly constant demand in times where there are no outbreaks, and sudden surges in demand in times where there are outbreaks.

Thus, it is recommended that measurable characteristics such as order cycle time, supply takt time, response time to deliver the product, on-time or on-schedule deliveries, and time service levels are used to define the threshold between short and long lead time.

3.3.2.6. Flexibility product attribute

Lastly, flexibility in measurable characteristics such as the handling of the change in demand, design, and delivery, is an aspect that can be designed inherently for a supply chain strategy. This can form part of the product categorization under the supply chain strategy implementation and management itself. Thus the 'flexibility' attribute should be considered not under the product attributes taxonomy but under the supply chain strategy taxonomy. This supply chain strategy taxonomy will be developed in Sections 3.6 of this chapter.

3.3.3. Deduced product attributes taxonomy

Based on the preceding discussion and the findings presented in this chapter, it is proposed that the critical product attributes for product categorization in the South African public healthcare pharmaceutical supply chain are product, demand, cost, life cycle and lead time to deliver, which form the acronym **PDCL^2**. These product attributes, together with examples of measurable characteristics for each attribute, are summarized in Table 3.3.

Table 3.3: Consolidated product attributes for product categorization in the public healthcare pharmaceutical supply chain (reproduced from Mapowo et al. (2019) © 2019 IEEE)

Public Healthcare Pharmaceutical Supply Chain Product Attributes (with gradations)	Examples of Measurable Characteristics
Product (standard or special)	Therapeutic nature, substitutability of the product, standardization of product category and physical characteristics.
Demand (stable or volatile)	Variability, volatility, volume, and uncertainty.
Cost to the supply chain (affordable or expensive)	Procurement cost, holding cost, obsolescence cost and distribution cost.
Life cycle (temporal or lasting)	Product lifetime, shelf life, obsolescence, and product quality.
Lead time to deliver (short or long)	Supply cycle time, supply takt time, response time to deliver product, on-time or on-schedule and time service levels.

In line with the preceding discussion, these consolidated product attributes can be viewed in binary gradations. These binary gradations are given in the first column of Table 3.3.

It is proposed that since the intention is to use the product attributes at both the national and provincial operational levels under the informed push model of the VAN reference framework, each province should determine and define its own threshold between the binary gradations within the boundaries provided by the national tier, based on the measurable characteristics associated with each product attribute. This means that each province is responsible for quantifying, for example, what constitutes a long lead time or what constitutes a high cost, based on the province's specific circumstances i.e. provincial healthcare budgets, the marketplace, ease of doing business, etc. As a recommendation to the various provinces, the basis for determining the thresholds between the binary gradations can be:

Product attribute: The proposed basis for determining this threshold requires a high-level understanding of certain classification and nomenclature systems that are used in healthcare. Consequently, this is discussed in detail in Section 3.4.

Demand attribute: The threshold between stable and volatile demand can be determined based on measurable characteristics such as volume, variability, volatility, and uncertainty, as established in Table 3.3. For the South African public healthcare pharmaceutical supply chain, variability, volatility, and uncertainty are recommended to be the most salient measurable characteristics for determining between stable and volatile demand. This is because the concepts of variability, volatility and uncertainty narrate to both demand and supply predictability and spikes in demand which significantly affect the upstream supply chain—bullwhip effect (Christopher et al. 2009). Hence, pharmaceutical products that have fairly constant or predictable demand in the short or medium-term demand and/or supply plans of a province can be considered 'stable' while those that spike unpredictably can be considered 'volatile'.

Cost to the supply chain attribute: The threshold between affordable and expensive cost can be determined based on measurable characteristics such as procurement cost, holding cost, obsolescence cost and distribution cost as established in Table 3.3. At the operational level, the true cost of the stated measurable characteristics is driven by factors such as the number of orders placed and order line weight which translates to lot sizes and replenishment frequency. Consequently, order line values, frequency of order lines and order line weights can then be used to determine between expensive and affordable cost based on the procurement cost, holding cost, obsolescence cost and distribution cost. This marks whether a product bundle's supply pipeline has an affordable or expensive cost to the supply chain (Harrison, Lee, & Neale, 2018; Qi et al., 2009).

Life cycle attribute: The threshold between temporal and lasting life cycle can be determined from the view of measurable characteristics such as product lifetime, shelf life, obsolescence, and product quality as established in Table 3.3. For the South African public healthcare pharmaceutical supply chain, it is recommended that the most important measurable characteristics in determining the threshold between temporal and lasting life cycle are: (i) the shelf life which defines the recommended time that pharmaceutical products can be stored while maintaining acceptable quality under specified conditions of distribution, storage, and display; and (ii) the lifetime which defines the first date of use until the pharmaceutical product expires/stops working. Shelf life and lifetime enable supply chain managers to determine the risk of obsolescence of pharmaceutical products and should be considered in the context of the cost to the supply chain i.e. procurement cost, holding cost, obsolescence cost and distribution cost. Products that require a short end-to-end pipeline, rapid time to market and have short shelf life and lifetime can be considered to have a temporal life cycle, with the opposite being true for a lasting life cycle.

Lead time to deliver attribute: The threshold between short and long lead time can be determined from the view of measurable characteristics such as supply cycle time, supply takt time, on-time or on-schedule and time service levels as established in Table 3.3. For the South African public healthcare pharmaceutical supply chain, it is recommended that important measurable characteristics in determining the threshold between short and long lead time to deliver pharmaceutical products are: (i) the supply takt time which defines the ratio between available time and customer demand; (ii) supply cycle time which defines the average time to complete a particular process in order to meet demand; and (iii) time service levels. Pharmaceutical products that cannot be sourced nor replenished rapidly based on the supply cycle time, supply takt time, and time service levels, can constitute the long lead time, while the opposite is true for a short lead time.

In this section, the triangulation method which involved the use of literature, SME input and the application of logical arguments and reasoning based on an understanding of SCM in public healthcare, has been used to propose the most appropriate product attributes for product categorization in the public healthcare pharmaceutical supply chain. These product attributes are essential in matching pharmaceutical products in the product portfolio with appropriate supply chain strategies in order to enhance the cost-effective and sustainable availability of medicines. Establishment of the PDCL^2 product attributes taxonomy, which defines the functional requirements of the product categorization framework design, provide answers to questions raised in the research agenda set by Mapowo, Bam, de Kock, and van Eeden (2018) for the incorporation of product categorization into the South African public healthcare pharmaceutical supply chain. It is deemed

feasible to incorporate the PDCL[2] product attributes taxonomy into the VAN reference framework of the South African public healthcare pharmaceutical supply chain specifically, and the taxonomy is most likely also applicable in the public healthcare pharmaceutical supply chains of other countries.

As briefly mentioned in the preceding discussion, the healthcare industry has established standardized classifications and nomenclature systems that are applicable to medication. The succeeding section provides an understanding of how pharmaceutical products can be bundled up together according to the established standardized classifications in the healthcare sector, thereby proposing a mechanism for determining the threshold between the 'standard' and 'special' gradations of the pharmaceutical 'product' attribute.

3.4. **Classification and nomenclature systems in healthcare**

The Global Standards 1 (GS1)[5], in an executive summary in 2015, compiled and suggested that healthcare classification and nomenclature systems are typically developed for distinct purposes, such as Anatomical Therapeutic Chemical (ATC) classification by the World Health Organization (WHO), tariff code harmonization by the World Customs Organization and more strategic purposes such as purchasing and spend analytics or regulatory purposes such as Global Device Nomenclature (GMDN) (Global Standards 1, 2015).

Table 3.4: Prominent horizontal and vertical classification and nomenclature standards (adapted from Global Standards 1 (2015))

System	Definition/Description	Maintenance Agency	Declared Purpose
eCl@ss	Standardized Material and Service Classification and Dictionary - cross-industry product data standard for classification and description of products and services	eCl@ss Association	Procurement, controlling and distribution. Company-wide process data management as well as engineering.
UNSPSC	United Nations Standard Products and Services Code® (UNSPSC®) is an open, global, multisector standard for efficient, accurate classification of products and services	Managed by GS1 US for the UN Development Programme (UNDP)	Used for: Cost-effective procurement optimization. Full exploitation of electronic commerce capabilities. Typically used by purchasing organizations for spend analysis
AHFS	American Hospital Formulary Service and Pharmacologic Therapeutic Classification - classification allows the grouping of drugs with similar pharmacologic, therapeutic, and/or chemical characteristics	American Society of Health-System Pharmacists	Clinical: The mission of AHFS Drug Information® (AHFS DI®) is to provide an evidence-based foundation for safe and effective drug therapy.

[5] GS1 is an international standards organization that develops and maintains global standards for the sake of business communication. It has worldwide member bodies in more than 100 countries.

Appendix C provides a listing of the various classification and nomenclature systems that are used in healthcare (limited and with a direct impact to supply chain strategies) and the acknowledged purpose of each system. Table 3.4 provides an excerpt of the list in Appendix C, detailing the two most commonly used horizontal (i.e. cross-industry) systems, namely: eCl@ss; and United Nations Standard Products and Services Code (UNSPSC). The table also provides detail on one vertical (i.e. industry-specific) system, namely: American Hospital Formulary Service and Pharmacologic Therapeutic classification (AHFS) (Hepp, Leukel, & Schmitz, 2007).

Research has suggested that bundling the pharmaceutical products according to the eCl@ss classification has the potential to aid with a number of functions in the supply chain, including: spend analysis; lot sizing in procurement; and better supply and distribution planning (Global Standards 1, 2015). The UNSPSC standard facilitates the mining of consumption data. As such, if it is employed, it could not only aid spend analysis but could also support more cost-effective procurement. Furthermore, in the context of VAN, by facilitating the mining of consumption data, the UNSPC standard could impact visibility and analytics positively. Categorizing products according to the AHFS standard would aid in grouping medicines with shared pharmacological and therapeutic characteristics—such products would most probably have similar demand trends.

An alternative mechanism for categorizing pharmaceutical products is to base this categorization on the medicine schedule, which defines different levels of regulatory control of pharmacologically active substances, either in the context of active pharmaceutical ingredients, naturally-occurring products or extracts thereof, or finished pharmaceutical products (Medicine Control Council, 2014). The Innovative Pharmaceutical Association South Africa (2016) distinguished pharmaceuticals to be either unscheduled medicine or over-the-counter (OTC) medicine or prescription medicine according to their schedules—where a medicine schedule is a number assigned to a pharmaceutical product according to its benefits and risks i.e. the lower the risk the lower the number assigned to it. Unscheduled medicines, for example, aspirin and vitamins have a schedule of 0 (S0) and these can be purchased in an open shop e.g. local supermarket, health shop or pharmacy. OTC medicines include treatments for headaches, colds and coughs and these have a schedule of 0, 1 and 2, and can be purchased without a prescription at a pharmacy. Prescription medicines have a schedule of 3 (S3) or higher and can only be obtained with a prescription from the doctor, dentist or permitted health professional (Innovative Pharmaceutical Association South Africa, 2016; Medicine Control Council, 2014). These schedules are summarized in Table 3.5.

Table 3.5: Medicine schedules (adapted from Innovative Pharmaceutical Association South Africa (2016))

Medicine schedule	Available at:
0	General shops like supermarkets e.g. simple analgesics
1	Over-the-counter (OTC) in a pharmacy e.g. antifungal skin creams
2	OTC in a pharmacy with sale record to be kept e.g. a cough and cold medication
3	Prescription only from the pharmacy dispensary—6 months repeat allowed e.g. diabetes medicine
4	Prescription only from the pharmacy dispensary—6 months repeat allowed e.g. anti-infectives
5	Prescription only from the pharmacy dispensary—repeats stipulated e.g. psycho-active medicines
6	Prescription only, therapeutic narcotics e.g. narcotic painkillers
7	Controlled substance e.g. cannabis and heroine
8	Strictly controlled substances e.g. nabilone, amphetamine and dexamphetamine

In this study, taking from the most salient medicine groupings from the various classification and nomenclature systems that are used in healthcare, medicine schedules will be used to grade the 'product' attribute of the established PDCL^2 product attributes taxonomy. In general, the scheduling status of a medicine/substance is decided based on the safety in use and the requirements for professional advice and/or supervision in the medicine use (Medicine Control Council, 2014). Moreover, consideration is given to the requirements for control over access, possession, and supply of these medicines as stipulated in international agreements/standards. The Medicine Control Council (2014) summarized the essential factors in determining the schedule of medication as follows:

- evidence of substance toxicity and the safety in use;
- the intended use of the substance/medicine;
- the need for medical diagnosis, monitoring, and management by a healthcare professional;
- the potential for abuse of the medicine; and
- the need for access to the medicine/substance.

In line with the approach proposed in Section 3.3, there is a need for a binary gradation of the 'product' attribute of the PDCL^2 product attributes taxonomy. It is proposed that the categories in the medicine schedule can be divided into two bundles for this purpose. More specifically, it is proposed that the S0, S1, S2, S3 and S4 medicine schedules can be bundled to form the "standard" category defined in the PDCL^2 product attributes taxonomy and the S5, S6, S7, and S8 medicine schedules can be bundled to form the "special" category. This bundling of the medicine schedules takes dosage form, route of administration, strength, indication, dose, duration of treatment or a combination of

these factors into account, with the less restrictive regulatory control of pharmacologically active substances constituting the S0-S4 bundle/gradation. Moreover the S0-S4 medicine schedule bundle are mostly high-volume products, administered with a limit of 6 months' repeat supply and have better ease of access/availability as they can be found in general shops and pharmacy dispensaries with less restrictive regulatory control (Innovative Pharmaceutical Association South Africa, 2016; Medicine Control Council, 2014). In contrast, the S5-S8 medicine schedule bundle/gradation are mostly low-volume products which may have a moderate to high potential for abuse or for producing dependence, which then necessitates close medical management and supervision and strict control over supply with some medicine only being available to medical practitioners who have obtained special permission from the Medicines Control Council for use and prescription (Medicine Control Council, 2014). Therefore, these two medicine schedule bundles/gradations (S0-S4 and S5-S8) can be supplied differently and would need different supply chain strategies based on the other gradations of the PDCL^2 product attributes taxonomy. Therefore, the medicine schedules will be identified as part of the design restrictions (R) of the framework input to the framework development.

In the development of the product categorization framework, it is important to note that the implementation of product categorization pursues or seeks to address different goals, this is discussed in the succeeding section.

3.5. **Which goals should product categorization target?**

Ketchen and Hult (2007) suggested that there are various goals that one could seek to achieve through the implementation of product categorization in a supply chain and that the methodologies employed in implementing product categorization depend upon the goal that is being pursued. Three potential goals that are associated with product categorization in a supply chain are:

- **Cost-based.** Costs (and profits) cannot be disregarded in the development of the product categorization concept, however, cost-based analyses only (i.e. estimating, allocating and assigning costs) leave much unanswered. Ozkul (2012) states that a particular shortcoming of cost-based analysis used in isolation is the inability to assign costs directly to vital business entities. Ketchen & Hult (2007) opine that the cost-based approach revolves around the connotation of resolving problems rather than seeking opportunities.

- **Value-based**. This approach entails categorizing products by economic value, for instance, the total revenue generated. The approach, therefore, is not exclusively concerned with assigning costs, instead of segmenting product categories to determine profitability (Lee, 2002). Ozkul

(2012) opine that the approach does not constitute categorizing just for the sake of categorizing and recommend that the categories that are used should be sizeable enough to complement the supply chain strategy.

- **Needs-based**. When the goal is needs-based, categorization is done on differentiated product drivers that clients have for a distinct supply chain service. Therefore products are categorized based on a common set of clients' needs and internal resources, such as sales, and the categorization can provide insight on determining and validating clients' needs (met or unmet) (Ketchen & Hult, 2007). The purpose is to match sector needs with the correct supply chain service with the aim of gaining competitive advantage (Fisher, 1997).

The product categorization concept as applied in the South African public healthcare pharmaceutical supply chain in this study, can be viewed as having both a needs-based and a cost-based goal. This is primarily due to the supply planning focus, which is on the sustainable availability of medication (need) in a cost-effective manner (cost).

A discussion of supply chain strategies is provided in the succeeding section to determine the most salient taxonomy for the product categorization framework development.

3.6. Generic supply chain strategies classifications

Various generic supply chain strategies classifications have been suggested in the literature and according to Fisher (1997), two supply chain types exist (i.e. physically efficient and market responsive) as briefly introduced in Section 2.2 and 3.2. Supply chains in various industries suffer from an excess of some products and a shortage of others due to the supply chain's inability to effectively predict demand (Harris et al., 2010). Fisher (1997) posited that the root cause of the problems such supply chains face is a mismatch between the product-type and the supply chain-type.

The various generic supply chain strategies classifications will be discussed in the remainder of this chapter as part of identifying building blocks for decision making on product categorization framework design requirement specifications.

3.6.1. Physically efficient and market responsive supply chain classification

Physically efficient supply chains' fundamental focus is cost reduction and the efficient use of resources (Fisher, 1997). Sullivan et al. (2007) emphasized that this type of supply chain pursues the creation of the lowest possible cost of operation through the removal of all non-value adding

activities, pursuing economies of scale and optimizing resource utilization. Fisher (1997) proposes that companies that offer functional products should employ an efficient supply chain.

In contrast, the market responsive supply chain is fundamentally focused on meeting the customer delivery expectations irrespective of demand variability (Fisher, 1997). Fisher (1997) proposes that market responsive supply chains are most appropriate for innovative products. The possibility of a stock-out increases when product demand is uncertain and volatile (Harris et al., 2010). Lee (2002) also asserts that supply disruption risks are mitigated in market responsive supply chains by the strategic placement of inventories and thus such a supply chain can adapt to customer, market, and supply uncertainty. Table 3.6 details the generic attributes of physically efficient and market responsive supply chains.

Table 3.6: Physically efficient and market responsive supply chains (adapted from Fisher (1997))

	Physically efficient	**Market responsive**
Primary purpose	Supply predictable demand efficiently at the lowest possible cost	Respond quickly to unpredictable demand to minimize stock-outs, forced markdowns, and obsolete inventory
Inventory strategy	Generate high turns and minimize inventory throughout the chain	Deploy significant buffer stocks of parts or finished goods
Lead-time focus	Shorten lead time if it does not increase the cost	Invest aggressively in ways to reduce lead time
Product-design strategy	Maximize performance and minimize cost	Use modular design to postpone product differentiation for as long as possible

As elaborated by Fisher (1997) when he classified supply chains as either physically efficient or market responsive, literature has further classified supply chain strategies based on: lean and agile (also inclusive of the leagile or hybrid supply chain). Another prominent classification that has been proposed in the literature and which is employed within the description of the VAN blueprint is the distinction between pull and push strategies (Birhanu et al., 2014). Other supply chain strategies do exist; however, they fundamentally derive and extend from the aforementioned supply chain classifications.

3.6.2. Lean and agile supply chain classification

Leanness and agility of supply chains have been employed for instance in cost reduction and coping with uncertainty, and these exhibited variations in production volume, the degree of product variety required and product variability (Birhanu et al., 2014). Classification based on leanness and agility (as well as leagility) has largely been attributed to Naylor, Naim, and Berry (1999), who defined agility and leanness as:

Agility—"using market knowledge and a virtual corporation to exploit profitable opportunities in a *volatile* marketplace."

Leanness—"developing a value stream to eliminate all waste, including time, and to ensure a *level* schedule"

In essence, the lean strategy is at most the equivalent of Fisher's physically efficient and, the agile strategy is at most the equivalent of Fisher's market responsive. Research has argued that lean principles are more convenient for functional/commodity products where demand is predictable and agile principles are more convenient for innovative products where there is unpredictable demand (Birhanu et al., 2014). The applications of leanness and agility are shown in Figure 3.1.

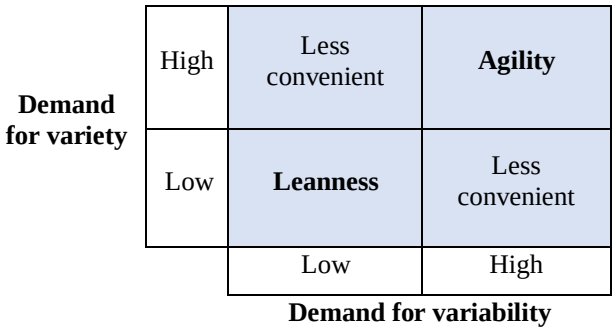

Figure 3.1: Leanness and agility applications (adapted from Naylor et al. (1999))

Minnich (2007) termed a combination of lean and agile strategies a hybrid supply chain, arguing that there are instances where either a purely lean or agile approach might not be appropriate, in which case the two may be combined to form a hybrid supply chain. The hybrid supply chain concept is synonymous to the 'Leagile' supply chain strategy which combines lean and agile strategies at a decoupling point (where leanness will be used upstream and agility downstream of the decoupling point) so as to optimize supply chain management (Naim & Gosling, 2011). Leagile supply chain strategies can be used where demand is stable and predictable for some products and the converse can be true for other products within the same product portfolio, hence the merging of the strategies. Christopher, Peck, and Towill (2006) went on to propose four types of supply chain pipelines sensitive to supply uncertainties and lead times as shown in Figure 3.2.

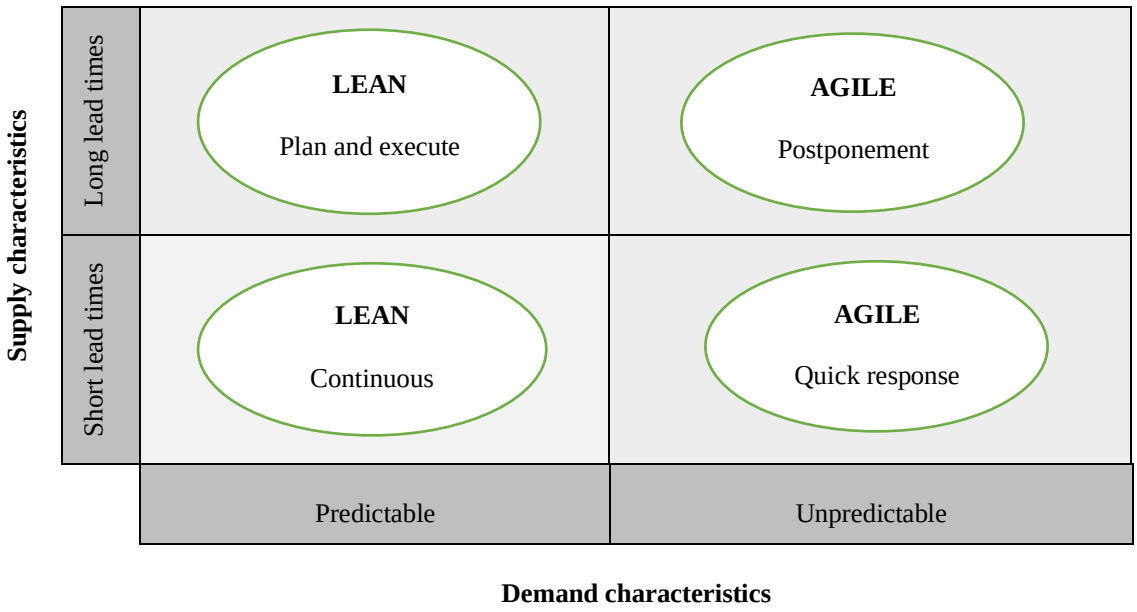

Figure 3.2: How demand/supply characteristics determine the pipeline selection strategy (adapted from Christopher et al. (2006))

Christopher et al. (2006) argued that a 'continuous replenishment' pipeline would be an appropriate strategy in situations where lead-times are short, and demand is predictable. They suggested that this is how companies such as Procter & Gamble use the Vendor Managed Inventory—which is the use of point-of-sale data for rapid replenishment of individual stores—to manage their supply chain with Wal-Mart in the USA. If demand is unpredictable and lead-times are long, the 'postponement' pipeline, which entails the use of strategic inventory to configure/assemble/distribute as per need, is viable (Christopher et al., 2006). When lead-times are long and demand is predictable, 'lean' strategies are employable and when lead-times are short and demand is unpredictable, 'agile' strategies are more viable (Christopher et al., 2006).

The use of lean, agile and leagile strategies can potentially be applied to the South African public healthcare pharmaceutical supply chain as product demand in the pharmaceutical product portfolio varies in stability and predictability.

3.6.3. Pull and push supply chain classification

Another prominent classification of supply chain strategies that have been proposed in the literature is the distinction between pull and push strategies. Birhanu et al. (2014) posited that long-term forecasts are the basis for production decisions in push-based systems, while demand drives production decisions in pull-based systems. In pull strategies, execution of processes is initiated in *response* to customer orders, and in push strategies, these processes are initiated in *expectation* of customer orders (Olhager, 2003). Pull and push strategies can be combined to form a push-pull

strategy similar to the case of lean and agile strategies being combined to form leagile strategies. Olhager (2003) asserted that in the push-pull strategy, based on network equilibrium, the push element is utilized in the component procurement while the pull element is used for production. Kim, Fowler, Shunk, and Pfund (2012), however, suggested that in as much as the push-pull strategy has benefits for example in lowering inventory costs and flexibility in adapting to a volatile market, the strategy has potential supply chain risks. These risks relate to the capability to fulfill orders and robustness against external variability. Birhanu et al. (2014) added that different locations require different inventory levels to be responsive to lead time requirements to customer deliveries. Unstable order fulfillment performance can occur if the processing time and transportation time are too long in relation to customer delivery lead time requirements, resulting in penalties for service level failures, opportunity costs and loss of goodwill (Kim et al., 2012).

A pull and push classification system describe the VAN concept where the shift is towards an informed push system as detailed in Sections 1.1 and 2.5.

3.6.4. Salient supply chain strategies classifications

Various supply chain strategies have been developed in research, which premised on the aforementioned strategies. The salient, most descriptive and holistic models being the ones developed by Perez (2013) in the form of six generic supply chain models, which he grouped into two clusters that align to the types of supply chains defined by Fisher—physically efficient and market responsive supply chains. These generic supply chain strategies align with the supply chain operations reference framework (SCOR)[6] four distinct processes, namely source; make; deliver; and plan (Huan, Sheoran, & Wan, 2004). Three of Perez's generic supply chains are oriented to achieve physical efficiency and the other three are oriented to achieve market responsiveness.

[6] The SCOR model integrates the well-known business process concepts such as: benchmarking, re-engineering, and process measurement, into a cross-functional framework with: standard descriptions of management processes; relationships among the standard processes; management practices that produce best performance; standard metrics to measure process performance; and standard alignment to software features and functionality (Huan et al., 2004).

The three physically efficient supply chain models defined by Perez (2013) are:

- *Continuous-flow supply chain*: This supply chain employs a 'make to stock' decoupling point where production is scheduled to replenish predefined stock levels based on a specific reorder point for inventory in the production cycle. It pursues high service levels and low inventory levels. It is mainly proposed for businesses with short shelf-life products, for example, bread and dairy products.

  In the South African public healthcare pharmaceutical supply chain, such a strategy is potentially useful in the supply of selected chronic medication which can potentially be regularized since the demand is stable and predictable. Pharmaceuticals can be supplied using a 'supply to stock' decoupling point. The strategy can also be used for seasonal prescription medication and certain OTC medication by replenishing predefined stock levels within the season of high demand. The same approach is possibly applicable even during seasons of low demand but with a different predefined stock level.

- *Efficient supply chain*: This supply chain has production scheduled based on sales expectations for the duration of the production cycle, using a 'make to forecast' model as a decoupling point. It has been proposed for businesses with commoditized products, for example, cement and steel.

  Such a supply chain strategy is potentially useful in the public healthcare pharmaceutical supply chain in supplying anticipated demand of prescription and OTC medication with a steady and predictable demand. Pharmaceuticals can use a 'supply to forecast' decoupling point. It can also be used in supplying forecasted vaccine medication according to the known demographics of a particular area/region.

- *Fast supply chain:* This supply chain has production scheduled in a single batch per stock keeping unit (SKU), with the size being defined by the season's sales expectations, and utilizing a 'make to forecast' decoupling point. The fast supply chain has been proposed for companies that engage in catalogue sales and trendy apparel, for example, fashionable clothing.

  Such a strategy is potentially useful in the public healthcare pharmaceutical supply chain in supplying seasonal pharmaceuticals of any category (chronic, prescription, OTC medicine, etc.) using a 'supply to forecast' decoupling point. It is possibly useful for pharmaceuticals that have a stable and predictable demand within the seasons.

The three market responsive supply chain models defined by Perez (2013) are:

- *Custom-configured supply chain:* This supply chain is characterized by multiple configurations of the finished product on a unique platform, using a 'configurable to order' decoupling point. The custom-configured supply chain has been recommended for assembly of personalized products, for example, computers and vehicles.

  Such a supply chain can possibly be useful in supplying personalized medicine which can be prescription, epidemic or vaccine pharmaceuticals in a public healthcare pharmaceutical supply chain. A 'configurable to need' decoupling point could potentially be used to supply strictly controlled substances/medicine of higher (7 or 8) medicine schedules, e.g. nabilone, amphetamine, and dexamphetamine, as per need of the targeted patients.

- *Agile supply chain:* This supply chain employs a 'make to order' or sometimes 'make to stock' decoupling point, where items are produced after a purchase order has been placed by the customer. It has been proposed for businesses that are characterized by unpredictable demand and is essential for companies that use unique specifications for each customer to manufacture products, for example, chemical specialties and packaging.

  This strategy can be used in a public healthcare pharmaceutical supply chain to supply pharmaceuticals according to unique needs of PHCFs that exist in unpredictable environments e.g. tourist resort areas where there is much movement of people in and out of the area. Such areas can potentially be prone to infections that may not normally be prevalent in an area, hence the need to be agile in reaction to such eventualities.

- *Flexible supply chain:* This supply chain is characterized by adaptability, which entails the capability to reconfigure internal processes to meet a specific need (or solve a problem) of a customer using a 'design to order' decoupling point. It is mainly proposed for service companies that encounter unexpected situations and emergencies faced with long periods of low workload and high demand peaks, for example, the medical emergency response sector.

  This strategy can possibly be useful in a public healthcare pharmaceutical supply chain in supplying epidemic medication during times of outbreaks as the adaptable approach could be useful in responding to emergencies in the healthcare system.

As discussed, the premise of this research is that aligning each pharmaceutical product with an appropriate supply chain strategy has the potential to optimize the performance of the public

healthcare supply chain and possibly enhance sustainable medication availability. Various levers are to be controlled in order to effectively implement the appropriate supply chain strategy and these are discussed in the succeeding section.

3.7. **Levers to control in supply chain strategy implementation**

Perez (2013) posited that the interrelation of four main elements shapes an organization's supply chain strategy. These four elements, therefore, encompass the levers that can be adjusted in order to switch from one supply chain strategy to another. The four elements proposed by Perez (2013) are:

- **The industry framework—the marketplace;**
  This entails the economic factors that influence competition in any industry and the interaction of suppliers, technological developments and customers (Cetinkaya, 2011; Perez, 2013). Perez (2013) posits that four main interrelated drivers exist within this framework:
  1. *Demand variation, or demand profile,* which influences asset utilization and drives production efficiency and product cost.
  2. *Market mediation costs,* which Fisher (1997) defined as costs emanating from mitigating imbalances of demand and supply, for example, price markdowns to counter excess supply.
  3. *Product lifecycle,* which influences the predictability of demand and market mediation costs, consequently impacting the speed of product development and continuous review of the product portfolios.
  4. *Relevance of the cost of assets to total cost* which relates to the asset utilization rate in correlation with business profits.
- **The organization's unique value proposal—its competitive positioning;**
  This, according to Perez (2013), entails the organization's competitive positioning by the use of 'order qualifiers' and 'order winners'. Order qualifiers define the minimum requirements in order to be considered as a relevant option by customers, whereas order winners define the best performance aspects of an organization that differentiate it from the rest thereby allowing it to win the customer. Determining the main 'order winners' as defined by the product attributes and service, allows the company's unique value proposal to shape the key drivers' synergy in driving the supply chain strategy to fulfill high service levels.
- **Internal processes—the supply chain processes;**
  Perez (2013) further highlights that internal processes drive interlinks within the supply chain activities under source-make-and-deliver approaches, with the most important elements being asset utilization and the decoupling point location, among other factors. A decoupling point has

been defined to be a process within the value chain where a product assumes unique characteristics or specifications for a distinct customer. There exists a high interdependence between asset utilization and the decoupling point location, for example:

1. When a business is oriented towards substantial relevance of cost of assets in relation to the total cost, and/or when the business' unique value proposal is focused on low cost, then high asset utilization is a necessity. As a result, the decoupling point should be positioned at the end of the transformation process, or at the output point of the most cost relevant process.
2. The production cycle drifts towards being long, so as to increase production efficiency when workload levelling is smoothed by forecasting. This is because, prior to a decoupling point, production processes are oriented towards a 'push' approach. In such an instance asset utilization is high.
3. Processes are oriented towards a 'pull' approach after the decoupling point, therefore workload is variable and driven by demand. Asset utilization is at a moderate level and the production cycle becomes shorter to reduce order cycle time.
4. Much inventory that is partially complete and ready to configure as per customer requirements, is located just before the decoupling point.
5. In instances where the decoupling point is located farthest from the customer's supply chain end, ease of customization of the product increases and buffering of demand should be supported by excess capacity. Furthermore, collaborative relationships with customers are mandated as they help reduce demand uncertainty.
6. In instances where the decoupling point is located toward the customer's end in the supply chain, product customization reduces. Consequently, the minimum order size is determined by the relevance of the transportation cost relative to the total cost.

- **Managerial focus—the link between the business strategy and supply chain processes.**
  Perez (2013) further highlights that the managerial focus entails the decision-making process that governs the alignment between the competitive positioning and supply chain processes of an organization. The managerial focus determines the coherence between the business' unique value proposal and the supply chain execution—which is a pass or fail area. Failures result from a managerial approach that emphasizes efficiency-oriented indicators irrespective of the organization's competitive positioning. Such an approach can cause a business to focus on local efficiencies which may conflict with the business' value proposal to customers, therefore creating a misalignment between the business strategy and the supply chain.

Literature has suggested that regardless of these elements involving multiple factors, only some of these factors are essential drivers for supply chain strategy formulation and implementation. Though

the factors have largely been developed based on a generic conceptualization of the manufacturing industry, concepts that are applicable to the public healthcare pharmaceutical supply chain (supply planning) can be interpolated from those provided. As mentioned in the introduction to this section, these factors established by Perez (2013) are some of the levers to note and control when establishing supply chain strategy implementation, and are summarized in Table 3.7. The rightmost column in the table gives an indication of whether each lever is applicable to supply planning in the context of public healthcare.

Table 3.7: Levers to control in supply chain strategy implementation (adapted from Perez (2013))

		Oriented to efficiency			Oriented to responsiveness			Healthcare supply planning applicable?
		Continuous-flow	Efficient	Fast	Custom-configured	Agile	Flexible	
Business Framework	Demand variation	Low	Medium to high	Medium to high	High	High	Unpredictable	X
	Product lifecycle	Long	Long	Short	Short to medium	Short to medium	Undetermined	X
	Market mediation cost	Low	Low	Medium to high	High	High	High	X
	Relevance of assets in total cost	Medium to high	Medium to high	Low to high	Low to high before PDP	Low to medium	low	
Competitive positioning	Main difference in service	High inventory turnover	Perfect orders	Short time from idea to market	User-friendly, low effort order entry	Agility relative to demand changes	Understanding of customers' needs	X
	Main difference in product	Best performance/cost ratio	Best price	Continuous portfolio renewal	Configurable product	Customizable product	Adaptable process	X
Managerial focus	End-to-end	Collaborative relationships to build synergies	Efficiency	Continuous portfolio renewal	Product configurability	Agile response to changes in demand	Resource flexibility	X
	Servicing	Information sharing for continuous improvement	Perfect orders	Short time from idea to market	Order accuracy	Short lead time	Understanding of customers' needs	X
	Product	Designed for fast manufacturability	Low cost at standard performance	Fast product development process	Modular design for multiple configurations	Designed for small batches	Supported by complementary services	X
	Transformation processes	Regular schedule in optimal SKUs	High rate of asset utilization	High rate of asset utilization	High rate of asset utilization before PDP/extra capacity after PDP	Extra capacity in manufacturing and downstream	Asset flexibility/capacity pooling	
	Sourcing	Collaborative relationships to build synergies	Lowest-total-cost-supplier (opportunistic)	Pool of suppliers with short lead times and oriented to innovation	Agile response to changes in demand	Short lead time	Agile response and process flexibility to adopt customers' requirements	X
	Demand buffering	Inventory of finished product	Inventory of finished product	Inventory of finished product	Inventory before PDP, extra capacity after	Extra capacity	Standby capacity/capacity pooling	X
	Order penetration point	Make to stock	Make to forecast, sometimes make to order	Make to forecast	Configured to order/ assembly to order	Make to order/make to stock	Design to order	X

		Oriented to efficiency			Oriented to responsiveness			Healthcare supply planning applicable?
		Continuous-flow	Efficient	Fast	Custom-configured	Agile	Flexible	
Supply chain profile	Minimum order size	Customers' replenishment needs	Minimum economic transportation batch	Collection forecast	End customers' (replenishment) needs	Minimum economic production/transportation batch	Minimum economic production batch	X
	Order cycle	Replenishment according to a fixed cycle	Fixed lead time or fixed cycle	According to collection schedule	As short as possible as per orders in PDP queue	As short as possible as per customers' orders in queue	Flexible, as short as possible	X
	Collaborative relationships	Strategic relationships with key customers to build synergies	Not relevant	Cooperate to anticipate market trends/joint design	Cooperation with key customers to anticipate aggregate demand at PDP	Cooperation with key customers to anticipate capacity requirements	Understanding of 'available to promise' at any moment	X
	Inventory strategy	Small and frequent batches to increase inventory turns	High level of inventory to optimize production efficiency	A single batch per SKU based on collection forecast	Inventory just before PDP	Materials/components under a common platform	Low inventory level and inventory pooling	X
	Customization	No	No	Usually no	Yes, just in PDP and downstream processes	Relevant in manufacturing and downstream processes	Relevant in design and downstream processes	
	Asset utilization rate	High to very high	Very high	High to very high	High before PDP, medium after PDP	Medium to high	Low to medium. Sometimes standby capacity	X
	Production cycle	As short as possible to reduce batch sizes	Maximize on increasing batch sizes and efficiency	As short as possible to reduce time from idea to market	Long before PDP, short in PDP and downstream	Variable as per customers' orders accepted in queue	As short as possible to reduce lead time	
	Rate (takt) of workload	Smoothed by customer demand	Smoothed by rolling forecast	Smoothed by collection forecast	Smoothed by rolling forecast before PDP, peaks after PDP	Peaks and valleys of high magnitude	Capacity on standby for occasional use, high peaks when used	X
	Sourcing buffering	Inventory/one supplier for each key component	Inventory/best-cost supplier on each occasion	Pool of suppliers	Inventory/pool of suppliers	Inventory/pool of suppliers	Pool of suppliers for critical resources	X

*PDP= Product decoupling point

As indicated in Table 3.7, a total of four levers have been deemed to not be applicable to supply planning in the context of public healthcare. The 'relevance of assets in total cost' lever is deemed not to be relevant because it is only critical in industrial sectors which have a high correlation between business profits and asset-utilization rate (Perez, 2013). In the public healthcare supply chain context, the stated correlation is not strong and can possibly be useful in the actual manufacturing of the pharmaceuticals—which is outside the scope of this study. As stated in the preceding sections, the study is concerned with the supply planning's product categorization, not inclusive of the pharmaceutical manufacturing on the supplier's side as this will only be catered for in the tenders and contracts between the NDoH and the suppliers. The 'transformation processes' lever has been described by Perez (2013) in the context of transforming the raw materials into finished products together with the setting of the decoupling points in between the transformation process. This can possibly relate to the transformation processes within the pharmaceuticals manufacturing, which is outside the scope of this study and is deemed not to be relevant to supply planning within the VAN strategy. The 'customization' lever has been set by Perez (2013) to be applicable to the product design and manufacturing process, and this is also outside the scope of this study. Hence, the 'customization' lever is deemed not to be relevant to supply planning in the context of public healthcare. The same argument holds for the 'production cycle' lever as this denotes the time period of the production process in between the transformation process from raw materials to finished products—which is outside the scope of this study as previously stated.

The definition and description of the aforementioned elements and levers for each supply chain strategy can be viewed as being generic. In the remainder of this chapter, each of the levers that have been deemed to be relevant to supply planning in the context of public healthcare will be discussed in the context of the VAN approach to supply chain management in general and service supply planning specifically. The aim is to provide how each of the levers could be operationalized in a South African public healthcare pharmaceutical supply chain that is managed according to the VAN principles in order to effect each of the six generic supply chain strategies that have been defined by Perez (2013).

Each supply chain strategy has its own decoupling point as established in the literature, particularly Section 3.6.4. Similar to the elements and levers, these decoupling points have also been defined generically. Consequently, there is a need to translate these definitions so that they are contextualized to the informed push model of the VAN strategy; public healthcare pharmaceutical supply chains; and service supply planning. In Table 3.8, the definition and description of the decoupling point for each of the six supply chain strategies in contextualized to public healthcare pharmaceutical supply chain; VAN informed push model; and service supply planning. As is evidenced in the table, this

contextualization does not involve altering the decoupling point, instead, the description of the decoupling point is merely altered slightly to align it to the context of a public healthcare pharmaceutical supply chain that operates according to informed push principles.

Table 3.8: Supply chain strategies and their decoupling points (adapted from Perez (2013))

Supply chain strategy	Generic decoupling point, adapted from Perez (2013)	Informed push model and public healthcare service supply planning-specific interpolated decoupling points	
		Decoupling point	Interpolated meaning
Continuous-flow supply chain strategy	Make to stock	Supply to stock	Supplying for stocking at facilities based on predefined stock levels.
Efficient supply chain strategy	Make to forecast/Make to order	Supply to forecast/ Supply to need	Supplying based on forecasted demand or based on the foreseen service needs of the facilities.
Fast supply chain strategy	Make to forecast	Supply to forecast	Supplying based on forecasted demand of facilities.
Custom-configured supply chain strategy	Configurable to order	Configurable to need	Configuring supply orders/formularies based on facility/patients' needs e.g. the case of personalized medicine
Agile supply chain strategy	Make to order'/Make to stock	Supply to need/ Supply to stock	Supply based on the foreseen service needs of the facilities or based on facilities' predefined stock levels.
Flexible supply chain strategy	Design to order	Design supply to need	Configuring the supply chain in response to facilities' or patients' service needs.

It is recommended that these decoupling points be used for decision making on sourcing plans and replenishment plans per province, which is the intended output of the product categorization framework to be developed.

The four main elements, as well as the levers contained in each element that have been deemed relevant to a public healthcare pharmaceutical supply chain, are discussed in the remainder of this chapter.

3.7.1. Business framework—VAN enabled

The roadmap of implementing the proposed supply chain strategies taxonomy and VAN will manage resource allocation across four main interdependent categories of intervention. Llewellyn (2016) mentioned that the rationale of the business framework in managing resource allocation will be to clarify and simplify how resources i.e. effort, time and money, are allocated across interventions. Priority setting becomes vital as the resources are devoted across the interventions in order to minimize opportunity cost pertaining to short term versus long term impacts in the supply chain. As indicated in Table 3.7, Perez's business framework element contains three levers that are applicable to supply planning in the context of public healthcare, namely: demand variation; product lifecycle; and market mediation cost.

The VAN reference framework has established the four categories of intervention which supply chain strategy implementation from a business framework viewpoint can be driven, to be:

3.7.1.1. VAN enabling elements

In as much as the roadmap for VAN implementation will seek to identify enabling elements to be addressed over the long term, these must correlate with the supply chain strategies capabilities. Dynamics of demand variation, product lifecycle and market mediation cost as they vary along the spectrum of low to high should be understood in order to align with the appropriate supply chain strategy. The VAN enabling elements involve elements that will then likely focus on the long-term aspects of VAN implementation and product categorization incorporation, and these are detailed in Figure 3.3. In the figure, the details in black text have been established in the VAN framework and that in red have been established by the author to show how the VAN enabling elements can be consistent with the product categorization concept.

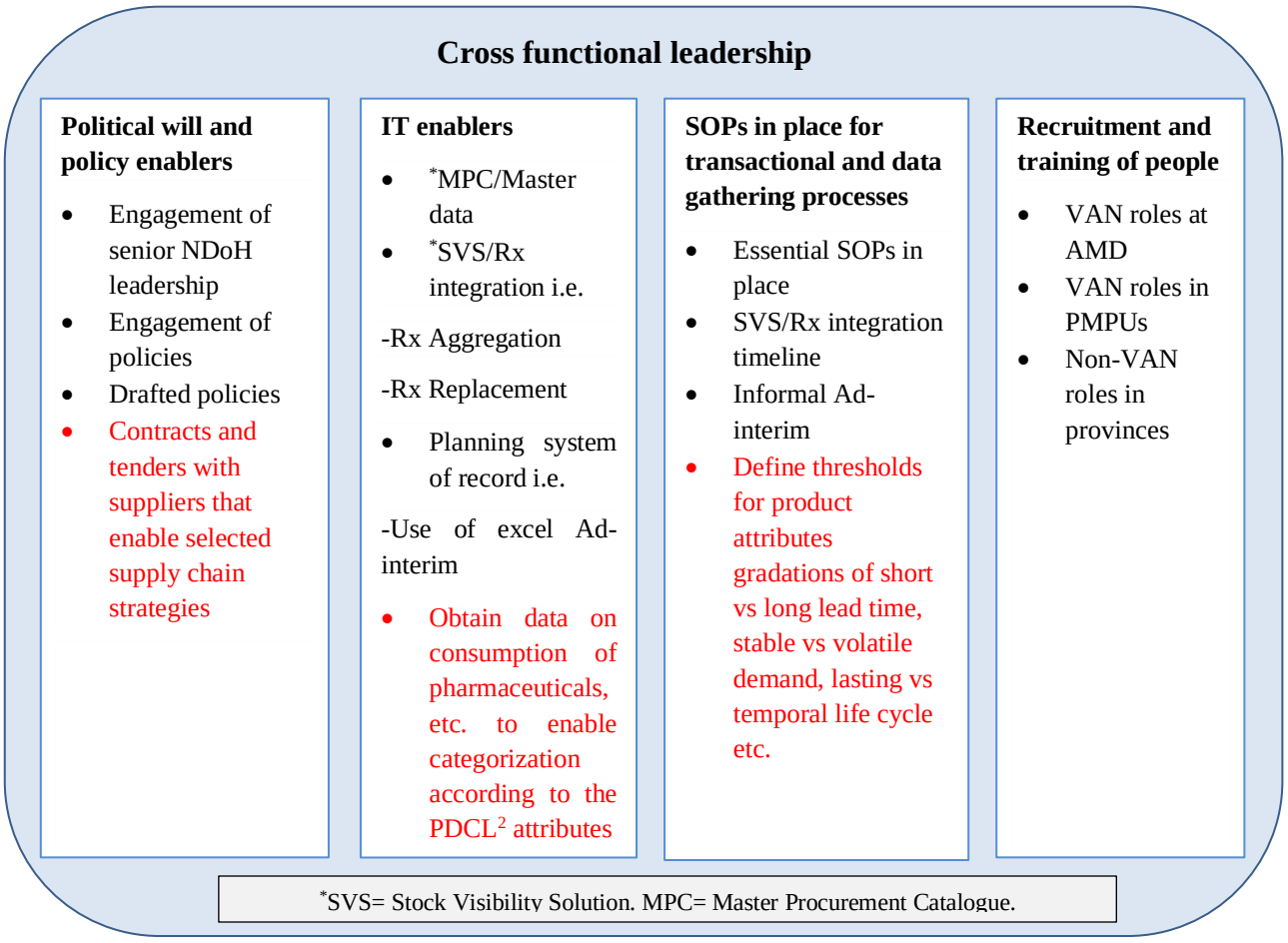

Figure 3.3: Enabling elements to be addressed over the long term (adapted from Llewellyn (2016))

The VAN reference framework suggests that standard operating procedures (SOPs) will form the basis for staff competencies, policies and IT functionality and hence in practice, the AMD will drive the designing, monitoring, continuous improvement and operating analytical processes at the national

tier and other levels (Llewellyn, 2016). AMD has been suggested by the VAN reference framework to be responsible for the support of other levels to enable capacity building and determine the granularity level of analytics throughout the system which will define the IT functional requirements (Llewellyn, 2016). In such cases, it is suggested that the analysis of complex links within the public healthcare pharmaceutical supply chain is feasible and all six supply chain strategies can be activated for the different product categories based on end-to-end data visibility. Furthermore, according to the VAN framework, the AMD will lead the development of policies for data sharing and protocols for key transactional processes which then act as the source for supply chain planning data.

High-quality data is crucial to enable the implementation of the VAN informed push model, but it is also a requirement to enable the categorization of products according to the PDCL^2 product attributes taxonomy. Llewellyn (2017) suggests that this high-quality data includes:

Timely and accurate stock on hand data: This facilitates supply planning. Timely data is essential for infrequent deliveries and accurate historical consumption data is critical for demand forecasting.

Up to date 'slowly changing' data: Maintaining formulary accuracy per facility is important for informed push of the appropriate pharmaceuticals based on the types of care offered by the facility. Up to date pricing data is important for reducing order amendments and forensic accounting on credit balances and accruals with suppliers.

Consistent pharmaceuticals and location master data: Consistent pharmaceuticals nomenclature, priorities, and substitutes to reduce ambiguity between clinicians, budgeters, demand and supply planners. Consistent specifications of pharmaceutical products and packaging for distribution planning as well as accurate location data and replenishment pipeline (supply chain strategy) to enable supply, network and inventory policy optimization.

3.7.1.2. VAN planning services

Since the VAN reference framework seeks to migrate to an informed push model, it raises the need to carefully manage the variability of local organizations, roles, and processes using short as-is/ to-be/ change cycles (Llewellyn, 2016). According to the VAN reference framework, the VAN services roll-out approach is enabled by locally relevant 'pockets' where a pocket is defined to be a collection of facilities that will roll out simultaneously, having common characteristics e.g. same budget ownership and same service levels (Llewellyn, 2016). Based on these similarities, it is suggested that such pockets of facilities should be serviced using the same supply chain strategies on distinct product

categories since they (the serviced facilities) share attributes such as market mediation costs, demand variation, and product lifecycles.

The VAN framework endeavors to make historical and actual internal supply chain data reliably available to drive supply, demand and distribution plans. This reliable availability of data would facilitate the efforts to implement any of Perez's six-supply chain strategies. Furthermore, the VAN framework intends to establish a cutover plan from facility ordering to informed push which takes into account the run-out of stock and any potential changes likely to cause data risks at any time (Llewellyn, 2016). In such a setting, it is suggested that it is feasible to then determine the appropriate placement of the decoupling point for each supply chain strategy for the various product categories.

3.7.1.3. Optimization analyses

The introduction of the VAN framework coupled with product categorization, will potentially enable and facilitate a basis for performance measurement and generate data to support the supply chain optimization. Consistent with the VAN reference framework suggestions, both the supply chain strategies taxonomy and the product categorization concept, in general, hold the potential to facilitate improved alignment between lead time to the facility and holding stock requirements. Furthermore, the VAN reference framework provides a platform for the supply chain strategies taxonomy as it seeks, in its implementation, to:

- Investigate constraints to minimum order quantities on direct delivery supply and optimize cross docks/ warehouses. This will be consistent with the supply chain decoupling points positioning, for example, the continuous flow supply chain strategy which uses a 'supply-to-stock' decoupling point and an efficient supply chain strategy which uses a 'supply-to-forecast' decoupling point, just to name a few.
- Improve forecasting accuracy and reduce order volatility by collaborating with suppliers to reduce supplier holding stock requirements as well as costs to the NDoH. Thus, suppliers' deliveries can be consolidated and adherence to delivery dates that are consistent with the individual supply chain strategies can be encouraged.
- Establish cross-docks or merges in transits, depending on the supply chain pipeline in question, to achieve delivery efficiencies and minimize large unallocated inventory volume.
- Improve supplier cash flow by enhancing payment processes and segmenting the supply base to identify the most strategic suppliers and enhance collaboration by negotiating prices and improving service delivery expectations.

3.7.1.4. Continuous improvement

The VAN reference framework proposes the feasibility of creating scalable and sustainable solutions through the use of overarching KPI dashboards/scorecards, prioritization of VAN services implementation, and evaluation of various options to optimize the overall system (Llewellyn, 2016). Supply chain strategies issues can be identified to seek continuous improvement by using, for example, a root-cause analysis approach coupled with a Plan, Do, Check and Act approach.

3.7.2. Competitive positioning—VAN enabled

The VAN reference framework has been developed and suggested to be an operating model that seeks to support the strategy for medicine availability. As such, the AMD strategy is driven by a complex, multi-stakeholder value chain which also underpins the achievement of the 90-90-90 targets[7] and Test & Treat implementation. Incorporating the proposed supply chain strategies taxonomy as part of the implementation of the VAN reference framework, is expected to contribute to steering the pharmaceuticals value chain from an as-is state where inefficiencies and sub-optimal service delivery are observed, to a to-be state where the informed push principle is fully implemented and the system is able to support the National Health Insurance (NHI) initiative (Llewellyn, 2016). The VAN reference framework has suggested that the AMD's role will be creating transversal contracts from which provinces can legitimately procure pharmaceuticals and 'on contract' procurement has been defined to be instances where:

- Pharmaceuticals are bought from a supplier with whom a national transversal contract exists.
- Pharmaceuticals are bought from a supplier where a buy-out situation exists—meaning the contracted supplier is out of stock and must involve a third party to fulfill orders.
- Pharmaceuticals are bought on a nationally facilitated quotation basis—which may happen because a tender will have failed to create a contract for a required essential item due to supplier/market failures.
- Pharmaceuticals are bought as per pressing need acknowledged and vetted according to the AMD guidelines.

[7] The 90-90-90 strategy entails that by 2020, 90% of vulnerable people should be screened for TB, 90% of people with TB should be diagnosed and treated, and the aim is to get 90% treatment success by the said time (Health Systems Trust, 2016). The 90-90-90 strategy also aims to facilitate 90% of people living with HIV to know their HIV status, 90% of people diagnosed of HIV should receive sustained antiretroviral therapy and 90% of all patients receiving antiretroviral therapy should have viral suppression—i.e. reduction of viral load to an undetectable level—by 2020 (Health Systems Trust, 2016).

As indicated in Table 3.7, both levers of the competitive positioning element are deemed relevant to a public healthcare pharmaceutical supply chain. These levers are 'main difference in service delivery' and 'main difference in pharmaceuticals'. It is evident that, under the 'on contract' conditions, the main difference in service of the supply chain strategies will be that: the continuous-flow strategy will need high inventory turnover; the efficient strategy will need perfect orders; the fast strategy will need a short time from ordering to market; the custom-configured strategy will need user-friendly order entry; the agile strategy will need agility relative to demand changes; and the flexible strategy will need an understanding of customer's exact needs (Olhager, 2003; Perez, 2013; Vonderembse, Uppal, Huang, & Dismukes, 2006). In the context of 'on contract' conditions, the main difference in pharmaceutical products as they are supplied will be: best performance/cost ratio in the case of the continuous-flow strategy; best price in the case of the efficient strategy; continuous product portfolio renewal in the case of the fast strategy; configurable product/orders in the case of the custom-configured strategy; customizable product/orders in the case of the agile strategy; and adaptable process in the case of the flexible strategy (Lamming, Johnsen, Zheng, & Harland, 2000; Perez, 2013; Rofin & Mahanty, 2017; Roscoe & Baker, 2014). The proposed operationalization of the two levers of the competitive positioning element in the context of the VAN blueprint and the South African public healthcare pharmaceutical supply chain, is summarized in Table 3.9.

Table 3.9: Proposed operationalized levers of competitive positioning element (adapted from Perez 2013))

		Oriented to efficiency			Oriented to responsiveness		
		Continuous-flow	**Efficient**	**Fast**	**Custom-configured**	**Agile**	**Flexible**
Competitive positioning	Main difference in service delivery	High pharmaceutical inventory turnover	Perfect orders	Short time from order to market	User-friendly as per need	Agility relative to demand changes	Based on patients' exact needs
	Main difference in pharmaceuticals	Best performance/ cost ratio	Best price	Continuous portfolio renewal	Configurable product	Customizable product	Adaptable process

3.7.3. Managerial focus—VAN enabled

The VAN reference framework has been suggested by Llewellyn (2016) to be enabled by a single AMD led governance structure which must coordinate three types of activities across multiple organizations and IT systems, namely:

- End to end visibility—where data is aggregated from multiple sources to bring end to end visibility across health commodities, programs and ultimately the entire supply chain.
- Analysis and insight—which involve business and market intelligence, data visualization and predictive modeling to create operational plans for optimizing the system.

- Continuous improvement—where standardized problem resolution processes and conditional actions are employed to resolve challenges and implement ongoing improvements.

Implementation of the VAN reference framework, in the context of the NHI, is meant to involve stakeholder engagement across multiple organizations with a clarification of connections between functions and their dependencies (Llewellyn, 2016). Llewellyn (2016) posited the core functions for short term review to include:

- Health products and finances forecasting;
- Demand planning of consumption at facilities;
- Supply planning and inventory planning;
- Distribution planning;
- Budget planning and payment of suppliers; and
- Linkage selection and update of the Master Procurement Catalogue and all other formularies.

As indicated in Table 3.7, four levers of the managerial focus element are deemed relevant to a public healthcare pharmaceutical supply chain. The proposed operationalization of the two levers of the competitive positioning element in the context of the VAN blueprint and the South African public healthcare pharmaceutical supply chain, is summarized in Table 3.10.

Table 3.10: Proposed operationalized levers of managerial focus element (adapted from Perez (2013))

		Oriented to efficiency			Oriented to responsiveness		
		Continuous-flow	Efficient	Fast	Custom-configured	Agile	Flexible
Managerial focus	End-to-end	Collaborative relationships to build synergies	Efficiency	Continuous pharmaceutical product portfolio renewal	Pharmaceutical product configurability	Agile response to changes in demand	Resource flexibility
	Servicing	Information sharing for continuous improvement	Perfect orders as per facilities' needs	Short lead time to deliver	Accuracy in orders supplied	Short lead time	Understanding of patients' needs
	Product	Operations designed for lean supply capability	Low cost at standard supply performance	Fast sourcing process	Modular design in orders for multiple configurations	Operations designed for supply in small batches	Operations supported by complementary services
	Sourcing	Collaborative relationships to build synergies	Lowest-total-cost-supplier (opportunistic)	Pool of suppliers with short lead times and oriented to innovation	Agile response to changes in demand	Short lead time	Agile response and process flexibility to adopt patients' requirements

Llewellyn (2016) suggests that the scope of the VAN strategy implementation with regards to pharmaceuticals includes:

- 14 pharmaceutical tenders on a rolling update schedule inclusive of vaccines;
- All products included in the national Essential Medicines List (EML); and
- Excludes medical-related item tenders.

The aspects detailed in the turbine imagery in Figure 3.4 drive supply planning within the VAN blueprint to determine inventory targets. The VAN strategy suggests that the inventory targets should be based on the demand plan, pipeline specific variables and supplier input which then determine consensus in supply planning across pharmaceutical products and geographies (Llewellyn, 2016). However, based on the findings of this study, it is proposed that the planning variables should include the PDCL^2 product attributes taxonomy coupled with the associated measurable characteristics of each attribute. Furthermore, it is proposed that the supply chain strategies taxonomy should be included as another driver for inventory targets (sourcing plan and replenishment plan) since these inventory targets facilitate supply chain strategy selection (order qualifiers vs order winners) and implementation.

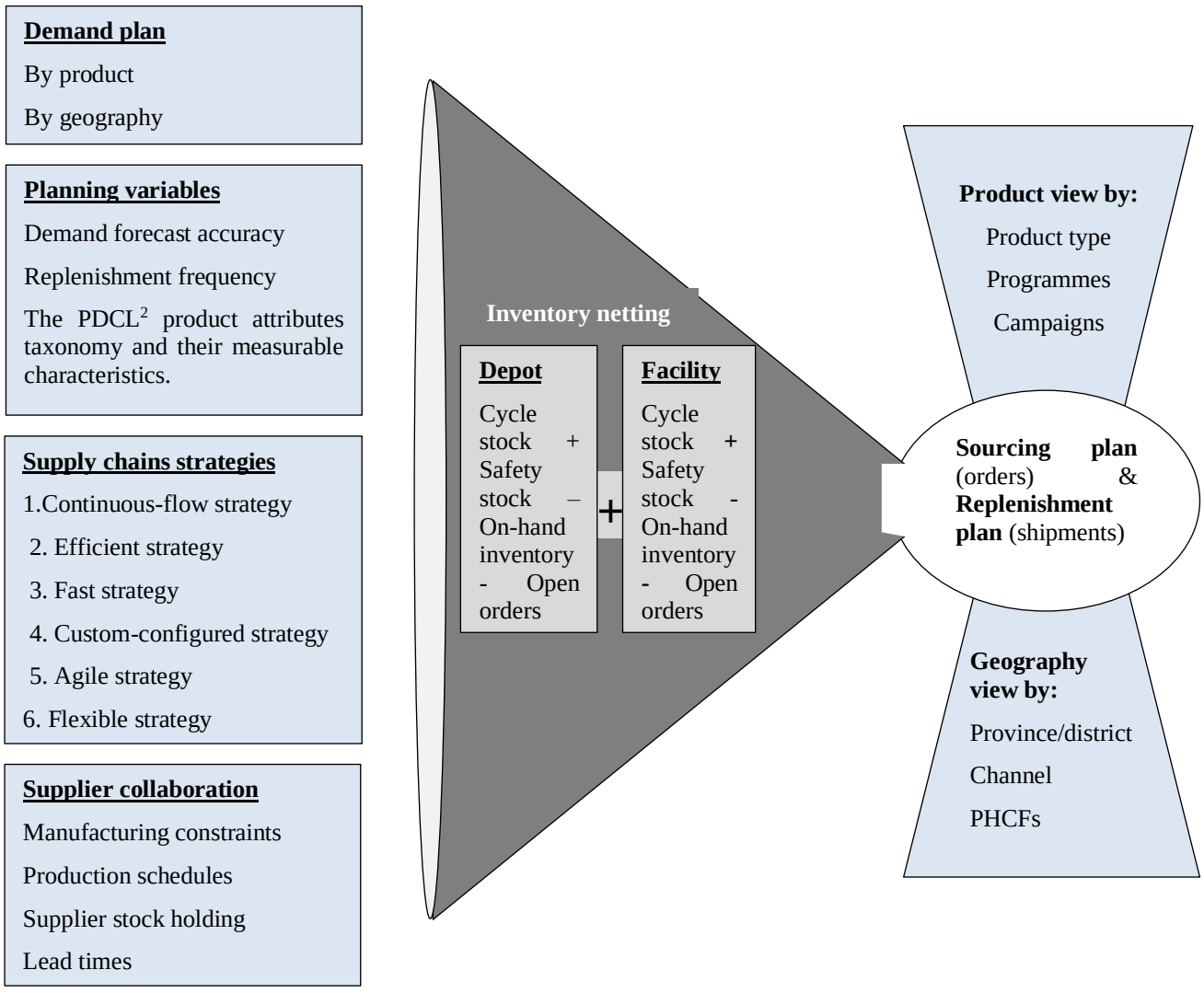

Figure 3.4: Supply planning overview with the PDCL^2 product attributes taxonomy and supply chain strategies taxonomy incorporated (adapted from Llewellyn (2016))

3.7.4. Supply chain focus—VAN enabled

Perez (2013) posited that the goals that are being pursued through the implementation of product categorization drive interactions between internal processes and activities, with an important interaction being the one between resource utilization and the decoupling point location.

The implementation of the VAN strategy—transforming to an informed push—implies a significant change to the South African public healthcare pharmaceutical supply chain. Various enablers need to be in place to facilitate the rolling out of the VAN strategy coupled with the proposed supply chain strategies taxonomy. According to Llewellyn (2016), key priorities include:

A fragmented IT landscape: An informed push model requires stock and consumption visibility, and therefore the implementation of the VAN strategy and the proposed supply chain strategies taxonomy will need to overcome a fragmented and incomplete IT landscape, as discussed in Section 2.4.2.1.

Capacity building for staff: An informed push model needs workforce training and retention of specialized skills to accomplish analytical work. Therefore, the implementation of the VAN strategy coupled with the proposed supply chain strategies taxonomy will need to build on existing skills and continuously improve professionalism within the SCM.

Governance: The VAN strategy coupled with the proposed supply chain strategies taxonomy will be implemented within a complex context of multiple stakeholders and interventions. Therefore, there is a need for strong governance to ensure synchronization with existing best practices and alignment with multiple efforts associated with the supply chain.

It is within the discussed context that supply chain improvement efforts have been suggested within the VAN strategy, and for the sake of this study, these will be coupled with recommendations for the proposed supply chain strategies taxonomy implementation. The improvement actions detail how visibility and analytics within the VAN strategy can be synchronized with the AMD provisions, as summarized in Table 3.11.

The current provincial role in planning involves: managing procurement and acquisition from suppliers on cross contracts; and managing stock—order processing, storage and distribution to PHCFs (Llewellyn, 2016). However, the new activities in the context of the VAN's supply planning and the supply chain strategies taxonomy implementation, as described in Table 3.11, will be: creating plans based on local consumption trends, physical distribution constraints, and stock availability; and providing planning data for national health budget alignment and aggregation (Llewellyn, 2017).

Table 3.11: VAN supply planning activities and supply chain strategies taxonomy implementation for Provincial Medicine Procurement Units (adapted from Llewellyn (2017))

Visibility and analytics	**Actions**	**Interactions with the AMD**
❖ Review alerts of facilities with long stock outs forecast based on the established pharmaceutical bundles/categories or inventory variances/deviations from plan.	❖ Configure supply chain strategies decoupling points accordingly. Determine if expediting with supplier or upstream supply can resolve stock out risks.	❖ Escalate specific short-term asks to the national supply planner: • Supplier negotiation in stock/payment issues.
❖ Conduct a root cause analysis based on the PDCL[2] product attributes taxonomy to determine the reason for inventory variances based on product bundles/categories: • Inventory policy: Is the safety stock correct? • Ordering process: Is there on-time approval and economic order quantities (EOQ)? • Is it an upstream inventory issue? • Is it a delivery issue (supplier or upstream depot)? • Is it payment issues?	❖ Determine if product bundle/category pipeline (supply chain strategy route) or safety stock settings need a review—assess the supply planning KPIs and consult the national tier to effect changes.	❖ Review supply planning and supply strategies methodology recurrently: • Change the inventory channel (product category pipeline) or inventory policy.
❖ Review shelf life and obsolescence wastage risks?	❖ Review the supplier performance (service levels)—identify issues to do with stock management and distribution standard operating procedures or adherence.	❖ Review the requirements for the standard operating procedure changes to prioritize transactional processes

Returning to Perez's (2013) remark on the importance of the interactions between internal processes and activities, when the VAN strategy and the supply chain strategies taxonomy are considered, it is evident that there exists a high interdependence between resource utilization and decoupling point location. Consequently, as indicated in Table 3.7, many levers should be influenced to facilitate a supply chain strategy implementation, most of which are deemed relevant to a public healthcare pharmaceutical supply chain. The proposed operationalization of the two levers of the competitive positioning element in the context of the VAN blueprint and the South African public healthcare pharmaceutical supply chain, is summarized in Table 3.12.

Table 3.12: Proposed operationalized levers of the supply chain profiles (adapted from Perez (2013))

		Oriented to efficiency			Oriented to responsiveness		
		Continuous-flow	Efficient	Fast	Custom-configured	Agile	Flexible
Supply chain profile	Demand buffering	Predefined safety stock levels	Predefined safety stock levels	Predefined safety stock levels	Inventory before PDP, extra capacity after	Extra capacity	Standby capacity or capacity pooling
	Order penetration point	Supply to stock	Supply to forecast, sometimes supply to need	Supply to forecast	Configured to need	Supply to need or supply to stock	Design supply to need
	Minimum order size	Patients' replenishment needs	Minimum economic transportation batch	Collection forecast	End patients' (replenishment) needs	Minimum economic supply or transportation batch	Minimum economic supply batch
	Replenishment supply cycle	Replenishment according to a fixed cycle	Fixed lead time or fixed cycle	According to collection schedule	As short as possible as per need in PDP queue	As short as possible as per patients' needs in queue	Flexible, as short as possible
	Collaborative relationships	Strategic relationships with key partners to build synergies	Strategic relationships with key partners to build synergies	Cooperate to anticipate market trends /joint design	Cooperation with key partners to anticipate aggregate demand at PDP	Cooperation with key partners to anticipate capacity requirements	Understanding of 'available to need' at any moment
	Inventory strategy	Small and frequent batches to increase inventory turns	High level of inventory to optimize supply efficiency	A single batch per SKU based on collection forecast	Inventory just before PDP	Stock under a common platform	Low inventory level and inventory pooling
	Customization	No	No	Usually no	Yes, just in PDP and downstream processes	Relevant in supply operations and downstream processes	Relevant in supply design and downstream processes
	Resource utilization rate	High to very high	Very high	High to very high	High before PDP, medium after PDP	Medium to high	Low to medium. At times standby capacity

		Oriented to efficiency			Oriented to responsiveness		
		Continuous-flow	Efficient	Fast	Custom-configured	Agile	Flexible
Supply chain profile	Supplier's supply cycle	As short as possible to reduce batch sizes	Maximize on increasing batch sizes and efficiency	As short as possible to reduce time from ordering to market	Long before PDP, short in PDP and downstream	Variable as per patients' orders accepted in queue	As short as possible to reduce lead time
	Rate (takt) of workload	Smoothed by patients demand	Smoothed by rolling forecast	Smoothed by collection forecast	Smoothed by rolling forecast before PDP, peaks after PDP	Peaks and valleys of high magnitude	Capacity on standby for occasional use, high peaks when used
	Sourcing buffering	Inventory/one supplier for each key product bundle/ category	Inventory/best-cost supplier on each occasion	Pool of suppliers	Inventory/pool of suppliers	Inventory/pool of suppliers	Pool of suppliers for critical resources

3.8. **Framework design requirements identified in Chapter 3**

Several framework design requirements have been defined in this chapter based on design requirements defined by van Aken et al. (2007), and are summarized in Table 3.13. The table details the selected design requirement as discussed in the chapter and the corresponding requirement ID.

Table 3.13: Framework design requirements identified in Chapter 3

Requirement	Req. ID
User requirements	
The framework must support supply planning decisions at different operational levels e.g. the national and provincial levels, by recommending an appropriate supply chain strategy for each pharmaceutical product.	U1
Each supply chain strategy, contextualized to the VAN strategy, should dictate an appropriate sourcing plan and replenishment plan based on its affiliated decoupling point.	U2
The framework must also provide a decision-making approach in special cases e.g. vaccine supply or delivery site restrictions and limited storage capacity.	U3
The framework's output, which identifies as output of a supply plan, should be usable as input to a distribution plan.	U4
Functional requirements	
The framework must provide a clear mechanism for categorizing products according to their attributes.	F1
Products should be categorized according to the PDCL[2] product attributes classification.	F2
Design restrictions	
The pharmaceuticals restricted to the demand plan product portfolio which describe the Essential Medicine List (EML) should be used as input to the supply plan product categorization framework.	R1
If products are bundled based on their inherent characteristics, the medicine schedules bundle S0-S4 and S5-S8 should be used.	R2

3.9. **Conclusion**

Objective 2 of the study was achieved in this chapter. Thus, a set of products attributes that are critical in matching product bundles/categories with appropriate supply chain strategies in the South African public healthcare supply chain were proposed. A brief overview of prominent standardized classifications and nomenclature systems used in the healthcare sector was provided and a basis for distinguishing between special and standard products was proposed based on one of these systems. A brief description of the goal of product categorization in the South African public healthcare supply chain was formulated. Furthermore, a critical supply chain strategies taxonomy for the product categorization framework development was determined and levers and controls for implementation of the identified supply chain strategies were discussed consistent with the VAN supply chain; VAN service supply planning; and the South African public healthcare pharmaceutical supply chain.

The proposed product categorization framework is presented in the next chapter.

Chapter 4

The VAN-Pharmaceutical Product Categorization Framework development

4.1. Introduction

Various design requirements for the product categorization framework have been derived and defined in the preceding chapters using a mixed-methods approach. Having laid the foundation throughout the preceding chapters, this chapter seeks to address Objective 3 of this study:

> Research objective 3: To develop a framework, drawing from the findings of the first and second objectives, for the incorporation of product categorization into the South African public healthcare pharmaceutical supply chain, providing detail on:
>
> a) The basis for categorization—i.e. aligning and matching pharmaceutical product categories with appropriate supply chain strategies coupled with respective decoupling points and thus formulate different supply pipelines for different products; and
>
> b) The implication of categorization—i.e. what aspects of the South African public healthcare pharmaceutical supply chain would be implicated based on the product categorization framework.

The succeeding section details the consolidated framework design requirements as established in this study. This is followed by a section presenting the schematic tree that depicts a description of the basis for categorization in determining which product attributes should be matched to which supply chain strategies and thus formulate different supply pipelines for different products. Consequently, a preliminary product categorization framework proposal (presented in Appendix D) will be developed and validated using SME interviews in Chapter 5.

Although the framework validation is only presented in Chapter 5, the final version of the framework that incorporates the changes that were made in response to the validation feedback received is the version that is presented in this chapter. The preliminary framework document is included in the validation pre-read document in Appendix D. This approach is followed to avoid: duplicating the

framework in the main document; and interrupting the flow of the narrative of the thesis with a detailed presentation of the validation feedback before the framework itself is presented.

Table 4.1: Consolidated design requirements from the preceding chapters

Design requirement	Req. ID	Chapter identified	
		2	3
User requirements [U]: Outputs			
The framework must support supply planning decisions at different operational levels e.g. the national and provincial levels, by recommending an appropriate supply chain strategy for each pharmaceutical product.	U1		X
Each supply chain strategy, contextualized to the VAN strategy, should dictate an appropriate sourcing plan and replenishment plan based on its affiliated decoupling point.	U2		X
The framework must also provide a decision-making approach in special cases e.g. vaccine supply or delivery site restrictions and limited storage capacity.	U3		X
The framework's output, which identifies as output of a supply plan, should be usable as input to a distribution plan.	U4		X
Functional requirements [F]: Parameters			
The framework must provide a clear mechanism for categorizing products according to their attributes.	F1		X
Products should be categorized according to the PDCL[2] product attributes classification.	F2		X
Design restrictions [R]: Inputs			
The pharmaceuticals restricted to the demand plan product portfolio which describe the Essential Medicine List (EML) should be used as input to the supply plan product categorization framework.	R1	X	
If products are bundled based on their inherent characteristics, the medicine schedules bundles S0-S4 and S5-S8 should be used.	R2	X	
Boundary conditions [B]: Controls			
The framework's output, in the form of recommendations for managing the public healthcare pharmaceutical supply chain, must align with the principles that underpin the Visibility and Analytics Network strategy, most importantly the concept of informed push.	B1	X	
The framework's output, in the form of recommendations for determining supply planning's sourcing and replenishment plans, must contribute to determination of supplier collaboration constraints (contracts and tenders) within the funding limitations.	B2	X	
The framework's output, in the form of recommendations for managing the public healthcare pharmaceutical supply chain, must align with the principles that underpin the South African Constitution.	B3	X	
Attention points [A]: Enablers			
The framework's recommendation for managing supply chain strategies should ideally incorporate the direct delivery and depot system that are already operational in the South African public healthcare pharmaceutical supply chain	A1	X	

4.2. **Consolidated design requirements**

Five different types of design requirements, for example, user requirements and design restrictions, are used in this research. As discussed in Section 1.5, these five types of design requirements are

based on the work of van Aken et al. (2007). Throughout the preceding chapters, a detailed set of framework design requirements have been deduced, based on a mixed-methods approach, and this set of design requirements is consolidated in Table 4.1. The table details the design requirement description, requirement ID, and the chapter in which the design requirements were identified.

As set out in Chapter 5, these design requirements were formally validated through semi-structured interviews with SMEs. The detailed results of the formal validation are presented in the following chapter, however, no changes to the design requirements were deemed necessary in response to the validation feedback received. Thus, the requirements presented here are also the final, validated set of framework design requirements.

As described in Section 1.5, the synthesis of these requirements to develop the framework is based on the systems engineering input-output transformation process adapted from the US Department of Defence Systems Management College (2001). The application of this input-output product categorization process to the different types of requirements is depicted in Figure 4.1 with:

- Design restrictions which are the input data—answered by the medicine schedules bundle: S0-S4 and medicine schedules bundles: S5-S8—as provided by the demand plan pharmaceuticals product portfolio;
- Functional requirements which are the parameters—answered by the PDCL^2 product attributes taxonomy—with which the synthesis of inputs is done to give outputs;
- Boundary conditions which define and determine the controls of operation for the framework based on the levers of the VAN design and supplier collaboration constraints;
- Attention points—which answer whether to use either the depot system or direct delivery system in the supply of pharmaceuticals—which are to be considered as enablers, in retrospect, as the framework is developed; and
- Framework user requirements which define outputs—answered by the continuous-flow supply chain strategy; efficient supply chain strategy; fast chain supply strategy; custom-configured supply chain strategy; agile supply chain strategy; and flexible supply chain strategy—from the framework which drive the determination of sourcing and replenishment plans to be used by the users—i.e. the VAN supply chain professionals.

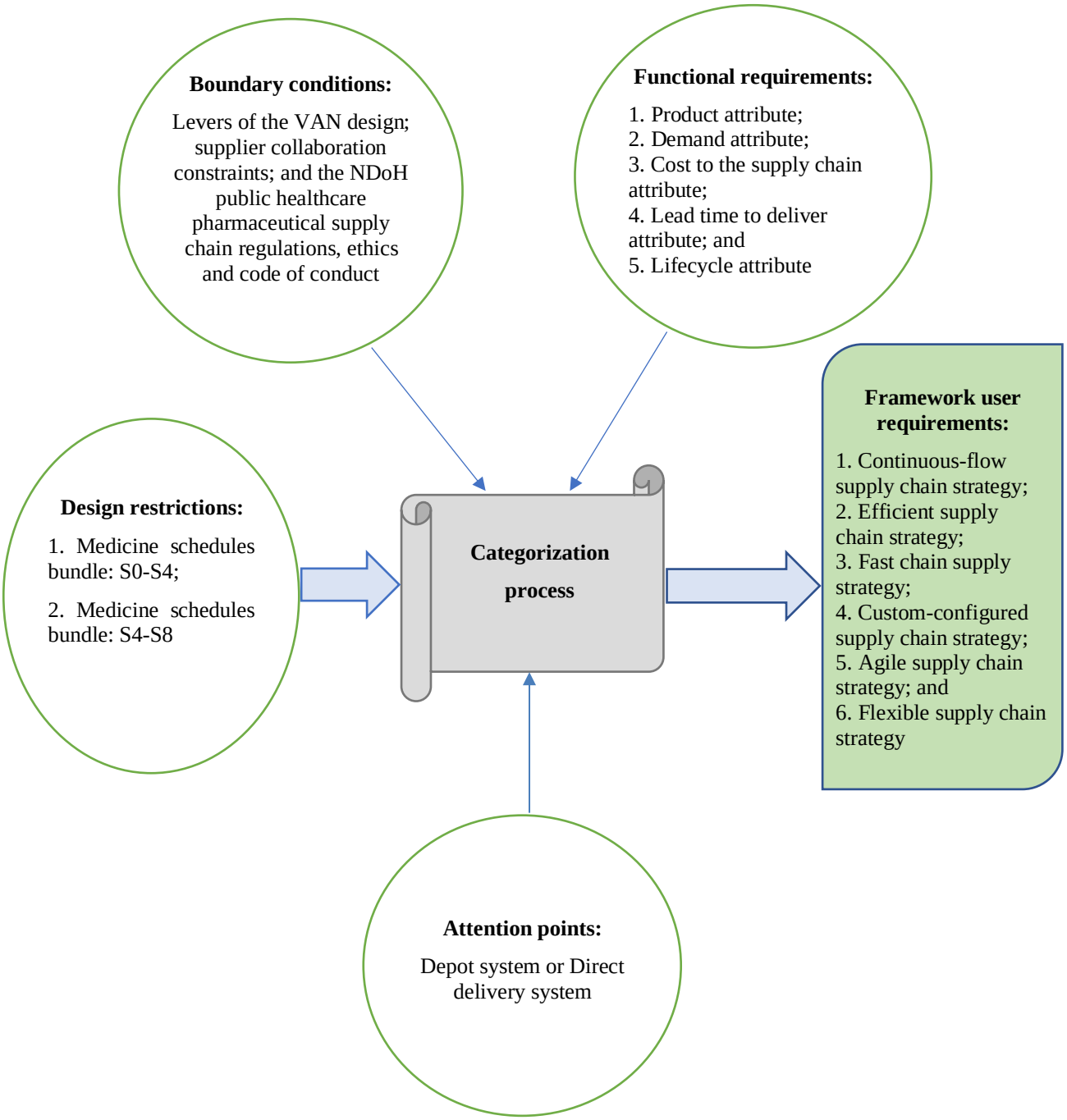

Figure 4.1: Input-output product categorization process (adapted from The US Department of Defence Systems Management College, 2001))

The set of five product attributes defined in the PDCL[2] product attributes taxonomy generates 32 potential unique combinations of attributes which the framework must be able to accommodate. Arranging the attributes in a specific order generates a schematic tree that is a useful mechanism for visualizing one element of the logic that underpins the product categorization framework. This is detailed in the next section.

4.3. The schematic tree that underpins the product categorization framework

In Figure 4.2, the PDCL^2 product attributes taxonomy is used to develop a schematic tree which illustrates the 32 unique combinations of the five product attributes. The schematic tree splits according to attributes in a deliberate hierarchical sequence, with the 'product' attribute being considered first. In the framework, a specific supply chain strategy, with an associated decoupling point, will be prescribed for each route, based on the discussed findings from this study.

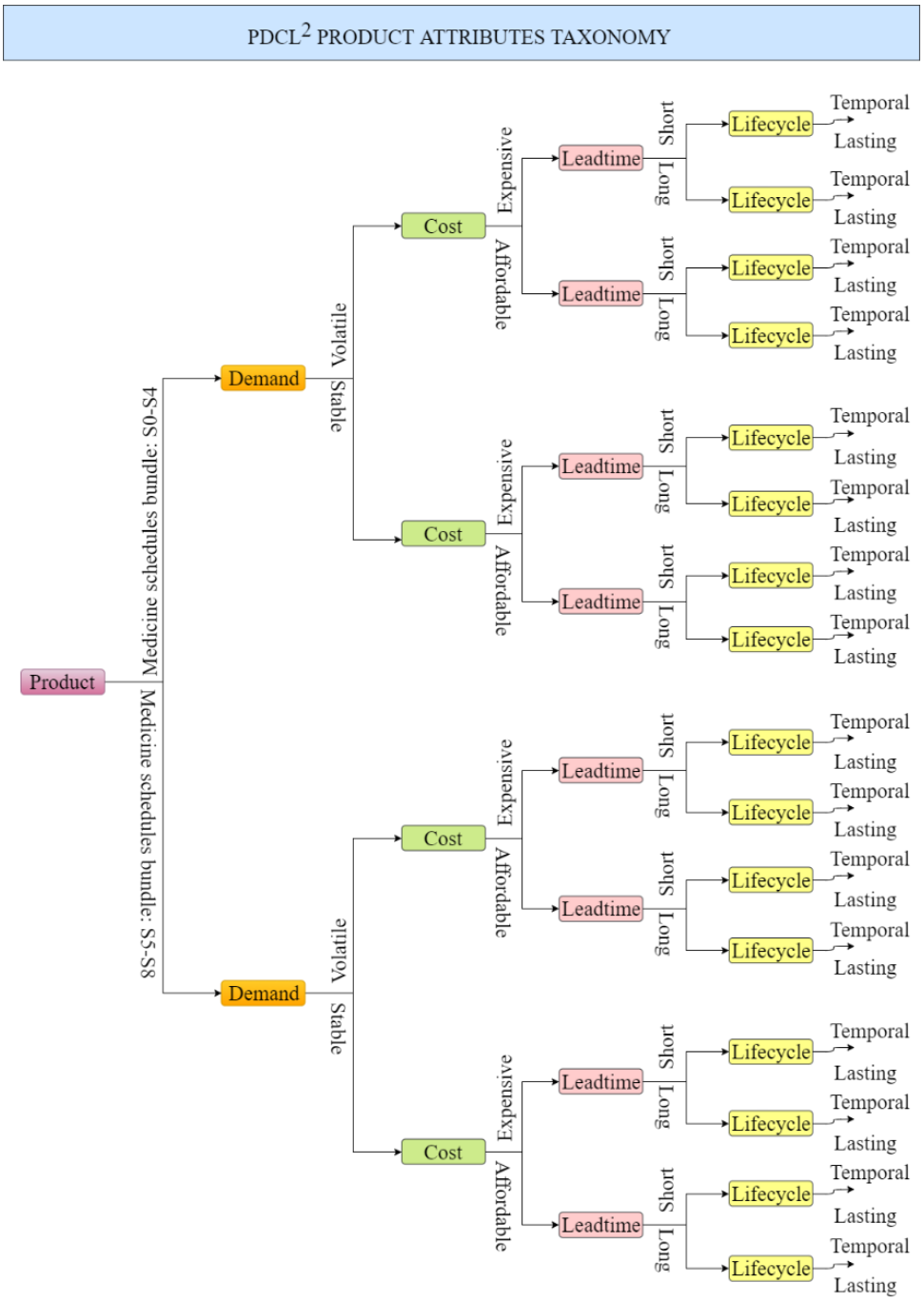

Figure 4.2: The schematic tree that underpins the product categorization framework

As indicated in the previous section, Perez's six supply chain strategies, contextualized to the South African public healthcare pharmaceutical supply chain, will constitute the set of potential recommended strategies in the framework. High-level guidelines on the strategies and associated decoupling points that would be most suited to each of the PDCL[2] attribute gradations are given in the remainder of this section.

According to Fisher (1997), generic products can either be primarily functional or primarily innovative but for this study pharmaceutical products have been distinguished in Section 3.4 based on their medicine schedules with the pharmaceutical bundles being either of medicine schedules bundle: S0-S4 or medicine schedules bundle: S5-S8. Knowing this product distinction from the onset will give an indication on whether to consider supply chain strategies oriented towards efficiency or responsiveness as developed by Fisher (1997) and expanded by Perez (2013), discussed in Sections 2.2; 3.2; 3.6; and 3.7. In this study, the 'product' attribute is graded as either medicine schedules bundle: S0-S4 or medicine schedules bundle: S5-S8, which correlates with the findings of Fisher (1997); Christopher and Towill (2002); and Perez (2013).

The second product attribute in the schematic tree hierarchy is the 'demand' attribute and this has been graded in this study as either stable or volatile, concurring with the findings of Christopher and Towill (2002) as well as those of Payne and Peters (2004). Broadly:

- In instances where demand is stable and predictable, medicines are better suited to supply chain strategies that have supply to forecast decoupling points;
- In instances where demand is volatile and the stock has to be supplied based on predefined safety stock levels, supply chain strategies that are driven by efficiency are more suitable; and
- In instances where demand is volatile and the stock has to be supplied to need or to stock, supply chain strategies that are oriented towards responsiveness are more suitable.

The third product attribute in the schematic tree hierarchy is the 'cost to the supply chain' attribute which is graded, in this study, as either expensive or affordable. The choice of appropriate supply chain strategies selection should be based on balancing required patients' service levels with the total costs of supplying that service level. Costing approaches that are driven by activity-based methods in the South African public healthcare pharmaceutical supply chain, which is mainly financed by the government and/or donors, enable VAN supply chain managers to make better-informed decisions. These decisions pertain to the patient, pharmaceutical product, and channel cost/profitability by providing the true cost of sending a particular pharmaceutical product via a certain supply chain pipeline (Harrison et al., 2018; van der Veeken & Rutten, 1998). In instances where the cost to the

supply chain is expensive, supply chain strategies oriented towards efficiency, where operations follow a lean thinking to eliminate wastes, may be useful as a mechanism for controlling costs. Under such circumstances, decoupling points such as supply to stock; supply to forecast; and supply to need can be of value. In instances where the cost to the supply chain is affordable, supply chain strategies that are oriented towards responsiveness could be valuable as these permit capacity pooling. In such instances, more stock can be held upstream (at the suppliers or a DoH depot), rather than at PHCFs, as it is affordable to supply the stock when needed. In instances where the cost to the supply chain is affordable and supply chain strategies oriented towards responsiveness are recommended, decoupling points, as defined in Table 3.8 and Table 3.12, that supply to need; or supply to stock; or that have supply orders/formularies that are configurable to need; or which can design supply to need, can be invaluable.

The fourth product attribute in the schematic tree hierarchy is the 'lead time to deliver' attribute which is graded as either short or long. The time taken to deliver pharmaceutical products starting from the time when the order was requested, will help the VAN supply chain professionals to determine decoupling points positioning and prioritizing the sequence of events with the end goal of serving the ultimate consumer within supply planning. Selection of whether to use the depot system or direct delivery can be facilitated for. Supply chain strategies oriented towards efficiency can be used as they (VAN supply chain managers) employ a lean approach of minimizing waste and thus enable the supply of pharmaceuticals as soon as possible to mitigate long lead times. However, in some instances it may be critical to be leagile, utilizing the positives of being both lean and agile. In instances where the lead time is long, decoupling points such as supply to stock; supply to forecast; and supply to need can be of value, and these correlate with supply chain strategies oriented towards efficiency as given in Table 3.8 and Table 3.12. When lead time is short, it facilitates for flexibility in responsiveness as it is possible to react and deliver pharmaceuticals rapidly and, in such circumstances, supply chain strategies oriented towards responsiveness can be utilized if need be.

The fifth product attribute in the schematic tree hierarchy is the 'life cycle' attribute graded as either lasting or temporal. Life cycle, which is derived from the shelf life and lifetime as detailed in Section 3.3.2.3, facilitates for supply chain strategies oriented towards efficiency when it is long. Supply to stock, supply to forecast or supply to need decoupling points can be used as driven by the longevity of pharmaceutical product shelf life and lifetime. Pharmaceutical products with short life cycles require both a short end-to-end pipeline and rapid time to deliver as established in Section 3.3.2.3, therefore, supply chain strategies oriented towards responsiveness are a viable option. This is applicable particularly to pharmaceutical products which need a cold chain e.g. vaccines, as their

short life cycle poses a great risk of obsolescence. Use of decoupling points that supply to stock may not be advantageous due to the risk of obsolescence. In the case of the short life cycle, a supply to need or supply to forecast decoupling point may be advantageous especially if the lead time to deliver is short and the demand is stable and predictable.

It is evident from the arguments presented in this section that a single product attribute cannot be used in isolation of the others when determining the appropriate supply chain strategy to use. Instead, the gradation of a product according to each of the five PDCL[2] product attributes needs to be considered before recommending a supply chain strategy and associated decoupling point.

From the 32 routes of the schematic tree, routes that yield the same recommended supply chain strategies can be grouped together and can form part of the inputs to a distribution plan. Though distribution planning is outside the scope of this study, it is recommended that the product categorization supply plan developed from this study, which facilitates for the determination of the sourcing plan and the replenishment plan by the VAN supply chain managers, be used to feed into the distribution plan. Bundling routes that share the same supply chain strategies, will avoid having more discrete supply chain pipelines than is necessary. It is neither desirable nor economically feasible to establish an extensive number of discrete supply chain pipelines for a distribution plan, as this would escalate operations management overheads, as discussed in Section 3.3 (Christopher et al., 2009; Godsell et al., 2011; Harris et al., 2010).

Having established the logic behind the schematic tree which underscores the product categorization framework termed the VAN-Pharmaceutical Product Categorization Framework[8], with an indication of grading between long and short lead time; temporal and lasting lifecycle etc. already provided in Section 3.3.3, the product categorization framework main index is presented in Table 4.3 in Section 4.4 and the product categorization process and framework is discussed based on the study's findings.

4.4. **The VAN-Pharmaceutical Product Categorization Framework**

Based on the input-output categorization process which the product categorization framework takes, an overarching process flow of the product categorization framework which can be used to describe

[8] The 'VAN-Pharmaceutical Product Categorization Framework' will be simply used synonymously with the 'product categorization framework'.

the usage of the framework is given in Figure 4.3. The framework that is presented here incorporates the changes that were made in response to the feedback that was received from SMEs during the framework validation. As previously mentioned, in order not to interrupt the flow of the narrative, the detailed description of the validation process, as well as the feedback that was received, is presented in the succeeding chapter. The preliminary version of the framework (i.e. the version that was sent out for validation) is included in the validation pre-read document in Appendix D.

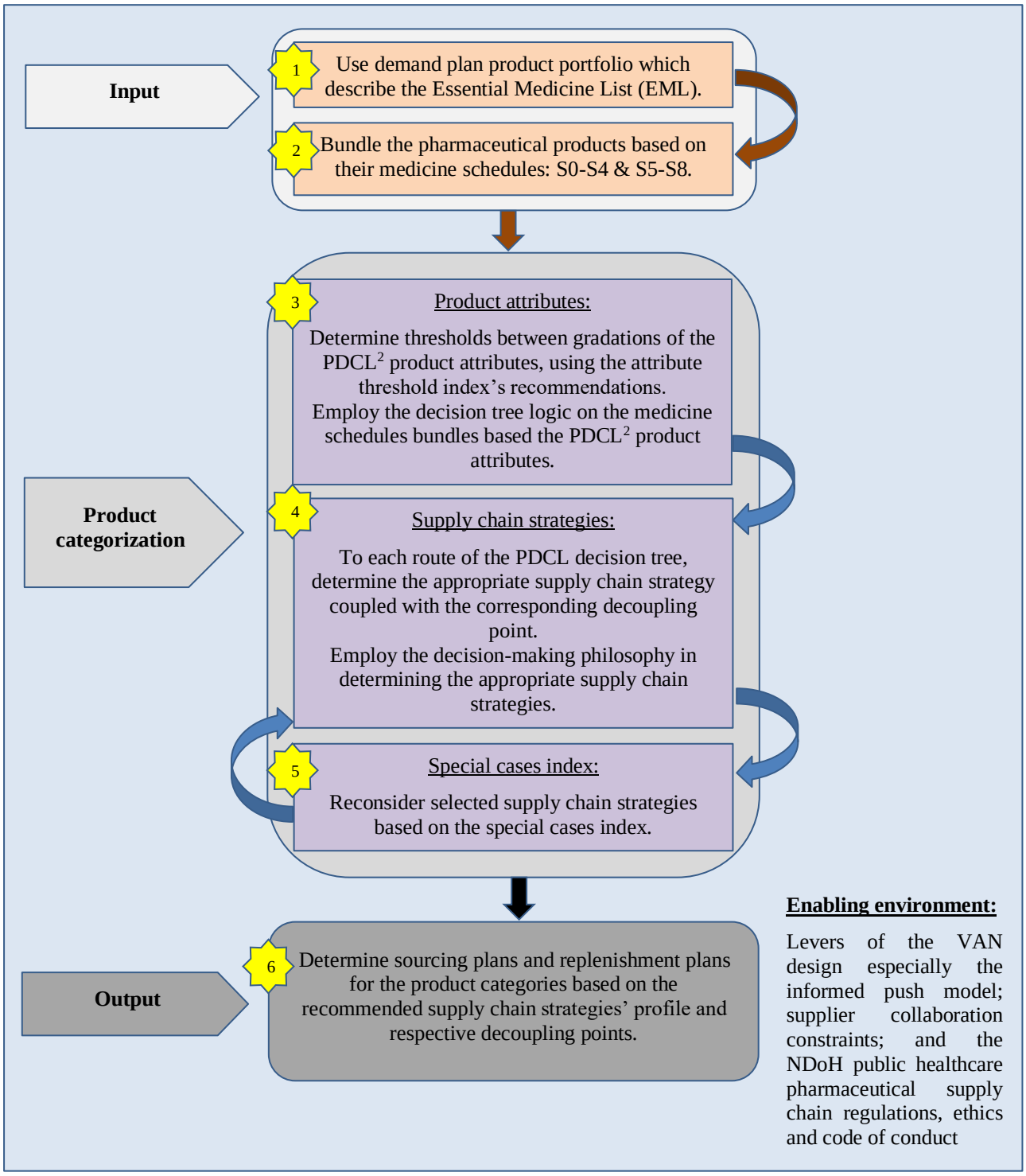

Figure 4.3: Overarching process flow of the VAN-Pharmaceutical Product Categorization Framework

As shown in Figure 4.3, the framework users must determine the threshold between the gradations for each of the PDCL^2 product attributes. A detailed discussion of information that is relevant to determining the threshold for each gradation was presented in Section 3.3.3, and the most salient information from this discussion is presented in Table 4.2. This summary of only the most salient information into table format is intended to facilitate ease of use of the framework.

Table 4.2: Consolidated product attributes with recommended thresholds for binary gradations (adapted from Mapowo et al. (2019) © 2019 IEEE)

Public healthcare pharmaceutical supply chain product attributes (with gradations)	**Examples of measurable characteristics**	**Recommended thresholds between the binary gradations for provinces in the South African public healthcare**
Product (standard or special)	Therapeutic nature, substitutability of the product, standardization of product category and physical characteristics.	Medicine schedules S0-S4 denoted as standard products and S5-S8 denoted as special products.
Demand (stable or volatile)	Variability, volatility, volume, and uncertainty.	Pharmaceutical products with fairly constant or predictable demand in the short or medium-term demand and/or supply plan of a province can be considered 'stable' while those that spike unpredictably can be considered 'volatile'.
Cost to the supply chain (affordable or expensive)	Procurement cost, holding cost, obsolescence cost and distribution cost.	Order line values, frequency of order lines and order line weights can then be used to determine between expensive and affordable cost based on the procurement cost, holding cost, obsolescence cost and distribution cost.
Life cycle (temporal or lasting)	Product lifetime, shelf life, obsolescence, and product quality.	Products that require a short end-to-end pipeline, rapid time to market and have short shelf life and lifetime can be considered to have a temporal life cycle, with the opposite being true for a lasting life cycle.
Lead time to deliver (short or long)	Supply cycle time, supply takt time, response time to deliver product, on-time or on-schedule and time service levels.	Pharmaceutical products that cannot be sourced nor replenished rapidly based on the supply cycle time, supply takt time and time service levels can constitute the long lead time, while the opposite is true for a short lead time.

The main index of the product categorization framework is presented in Table 4.3. A leagile (lean + agile) approach is employed in proposing the most appropriate supply chain strategies so that the framework users (VAN supply chain managers) can capitalize on the benefits of being lean (efficient strategies) and those of being agile (responsive strategies). The high-level discussion of strategies that are best suited to each of the PDCL^2 product attributes, described in Section 4.3, informed the selection of the most appropriate strategies for each of the 32 routes. The index offers recommendations rather than rigid prescriptions. Hence more than one appropriate supply chain strategy is recommended for each route. This approach reflects the complex reality of recommending an appropriate strategy based on the simultaneous consideration of the five PDCL^2 product attributes. This approach also ensures that the use of the index does not make it infeasible to limit the number of discrete supply chain pipelines that need to be included in a distribution plan. As discussed in the previous section, this is desirable, both in terms of economic and operational feasibility.

Table 4.3: VAN-Pharmaceutical Product Categorization Framework main index

	The PDCL[2] product attributes taxonomy										Supply chain strategies taxonomy	
	Product		Demand		Cost		Leadtime		Lifecycle			
	Schedules bundle: S0-S4	*Schedules bundle: S5-S8*	*Volatile*	*Stable*	*Expensive*	*Affordable*	*Short*	*Long*	*Temporal*	*Lasting*	**Supply chain strategies**	**Decoupling points**
1.	X		X		X		X		X		Fast or Agile strategy	Supply to forecast or Supply to need/stock
2.	X		X		X		X			X	Efficient or Agile strategy	Supply to forecast/need or Supply to need/stock
3.	X		X		X			X	X		Efficient or Fast or Agile strategy	Supply to forecast/need or Supply to forecast or Supply to need/stock
4.	X		X		X			X		X	Efficient or Agile strategy	Supply to forecast/need or Supply to need/stock
5.	X		X			X	X		X		Fast or Agile or Flexible strategy	Supply to forecast or Supply to need/stock or Design-supply to need
6.	X		X			X	X			X	Efficient or Agile or Flexible strategy	Supply to forecast/need or Supply to need/stock or Design-supply to need
7.	X		X			X		X	X		Fast or Agile strategy	Supply to forecast or Supply to need/stock
8.	X		X			X		X		X	Efficient or Agile strategy	Supply to forecast/need or Supply to need/stock
9.	X			X	X		X		X		Efficient or Agile strategy	Supply to forecast/need or Supply to need/stock
10.	X			X	X		X			X	Continuous-flow or Efficient strategy	Supply to stock or Supply to forecast/need
11.	X			X	X			X	X		Efficient or Fast or Agile strategy	Supply to forecast/need or Supply to forecast or Supply to need/stock
12.	X			X	X			X		X	Continuous-flow or Efficient or Agile	Supply to stock or Supply to forecast/need or Supply to need/stock
13.	X			X		X	X		X		Continuous-flow or Efficient or Fast	Supply to stock or Supply to forecast/need or Supply to forecast
14.	X			X		X	X			X	Continuous-flow or Efficient strategy	Supply to stock or Supply to forecast/need
15.	X			X		X		X	X		Efficient or Fast or Agile strategy	Supply to forecast/need or Supply to forecast or Supply to need/stock
16.	X			X		X		X		X	Continuous-flow or Efficient or Fast	Supply to stock or Supply to forecast/need or Supply to forecast
17.		X	X		X		X		X		Fast or Custom-configured or Agile	Supply to forecast or Configurable to need or Supply to need/stock
18.		X	X		X		X			X	Fast or Agile or Flexible strategy	Supply to forecast or Supply to need/stock or Design-supply to need
19.		X	X		X			X	X		Fast or Custom-configured or Agile	Supply to forecast or Configurable to need or Supply to need/stock
20.		X	X		X			X		X	Efficient or Agile or Flexible strategy	Supply to forecast/need or Supply to need/stock or Design-supply to need
21.		X	X			X	X		X		Fast or Custom-configured or Flexible	Supply to forecast or Configurable to need or Design-supply to need

	The PDCL^2 product attributes taxonomy										Supply chain strategies taxonomy	
	Product		Demand		Cost		Leadtime		Lifecycle			
	Schedules bundle: S0-S4	*Schedules bundle: S5-S8*	*Volatile*	*Stable*	*Expensive*	*Affordable*	*Short*	*Long*	*Temporal*	*Lasting*	**Supply chain strategies**	**Decoupling points**
22.		X	X			X	X			X	Fast or Custom-configured or Agile	Supply to forecast or Configurable to need or Supply to need/stock
23.		X	X			X		X	X		Fast or Custom-configured or Flexible	Supply to forecast or Configurable to need or Design-supply to need
24.		X	X			X		X		X	Fast or Custom-configured or Agile	Supply to forecast or Configurable to need or Supply to need/stock
25.		X		X	X		X		X		Efficient or Fast or Agile strategy	Supply to forecast/need or Supply to forecast or Supply to need/stock
26.		X		X	X		X			X	Efficient or Fast or Custom-configured	Supply to forecast/need or Supply to forecast or Configurable to need
27.		X		X	X			X	X		Efficient or Fast or Flexible strategy	Supply to forecast/need or Supply to forecast or Design-supply to need
28.		X		X	X			X		X	Efficient or Fast or Custom-configured	Supply to forecast/need or Supply to forecast or Configurable to need
29.		X		X		X	X		X		Continuous-flow or Efficient or Fast	Supply to stock or Supply to forecast/need or Supply to forecast
30.		X		X		X	X			X	Continuous-flow or Efficient	Supply to stock or Supply to forecast/need
31.		X		X		X		X	X		Continuous-flow or Efficient or Fast	Supply to stock or Supply to forecast/need or Supply to forecast
32.		X		X		X		X		X	Continuous-flow or Efficient	Supply to stock or Supply to forecast/need

In the use of the product categorization framework, the users have to be cognizant of various special conditions which may necessitate an adjustment to the recommended strategy for the route. These special conditions and the associated adjusted supply chain strategy recommendations are indexed in Table 4.4.

Table 4.4: VAN-Pharmaceutical Product Categorization Framework special cases index

Condition	Recommendation
Are the pharmaceuticals seasonal?	Opt for elements of supply chain strategies oriented towards efficiency when out of season and towards responsiveness when in season.
Are the pharmaceutical products personalized medicine?	Opt for the elements of the custom-configured supply chain strategy.
Are the pharmaceutical products vaccines?	Opt for a cold chain using a leagile (lean + agile) approach. Make use of elements of both strategies oriented towards efficiency and responsiveness.
Are the pharmaceutical products epidemic medicine?	Opt to orient towards the responsive strategies especially either agile and/or flexible supply chain strategies.
Are the pharmaceutical products chronic medication?	Opt for supply chain strategies oriented towards efficiency.
Does the facility to which the products are being supplied have low storage capacity (though it is easily accessible)?	Maintain the supply chain profile of the selected supply chain strategy as given in Table 3.12. Check applicability of direct delivery as compared to the depot system.
Is the facility to which the products are being supplied easily accessible and its storage capacity is high?	Maintain the supply chain profile of the selected supply chain strategy as given in Table 3.12. Check applicability of direct delivery as compared to the depot system.
Is the facility to which the products are being supplied not easily accessible and its storage capacity is low?	Buffer the supply chain profile of the selected supply chain strategy as given in Table 3.12 using the nearest facility with better capacity.
Is the facility to which the products are being supplied not easily accessible, though the storage capacity is high?	Opt for supply chain strategies with supply to stock/need/forecast decoupling points. Check applicability of the depot system as compared to direct delivery.

* Facilities that are defined as a local 'pocket' (Section 3.7.1.2) within the VAN approach should manage each product category according to the same supply chain strategy.
*In all other circumstances not specified, stick to the provisions of the product categorization framework.

4.4.1. Patterns in the VAN-Pharmaceutical Product Categorization Framework

Several patterns are evident in the recommended supply chain strategies, and associated decoupling points, for the 32 routes in Table 4.3. These are briefly discussed in the remainder of this section.

4.4.1.1. Medicine schedules bundles: S0-S4

The appropriate supply chain strategies selected in most routes for the S0-S4 medicine schedules bundles are oriented towards efficiency (lean). This is because in the South African public healthcare sector, S0-S4 medicines tend to be used for conditions with a great burden of disease and these are therefore mostly high-volume products.

Other supply chain strategy options that were recommended for this group of medicines, were those that are oriented towards responsiveness (agile) meaning that in such instances a leagile (lean + agile) approach was preferred. Using supply chain strategies with a leagile approach can help in lowering the cost of supply to the supply chain; providing high relevance of resource utilization to the total

cost; and enhancing end-to-end efficiency thus enhancing availability and access to medicines and impacting supply chain efficiency positively.

In all routes where the demand was stable, supply chain strategies with supply to forecast/need decoupling points were recommended. When demand was volatile, supply to stock/forecast decoupling points were recommended. A major motivation for considering supply chain strategies oriented towards efficiency (lean), was the opportunity to minimize wastes and consequently cost. Supply chain strategies with supply to need or supply to forecast decoupling points are mostly used in instances where lifecycle is temporal.

4.4.1.2. Medicine schedules bundle: S5-S8

The appropriate supply chain strategies selected in most instances/pipelines for the S5-S8 medicine bundles are oriented towards responsiveness (agile). In some instances, a mixture of supply chain strategies oriented towards both efficiency and responsiveness were recommended. This is because of the need to curb market mediation costs and be responsive in times of outbreaks, uncertainties in demand and uncertainties in customers' needs by pooling capacity, since S5-S8 pharmaceuticals are mostly not high-volume products.

The custom-configured and flexible strategies were frequently recommended in instances/pipelines where demand was volatile. This was due to the need to incorporate customization in the supply design and develop collaborative relationships with stakeholders affiliated to the South African public healthcare pharmaceutical supply chain based on 'availability to need' at any moment. Therefore, the supply to forecast; supply to need; and design supply to need decoupling points have been recommended. However, in instances where the demand is stable and the cost is expensive, the supply chain strategies selected are largely oriented towards both efficiency and responsiveness, pursuing a leagile approach. This helps in capitalizing on strengths from both approaches of efficiency and responsiveness to lower the cost of supply to the supply chain; provide high relevance of resource utilization to the total cost; and enhance end-to-end efficiency as established in the preceding discussion.

Having described the patterns that are evident within the product categorization framework, an in-depth view of the categorization framework itself is given in the following section, more specifically to show the decision-making approach/philosophy in selecting the appropriate supply chain strategy per supply route.

4.5. Demonstration of the decision-making philosophy

From each medicine schedules bundle, two routes will be chosen as examples. The first route chosen as an example from each schedules bundle is a product with: volatile demand; expensive cost; short lead time; and temporal life cycle. The second route chosen as an example from each schedules bundle is a product with: stable demand; affordable cost; long lead time; and lasting life cycle. These are the first and the last routes for each medicine schedules bundle in Table 4.3. The decision-making approach/philosophy taken in recommending the supply chain strategies for each example route is provided in the paragraphs that follow.

❖ **Route 1:**

Medicine schedules bundle S0-S4 includes mostly high-volume products, with ease of access and a maximum repeat limit of six months, as previously established in Section 3.4. If such pharmaceuticals have a volatile demand, then there is a need to supply to stock or supply to need or at least supply to forecast to buffer the demand in times of uncertainties. Furthermore, since the cost to the supply chain in Route 1 is expensive, then there is a need to orient the supply chain towards efficiency (lean) to cut out costs and wastes. However, since the lead time is short and the life cycle is temporal, it calls for agility in responding to need with rapid replenishment to curb the risk of obsolescence due to the shortness of the lifecycle. Hence, the advantages of orienting the supply chain towards responsiveness (agility) are also needed and are facilitated by cooperation with key partners to anticipate capacity requirements. It is deemed necessary to make minimum order sizes based on the end patients' replenishment needs in order to cut down on costs to the supply chain and short time from order to market/PHCFs. Therefore, Route 1 can benefit from being leagile (both lean and agile). Consequently, a fast or agile strategy with either supply to forecast or supply to need/stock decoupling points is recommended.

❖ **Route 16**

As a second example from the S0-S4 medicine schedules bundle, if such pharmaceuticals have a stable demand, then there is ease of forecasting and the products can be supplied to stock with replenishment according to a fixed cycle. This is made possible, as according to Route 16, the cost to the supply chain is affordable therefore the frequent delivery of small batches to increase inventory is feasible, with the minimum order size based on the patients' replenishment needs. Orienting the supply chain towards efficiency (lean) will be preferred in order to maximize the efficiency that can be attained as, with the stable demand, there is less need for orienting towards responsiveness. Since the lead time is long and the life cycle is lasting in Route 16, it is feasible to use a supply to stock or supply to forecast/need decoupling point, as provided by the continuous-flow, efficient and fast

strategy, because the risk of obsolescence is low, and demand is predictable. To mitigate the long lead time, it is necessary to develop strategic collaborative relationships with key partners to build synergies and supply rapidly. Therefore, a continuous-flow or efficient or fast strategy with either a supply to stock, a supply to forecast/need, or a supply to forecast decoupling point, is recommended for Route 16.

❖ **Route 17**

Under the medicine schedules bundle S5-S8, which is mostly low-volume products, access is extensively regulated, and dosage repeats can exceed six months, as established in Section 3.4. If the pharmaceuticals have volatile demand and the cost to the supply chain is expensive, supply chain strategies oriented towards responsiveness to mitigate the unpredictability in demand can be appropriately employed. Moreover, if the lifecycle is temporal and the lead time is short, there is a need for rapid replenishment when necessary, keeping in mind the risk of obsolescence due to the shortness of the lifecycle of such products. It is deemed necessary to make the minimum order size based on the end patients' replenishment needs in order to cut down on costs to the supply chain, hence some elements of orienting the supply chain towards efficiency are called for. Under such conditions, a leagile approach can be beneficial, capitalizing on both elements of efficiency (lean) and responsiveness (agile). If there is need to use personalized medicine, with the formulary customized based on the special needs of the patients or PHCFs, a configure to need decoupling point can be a useful mechanism to facilitate cooperation with key partners or PHCFs, by allowing aggregate demand to be anticipated at the product decoupling point. Therefore, a fast, a custom-configured, or an agile strategy with a supply to forecast, a configure to need, or a supply to need/stock decoupling point is recommended for Route 17.

❖ **Route 32**

As a second example from the S5-S8 medicine schedules bundle, if the demand is stable, cost is affordable to the supply chain and lead time is long, then it is best to opt for supply chain strategies that are oriented towards efficiency, since there is ease of forecasting and efficient strategies can go some way towards mitigating the long lead time. The order cycle can be oriented towards a fixed cycle or a collection schedule and it is recommended to make the resource utilization rate high or very high since the condition within Route 32 is that the cost to the supply chain is affordable and such an approach is therefore permissible. Moreover, since the lifecycle is lasting, it is feasible to make use of a high level of inventory to optimize supply efficiency. It is more beneficial to orient such a supply pipeline towards efficiency than towards responsiveness. A supply to stock or a supply

to forecast/need decoupling point is useful in such circumstances, corresponding to a continuous-flow or efficient strategy respectively.

As established in Table 4.4, in special cases, the provisions of the index will take precedence over what the above discussions provide, otherwise, if the special cases are not applicable then the preceding decision-making philosophy stands.

In the following section, the relevance of the product categorization framework within the South African public healthcare pharmaceutical supply chain is discussed.

4.6. The VAN-Pharmaceutical Product Categorization Framework in the South African public healthcare pharmaceutical supply chain

This section discusses how the product categorization framework could be integrated into the broader South African public healthcare pharmaceutical supply chain. The discussion is organized according to the five categories of design requirements.

4.6.1. Design restrictions [R]: Inputs

The two medicine schedules bundles (S0-S4 and S5-S8) found in the pharmaceutical product portfolio or Essential Medicine List (EML) or Master Procurement Catalogue (MPC) have been considered as inputs to the framework. As previously discussed, the S0-S4 medicine schedules bundle contains mostly high-volume products with better ease of access and a maximum repeat limit of six months while the S5-S8 medicine schedules bundle contains mostly low-volume products with access that is extensively regulated, and dosage repeats that can exceed six months. The entire pharmaceutical portfolio, including chronic medicine, prescription medicine, over-the-counter (OTC) medicine, epidemic medicine, and vaccine medicine is encompassed by these two categories. These products already exist in the South African public healthcare pharmaceutical supply chain and bundling them up according to the medicine schedules bundles, will aid in making these product bundles/categories less sensitive to slight changes in the pharmaceutical product portfolio. Such bundling ensures that categories do not have to be reconfigured each time there is a slight change in the pharmaceutical product portfolio. Hence, using the medicine schedules as the basis for bundling will potentially enhance the sustainability of the established categories regardless of the slight changes in the product portfolio that may occur over time.

4.6.2. Functional requirements [F]: Parameters

The establishment of the PDCL^2 product attributes taxonomy detailed in Section 3.3, which answer the functional requirements of the product categorization framework design, provide answers to questions raised in the research agenda set by Mapowo et al. (2018) for the incorporation of product categorization into the South African public healthcare pharmaceutical supply chain. The PDCL^2 product attributes taxonomy, a component of the product categorization framework is deemed applicable in the VAN supply chain, VAN service supply planning, and the South African public healthcare pharmaceutical supply chain. Though the taxonomy was specifically developed for the contemporary South African context, it is most likely also more widely applicable in other public healthcare pharmaceutical supply chain country settings. As established in Section 3.3.3, it is proposed that since the intention is to use the PDCL^2 product attributes taxonomy at national, provincial and facility tiers under the informed push model of the VAN strategy, each province should determine and define its own threshold between the binary gradations based on the measurable characteristics associated with each product attribute. These thresholds should be determined and defined within the boundaries provided by the national and provincial tiers as previously detailed in this study. Examples of such boundaries include the National Treasury allocations; the Affordable Medicines Directorate (AMD); essential medicines selection; the standard treatment guidelines (STGs) and essential medicines lists (EMLs) at the provincial level; NDoH public healthcare pharmaceutical supply chain regulations, ethics and code of conduct; the health tenders and contracts; and finally, the licensed individuals and facilities involved in the pharmaceutical products delivery. This means that, in the use of the product categorization framework, each province is responsible for quantifying, for example, what constitutes a long lead time or what constitutes a high cost using recommendations such as those given in Section 3.3.3, based on the province's specific circumstances i.e. provincial healthcare budgets, marketplace, ease of doing business, etc.

4.6.3. User requirements [U]: Outputs

The supply chain strategies taxonomy established in Sections 3.5, 3.6, and 3.7 together with the elements of each strategy which have been contextualized to the contemporary South African context, are useful as outputs of the product categorization framework. The product categorization framework with its set of supply chain strategies together with their decoupling points as defined in Table 3.8, will support supply planning decisions at different operational levels e.g. the national and provincial levels, by recommending an appropriate supply chain strategy for each pharmaceutical product. These supply chain strategies, contextualized to the VAN strategy, will be used to drive the sourcing/supply plan (i.e. supplier **orders** required) and a replenishment plan (i.e. stock **transfers** required) for each

pharmaceutical product, as previously mentioned in the study. These strategies have been established in the study as: continuous-flow supply chain strategy; efficient supply chain strategy; fast supply chain strategy; custom-configured supply chain strategy; agile supply chain strategy; and flexible supply chain strategy.

The VAN supply chain managers, under the informed push model, will use (one of) the supply chain strategies and decoupling points recommended by the product categorization framework and make use of the decision-making approach in special cases e.g. vaccine supply or delivery site restrictions and limited storage capacity as given in Table 4.4. However, in as much as the established product categorization framework for supply planning seeks to satisfy a demand plan, the recommended supply chain strategies and decoupling points in the framework can be useful as inputs to a distribution plan and are thus recommended as a future study.

4.6.4. Boundary conditions [B]: Controls

The boundary conditions within the product categorization framework define and determine the controls of operation for the framework based on the levers of the VAN design, supplier collaboration constraints, and the NDoH public healthcare pharmaceutical supply chain regulations, ethics and code of conduct. These boundary conditions, as discussed in Section 2.4, provide an enabling environment for the public healthcare pharmaceutical supply chain's operational functions, namely: product selection; quantification and procurement; inventory and distribution; and product use. The South African NDoH can make use of the product categorization framework in conjunction with the sector-wide Procurement Division which was established in Section 2.4 to be responsible: for the essential medicines selection; the standard treatment guidelines (STGs) and essential medicines lists (EMLs) development for each health system level; the administration of health tenders and contracts; and finally, the licensing of the individuals and facilities involved in the pharmaceutical products delivery (Perumal-Pillay & Suleman, 2017). The product categorization framework will work within the South African public healthcare pharmaceutical supply chain governed by a legal framework consisting of policies, legislations, guidelines and SOPs, as previously discussed in this study, defined by The National Department of Health (1996) in the South African national drug policy to consist of: (i) medicine selection; (ii) traditional medicines; (iii) medicine pricing; (iv) procurement and distribution; (v) rational use of medicines; (vi) human resource management; (vii) research and development; (viii) technical cooperation; (ix) monitoring and evaluation; and (x) regulations and legislations.

4.6.5. Attention points [A]: Enablers

As discussed in Sections 2.4 and 2.5, the South African pharmaceutical distribution network involves the central medicine stores, regional depots, hospital facilities and PHCFs (Berger et al., 2010; Zuma, 2016). The supply chain strategies and decoupling points in the product categorization framework have been recommended cognizant of the two main methods of distribution, i.e. the depot system and direct delivery approach, which have been discussed in Sections 2.4 and 2.5. Use of third-party logistics (3PL) services between the regional/district depots and PHCFs by some provinces enable the distribution of pharmaceuticals under the depot system. Other provinces use contractors based on weight consignment so that deliveries cannot take place until the accumulation of stock reaches a certain threshold for dispatch (Berger et al., 2010). As previously mentioned in the study, a minority of the provinces employ a direct delivery system where medicines are directly distributed from the supplier/depots to the PHCFs, whereas with the rest of the provinces, stock flows through all the levels downstream (Zuma, 2016). As previously alluded to, the distribution of medicine downstream through all the levels, i.e. from provincial depot to district depot to hospital facilities to PHCFs, can affect the lead-times to deliver pharmaceuticals which consequently may shorten medicine lifecycle (shelf life and life time). Thus, in developing a distribution plan (which is outside the scope of this study), it is recommended to take cognizance of the supply chain strategy decoupling point in use (i.e. supply to forecast; supply to stock; supply to need; configurable to need; or design supply to need).

4.7. Conclusion

The design requirements derived and defined in Section 1.5 in line with the approach recommended by van Aken et al. (2007), have been researched and synthesized in this study using a mixed-methods approach to develop a product categorization framework, thereby addressing Objective 3 of this study. At the start of the chapter, framework design requirements were consolidated followed by a presentation of the schematic tree that underpins the framework. The basis for product categorization was then established—i.e. determining which product attributes should be matched to which supply chain strategies and decoupling points—thus formulating different supply pipelines for different products. Patterns that are evident in the product categorization framework were discussed and a demonstration of the decision-making philosophy that underpinned the establishment of these routes was detailed. Furthermore, the implication of categorization was discussed – i.e. what aspects of the South African public healthcare pharmaceutical supply chain would be implicated based on the product categorization framework.

As discussed, the framework presented in this chapter already incorporates the updates that were made in response to the feedback received during the validation process. The validation process is detailed in the following chapter.

Chapter 5

Validation of the VAN-Pharmaceutical Product Categorization Framework

5.1. Introduction

The preliminary product categorization framework was developed based on five categories of framework design requirements, utilizing the systems engineering input-output transformation process illustrated in Figure 1.2 and in more detail in Figure 4.1. The framework made use of the product attributes (determined to be the PDCL^2 product attributes taxonomy) critical in matching pharmaceutical product categories (initially based on their medicine schedules bundles: S0-S4; and S5-S8) with appropriate supply chain strategies (determined to be the supply chain strategies taxonomy adapted from Perez (2013)) in the South African public healthcare pharmaceutical supply chain particularly VAN strategy supply planning. The aim of this chapter is to verify and validate the product categorization framework consistent with Objective 4 of this study:

Research objective 4: To verify and validate the framework using subject matter experts (SMEs) validation interviews and a case study application. The sub-objectives associated with research objective 4 are:

a) Validation interviews and iterative improvement of the framework—from preliminary to final product categorization framework—based on subject matter expert (SME) feedback; and

b) To validate the final framework using a case study application and establish recommendations for future research.

In summary, the validation of this research was done in two parts:

1. *Framework validation through SME input analysis:* Aiming to validate the design requirements employed in the framework development and the overarching construct of the product categorization framework.
2. *Framework validation through case study application:* Aiming to test the operability and applicability of the principles of the product categorization framework.

A detailed discussion of the validation strategy employed in this research was presented in Section 1.6. Both components of the validation contribute to ensuring a strengthened construct validity and internal validity of the product categorization framework. This is achieved by validating the integrity of the research output (the framework), specifically whether the design requirements that were used as the basis for the framework development are accurate, whether the framework is useful in addressing the investigated concept, and whether the recommendations that are provided by the framework are appropriate.

5.2. **Validation through SME input analysis**

Mouton (2001) states that engagement with SMEs can be done using four different approaches, namely: (i) free attitude interviews; (ii) telephonic interviews; (iii) semi-structured interviews; and/or (iv) structured questionnaires. As established in Section 1.6, this study will employ interviews with SMEs—using semi-structured interviews and Likert scale rankings—in the form of an electronic questionnaire. Participants were prompted to answer a series of predetermined questions to allow for the analysis and interpretation of the collected evidence in a standard. According to Bryman and Bell (2014), the concept of e-research or online interviews can be used for both semi-structured interviews and self-completion questionnaires. Thus, semi-structured interviews and Likert scale rankings were employed in engaging the SMEs.

A validation framework document which summarized the findings from this study served as a pre-read material for the SMEs to familiarize with the study prior to the validation session. The pre-read document that was sent to the SMEs is included in Appendix D.

The session required the SMEs to first familiarize themselves with the validation document pre-read document (detailed in Appendix D) to understand the overview of the study. Afterward, the participants were then required to complete a semi-structured interview sent out in the format of a Google form. In the semi-structured interview, participants were required to validate the framework design requirements and/or recommend improvements to the preliminary product categorization framework in the context of the VAN and the South African public healthcare pharmaceutical supply chain. After the completion of the validation session, the suggested improvements were incorporated into the preliminary product categorization framework to develop the final product categorization framework, presented in Chapter 4, which was then used in the case study workshop. The interviewees who participated in the SME input analysis were from diverse areas of expertise, as is detailed in the next section.

5.2.1. SME's background—the interviewees

According to Creswell (2014), qualitative participants are identified from purposeful sampling as opposed to random sampling, as these individuals are purposefully selected based on merit. The merit includes the participant's expertise and knowledge applicable to the research topic which enables the participant to best assist the researcher concerning the research problem.

In order to holistically examine the research problem and to gain insightful feedback from the process, six experts in public healthcare and/or supply chain management and/or the VAN strategy were identified as SMEs. A summary of the SME's background is given in Table 5.1.

Table 5.1: Interviewee background summary for SME input analysis

Sector	Participant (P)	Background/Occupation	Reason for inclusion
Public healthcare (pharmaceuticals), VAN strategy and supply chain management	P1	An Industrial Engineer, Ph.D. candidate and a researcher in maturity models for demand-driven supply chain management in the public healthcare sector.	Knowledge in public healthcare supply chain maturity models is useful in determining and validating the framework on which product attributes are relevant in a public healthcare pharmaceutical supply chain.
Supply chain management and public healthcare (pharmaceuticals)	P2	Experienced in extensive end-to-end supply chain and business excellence knowledge with hand-on experience through 30 years of international corporate exposure (Ricoh, Lego, Janssen Pharmaceuticals, Johnson and Johnson). Held international Global Executive positions across the pillars of Plan, Make, Source, Deliver including Director of Global Demand Management and Sales & Operations Planning Centre of Excellence. Has the Board of Director level experience and member of the SAPICS supply chain management professional body.	Hands-on experience in leading process and technology improvement initiatives, as well as extensive and end-to-end supply chain and business excellence knowledge, is vital in validating the design requirements employed in the framework development and the overarching construct of the product categorization framework.
Public healthcare (pharmaceuticals) and supply chain management	P3	A researcher with experience in ICT systems operation and projects particularly in the healthcare environment. Formerly served as an IT manager for the Health Commodity Tracking System (HCTS) supply chain management systems in Ethiopia. Extensive exposure to the pharmaceutical logistic information tracking system in supply chain management projects undertaken to improve the effectiveness and efficiency of pharmaceutical commodities management.	Experience and knowledge in pharmaceutical commodities management are relevant to the concept of product categorization. Exposure to projects that focus on improving the effectiveness and efficiency of pharmaceutical products management for the public healthcare pharmaceutical supply chain is also relevant.
Public healthcare; Supply chain management; and VAN strategy	P4	An industrial engineer, Ph.D. candidate and a researcher in policy analysis for the VAN reference framework implementation in the South African public healthcare supply chain.	Knowledge about the VAN and policy analysis of the public healthcare supply chain is essential in validating the design requirements (particularly the 'boundary conditions' which underpin the levers of the VAN design; supplier collaboration

Sector	Participant (P)	Background/Occupation	Reason for inclusion
			constraints; and the NDoH public healthcare pharmaceutical supply chain regulations, ethics and code of conduct) employed in the framework development.
Public healthcare (pharmaceuticals) and supply chain management	P5	A pharmacist with experience as a Dispensary Manager; Drug Distributor; Public health consultant and Chief of Party - USAID Global Health Supply Chain Program-Technical Assistance. Has worked with the Public and Private Sector pharmaceutical distribution for 25 years. Currently working in the South African NDoH.	Knowledge about pharmaceuticals distribution is invaluable in the product categorization framework validation. This gives an in-depth input to the operational functions of the public healthcare supply chain, particularly medicine selection.
Public healthcare (pharmaceuticals) and supply chain management	P6	A Professional Industrial Engineer with extensive experience (more than 20 years) in Supply Chain Management and Planning in South and Southern Africa (South Africa, Lesotho, Swaziland, Namibia, Botswana, Zambia, and Mozambique). Possesses skills in process modelling, business process re-engineering, capital investment optimization, value engineering, project management, the theory of constraints, world class manufacturing and Six Sigma. Currently working as a supply chain consultant in the South African NDoH.	Knowledge about the pharmaceutical supply chain management, particularly in the South African NDoH, process modelling, project management and understanding of the theory of constraints are highly relevant to the product categorization framework validation.

5.2.2. Semi-structured interview questions

The semi-structured interview questioned the interviewees on the design requirements, presented in Section 4.2, that were employed in the framework development and consequently the overarching construct of the product categorization framework itself. In most questions, the 5-point Likert scale was used to measure responses as this provided a greater degree of nuance than a simple ‘yes/no’.

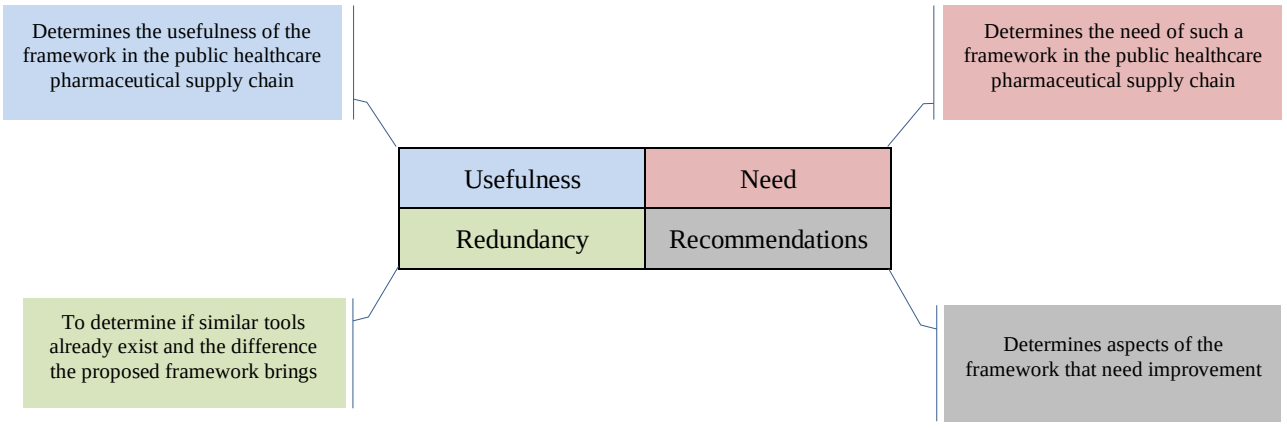

Figure 5.1: Aspects considered in semi-structured interview questionnaire formulation (adapted from Creswell (2014); Mouton (2001))

Furthermore, this gave granular feedback through a wide range of ranked answer options. The Likert scale ranged from ‘strongly agree’ to ‘strongly disagree’. If the interviewee ‘disagreed’ to a question, an open-ended question which requested the interviewee to provide an explanation for the answer was given as a follow-up question. The criteria incorporated in developing the validation questions and the key aspects of the semi-structured interview is given in Figure 5.1.

A summary of the validation questions is given in Table 5.2, the full questionnaire is provided in Appendix E.

Table 5.2: SME input analysis questions

Aspect	No.	Question
Functional requirements [F]: Parameters	1	Do you think the established PDCL^2 product attributes taxonomy is a clear mechanism for categorizing pharmaceutical products according to their attributes?
	2	Do you think the product attributes can be practically used to categorize pharmaceuticals effectively and efficiently?
	3	Do you think the recommended approach for defining thresholds between the binary gradations for provinces in the South African public healthcare is reasonable?
User requirements [U]: Outputs	4	Do you think the supply chain strategies employed, based on Perez (2013), i.e.: continuous-flow; efficient; fast; custom-configured; agile; and flexible supply chain strategies, are appropriate?
	5	Do you think these supply chain strategies coupled with their respective decoupling points can be used effectively in a VAN-enabled public healthcare supply chain?
	6	Do you think the interpolated meanings ascribed from the generic decoupling points are reasonable for an informed push model and public healthcare service supply planning?
	7	Can the recommended supply chain strategies for each pharmaceutical product support supply planning decisions at different operational levels e.g. the national and provincial levels?
Design restrictions [R]: Inputs	8	Do you think the bundling up of pharmaceutical products based on their schedules, the first bundle being S0-S4 and the second being S5-S8, is reasonable?
	9	Do you think the use of these two medicine schedules bundles to describe the two gradations of the 'product' attribute in the PDCL^2 product attributes taxonomy is reasonable?
Boundary conditions [B]: Controls	10	Do you agree with the boundary conditions which define the product categorization framework design’s preferred solution space?
Attention points [A]: Enablers	11	Do you agree with the acknowledging of the direct delivery and depot system attention points?
The product categorization framework	12	Do you think the logic that governs the schematic tree which underpins the product categorization framework is appropriate?
	13	Do you think 'the product categorization framework special cases index' is useful in aiding framework decision-making under stated special cases?
	14	Do you think the decision-making philosophy employed in the product categorization framework is reasonable?
	15	Do you think the incorporation of the product categorization framework in the context of the VAN strategy for the South African public healthcare pharmaceutical supply chain is beneficial?
	16	To what extent do you agree that the product categorization framework can be used to categorize pharmaceuticals to enhance sustainable availability of medicines in a public healthcare pharmaceutical supply chain?
	17	Are there any comments/additions/subtractions to the construct of the framework that you would like to make?

5.2.3. SME semi-structured interview feedback

A summary of the responses is given in Figure 5.2. As discussed, interviewees were also afforded the opportunity to provide more detailed feedback via open questions. The responses received to the open questions are summarized in Table 5.3. As is evident from Figure 5.2, interviewees mostly selected 'agree' or 'strongly agree' as feedback, broadly indicating positive feedback. Notable exceptions are Questions 7, 8 and 9 where one interviewee selected 'disagree' as feedback, furthermore, in the case of Question 9, a further three interviewees selected 'neutral' as feedback. These three questions are therefore selected for more in-depth discussion.

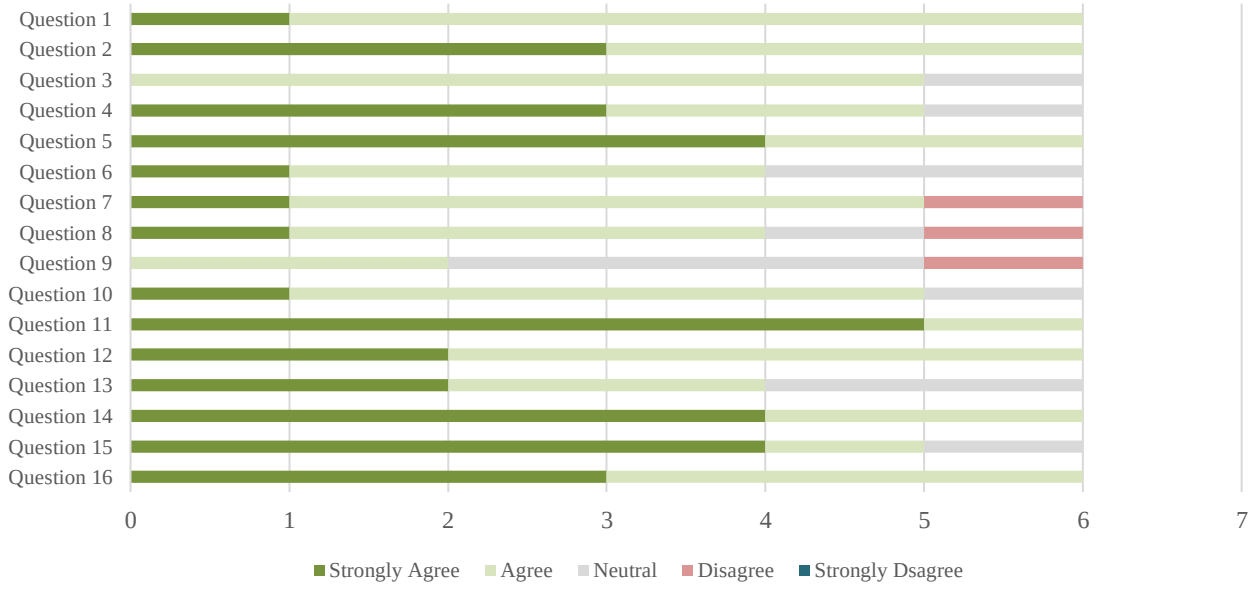

Figure 5.2: SME feedback to the Likert scale semi-structured interview questionnaire

In Question 7, interviewees were asked to indicate whether the recommended supply chain strategies for each pharmaceutical product could support supply planning decisions at different operational levels (e.g. the national and provincial levels). All participants either agreed or strongly agreed that it could, however, one participant disagreed specifically with the involvement of the national tier, stating that "*Most of this will be for provincial level. National will only use this for strategic stock buffering and for national phase in and out type of discussions".* This feedback highlights the need to provide the framework for both national and provincial tiers, though much emphasis will be on the provincial tier as established throughout this study.

In Question 8 interviewees were asked whether they thought the bundling up of pharmaceutical products based on their schedules, the first bundle being S0-S4 and the second being S5-S8, is reasonable. Though four participants either agreed or strongly agreed, one was neutral and one disagreed. The participant that disagreed stated that the S7-S8 medicines are not extensively used in

the South African public healthcare. This input is appreciated, however, since the intention of this study is to develop a framework that can not only accommodate pharmaceuticals that are commonly used in the public healthcare sector, but also those that are less commonly used, the S7-S8 medicine schedules were maintained in the framework for those few cases where these might be applicable. It is argued that this is in line with a holistic and sustainable approach to developing the framework.

In Question 9 interviewees were asked whether they thought the use of these two medicine schedules bundles to describe the two gradations of the 'product' attribute in the PDCL^2 product attributes taxonomy is reasonable. Two participants agreed, three indicated a neutral response and one disagreed, giving identical reasoning to that provided for Question 8. For similar reasons to those set out in the previous paragraph, the S7-S8 medicine schedules were maintained in the framework.

The feedback received in response to Questions 7, 8, and 9 were discussed here as examples. The complete feedback that was received, as well as responses to this feedback, is provided in Table 5.3.

Table 5.3: SME feedback to semi-structured interview questionnaire

Aspect	No.	Feedback and updates necessary to the study
Functional requirements [F]: Parameters	1	All the participants agreed (1 strongly agreed and 5 agreed) that the established PDCL^2 product attributes taxonomy is a clear mechanism for categorizing pharmaceutical products according to their attributes. In agreement, participant P5 emphasized the need *"to account for physical attributes of the product i.e. cold chain, weight and volume"* which was an aspect addressed in Section 4.4 particularly the special cases index in Table 4.4 and the decision making philosophy in Section 4.5.
	2	All the participants agreed (3 strongly agreed and 3 agreed) that the product attributes can be practically used to categorize pharmaceuticals effectively and efficiently.
	3	Five participants (5 agreed) thought that the recommended approach for defining thresholds between the binary gradations for provinces in the South African public healthcare is reasonable. One participant's response (P4) was neutral. However, since the bulk (5/6) of the participants agreed, the recommended approach for defining thresholds between the gradations is deemed reasonable for the provinces.
User requirements [U]: Outputs	4	Five of the participants agreed (3 strongly agreed and 2 agreed) that the supply chain strategies employed, based on Perez (2013), i.e.: continuous-flow; efficient; fast; custom-configured; agile; and flexible supply chain strategies, are appropriate. One participant's response was neutral.
	5	All the participants agreed (4 strongly agreed and 2 agreed) that the employed supply chain strategies coupled with their respective decoupling points can be used effectively in a VAN-enabled public healthcare supply chain.
	6	Four participants (1 strongly agreed and 3 agreed) thought that the interpolated meanings ascribed from the generic decoupling points are reasonable for an informed push model and public healthcare service supply planning? Two participants' responses were neutral. However, in agreement, P5 suggested that *"the healthcare facilities need categorization too based on location, size and storage capacity. Although location will be accounted for in lead time".* This has been determined to be part of future research to develop a facility categorization criterion to work in conjunction with the product categorization framework. Moreover, this health facilities categorization can be invaluable under a distribution plan (which is outside this study's scope) to which the output of this study is an input.

Aspect	No.	Feedback and updates necessary to the study
	7	Five of the participants agreed (1 strongly agreed and 4 agreed) that the recommended supply chain strategies for each pharmaceutical product can support supply planning decisions at different operational levels e.g. the national and provincial levels. However, 1 disagreed with the involvement of the national tier, stating that "*Most of this will be for provincial level. National will only use this for strategic stock buffering and for national phase in and out type of discussions".* This highlights the need to provide the framework for both national and provincial tiers, though much emphasis will be on the provincial tier as established throughout this study.
Design restrictions [R]: Inputs	8	Four participants (1 strongly agreed and 3 agreed) thought that the bundling up of pharmaceutical products based on their schedules, the first bundle being S0-S4 and the second being S5-S8, is reasonable. One participant's response (P4) was neutral. However, one participant (P5) disagreed stating that the S7-S8 medicines are not extensively used in the South African public healthcare. This input is appreciated, however, since the intention of this study is to develop a framework that can not only accommodate pharmaceuticals that are commonly used in the public healthcare sector, but also those that are less commonly used, the S7-S8 medicine schedules were maintained in the framework for those few cases where these might be applicable. It is argued that this is in line with a holistic and sustainable approach to developing the framework.
	9	Two participants (2 agreed) thought that the use of these two medicine schedules bundles to describe the two gradations of the 'product' attribute in the PDCL^2 product attributes taxonomy is reasonable. Three participants' responses were neutral. One participant disagreed and the explanation (as well as the reason for maintaining the initial position) is as given for question 8.
Boundary conditions [B]: Controls	10	Five participants (1 strongly agreed and 4 agreed) agreed with the boundary conditions which define the product categorization framework design's preferred solution space. One participant's response was neutral.
Attention points [A]: Enablers	11	All the participants agreed (5 strongly agreed and 1 agreed) with the acknowledging of the direct delivery and depot system attention points. In agreement, P1 stated that *"Global discussion are to move towards direct delivery provided that capacity is increased at facility level else the depot system will effectively act as a buffer".* This reaffirmed the need to consider both the direct delivery and the depot system within the product categorization framework.
The product categorization framework	12	All the participants agreed (2 strongly agreed and 4 agreed) with the logic that governs the schematic tree which underpins the product categorization framework to be appropriate. In agreement, P2 added that *"The schematic tree may have to differ according to the situation of the market where for example cost might end up being the last decision if there is an epidemic."* This was incorporated into Sections 4.3 and 4.5.
	13	Four participants (2 strongly agreed and 2 agreed) agreed that 'the product categorization framework special cases index' is useful in aiding framework decision-making under the stated special cases. Two other participants' responses were neutral. In agreement, P2 emphasized that there is need for "availability of distribution resources at a time of urgency, especially cold chain - keeping quality and compliance in mind" when using the special cases index. P5 added that *"No one size fits all and there will be special cases. Strategic supply must be considered based on the therapeutic use of the product i.e. for ARVs if a patient miss treatment they may become resistant and there need to use more expensive medicines to treat their condition".* This reaffirmed the importance of the Product Categorization special cases index. P6 added that it can *"probably become more useful and familiar when one starts using and interacting with it more often".*
	14	All the participants agreed (4 strongly agreed and 2 agreed) that the decision-making philosophy employed in the product categorization framework is reasonable.
	15	Five participants (4 strongly agreed and 1 agreed) agreed that the incorporation of the product categorization framework in the context of the VAN strategy for the South African public

Aspect	No.	Feedback and updates necessary to the study
		healthcare pharmaceutical supply chain is beneficial. One other participant's response was neutral.
	16	All the participants agreed (3 strongly agreed and 3 agreed) when asked to what extent they agreed that the product categorization framework can be used to categorize pharmaceuticals to enhance sustainable availability of medicines in a public healthcare pharmaceutical supply chain. In agreement, P6 mentioned that *"I think it could work and is worth a try. Might have to try and simplify it further to ensure consistent application".*
	17	This was set as an open-ended question which required participants to provide any comments/additions/subtractions to the construct of the framework: **P1:** No additional comment. **P2:** *"The patient should always be top of mind, therefore my comment with regards to the decision framework and cost. These are special cases and should be handled with speed. How will this be measured and what KPI's will be used to ensure that there is speed to market for the patients within the VAN framework?"* This emphasizes the use of the informed push model as provided within the VAN strategy. It also emphasizes the main goal of this study which is sustainable availability and access to medicines for the patients cost-effectively. However, measurement of KPIs used to ensure that there is speed to market for the patients within the VAN strategy, though outside this study's scope, can be acknowledged as future study. **P3:** "*The logic behind the framework is strong and it is a good contribution to the supply chain of pharmaceutical products. I recommend, the classification of pharmaceutical products to be consulted with pharmacists who have deeper knowledge about the commodities. Furthermore, laboratory supplies are usually integrated with pharmaceutical supply chain especially in the HIV/AIDS programs due to dependencies between the two commodities and to minimize supply chain costs. Hence it can be a recommendation for future research studies"* This highlights that in as much as this study focused on supply of 'drugs' and not 'devices' as established in Section 1.3, it is necessary to have future study on how the supply of drugs and devices can be merged to minimize costs. This can be done in consultation with pharmacists since they possess deeper knowledge of both drugs and devices and how they can be merged. P4: No additional comment. P5: "*I have added some in the comments above. Please feel free to reach out to me if you require clarification on any of these comments."* Additions and questions were added within the questionnaire. P6: *"Very good - well done".*

5.2.4. SME input analysis conclusion

Overall, the results of the semi-structured interviews with SMEs indicate that the participants were content with the proposed product categorization framework. There was consensus on the idea that the product categorization framework can be used to categorize pharmaceuticals to enhance sustainable availability of medicines in a public healthcare pharmaceutical supply chain. In particular, the incorporation of the product categorization framework in the context of the VAN strategy proved to be beneficial to the South African public healthcare pharmaceutical supply chain.

The strong degree of positive feedback indicates that the design requirements employed in the framework development and the overarching construct of the product categorization framework are valid.

5.3. Validation through case study application

Mouton (2001) states that a case study provides a detailed examination of an already existing case with the aim of providing descriptive, explanatory and exploratory findings. Four types of case study design methods are posited by Yin (2013), namely: single-case; multiple-case; holistic; and embedded case designs based on a 2 x 2 matrix. The holistic single-case design approach is chosen for this study. This is because the case for this study is underpinned by a combination of 'critical' (the VAN strategy and the product categorization framework designs) and 'unusual' (applicability and operability of the VAN strategy and the product categorization framework) rationales.

The case study was conducted in a workshop format held at the head office of the NDoH in Pretoria. Preparation for the workshop included selecting three pharmaceuticals and four healthcare facilities (demand sites) to use as cases and preparing a fact sheet with data on these pharmaceuticals and facilities. In line with the holistic single-case design employed in this study, the validation pre-read document (detailed in Appendix D) was sent to participants ahead of the workshop.

The workshop session started with a brief overview presentation of how the product categorization framework functions in matching product categories, based on their critical product attributes, with appropriate supply chain strategies in the South African public healthcare supply chain, particularly in the context of VAN supply planning. Next, the product categorization framework was applied to the three pharmaceuticals that had been selected for the case study to test the operability and applicability of the principles of the framework. The workshop participants contributed towards analyzing and identifying the potential impact of the final product categorization framework in enhancing sustainable availability of medicines in the South African public healthcare pharmaceutical supply chains. The participants were then requested to score the framework against various dimensions.

5.3.1. Case study participants' background

As in the validation through SME input analysis, qualitative participants in the holistic single-case design were identified via purposeful sampling, based on merit. The main focus for the case study application is to test the applicability and operability of the product categorization framework in the South African public healthcare pharmaceutical supply chain. Therefore, participants with extensive experience in SCM in the South African public healthcare sector were identified to best assist the researcher concerning the case study application. A summary of the case study participants' background is given in Table 5.4, as is indicated, both fulfill senior roles in the NDoH. An acknowledged limitation is the small number of workshop participants. The main reason for having

such a small number of participants is that there are a limited number of individuals in the South African public healthcare sector that possess the level of expertise that was sought for the purpose of the case study validation. A third participant was scheduled to participate but had to withdraw at short notice due to unforeseen personal circumstances.

Table 5.4: Case study participants' background

Sector	Participant (P)	Background/Occupation	Reason for inclusion
Public healthcare (pharmaceuticals) and supply chain management	P1	A pharmacist working with the South African NDoH. Possesses experience as a dispensary manager, public health consultant, and USAID Global Health Supply Chain Program technical assistant. Has worked within the pharmaceutical distribution of the public and private sector for 25 years.	Knowledge in pharmaceutical dispensing and distribution is invaluable in giving an in-depth input to the product categorization framework, specifically related to medicine selection and operational functions in general.
Public healthcare (pharmaceuticals) and supply chain management	P2	An Industrial Engineer with 20 years' experience with SABMiller in planning, manufacturing, capital optimization, and supply chain. Possesses experience in public healthcare pharmaceutical supply chain optimization for the South African NDoH focusing on demand and supply planning.	Knowledge in public healthcare pharmaceutical SCM, particularly in the South African NDoH, is vital for the product categorization framework case study application.

5.3.2. Case study application and evaluation feedback

The case study followed the overarching process flow of the product categorization framework as given in Figure 4.3. The fact sheets, containing information on each of the PDCL^2 product attributes for the three pharmaceuticals (detailed in Appendix F) were used as input to enable participants to determine the thresholds for gradations in terms of each of the PDCL^2 attributes (e.g. stable vs volatile demand, expensive vs affordable cost). The information provided in Section 3.3.3 of this main document was summarised in tabular format (Table 2.1 of the pre-read document) to provide guidelines to the workshop participants on determining the threshold for each of the product attributes. Next, attributes of the four healthcare facilities (i.e. the demand sites, detailed in Appendix F) were used as inputs to determine whether any of the adjustments recommended in the special cases index (Table 4.4) had to be applied to the recommended strategy and decoupling point for each of the three pharmaceuticals.

5.3.2.1. Gradation of pharmaceuticals according to product attributes

Three medicines were selected for the purpose of the case study, namely: i) Dolutegravir 50mg x 30 tablets; ii) Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity); and iii) Alprostadil, 0.5mg/ml, 1ml injection. One of these medicines is a chronic (ARV) medicine, the second is a vaccine (seasonal) medicine, and the third is a specialized psychotic medicine; thus, the three pharmaceuticals have distinct behaviour in the public healthcare pharmaceutical supply chain and are therefore deemed an appropriate choice to demonstrate the operability of the framework. The data set used in in the case study application had limitations emanating from the unavailability of raw data in the South African public healthcare, though unavailability of data is not uncommon in medical data. Thus, a fact sheet was developed to inform the data for the use of the PDCL^2 product attributes taxonomy within the case study application for data such as cost to the supply chain data; lifecycle data; lead time data, etc. Such data was not readily available and could not be used at the time of the case study application hence, hypothetical description/data of the product attributes was established (informed by the public healthcare Master Procurement Catalogue (MPC)). A summary of the descriptions of the stated pharmaceutical drugs, which gives an overview of how the participants managed to distinguish between the PDCL^2 product attributes gradations, is given below and is fully described in Appendix F.

- **‘Product’ attribute**

Information from the MPC was used to determine whether each of the three pharmaceuticals were part of the EML, and to which therapeutic category and form of administration (injection, tablets, solution, granules, etc.) each pharmaceutical belonged. It was then determined which medicine schedule each pharmaceutical fall under. Thus, each of the three pharmaceuticals was classified as belonging to either the S0-S4 or the S5-S8 medicine schedules, thereby completing the gradation in terms of the ‘product’ attribute.

- **‘Demand’ attribute**

A decision was taken to use demand data from a 6-month period and, for each pharmaceutical, the monthly demand volume (units) was established together with the associated percentage monthly change in volume. From such data, the volatility which entails the variation in product demand over a period could be determined using either the standard deviation or the variance, these two statistics were calculated using Microsoft Excel. Participants used their discretion to determine what constitutes stable demand in contrast to volatile demand based on the magnitude of the standard deviation or variance for each of the three pharmaceuticals. Participants emphasized the need to consider high volume in contrast to low volume products as well as the physical attributes of the

products e.g. drip liquid which comes in high volumes and is bulky. Participants also highlighted that a 6-month period is a short timeframe when considering seasonal products and, in such cases, longer periods e.g. 24 months are preferable.

❖ **'Cost to the supply chain' attribute**

The MPC was used to determine the following information for each of the three pharmaceuticals: the price/unit; the minimum order quantity (MOQ); the holding cost/unit at a facility; the obsolescence cost/unit; and the distribution cost/unit. The cost/MOQ in the fact sheet was compared to the expected performance benchmarked to the best practices of ISO 13485:2016[9] as an example. Participants used this data to grade each of the three pharmaceuticals as having either an affordable or an expensive cost to the supply chain. However, participants highlighted that it could be more appropriate for the various provinces to use the absolute cost/product contrary to benchmarking it against a standard or cost/MOQ.

❖ **'Lead time to deliver' attribute**

Information on the lead times to deliver for each product, based on tenders, contracts and distribution plans, was extracted from the MPC. In the case study application, the lead time of each of the three pharmaceutical products was benchmarked against the median lead time of the rest of the products in the MPC. The median lead time of all of the products in the MPC is 14 days, whilst the lead times of the three pharmaceutical products under consideration are 21, 10, and 7 days, therefore the three products that were selected for the case study represent a range of lead times. Based on this data, participants graded each of the three products as having either a short or long lead time.

❖ **'Lifecycle' attribute**

For each of the three pharmaceuticals, data on both the lifetime (thus the time from the manufacture date to the expiry of the product) as well as whether the product needs to be stored at a specific temperature were included in the factsheet. Two of the pharmaceuticals do not require temperature-controlled storage and have lifetimes of 12 and 24 months respectively, while the third has a shelf life of 12 months at 2 - 8°C. Based on this data, participants distinguished between lasting and

[9] ISO 13485:2016 defines the quality management standards that an organization must adhere to for it to demonstrate its ability to supply medical devices and related services that consistently meet customer requirements and other applicable regulatory requirements. Organizations can be involved in different lifecycle stages e.g. design and development, production, storage and distribution, or installation of a medical device and provision of associated activities, e.g. technical support.

temporal lifecycles. Participants emphasized that the majority of pharmaceuticals that are handled by the NDoH have a 24-month lifetime which can be classified as a lasting lifecycle.

The gradation of each of the three pharmaceuticals for each attribute is detailed in Table 5.5. There was no disagreement between the two workshop participants in terms of these gradations.

Table 5.5: PDCL^2 product attributes gradations for the case medicines

Medicine	**Product**		**Demand**		**Cost to supply chain**		**Lead time**		**Lifecycle**	
	S0-S4	*S5-S8*	*Volatile*	*Stable*	*Expensive*	*Affordable*	*Short*	*Long*	*Temporal*	*Lasting*
Dolutegravir 50mg x 30 tablets	x			x		x		x		x
Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity)	x		x			x	x		x	
Alprostadil, 0.5mg/ml, 1ml injection		x		x	x		x		x	

5.3.2.2. Supply chain strategy routes identified from the case study

Based on the PDCL^2 product attributes gradations summarized in Table 5.5, the routes as well as the recommended supply chain strategies and decoupling points were identified using the main index of the product categorization framework (Table 3.1 of Appendix D). These are:

- *Dolutegravir 50mg x 30 tablets:* Route 16. Continuous-flow, efficient, or fast strategies with decoupling points: supply to stock; supply to forecast/need; or supply to forecast, respectively.
- *Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity):* Route 5. Fast, agile, or flexible strategy with decoupling points: supply to forecast; supply to need/stock; or design-supply to need, respectively.
- *Alprostadil, 0.5mg/ml, 1ml injection:* Route 25. Efficient, fast, or agile strategy with decoupling points: supply to forecast/need; supply to forecast; or supply to need/stock, respectively.

5.3.2.3. Application of the special cases index

Following the overarching process flow of the product categorization framework as given in Figure 4.3, the presence of any of the conditions detailed in the special cases index (Table 4.4), was considered next. As mentioned previously, a succinct description of the conditions at four facilities to which the medicines are to be supplied was formulated as part of the preparation for the case study workshop. The conditions at the four facilities are:

- Facility A: A district hospital with low storage capacity (though it is easily accessible).
- Facility B: A district hospital with high capacity and easily accessible.

- ❖ Facility C: A remote clinic not easily accessible, though the storage capacity is high.
- ❖ Facility D: A remote clinic not easily accessible and the storage capacity is low.

It was evident at this that point the product categorization framework special cases index (detailed in Table 4.4) was vital in deciding on one supply chain strategy out of the two or three strategies recommended for each of the three pharmaceutical products.

5.3.2.4. Summarized results for each case

Based on the product categorization framework special cases index and the supply chain strategy profiles, participants stated that Dolutegravir tablets can use a continuous-flow strategy with a supply to stock decoupling point when being supplied to Facility A. This is largely due to the need to mitigate the low storage capacity by use of facility replenishment according to a fixed cycle and a supplier's supply cycle that is as short as possible to reduce batch sizes among other attributes of the continuous flow strategy profile. An efficient supply chain strategy was deemed useful when supplying Dolutegravir tablets to Facility B. This is to ensure a high level of inventory through predefined safety stock levels for demand buffering while optimizing supply efficiency via a very high resource utilization rate, among other attributes of the efficient supply chain profile. A fast supply chain strategy was deemed useful in supplying Dolutegravir tablets to Facilities C and D due to the need to have a replenishment supply cycle based on a collection schedule, a resource utilization rate which can be high to very high, and a supplier's supply cycle that is as short as possible to reduce time from ordering to market (facilities). However, in the case of Facility D, neighboring facilities can also be used to buffer inventory.

The flexible strategy was deemed useful in instances where the supply of the influenza vaccine injection, which is a seasonal drug, is in season. The flexible strategy is associated with a flexible and as short as possible replenishment supply cycle and resource utilization rate that is low to medium with standby capacity when supplying to facilities. Out of season, the fast strategy with supply to forecast decoupling point was deemed useful for reasons previously mentioned for this strategy.

The efficient strategy with a supply to forecast/need decoupling point was deemed useful in supplying the Alprostadil injection to Facilities B and C for similar reasons as those previously mentioned for this strategy. The fast strategy with a supply to forecast decoupling point was deemed useful in supplying the Alprostadil injection to Facility A for reasons previously stated for this strategy. When supplying this pharmaceutical to Facility D, an agile strategy with a supply to need/stock decoupling point could be used in order to: keep resource utilization on medium to high levels; maintain an

inventory/pool of suppliers for sourcing buffering; and keep the replenishment supply cycle as short as possible as per patients' needs.

The discussion above facilitates for the determination of sourcing plans and replenishment plans for the product categories based on the recommended supply chain strategies' profile and associated decoupling points which will be done by VAN professionals in each of the nine South African provinces. This will be done cognizant of the levers of the VAN design, especially: the informed push model; supplier collaboration constraints; and the NDoH public healthcare pharmaceutical supply chain regulations, ethics and code of conduct.

5.3.2.5. Framework scoring at the conclusion of the workshop

At the conclusion of the case study workshop, the two participants were requested to score the framework against two key dimensions, namely:

1. Do you think the use of the product categorization framework and its tools is robust and sustainable for the South African public healthcare pharmaceutical supply chain in the context of the VAN supply planning?
2. Do you think the use of the product categorization framework and its tools is beneficial in enhancing sustainable availability of medicines in the South African public healthcare pharmaceutical supply chain in the context of the VAN supply planning?

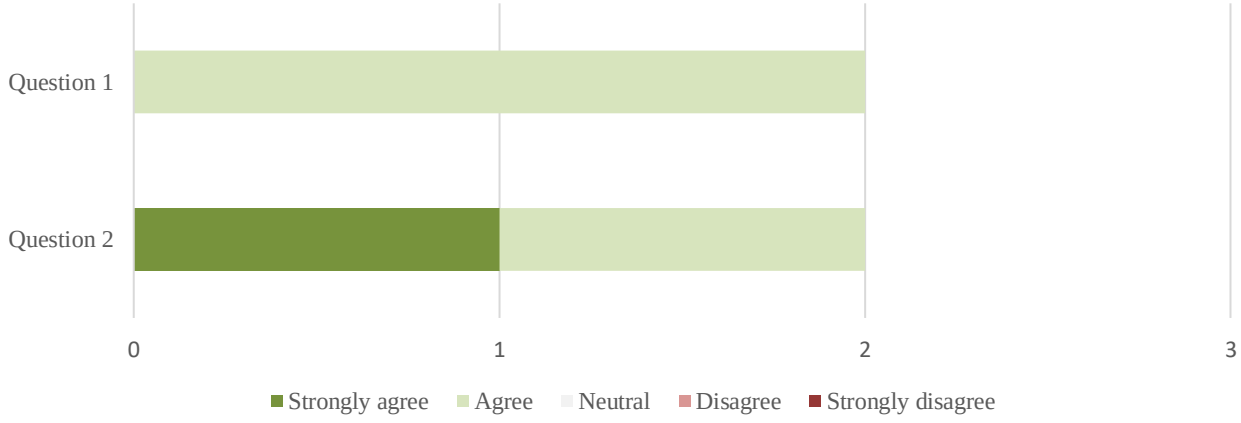

Figure 5.3: Participant feedback to the framework score questions

As is illustrated in Figure 5.3, in both instances participants agreed that the use of the product categorization framework and its tools is robust and sustainable and that the use of the framework would be beneficial in enhancing sustainable availability of medicines in the South African public healthcare pharmaceutical supply chain in the context of the VAN supply planning.

5.3.3. Case study application conclusion

The final product categorization framework was applied and thereby validated by the use of a case study application which sought to confirm the operability and applicability of the product categorization framework in the South African public healthcare context. The case study workshop, conducted with participants from the NDoH SCM, illustrated that the framework can provide a clear mechanism for categorizing pharmaceutical products according to their attributes. Throughout the discussions, the workshop participants endorsed that the supply chain strategies coupled with their respective decoupling points can be used effectively in a VAN-enabled public healthcare supply chain. In terms of the framework scoring data gathered at the end of the case study workshop, it is recognized that it is not ideal to have only two data points for these metrics, and the limited number of workshop participants has already been discussed in Section 5.3.1. It is, however, argued that the data presented in Figure 5.3, should be viewed as supplementary to the conclusions that can be drawn on the operability and applicability of the framework from considering the case study as a whole.

In conclusion, based on the details of the case study as a whole, it can be concluded that the product categorization framework is operable, applicable and beneficial to the South African public healthcare pharmaceutical supply chain. This conclusion is supported by the supplementary data gathered from the two workshop participants.

5.4. **Conclusion**

In the first part of this chapter, the preliminary product categorization framework was validated using SME input analysis through semi-structured interviews. Feedback from the SMEs was incorporated to develop the final product categorization framework. As previously mentioned, in order to avoid both duplicating the framework in the main document and interrupting the flow of the narrative of the thesis, the preliminary product categorization framework which was validated using SME input analysis is presented in Appendix D, while the version of the framework that is presented in Chapter 4 incorporates all changes that were made in response to the validation feedback.

In the second part of the chapter, a case study is presented. The final version of the framework, presented in Chapter 4, was used during the case study workshop. Based on the results of the case study, the framework has been found to be operable and applicable in the contemporary South African public healthcare pharmaceutical supply chain. It is also concluded that the framework has the potential to make a contribution towards enhancing sustainable availability of medicines.

Chapter 6

Conclusions and recommendations

This chapter presents a summary of the research findings of each chapter. A discussion of the limitations and contributions of the study will also be presented followed by recommendations for future research based on the foundations laid in this study.

6.1. Research summary

The background, research aim and objectives, scope of the study, research design and methodology, and the validation strategy were presented in Chapter 1. Background of the research was provided by setting out the need to curb stockouts within the South African public healthcare pharmaceutical supply chain. It was proposed that a mixed-method research can be used to answer the question: how best to match pharmaceutical products and their attributes with supply chain strategies in the South African public healthcare pharmaceutical supply chain to enhance sustainable availability of medicines based on the VAN strategy? Five categories of requirements, posited by van Aken et al. (2007), were proposed for use in this research to ensure a balanced approach in the design and development of a framework, namely: user requirements; functional requirements; design restrictions; boundary conditions; and attention points. A basic systems engineering approach underscored by a basic input-output transformation process was formulated for use in the research.

The rationale for the research was developed in Chapter 2, providing arguments for the likely benefit of incorporating the concept of product categorization into the South African public healthcare pharmaceutical supply chain. Objective 1 was therefore addressed in this chapter. A systematic literature review was employed to identify relevant literature on the concept of product categorization—its applications in industries, impacts, and concepts used in the application thereof. The chapter further investigated the product categorization methods that have been used in relation to SCM in various industries, including the healthcare industry. The chapter aimed at deriving information from the literature that could be used to draw conclusions on the likely feasibility and applicability of product categorization in the South African public healthcare pharmaceutical supply chain. Findings from this chapter were published in a peer-reviewed conference article presented at

the 29th annual conference of the Southern African Institute for Industrial Engineering[10]. Two categories of framework design requirements, namely boundary points and attention points, were identified and defined in this chapter.

Objective 2 was addressed in Chapter 3, developing the set of product attributes to be used as the basis for categorization in the framework and identifying an appropriate supply chain strategies taxonomy to utilize in the framework development. A triangulation method was used to determine the product attributes that are critical in matching pharmaceutical products with appropriate supply chain strategies in the South African public healthcare supply chain. The identified set of attributes are product, demand, cost to the supply chain, lead time to deliver and life cycle, which forms the acronym PDCL^2. Findings from this section of the chapter were published in a peer-reviewed conference article presented at the 25th ICE/IEEE International Technology Management Conference[11]. The chapter also sought to understand how pharmaceutical products can be bundled together for the purpose of the framework, using established standardized classifications and nomenclature in the healthcare sector. A threshold that is based on the medicine schedule bundles was selected. Six supply chain strategies that have been formulated by Perez (2013) were proposed as appropriate for use in the framework development. Three of these strategies are oriented to achieve efficiency (i.e. continuous-flow, efficient, and fast strategies) and the other three are oriented to achieve responsiveness (i.e. custom-configured, agile, and flexible strategies). Operational levers for implementation of the identified supply chain strategies were discussed consistent with: the VAN supply chain; VAN service supply planning; and the South African public healthcare pharmaceutical supply chain. The last three categories of the framework design requirements were identified in this chapter, namely: user requirements; functional requirements; and design restrictions.

In line with Objective 3 of the study, the framework design was presented in Chapter 4. The chapter started with a presentation of the consolidated design requirements, identified in Chapters 2 and 3. A schematic tree that depicts the underlying structure of the framework was presented next. The final version of the framework, incorporating changes made in response to the feedback received during

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[10] The article citation is: Mapowo, N., Bam, L., de Kock, I., & van Eeden, J. (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, Spier, Stellenbosch, South Africa* (pp. 391–404).

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validation was also presented. The detailed logic underpinning a set of framework recommendations was documented to serve as an illustration. Finally, the way in which the framework could be integrated into the broader South African public healthcare pharmaceutical supply chain was briefly discussed.

The validation of the framework was presented in Chapter 5. In line with the validation strategy described in Chapter 1, two phases of validation were conducted. During the first phase of validation, the design requirements and the framework was validated using SME interviews. The feedback indicated that: the design requirements were accurate, and the overarching construct of the VAN-Pharmaceutical Product Categorization Framework is valid and expected to be beneficial to the South African public healthcare pharmaceutical supply chain under the VAN informed push model. Therefore, not many changes were made in the final product categorization framework. During the second phase of validation, a case study was implemented via a workshop hosted at the NDoH SCM section. The aim of the case study was to test the operability and applicability of the product categorization framework. Three pharmaceutical products, as well as four hypothetical healthcare facilities (demand sites), were selected for use during the case study. The case study affirmed that the product categorization framework is operable, applicable and likely to be beneficial to the South African public healthcare pharmaceutical supply chain.

6.2. **Contributions to literature and practice**

This research contributes to both the academic literature and the public healthcare pharmaceutical SCM. It adds to the body of literature by providing an example of how a mixed-methods approach can be applied to developing a framework to address a real-world operational problem. Literature had not provided critical product attributes specifically for the public healthcare pharmaceutical SCM and this study provides this in the form of the $PDCL^2$ product attributes taxonomy. Finally, the framework itself constitutes a contribution to literature.

In terms of contributions to practice, this study proposes a mechanism for enhancing sustainable availability of medicines within the South African public healthcare pharmaceutical supply chain by employing supply chain strategies that are aligned to the attributes of products. The VAN strategy informed push model within the South African public healthcare pharmaceutical supply chain currently does not incorporate the product categorization concept, the framework that has been developed in this research, therefore, makes a valuable contribution to the VAN toolkit. The VAN-Pharmaceutical Product Categorization Framework main index offers recommendations rather than rigid prescriptions, hence more than one appropriate supply chain strategy is recommended for each route. This enables the framework users to limit the number of discrete supply chain pipelines that

need to be included in a distribution plan as this is desirable both in terms of economic and operational feasibility.

6.3. **Limitations to the study**

This study was set within an SCM system of Product Service Supply Chains (PSSCs) where delivery of healthcare by practitioners in the South African public healthcare supply chain is deemed to be the service while the medication/pharmaceuticals are the products. The research output is mainly intended for VAN professionals who will analyze and optimize complex links at the provincial level in the public healthcare pharmaceutical supply chain informed push model. These professionals make inventory planning and management recommendations to primary healthcare facilities (PHCFs), though they will be informed by the provisions at the national level. Furthermore, this study focused on the VAN strategy supply planning which makes use of the demand plan as input and the supply plan's output becomes an input to a demand plan. Thus, the demand plan and the distribution plan were not in the scope of this study.

A number of limitations that relate to the case study were highlighted in the preceding chapter, namely: the small number of workshop participants; and the limited publicly available data for use in the case study.

6.4. **Recommendations and future work**

During the process of conducting this research, recommendations and opportunities for future study were identified. These are detailed in the following sections.

6.4.1. Recommendations

In the use of the PDCL^2 product attributes taxonomy, it is proposed that each province should determine and define its own threshold between the attributes' binary gradations within the boundaries provided by the national tier, based on the measurable characteristics associated with each product attribute. This means that each province should be responsible for quantifying, for example, what constitutes a long lead time or what constitutes a volatile demand, based on the province's specific circumstances (i.e. provincial healthcare budgets, the marketplace, ease of doing business, etc.).

It is recommended that, from the 32 routes of the schematic tree in the VAN-Pharmaceutical Product Categorization Framework, routes that yield the same recommended supply chain strategies can be grouped together and can form part of the inputs to a distribution plan. Therefore, it is recommended that the product categorization supply plan developed from this study, which facilitates the

determination of the sourcing plan and the replenishment plan by the VAN supply chain managers, be used to feed into the distribution plan. The recommendation to bundle routes that share the same supply chain strategies will help to avoid having more discrete supply chain pipelines than is necessary. It is neither desirable nor economically feasible to establish an extensive number of discrete supply chain pipelines for a distribution plan, as this would escalate operations management overheads, as discussed in the study.

6.4.2. Future work

Based on the findings from the SME input analysis and the case study application, there is a need for further research on how best to categorize healthcare facilities based on location, size, storage capacity, etc. under a distribution plan. These 'pockets'—where a pocket is defined as a collection of facilities that will roll out simultaneously, having common characteristics (e.g. same budget ownership, and same service levels)—should be serviced using the same supply chain strategies for each of the routes, since they (the serviced facilities) share attributes such as market mediation costs, demand variation, and product lifecycles. In as much as distribution planning was outside the scope of this study, a facility categorization criterion could work in conjunction with the VAN-Pharmaceutical Product Categorization Framework—but this suggestion needs to be tested and validated.

Furthermore, during the validation workshops, it was identified that there is a need for research on the measurement of KPIs that will be used to monitor the speed to market for pharmaceuticals within the VAN framework—although this was outside the scope of this study. This will contribute to ensuring that the patient is always the priority.

In the study, it was identified that laboratory supplies ('devices' as defined in Section 1.3) are usually integrated within the pharmaceutical supply chain, especially in HIV/AIDS programs, due to dependencies between the two commodities and to minimize supply chain costs. Therefore, in as much as this study focused on the supply of 'drugs' and not 'devices' as established in Section 1.3, future research on how the supply of drugs and devices can be merged to minimize costs is recommended.

Lastly, though the framework was designed specifically for the contemporary South African context, it is likely that it may be more widely applicable, especially to other countries that are utilizing the VAN concept. Thus, future research on the transferability of the VAN-Pharmaceutical Product Categorization Framework to other countries would be valuable. Research could also be conducted

on understanding which dynamics of the VAN-Pharmaceutical Product Categorization Framework should be adapted in order to make the framework suitable for countries where the VAN strategy is not implemented, and where approaches such as an uninformed push or uninformed pull are used to manage the supply chain.

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Appendix A: Products attributes semi-structured interview

A google form was used to present the semi-structured interview and participants were informed that the aim of this study is to determine a shortlist of the most important product attributes to be used in matching product categories with appropriate supply chain strategies—product categorization—in order to enhance sustainable availability of medicines in a public healthcare pharmaceutical supply chain. The scope of the study is limited to product categorization for supply planning at national and provincial tiers of the department of health. The supply planning aims to drive decision making in sourcing and replenishment of pharmaceuticals to enhance sustainable availability of medicines to end users at public healthcare facilities. The author had in mind the product attributes given in Table 1 and the product categorization methods attached. You can (if necessary) make use of the attached information to respond to the following questions. Three open-ended questions are provided at the end. Eight minutes is all it can take!

Table 1: Product attributes and their measurable characteristics (reproduced from Mapowo, Bam, de Kock, and van Eeden (2019) © 2019 IEEE)

Product attributes	**Examples of measurable characteristics**	**DWV^3**	**The three-dimensional global classification system**	**PSC**
Cost	Supply chain, inventory, and manufacturing			
Demand	Variability, predictability, volatility, and volume	✖	✖	✖
Quality	Defects and yield percentage			
Financial	Profit margin per part			
Product	Physical characteristics		✖	✖
Lifecycle	Phase and length of time in phase	✖		
Design	Manufacturability of the product			
Standardization	Few customized features of the product			
Customer	Responsiveness in service			✖
Uncertainty	Customer demand and market environment			
Delivery	On-time or on-schedule	✖		
Flexibility	Handling of change in demand, design, and delivery			✖
Inventory	Product held in Kanban/JIT inventory			
Lead time	Response time to deliver product		✖	
Production	Capability and capacity to produce in a lean environment			

These 15 product attributes in Table 1 can be seen to be the basis for determination on the three well documented methods that can address SCM product categorization selection, namely: the DWV^3 by Christopher and Towill (2000), the three-dimensional global classification system by Christopher and Towill (2002) and the Product Supply Characterization (PSC) model by Payne and Peters (2004).

1.1 The DWV^3 classification

The DWV^3 classification system utilizes five product attributes, namely the **D**uration of the product lifecycle, the time **W**indow for delivery, the **V**olume, the **V**ariety and the **V**ariability, which build the acronym DWV^3. This classification method is mainly used to develop focused demand chains where processes are prioritized as a sequence of events with the end view of serving the ultimate consumer (Christopher & Towill, 2000).

1.2 The three-dimensional global classification system

The three-dimensional global classification system utilizes three product attributes, namely: product, demand, and lead-times. Each attribute is classified as one of two gradations (Christopher & Towill, 2002):

- Product (standard or special);
- Demand (stable or volatile); and
- Lead-time (short or long).

The three-dimensional global classification system was developed with a focus on linking the supply chain strategy with the product lifecycle management, signifying that the most suitable supply chain strategy of a product differs depending on its stage in the product lifecycle (Christopher & Towill, 2002).

1.3 The Product Supply Characterization (PSC) model

Payne and Peters (2004) asserted that the PSC's focus is on addressing total supply chain costs and service performance to the customer. The PSC model utilizes seven (7) product attributes which are:

- Volume,
- Volatility,
- Order line value,
- The frequency of order lines,
- Order line weight,
- Substitutability of a product and
- Number of customers buying each product

Based on the information provided above (including the highly respected knowledge you possess), please answer the following short questions:

1. Which product attributes in Table 1 would you say are important in determining product categories and matching them with distinct supply chain strategies in a public healthcare pharmaceutical supply chain—for supply planning? *Mark with an (x) for each appropriate answer.*

	Strongly unimportant	Unimportant	Neutral	Important	Strongly important
Cost (Supply chain/inventory/manufacturing)	O	O	O	O	O
Demand (Variability, predictability, volatility, and volume)	O	O	O	O	O
Quality (Defects and yield percentage)	O	O	O	O	O
Financial (Profit margin per part)	O	O	O	O	O
Product (Physical characteristics)	O	O	O	O	O
Lifecycle (Phase and length of time in phase)	O	O	O	O	O
Design (Manufacturability of the product)	O	O	O	O	O
Standardization (Few customized features of the product)	O	O	O	O	O
Customer (Responsiveness in service)	O	O	O	O	O
Uncertainty (Customer demand and market environment)	O	O	O	O	O
Delivery (On-time or on-schedule)	O	O	O	O	O
Flexibility (Handling of change in demand, design, and delivery)	O	O	O	O	O
Inventory (Product held in Kanban/JIT inventory)	O	O	O	O	O
Lead time (Response time to deliver product)	O	O	O	O	O
Production (Capability and capacity to produce in a lean environment)	O	O	O	O	O

2 What is your comment on the product attributes employed in the 3 generic product categorization methods provided in the attached information above, with regards to determination of product attributes usable in product categorization in public healthcare pharmaceutical supply planning?

3. Apart from the 15 product attributes that were asked about, compiled by Sullivan (2007) as highlighted in the attached information, are there any other product attributes you think are critical for supply planning and product categorization in a public healthcare pharmaceutical supply chain (taking heed of semantics)? *Please state and motivate*

4. Upon completion of the study, I wish to send you a feedback on the outcome of the study. Please provide your frequently used email address if you are willing to get the feedback.

Thank you very much for your time.

Appendix B: Background of SMEs used in developing the product attributes taxonomy

Individuals that are considered to be SMEs in either SCM or management of healthcare systems were selected as respondents to the semi-structured interview presented in Appendix A and their backgrounds are thus detailed here in Appendix B. The SMEs belonged to different expertise within various areas of specialty. These include the business analysis and improvement perspective, the VAN perspective, policy analysis perspective, maturity models analysis perspective, informed push model analysis perspective, strategic and operational supply chain management perspective and the healthcare supply chain governance perspective. The input provided by these SMEs formed the second component of the triangulation method used in the determination of the most critical product attributes to public healthcare pharmaceutical supply chains. Table 1 presents the sector; background/occupation; and the reason for inclusion for each of the SMEs.

Table 1: SMEs used in developing the product attributes taxonomy

Sector	Professional (P)	Background/occupation	Reason for inclusion
Healthcare and/or supply chain management	P1	A researcher with experience as an external consultant, Technical Advisor: leadership and governance—advising district health management in South Africa on leadership and governance issues and a board member at Uhambo Foundation. Currently working as a Senior Analyst at Broadreach Healthcare.	Extensive experience in healthcare governance issues and internal project management enables good and unique opinions about critical product attributes essential for a public healthcare pharmaceutical supply chain, especially in South Africa.
	P2	A researcher and experienced professional in the field of Logistics and Supply Chain Management particularly strategic and operational supply chain management in support of development and humanitarian programmes. Served as the director and principal consultant of a supply chain consultancy firm and worked for UNICEF in Copenhagen as a supply chain specialist focusing on capacity development and programme integration.	Knowledge and expertise in Logistics and Supply Chain Management is vital in determining product attributes that sit well with strategic and operational pharmaceutical supply chain management.
	P3	An Industrial Engineer and a researcher in maturity models for demand-driven supply chain management in the public healthcare sector.	Knowledge in public healthcare supply chain maturity models is useful in determining and possibly developing a framework or model for which product attributes hits the 'mark' in public healthcare pharmaceutical supply chain.

Sector	Professional (P)	Background/occupation	Reason for inclusion
	P4	A researcher with experience in ICT systems operation and project environment particularly healthcare environment. Once served as an IT manager for Health Commodity Tracking System (HCTS) in supply chain management systems in Ethiopia. Use of pharmaceutical logistic information tracking system was extensive in the pharmaceutical supply chain management projects he undertook for effective and efficient pharmaceutical commodities management.	Experience and knowledge in pharmaceutical commodities management is useful in my study of pharmaceutical product categorization. More specifically, useful in prioritizing product attributes essential for the public healthcare pharmaceutical supply chain.
	P5	A researcher with extensive experience in business engineering services and research. Particular expertise is in business modeling, analysis, and improvement. Worked on projects that pertain to business analysis, enterprise design, innovation management, systems implementation, process mapping, and value chain analysis.	Understanding of the business (commercial) sector will provide an input that will still help the public healthcare pharmaceutical supply chain to stay competitive in spite of differences in focal points between the commercial and healthcare sectors.
	P6	An industrial engineer and a researcher in policy analysis for the VAN reference framework implementation in the South African public healthcare supply chain	An input from an angle of someone researching about the VAN and also policy analysis of the public healthcare supply chain is essential in determining critical product attributes from a policy standpoint.
	P7	A researcher with experience as a Director of Intra-Health International "Informed push model" project in Senegal. Worked with the health products cold chain in Mali and served health organizations on global, continental, regional and inter-country assignments. Notably, he has served as Head of Immunization System Strengthening Unit in the World Health Organization-Africa regional office on innovative solutions to existing and emerging challenges in health supply systems.	Experience in understanding the informed push model—which is the aim of the VAN reference framework in the South African public healthcare pharmaceutical supply chain, is quite an asset to this study. Furthermore, his knowledge in African innovative solutions to existing and emerging challenges on health supply systems is important in the determination of critical product categorization attributes in the South African public healthcare pharmaceutical supply chain.

Appendix C: Classification and nomenclature in healthcare

The Global Standards 1 (GS1) is an international standards organization that develops and maintains global standards for the sake of business communication. It has worldwide member bodies in more than 100 countries. In an executive summary in 2015, healthcare classification and nomenclature systems that are typically developed for distinct purposes were compiled and suggested. A listing of the various classification and nomenclature systems that are used in healthcare (limited and with a direct impact to supply chain strategies) and the acknowledged purpose of each system is presented here in Table 1.

Table 1: Classification and nomenclature systems used in healthcare with a direct impact on supply chain strategies (adapted from Global Standards 1 (2015))

System	Definition/Description	Maintenance Agency	Declared Purpose
AHFS	American Hospital Formulary Service and Pharmacologic Therapeutic Classification - classification allows the grouping of drugs with similar pharmacologic, therapeutic, and/or chemical characteristics	American Society of Health System Pharmacists	Clinical: The mission of AHFS Drug Information® (AHFS DI®) is to provide an evidence-based foundation for safe and effective drug therapy.
CND	Classificazione Nazionale dei Dispositivi medici (CND) - Italian classification system for medical devices	Italian Health Ministry	Assessments of adverse events, transparent procurement processes by the national health system.
CPV	Common Procurement Vocabulary (CPV) establishes a single classification system for public procurement aimed at standardizing the references used by contracting authorities and entities to describe the subject of procurement contracts	The Office for Official Publications of the European Communities (OPOCE)	The CPV establishes a single classification system for public procurement aimed at standardizing the references used by contracting authorities and entities to describe the subject of procurement contracts.
eCl@ss	Standardized Material and Service Classification and Dictionary - cross industry product data standard for classification and description of products and services	eCl@ss Association	Procurement, controlling and distribution. Company-wide process data management as well as engineering.
GMDN	Global Medical Device Nomenclature -To give a common generic descriptor for medical devices having similar features, characteristics and intended use for exchange of data between regulatory bodies.	GMDN Agency	The GMDN is used for: Data exchange between manufacturers, regulators and healthcare authorities. Exchange of post-market vigilance information. Supporting inventory control in hospitals. Purchasing and supply chain management

System	Definition/Description	Maintenance Agency	Declared Purpose
GPC	Global Product Classification - A system that gives a common language for grouping products in the same way	GS1	GPC gives buyers and sellers a common language to group products the same way globally to ensure effective data synchronization in the Global Data Synchronization Network (GDSN).
NAPCS	North American Product Classification System Identify, define, and classify the final products and services produced and transacted by reporting units within each industry	US Census Bureau, jointly with like agencies of Canada and Mexico	The long-term objective of NAPCS is to develop a market oriented, or demand-based, hierarchical classification system for products (goods and services)
NHS eClass	The National Health System (NHS)-eClass is a bespoke classification system for products and services, managed by the English NHS. The purpose of NHSeClass is to facilitate the accurate analysis of expenditure.	NHS-eClass was for the English NHS but is now administered by NHS Shared Business Services.	NHS-eClass was designed to support the accurate and standardized classification and cataloguing of products and services,
UNSPSC	United Nations Standard Products and Services Code® (UNSPSC®) is an open, global, multisector standard for efficient, accurate classification of products and services	Manged by GS1 US for the UN Development Programme (UNDP)	Used for: Cost-effective procurement optimization. Full exploitation of electronic commerce capabilities. Typically used by purchasing organizations for spend analysis

Appendix D: Framework validation document

Development of a product categorization taxonomy framework for the South African public healthcare pharmaceutical supply chain to enhance sustainable availability of medicines—VAN enabled

PRODUCT CATEGORIZATION FRAMEWORK VALIDATION

Private and confidential document

PRE-READ DOCUMENT

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FOREWORD

This document serves as pre-read material necessary for validation. The document provides an understanding of the product categorization taxonomy framework developed for the South African public healthcare pharmaceutical supply chain in the context of supply planning for the Visibility and Analytics Network (VAN). An overview of the background of the study, the methodology and a summary of the study's literature is provided. Consequently, the product categorization framework together with the decision-making philosophy is given.

In the interest of maximizing on the limited time available, each participant should ideally read through this document prior to filling in the assessment questionnaire. Participants should focus more on pages 3-4; and 12-18.

Newton Mapowo Date

1.0 Introduction

This section aims to provide an overview of the research inquiry by summarizing the background, research question, research aim, and the research design and methodology in developing the product categorization framework.

1.1 Background

The South African National Department of Health (NDoH) is in the process of rolling out the Visibility and Analytics Network (VAN) reference framework, with the aim of ensuring sustained availability of and access to medicines (Llewellyn, 2017). One of the objectives of the VAN strategy is to transform South Africa's public healthcare pharmaceutical supply chain from an 'uninformed pull' system to an 'informed push' system. The distinction between these respective systems being that specialized supply chain management professionals will be utilized in each province. These professionals will analyze and optimize complex links in the public healthcare pharmaceutical supply chain and make inventory planning and management recommendations to primary healthcare facilities (PHCF), rather than the PHCFs doing so on their own. An informed push model will relieve the PHCF's staff of sophisticated and time-consuming supply chain planning work and enable them to focus more on healthcare delivery (Llewellyn, 2017).

At present, the VAN strategy does not incorporate the concept of product categorization—which entails the organization of products into categories according to shared attributes; more specifically, when supply chains are considered, attributes that are related or could influence the best supply chain management strategy for said products. Fisher (1997) proposed that the reason why supply chains do not perform as expected despite increased investments in effort and resources is an improper alignment of product attributes and supply chain strategies. Simchi-Levi, Clayton and Raven (2013) reasoned that "one size does not fit all" in the formulation of a supply chain strategy, highlighting the fact that different supply chain management strategies are most likely needed for products that differ in terms of attributes such as variability, volume, lead-time, lifecycle etc.

In order to propose an approach for applying the principle of product categorization in the South African public healthcare pharmaceutical supply chain, the following research question and aim are pursued. The main question that guided this study was: How best to match pharmaceutical products and their attributes with supply chain strategies in the South African public healthcare pharmaceutical supply chain to enhance sustainable availability of medicines?

1.2 Research aim

The aim of this research inquiry is to contribute towards improving the sustainable availability of medicines in the South African public healthcare pharmaceutical supply chain by proposing a suitable framework for the application of the concept of product categorization.

1.3 Methodology of the research

For the study, a mixed method research approach was employed where secondary quantified data sources on the South African public healthcare pharmaceutical supply chain were utilized to determine and define the research problem. Framework design requirement categories were identified as defined and given in the table.

Table 1.1: Framework design requirement categories (adapted from van Aken, Berends, and van der Bij (2006))

Framework design requirement category	Generic definition of requirement category
User requirements [U]	These are the critical and distinct requirements, as deemed by the framework user, which are used to define the constraints in framework development.
Functional requirements [F];	These are the fundamental enablers which facilitates the functionality, performance or result of the framework's design and use.
Design restrictions [R];	These are the scope, exclusions, limits, and elements of the framework design's preferred solution space.
Boundary conditions [B];	These are the categorical requirements or rules that cannot be altered and must be met e.g. ethics, code of conduct and legislation.
Attention points [A].	These are the desirable and relevant requirements of the framework design though they are not binding nor restrictive.

The synthesis of these requirements to develop the framework followed a basic input-output categorization process, as in Figure 1.1:

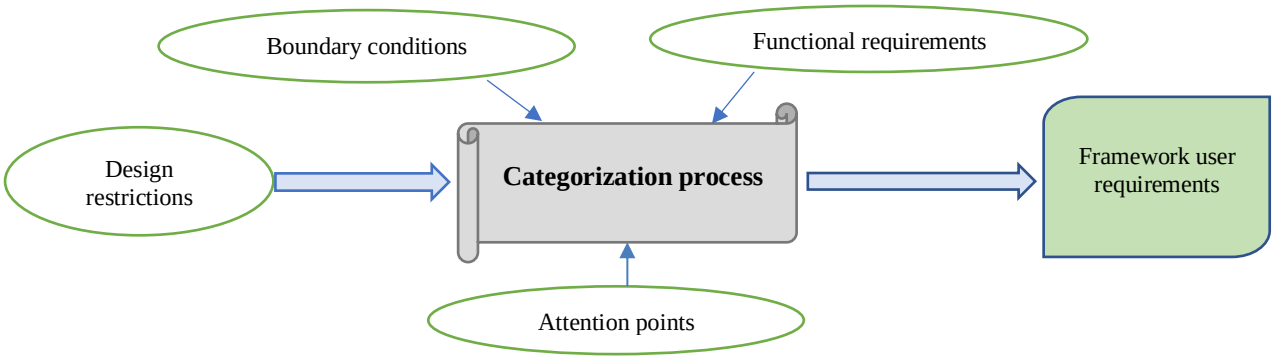

Figure 1.1: Input-output transformation process (adapted from The US Department of Defense Systems Management College (2001))

To determine these framework design requirements, the rationale which explored the concept of product categorization and the South African public healthcare pharmaceutical supply chain was given. Next, solutions were developed which were the product attributes taxonomy and the supply chain strategies taxonomy. Consequently, the product categorization framework was developed based on the findings.

1.4 The aim of this workshop

The workshop's first objective is to review and validate framework design requirements used to develop the preliminary product categorization framework and the framework's construct itself. This is accomplished by getting feedback from subject matter experts (SMEs) on the framework. Consequently, based on the feedback received from the SMEs, necessary iterations and/or improvements will be made to develop a final product categorization framework. The second objective (after the validation session and updating the preliminary framework based on the SME feedback) is to conduct a case study on the final product categorization framework which will also require an SME engagement workshop. The case study will account for operability and applicability of the final product categorization framework.

The succeeding section details the literature that supported the development of the preliminary product categorization framework. The reader can skip some of the pertinent parts of the literature overview if familiar with the content, but readers can find the preliminary product categorization framework in Section 3 (page 12).

2.0 Literature overview

In this section, the supportive literature for the development of the product categorization framework is briefly discussed. Firstly, a brief discussion of the VAN strategy in the South African public healthcare supply chain will be given. Secondly, the formulation of the product attributes taxonomy will be discussed. Thirdly, the classification and nomenclature in healthcare will be summarized. Fourthly, the synthesis of the supply chain strategies taxonomy will be established giving detail on the levers to control in supply chain strategy implementation.

2.1 The VAN strategy in the South African public healthcare pharmaceutical supply chain

The demand plan feeds into the supply plan and the supply plan feeds into the distribution plan within the South African public healthcare pharmaceutical supply chain (Llewellyn, 2017). The scope of this study focuses on the supply planning, which under the VAN strategy seeks for coordination of inventory and orders to optimize the delivery of products to meet the patients' needs—i.e. to provide sufficient products at the right place and at the right time in order to fulfil the demand plan.

The outputs from a supply plan are sourcing orders and replenishment orders with supply planning variables such as lead time, safety stock, stock on hand, minimum order quantities and delivery channel costs (Llewellyn, 2017). The product categorization framework's recommended supply chain strategies aligned with pharmaceutical products and their product attributes, are thus proposed from this study to drive the sourcing orders and replenishment orders. This will be enabled by the VAN stage 3 operationalization which utilizes trained and informed supply chain planners. The planners use technology to make order recommendations based on the visible sock levels and consumption data at facilities (Llewellyn, 2017).

2.2 Solution development: Product attributes and supply chain strategies taxonomy

This section discussed, synthesized and determined the product attributes that are critical in matching product categories with appropriate supply chain strategies in the South African public healthcare supply chain particularly the VAN supply planning. The section also gives an understanding of how pharmaceutical products can be bundled up together according to the established standardized classifications and nomenclature in the healthcare sector. Furthermore, supply chain strategies were identified that were critical for the product categorization framework development and levers and controls for supply chain strategies implementation was given consistent with the VAN supply chain; VAN service supply planning; and the South African public healthcare pharmaceutical supply chain.

2.2.1 Salient supply chain-driving product attributes

After conducting an extensive systematic literature review, it was identified that the product attributes established from literature are generic and research has not yet considered determining critical product attributes in the public healthcare pharmaceutical supply chain sector specifically. While there are certainly many commonalities between the dynamics of commercial sector supply chains and public healthcare supply chains, there are also distinct differences which were taken into consideration when selecting appropriate product attributes for product categorization in a public healthcare supply chain.

Due to the differences in characteristics between the commercial and the public healthcare supply chains, the triangulation approach was used to synthesize and identify critical product attributes to public healthcare thereby enabling a strengthened construct validity and internal validity. The triangulation method firstly took into account the understanding of the supply chain-driving product categorization methods as applied in various industries' supply chains and subsequent product attributes as provided in the literature. Secondly, subject

matter experts (SMEs) were consulted to cross-check what literature provided, interpolating these provisions to public healthcare pharmaceutical supply chains. Finally, provisions from literature and inputs from SMEs were synthesized and a final list of proposed product attributes for use in public healthcare pharmaceutical supply chains were developed through the application of logical arguments and reasoning.

Based on the findings from the triangulation method employed, it is proposed that the critical product attributes for product categorization in the South African public healthcare pharmaceutical supply chain are product, demand, cost to the supply chain, life cycle and lead time to deliver, which form the acronym **PDCL^2**. These product attributes, together with examples of measurable characteristics for each attribute, are summarized in Table 2.1.

Table 2.1: Consolidated product attributes for product categorization in the public healthcare pharmaceutical supply chain (adapted from Mapowo, Bam, de Kock, and van Eeden (2019) © 2019 IEEE)

Public healthcare pharmaceutical supply chain product attributes (with gradations)	Examples of measurable characteristics	Recommended thresholds between the binary gradations for provinces in the South African public healthcare
Product (standard or special)	Therapeutic nature, substitutability of the product, standardization of product category and physical characteristics.	A more entailing threshold between the standard and special gradations is given in detail in Section 2.2.2.
Demand (stable or volatile)	Variability, volatility, volume, and uncertainty.	Pharmaceutical products with fairly constant or predictable demand in the short or medium-term demand and/or supply plan of a province can be considered 'stable' while those that spike unpredictably can be considered 'volatile'.
Cost to the supply chain (affordable or expensive)	Procurement cost, holding cost, obsolescence cost and distribution cost.	Order line values, frequency of order lines and order line weights can then be used to determine between expensive and affordable cost based on the procurement cost, holding cost, obsolescence cost and distribution cost.
Life cycle (temporal or lasting)	Product lifetime, shelf life, obsolescence, and product quality.	Products that require a short end-to-end pipeline, rapid time to market and have short shelf life and lifetime can be considered to have a temporal life cycle, with the opposite being true for a lasting life cycle.
Lead time to deliver (short or long)	Supply cycle time, supply takt time, response time to deliver product, on-time or on-schedule and time service levels.	Pharmaceutical products that cannot be sourced nor replenished rapidly based on the supply cycle time, supply takt time and time service levels can constitute the long lead time, while the opposite is true for a short lead time.

It is proposed that since the intention is to use the product attributes at national and provincial tiers' operational levels under the informed push model of the VAN reference framework, each province should determine and define its own threshold between the binary gradations basing on the measurable characteristics given in Table 2.1 as per the boundaries provided by the national tier. This means that each province is responsible for quantifying, for example, what constitutes a long lead time or what constitutes a high cost, based on the province's specific circumstances i.e. provincial healthcare budgets, marketplace, ease of doing business etc. As a recommendation to the various provinces, the basis for determining the thresholds between the binary gradations is recommended in the third column of Table 2.1.

2.2.2 Classification and nomenclature systems in healthcare

The most salient distinction of pharmaceutical products is based on their medicine schedules which allows for different levels of regulatory control of pharmacological substances—where a medicine schedule is a number assigned to a pharmaceutical product according to its benefits and risks i.e. the lower the risk the lower the number assigned to it. These schedules are summarized in Table 2.2.

Table 2.2: Medicine schedules (adapted from Innovative Pharmaceutical Association South Africa (2016))

Medicine schedule	Available at:
0	General shops like supermarkets e.g. simple analgesics
1	Over-the-counter (OTC) in a pharmacy e.g. antifungal skin creams
2	OTC in a pharmacy with sale record to be kept e.g. a cough and cold medication
3	Prescription only from the pharmacy dispensary—6 months repeat allowed e.g. diabetes medicine
4	Prescription only from the pharmacy dispensary—6 months repeat allowed e.g. anti-infectives
5	Prescription only from the pharmacy dispensary—repeats stipulated e.g. psycho-active medicines
6	Prescription only, therapeutic narcotics e.g. narcotic painkillers
7	Controlled substance e.g. cannabis and heroine
8	Strictly controlled substances e.g. nabilone, amphetamine and dexamphetamine

In this study, taking from the most salient medicine groupings from the various classification and nomenclature systems that are used in healthcare, medicine schedules will be used to grade the 'product' attribute of the established PDCL^2 product attributes taxonomy. Moreover, for the VAN supply chain; VAN service supply planning; and the South African public healthcare pharmaceutical supply chain's product categorization framework, two binary 'product' attribute gradations of these medicine schedules bundles can be established for the developed PDCL^2 product attributes taxonomy. The first being the S0, S1, S2, S3 and S4 medicine schedule bundle and the second being the S5, S6, S7, and S8 medicine schedule bundle. The S0-S4 medicine schedules bundle are mostly high-volume products, administered with a limit of 6 months' repeat supply and have better ease of access/availability as they can be found in general shops and pharmacy dispensaries with less restrictive regulatory control (Innovative Pharmaceutical Association South Africa, 2016; Medicine Control Council, 2014).

However, the S5-S8 medicine schedule bundle/gradation are mostly low volume products which may have a moderate to high potential for abuse or for producing dependence, which then necessitates close medical management and supervision and strict control over supply with some medicine only available to medical practitioners who have obtained special permission from the Medicines Control Council for use and prescription (Medicine Control Council, 2014). Therefore, these two medicine schedule bundles/gradations (S0-S4 and S5-S8) can be supplied differently and would need different supply chain strategies based on the other gradations of the PDCL^2 product attributes taxonomy. Thus, the medicine schedules were identified as part of design restrictions (R) and will contribute to the framework development as the input to the framework since the product categorization framework can only categorize what already exist within the pharmaceutical product portfolio.

2.3 Supply chain strategies taxonomy

Having discussed various supply chain strategies, the most salient strategies for product categorization in the context of the VAN supply chain; VAN service supply planning; the South African public healthcare pharmaceutical supply chain; and the NDoH were identified as defined by Perez (2013):

Continuous-flow supply chain strategy: This supply chain employs a 'make to stock' decoupling point where production is scheduled to replenish predefined stock levels based on a specific reorder point for inventory in the production cycle. It pursues high service levels and low inventory levels.

Efficient supply chain strategy: This supply chain has production scheduled based on sales expectations for the duration of the production cycle, using a 'make to forecast' model as a decoupling point.

Fast supply chain strategy: This supply chain has production scheduled in a single batch per stock keeping unit (SKU), with the size being defined by the season's sales expectations, and utilizing a 'make to forecast' decoupling point.

Custom-configured supply chain strategy: This supply chain is characterized by multiple configurations of the finished product on a unique platform, using a 'configurable to order' decoupling point.

Agile supply chain strategy: This supply chain employs a 'make to order' or sometimes 'make to stock' decoupling point, where items are produced after a purchase order has been placed by the customer.

Flexible supply chain strategy: This supply chain is characterized by adaptability, which entails the capability to reconfigure internal processes to meet a specific need (or solve a problem) of a customer using a 'design to order' decoupling point.

This set of supply chain strategies underscore the user requirements (U) of the product categorization framework development and will be used to link and match appropriately with each distinct pharmaceutical products bundle/category based on the established PDCL[2] product attributes taxonomy. Each supply chain strategy has its own decoupling point defined generically in literature, but however, these definitions were translated to the informed push model of the VAN strategy; public healthcare pharmaceutical supply chain; and service supply planning in the study. Table 2.3 describes the decoupling points when contextualized and applied to public healthcare pharmaceutical supply chain; VAN informed push model; and service supply planning:

Table 2.3: Supply chain strategies and their decoupling points (adapted from Perez (2013))

Supply chain strategy	**Generic decoupling point, adapted from Perez (2013)**	**Informed push model and public healthcare service supply planning-specific interpolated decoupling points**	
		Decoupling point	**Interpolated meaning**
Continuous-flow supply chain strategy	Make to stock	Supply to stock	Supplying for stocking at facilities based on predefined stock levels.
Efficient supply chain strategy	Make to forecast/Make to order	Supply to forecast/ Supply to need	Supplying based on forecasted demand or based on the foreseen service needs of the facilities.
Fast supply chain strategy	Make to forecast	Supply to forecast	Supplying based on forecasted demand of facilities.
Custom-configured supply chain strategy	Configurable to order	Configurable to need	Configuring supply orders/formularies based on facility/patients' needs e.g. case of personalized medicine
Agile supply chain strategy	Make to order'/Make to stock	Supply to need/ Supply to stock	Supply based on the foreseen service needs of the facilities or based on facilities' predefined stock levels.
Flexible supply chain strategy	Design to order	Design supply to need	Configuring the supply chain in response to facilities' or patients' service needs.

It is recommended that the established decoupling points be used for decision making in sourcing plans and replenishment plans per province, which is the intended output of the product categorization framework to be developed. The study detailed how this supply chain strategies taxonomy within the product categorization framework to be developed, will be embedded within the four main elements that shape supply chain strategy implementation i.e. business framework; competitive positioning; managerial focus; and supply chain focus as defined by the Perez (2013) framework. These four main elements, detailed in Table 2.4, were considered for the proposed supply chain strategies taxonomy within the VAN strategy implementation, South African public healthcare pharmaceutical supply chain and the NDoH according to Perez (2013).

Table 2.4: Supply chain strategies taxonomy contextualized to supply planning—VAN enabled (adapted from Perez (2013))

		Oriented to efficiency			Oriented to responsiveness		
		Continuous-flow	**Efficient**	**Fast**	**Custom-configured**	**Agile**	**Flexible**
Business framewor	Demand variation	Low	Medium to high	Medium to high	High	High	Unpredictable
	Product lifecycle	Long	Long	Short	Short to medium	Short to medium	Undetermined
	Market mediation cost	Low	Low	Medium to high	High	High	High
Competitive positioning	Main difference in service delivery	High pharmaceutical inventory turnover	Perfect orders	Short time from order to market	User-friendly as per need	Agility relative to demand changes	Based on patients' exact needs
	Main difference in pharmaceuticals	Best performance/ cost ratio	Affordability	Continuous portfolio renewal	Configurable product	Customizable product	Adaptable process
Managerial focus	End-to-end	Collaborative relationships to build synergies	Efficiency	Continuous pharmaceutical product portfolio renewal	Pharmaceutical product configurability	Agile response to changes in demand	Resource flexibility
	Servicing	Information sharing for continuous improvement	Perfect orders as per facilities' needs	Short lead time to deliver	Accuracy in orders supplied	Short lead time	Understanding of patients' needs
	Product	Operations designed for lean supply capability	Low cost at standard supply performance	Fast sourcing process	Modular design in orders for multiple configurations	Operations designed for supply in small batches	Operations supported by complementary services
	Sourcing	Collaborative relationships to build synergies	Lowest-total-cost-supplier (opportunistic)	Pool of suppliers with short lead times and oriented to innovation	Agile response to changes in demand	Short lead time	Agile response and process flexibility to adopt patients' requirements

		Oriented to efficiency			Oriented to responsiveness		
		Continuous-flow	**Efficient**	**Fast**	**Custom-configured**	**Agile**	**Flexible**
Supply chain profile	Demand buffering	Predefined safety stock levels	Predefined safety stock levels	Predefined safety stock levels	Inventory before PDP, extra capacity after	Extra capacity	Standby capacity or capacity pooling
	Order penetration point	Supply to stock	Supply to forecast, sometimes supply to need	Supply to forecast	Configured to need	Supply to need or supply to stock	Design supply to need
	Minimum order size	Patients' replenishment needs	Minimum economic transportation batch	Collection forecast	End patients' (replenish-ment) needs	Minimum economic supply or transportation batch	Minimum economic supply batch
	Replenishment supply cycle	Replenishment according to a fixed cycle	Fixed lead time or fixed cycle	According to collection schedule	As short as possible as per need in PDP queue	As short as possible as per patients' needs in queue	Flexible, as short as possible
	Collaborative relationships	Strategic relationships with key partners to build synergies	Strategic relationships with key partners to build synergies	Cooperate to anticipate market trends /joint design	Cooperation with key partners to anticipate aggregate demand at PDP	Cooperation with key partners to anticipate capacity requirements	Understanding of 'available to need' at any moment
	Inventory strategy	Small and frequent batches to increase inventory turns	High level of inventory to optimize supply efficiency	A single batch per SKU based on collection forecast	Inventory just before PDP	Stock under a common platform	Low inventory level and inventory pooling
	Customization	No	No	Usually no	Yes, just in PDP and downstream processes	Relevant in supply operations and downstream processes	Relevant in supply design and downstream processes
	Resource utilization rate	High to very high	Very high	High to very high	High before PDP, medium after PDP	Medium to high	Low to medium. At times standby capacity
	Supplier's supply cycle	As short as possible to reduce batch sizes	Maximize on increasing batch sizes and efficiency	As short as possible to reduce time from ordering to market	Long before PDP, short in PDP and downstream	Variable as per patients' orders accepted in queue	As short as possible to reduce lead time
	Rate (takt) of workload	Smoothed by patients demand	Smoothed by rolling forecast	Smoothed by collection forecast	Smoothed by rolling forecast before PDP, peaks after PDP	Peaks and valleys of high magnitude	Capacity on standby for occasional use, high peaks when used
	Sourcing buffering	Inventory/one supplier for each key product bundle/ category	Inventory/best-cost supplier on each occasion	Pool of suppliers	Inventory/pool of suppliers	Inventory/pool of suppliers	Pool of suppliers for critical resources

The literature review and synthesis helped to identify the framework design requirements, consolidated in Table 2.5, i.e. User requirements [U]; functional requirements [F]; design restrictions [R]; Boundary conditions [B]; and Attention points [A] as defined by van Aken et al. (2006). The preliminary product categorization framework proposition for matching product bundles/categories with appropriate supply chain strategies will be given in Section 3.0.

Table 2.5: Consolidated design requirements from the literature study and synthesis

Design requirement	Req. ID
User requirements [U]: Outputs	
The framework must support supply planning decisions at different operational levels e.g. the national and provincial levels, by recommending an appropriate supply chain strategy for each pharmaceutical product.	U1
Each supply chain strategy, contextualized to the VAN strategy, should dictate an appropriate sourcing plan and replenishment plan based on its affiliated decoupling point.	U2
The framework must also provide a decision-making approach in special cases e.g. vaccine supply or delivery site restrictions and limited storage capacity.	U3
The framework's output, which identifies as output of a supply plan, should be usable as input to a distribution plan.	U4
Functional requirements [F]: Parameters	
The framework must provide a clear mechanism for categorizing products according to their attributes.	F1
Products should be categorized according to the PDCL^2 product attributes classification.	F2
Design restrictions [R]: Inputs	
The pharmaceuticals restricted to the demand plan product portfolio which describe the Essential Medicine List (EML) should be used as input to the supply plan product categorization framework.	R1
If products are bundled based on their inherent characteristics, the medicine schedules bundles S0-S4 and S5-S8 should be used.	R2
Boundary conditions [B]: Controls	
The framework's output, in the form of recommendations for managing the public healthcare pharmaceutical supply chain, must align with the principles that underpin the Visibility and Analytics Network strategy, most importantly the concept of informed push.	B1
The framework's output, in the form of recommendations for determining supply planning's sourcing and replenishment plans, must contribute to determination of supplier collaboration constraints (contracts and tenders) within the funding limitations.	B2
The framework's output, in the form of recommendations for managing the public healthcare pharmaceutical supply chain, must align with the principles that underpin the South African Constitution.	B3
Attention points [A]: Enablers	
The framework's recommendation for managing supply chain strategies should ideally incorporate the direct delivery and depot system that are already operational in the South African public healthcare pharmaceutical supply chain	A1

3.0 Product categorization framework development

The synthesis of the design requirements to develop the framework was based on the systems engineering input-output transformation process adapted from the US Department of Defence Systems Management College (2001) initially given in Figure 1.1. A framework derived from such a process will potentially enable the users—VAN supply chain managers—to determine appropriate product-driven supply chain sourcing and replenishment strategies for the pharmaceutical products so as to enhance the sustainable supply of medicines and improve the supply chain performance. The proposed preliminary product categorization framework, based on the framework design requirements established in the study, will be underpinned by a schematic tree. The logic that governs the schematic tree, which underpins the product categorization framework, is detailed in the next section.

3.1 The schematic tree that underpins the product categorization framework

The PDCL^2 product attributes taxonomy underscores the schematic tree and allows for analysis of a combination of pre-existing conditions on a product bundle/category before a supply chain strategy and decoupling point can be recommended. The PDCL^2 product attributes taxonomy is set out in a schematic tree hierarchical sequence of the product attributes to consider, with 'product' being the first; 'demand' the second; 'cost to the supply chain' the third; 'lead time' the fourth; and 'lifecycle' the fifth as given in Figure 3.1.

Based on various combinations of different gradations of the PDCL^2 product attributes taxonomy, pharmaceuticals bundled first according to their schedules will yield 32 routes from the schematic tree. To each route, supply chain strategies coupled with their decoupling points were recommended based on the discussed findings from the study. The six supply chain strategies from the supply chain strategies taxonomy identified in the study were used as outcome decisions of the schematic tree.

The product categorization framework, presented in Table 3.1, took a leagile (lean + agile) approach in selecting most of the appropriate supply chain strategies so that the framework users (VAN supply chain managers) can capitalize on benefits of being lean and those of being agile. These appropriate supply chain strategies were established based on a recommending approach rather than a prescriptive approach. This means that appropriate supply chain strategies are recommended to each route as two or three appropriate options from which supply chain professionals in different provinces can decide from. The supply chain strategies were selected counterbalancing orientation towards efficiency (lean) and responsiveness (agile).

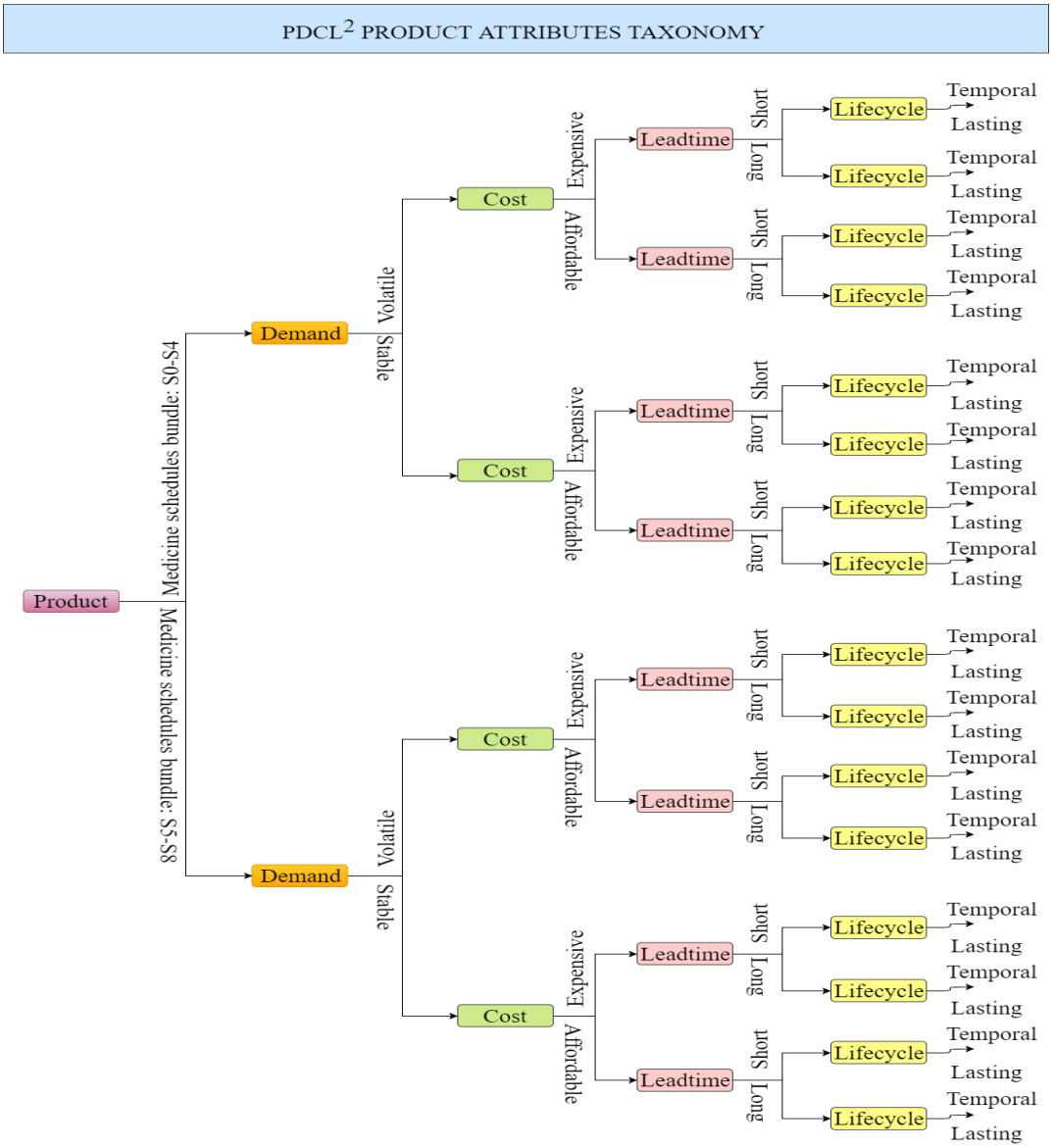

Figure 3.1: The schematic tree that underpins the product categorization framework

3.2 The preliminary product categorization framework proposal and analysis

Based on the input-output categorization process which the product categorization framework takes, an overarching process/flow followed by the preliminary product categorization framework which can be used to describe the usage of the framework is given in Figure 3.2.

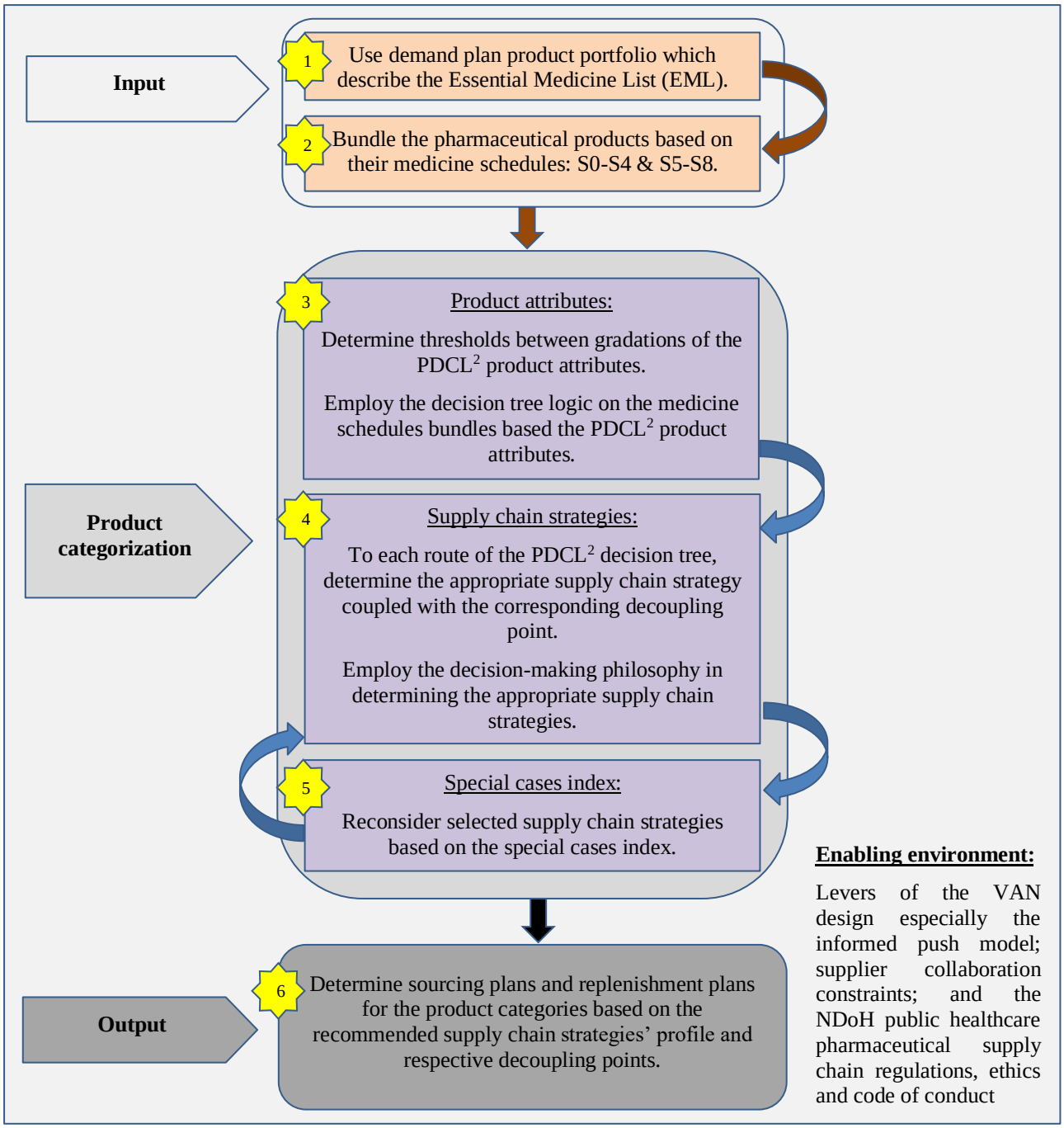

Figure 3.2: Overarching process flow of the product categorization framework

The schematic tree philosophy, described in the preceding section, was used to examine preexisting requisites and conditions (using the medicine schedules bundles from the product portfolio and the PDCL^2 product attributes taxonomy) and recommend appropriate supply chain strategies to be employed. The product categorization framework is presented in Table 3.1.

Table 3.1: The product categorization framework

	The PDCL² product attributes taxonomy										Supply chain strategies taxonomy	
	Product		Demand		Cost to SC		Leadtime		Lifecycle			
	Schedules bundle: S0-S4	*Schedules bundle: S5-S8*	*Volatile*	*Stable*	*Expensive*	*Affordable*	*Short*	*Long*	*Temporal*	*Lasting*	**Supply chain strategies**	**Decoupling points**
1.	X		X		X		X		X		Fast or Agile strategy	Supply to forecast or Supply to need/stock
2.	X		X		X		X			X	Efficient or Agile strategy	Supply to forecast/need or Supply to need/stock
3.	X		X		X			X	X		Efficient or Fast or Agile strategy	Supply to forecast/need or Supply to forecast or Supply to need/stock
4.	X		X		X			X		X	Efficient or Agile strategy	Supply to forecast/need or Supply to need/stock
5.	X		X			X	X		X		Fast or Agile or Flexible strategy	Supply to forecast or Supply to need/stock or Design-supply to need
6.	X		X			X	X			X	Efficient or Agile or Flexible strategy	Supply to forecast/need or Supply to need/stock or Design-supply to need
7.	X		X			X		X	X		Fast or Agile strategy	Supply to forecast or Supply to need/stock
8.	X		X			X		X		X	Efficient or Agile strategy	Supply to forecast/need or Supply to need/stock
9.	X			X	X		X		X		Efficient or Agile strategy	Supply to forecast/need or Supply to need/stock
10.	X			X	X		X			X	Continuous-flow or Efficient strategy	Supply to stock or Supply to forecast/need
11.	X			X	X			X	X		Efficient or Fast or Agile strategy	Supply to forecast/need or Supply to forecast or Supply to need/stock
12.	X			X	X			X		X	Continuous-flow or Efficient or Agile	Supply to stock or Supply to forecast/need or Supply to need/stock
13.	X			X		X	X		X		Continuous-flow or Efficient or Fast	Supply to stock or Supply to forecast/need or Supply to forecast
14.	X			X		X	X			X	Continuous-flow or Efficient strategy	Supply to stock or Supply to forecast/need
15.	X			X		X		X	X		Efficient or Fast or Agile strategy	Supply to forecast/need or Supply to forecast or Supply to need/stock
16.	X			X		X		X		X	Continuous-flow or Efficient or Fast	Supply to stock or Supply to forecast/need or Supply to forecast
17.		X	X		X		X		X		Fast or Custom-configured or Agile	Supply to forecast or Configurable to need or Supply to need/stock
18.		X	X		X		X			X	Fast or Agile or Flexible strategy	Supply to forecast or Supply to need/stock or Design-supply to need
19.		X	X		X			X	X		Fast or Custom-configured or Agile	Supply to forecast or Configurable to need or Supply to need/stock
20.		X	X		X			X		X	Efficient or Agile or Flexible strategy	Supply to forecast/need or Supply to need/stock or Design-supply to need
21.		X	X			X	X		X		Fast or Custom-configured or Flexible	Supply to forecast or Configurable to need or Design-supply to need
22.		X	X			X	X			X	Fast or Custom-configured or Agile	Supply to forecast or Configurable to need or Supply to need/stock
23.		X	X			X		X	X		Fast or Custom-configured or Flexible	Supply to forecast or Configurable to need or Design-supply to need

	The PDCL² product attributes taxonomy										Supply chain strategies taxonomy	
	Product		Demand		Cost to SC		Leadtime		Lifecycle			
	Schedules bundle: S0-S4	*Schedules bundle: S5-S8*	*Volatile*	*Stable*	*Expensive*	*Affordable*	*Short*	*Long*	*Temporal*	*Lasting*	**Supply chain strategies**	**Decoupling points**
24.		X	X			X		X		X	Fast or Custom-configured or Agile	Supply to forecast or Configurable to need or Supply to need/stock
25.		X		X	X		X		X		Efficient or Fast or Agile strategy	Supply to forecast/need or Supply to forecast or Supply to need/stock
26.		X		X	X		X			X	Efficient or Fast or Custom-configured	Supply to forecast/need or Supply to forecast or Configurable to need
27.		X		X	X			X	X		Efficient or Fast or Flexible strategy	Supply to forecast/need or Supply to forecast or Design-supply to need
28.		X		X	X			X		X	Efficient or Fast or Custom-configured	Supply to forecast/need or Supply to forecast or Configurable to need
29.		X		X		X	X		X		Continuous-flow or Efficient or Fast	Supply to stock or Supply to forecast/need or Supply to forecast
30.		X		X		X	X			X	Continuous-flow or Efficient	Supply to stock or Supply to forecast/need
31.		X		X		X		X	X		Continuous-flow or Efficient or Fast	Supply to stock or Supply to forecast/need or Supply to forecast
32.		X		X		X		X		X	Continuous-flow or Efficient	Supply to stock or Supply to forecast/need

In the use of the product categorization framework, the users have to be cognizant of various special conditions which may affect both medicine schedules bundles (S0-S4; and S5-S8) and may necessitate a slightly different view of the framework. These recommendations will aid in realigning supply chain strategy selection together with their decoupling points. These conditions and recommendations are indexed in Table 3.2.

Table 3.2: Product categorization framework special cases index

Condition	Recommendation
Are the pharmaceuticals seasonal?	Opt for elements of supply chain strategies oriented towards efficiency when out of season and towards responsiveness when in season.
Are the pharmaceutical products personalized medicine?	Opt for the elements of the custom-configured supply chain strategy.
Are the pharmaceutical products vaccines?	Opt for a cold chain using a leagile (lean + agile) approach. Make use of elements of both strategies oriented towards efficiency and responsiveness.
Are the pharmaceutical products epidemic medicine?	Opt to orient towards the responsive strategies especially either agile and/or flexible supply chain strategies.
Are the pharmaceutical products chronic medication?	Opt for supply chain strategies oriented towards efficiency.
Does the facility to which the products are being delivered have low storage capacity (though it is easily accessible)?	Maintain the supply chain profile of the selected supply chain strategy. Check applicability of direct delivery as compared to the depot system.
Is the facility to which the products are being delivered easily accessible and its storage capacity is high?	Maintain the supply chain profile of the selected supply chain strategy. Check applicability of direct delivery as compared to the depot system.
Is facility to which the products are being delivered not easily accessible and its storage capacity is low?	Buffer the supply chain profile of the selected supply chain strategy using the nearest facility with better capacity.
Is facility to which the products are being delivered not easily accessible, though the storage capacity is high?	Opt for supply chain strategies with supply to stock/need/forecast decoupling points. Check applicability of the depot system as compared to direct delivery.

*In all other circumstances not specified, stick to the provisions of the product categorization framework.

A demonstration of the decision-making philosophy in the product categorization framework is given in the succeeding discussion.

3.2.1 Demonstration of the decision-making philosophy

It would be tedious to provide the decision approach for each of the 32 routes of the product categorization framework, therefore, for the sake of demonstrating the decision-making approach to the reader, building on the schematic tree, two representative routes will be chosen. The intention is to demonstrate the synthesis involved in the decision-making approach/philosophy hence Route 1 and Route 32 will be discussed.

❖ **Route 1:**

If the medicine schedules bundle: S0-S4, which is mostly high-volume products; with better ease of access; and a maximum repeat limit of six months as previously established, has pharmaceuticals that have a volatile demand then there is need to supply to stock or supply to need or at least supply to forecast to buffer the demand in times of uncertainties. Furthermore, since the cost to the supply chain in Route 1 is expensive then there is need to orient the supply chain towards efficiency (lean) to cut out costs and wastes. However, since the lead time is short and the life cycle is temporal, it calls for agility in responding to need with rapid replenishment to curb the risk of obsolescence due to the shortness of the lifecycle. Hence, the advantages of orienting the supply towards responsiveness (agility) are also needed facilitated by cooperation with key partners to anticipate capacity requirements. It is deemed necessary to make minimum order sizes based on the end patients' replenishment needs in order to cut down on cots to the supply chain and short time from order to market/PHCFs. Therefore, such an instance/pipeline with the conditions given in Route 1 can benefit from being leagile (both lean and agile). Thus, medicine schedules bundle: S0-S4, under these conditions, is recommended to use a fast or agile strategy with supply to forecast or supply to need/stock decoupling points respectively.

❖ **Route 32**

Under the medicine schedules bundle: S5-S8, which is mostly low-volume products; extensively regulated access; and dosage repeats that can exceed six months as previously established, if the demand is stable, cost is affordable to the supply chain and lead time is long, then there is need to opt for supply chain strategies oriented towards efficiency since there is ease of prediction/forecasting and mitigate the long time from order to the facilities. The order cycle can be oriented towards a fixed cycle or a collection schedule and it is recommended to make the resource utilization rate high or very high since the condition within Route 32 is that the cost to the supply chain is affordable and therefore is permissible. Moreover, since the lifecycle is lasting, then it is feasible to make use of high level of inventory to optimize supply efficiency. It is not highly necessary to orient such a supply pipeline towards responsiveness but rather towards efficiency. A supply to stock or a supply to forecast/need decoupling point is useful in such circumstances, corresponding to a continuous-flow or efficient strategy respectively.

Appendix E: SME input analysis questionnaire

A google form was used to present the semi-structured interview and SMEs were informed that they were regarded as experts in public healthcare and/or supply chain management and/or the Visibility Analytics Network (VAN) strategy. As such, they were kindly requested to give their input on the preliminary product categorization framework developed, to which a pre-reading document, presented in Appendix D, was provided prior to the assessment. The assessment first assessed the design requirements established and employed in the development of the product categorization framework and subsequently, the construct of the framework itself was assessed.

The responses were ranked from strongly agree to strongly disagree, so it was requested that SMEs provide the extent to which they agree with the questions posed. The assessment was postulated to take about 8 minutes.

Please provide your name and surname:

Please provide a brief description of your professional background and experience:

Please provide your frequently used email address for follow-up on responses provided:

FUNCTIONAL REQUIREMENTS [F]: Parameters

These are the parameters by which the framework provides a clear mechanism for categorizing products according to their attributes. Products should be categorized according to the established PDCL2 product attributes classification. $PDCL^2$ = Product; Demand; Cost to the supply chain; Lead time to deliver; and Life cycle.

1. Do you think the established PDCL2 product attributes taxonomy is a clear mechanism for categorizing pharmaceutical products according to their attributes?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

2. Do you think the product attributes can be practically used to categorize pharmaceuticals effectively and efficiently?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

3. Do you think the recommended approach for defining thresholds between the binary gradations for provinces in the South African public healthcare is reasonable?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

USER REQUIREMENTS [U]: Outputs

The framework must support supply planning decisions at different operational levels e.g. the national and provincial levels, by recommending an appropriate supply chain strategy for each pharmaceutical product. Each supply chain strategy, contextualized to the VAN strategy, should dictate an appropriate sourcing plan and replenishment plan based on its affiliated decoupling point. The framework must also provide a decision-making approach in special cases e.g. vaccine supply or delivery site restrictions and limited storage capacity. The framework's output, which identifies as output of a supply plan, should be usable as input to a distribution plan. The employed supply chain strategies framework, based on Perez (2013), consists of: continuous-flow; efficient; fast; custom-configured; agile; and flexible supply chain strategies.

4. Do you think the supply chain strategies employed, based on Perez (2013), i.e: continuous-flow; efficient; fast; custom-configured; agile; and flexible supply chain strategies, are appropriate?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

5. Do you think these supply chain strategies coupled with their respective decoupling points can be used effectively in a VAN-enabled public healthcare supply chain?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

6. Do you think the interpolated meanings ascribed from the generic decoupling points are reasonable for an informed push model and public healthcare service supply planning?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

7. Can the recommended supply chain strategies for each pharmaceutical product support supply planning decisions at different operational levels e.g. the national and provincial levels?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

DESIGN RESTRICTIONS [R]: Inputs

The pharmaceuticals restricted to the demand plan product portfolio which describe the Essential Medicine List (EML) should be used as input to the supply plan product categorization framework. If products are bundled based on their inherent characteristics, the medicine schedules bundles S0-S4 and S5-S8 should be used.

8. Do you think the bundling up of pharmaceutical products based on their schedules, the first bundle being S0-S4 and the second being S5-S8, is reasonable?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

9. Do you think the use of these two medicine schedules bundles to describe the two gradations of the 'product' attribute in the PDCL^2 product attributes taxonomy is reasonable?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

BOUNDARY CONDITIONS [B]: Controls

The framework's output, in the form of recommendations for managing the public healthcare pharmaceutical supply chain, must align with the principles that underpin the Visibility and Analytics Network strategy, most importantly the concept of informed push. The framework's output, in the form of recommendations for determining supply planning's sourcing and replenishment plans, must contribute to determination of supplier collaboration constraints (contracts and tenders) within the funding limitations. The framework's output, in the form of recommendations for managing the public healthcare pharmaceutical supply chain, must align with the principles that underpin the South African Constitution.

10. Do you agree with the boundary conditions which define the product categorization framework design's preferred solution space?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

ATTENTION POINTS [A]: Enablers

The framework's recommendation for managing supply chain strategies should ideally incorporate the direct delivery and depot system that are already operational in the South African public healthcare pharmaceutical supply chain.

11. Do you agree with the acknowledging of the direct delivery and depot system attention points?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

THE PRODUCT CATEGORIZATION FRAMEWORK

The design requirements are synthesized to develop the product categorization framework, based on the systems engineering input-output transformation process. The product categorization framework entails the organization of pharmaceutical products into categories according to shared attributes (the PDCL^2 product attributes) which influence the selection of an appropriate supply chain strategy and

associated decoupling point. The framework aims to enhance sustainable availability and access to medicines in the public healthcare.

12. Do you think the logic that governs the decision tree which underpins the product categorization framework is appropriate?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

13. Do you think 'the product categorization framework special cases index' is useful in aiding framework decision-making under stated special cases?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

14. Do you think the decision-making philosophy employed in the product categorization framework is reasonable?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

15. Do you think the incorporation of the product categorization framework in the context of the VAN strategy for the South African public healthcare pharmaceutical supply chain is beneficial?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

16. To what extent do you agree that the product categorization framework can be used to categorize pharmaceuticals to enhance sustainable availability of medicines in a public healthcare pharmaceutical supply chain?

Strongly agree	Agree	Neutral	Disagree	Strongly disagree
O	O	O	O	O

If you disagreed, please kindly provide some more information explaining why:

17. Are there any comments/additions/subtractions to the construct of the framework that you would like to make?

Appendix F: Product categorization framework—Case study application

By: Newton Mapowo

Foreword

This document serves as a fact sheet with data that details the description of pharmaceutical products for use within the PDCL^2 product attributes taxonomy, the Product Categorization framework as a whole and the Product Categorization framework special cases index. This information will be used to conduct a case study in conjunction with the pre-read framework document. The case study shall follow the overarching process flow of the Product Categorization framework as given in Figure 3.2 (page 14) of the pre-read document. The aim of the case study is to show the operability and applicability of the Product Categorization framework, hence three pharmaceutical products with distinct and different behaviour in the public healthcare pharmaceutical supply chain will be chosen as examples for demonstration. In the use of the PDCL^2 product attributes taxonomy, data for the product attributes e.g. cost to the supply chain data; lifecycle data; lead time data etc was not readily available and could not be used at the time of the case study. Hence, hypothetical description of the product attributes was established (informed by the public healthcare Master Procurement Catalogue (MPC)) which enable participants to determine the thresholds for gradations of these attributes e.g. stable vs volatile; expensive vs affordable etc based on the said hypothetical but practicable descriptions. Hypothetical but practicable descriptions were also given for the facilities to which the medicine can be supplied. These descriptions give an overview of the pre-existing conditions or characteristics of the selected pharmaceuticals and facilities before the Product Categorization framework can be applied to test operability and applicability.

Pharmaceutical drugs employed in the case study

Three medicines were selected for the purpose of the case study, namely: Dolutegravir 50mg x 30 tablets; Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity); and Alprostadil, 0.5mg/ml, 1ml injection. These medicines can give a clearer view of the operability and applicability of the Product Categorization framework as one is a chronic (ARV) medicine, the other is a vaccine (seasonal) medicine, and the other is a specialized psychotic medicine thus they have distinct and different behaviour in the public healthcare pharmaceutical supply chain. The distinction between the gradations of the product attributes can be distinguished as provided in Table 2.1 (page 6) of the pre-read document. A more entailing description/dataset of the selected medicines together with their characteristics within the PDCL^2 product attributes taxonomy is given in the succeeding sections.

1.1 'Product' attribute

Dolutegravir 50mg x 30 tablets is part of the Essential Medicine List (EML) in the MPC from the medicine schedules bundle S0-S4 (standard). It falls under the ARV therapeutic category and is administered in the form of tablets.

Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity) is also part of the EML from the medicine schedules bundle S0-S4 (standard). It falls under the vaccines therapeutic category and is administered in the form of an injection.

Alprostadil, 0.5mg/ml, 1ml injection is part of the EML from the medicine schedules S5-S8 (special). It falls under the psychiatric agents therapeutic group and is administered in the form of an injection.

1.2 'Demand' attribute

Volatility which entails the variation in product demand over a period of time can be determined using the standard deviation calculation. Standard deviation is the degree to which the volume varies from the average (mean) over the given period of time. Variability of the products can be determined using the variance which depicts measure of the dispersion of the data (volume) around the mean.

- If the monthly demand in volume together with percentage monthly volume change of the Dolutegravir 50mg x 30 tablets is as given below:

Month	January	February	March	April	May	June
Demand volume (units)	60 000	65 000	63 000	61 000	64 000	62 000
% monthly change		8.33%	-3.08%	-3.17%	4.92%	-3.13%

Using Excel formulae, the monthly standard deviation is 5.48% which represents the monthly volatility of the Dolutegravir 50mg x 30 tablets and the variance is 0.30% which represents the variability of the Dolutegravir 50mg x 30 tablets.

- If the monthly demand in volume together with percentage monthly volume change of the Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity) is as given below:

Month	January	February	March	April	May	June
Demand volume (units)	1500	3000	2000	6000	13000	17000
% monthly change		100.00%	-33.33%	200.00%	116.67%	30.77%

Using Excel formulae, the monthly standard deviation is 88.56% which represents the monthly volatility of the Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity) and the variance is 78.43% which represents the variability of the Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity).

- If the monthly demand in volume together with percentage monthly volume change of the Alprostadil, 0.5mg/ml, 1ml injection is as given below:

Month	January	February	March	April	May	June
Demand volume (units)	500	510	570	500	550	550
% monthly change		2.00%	11.76%	-12.28%	10.00%	0.00%

Using Excel formulae, the monthly standard deviation is 9.58% which represents the monthly volatility of the Alprostadil, 0.5mg/ml, 1ml injection and the variance is 0.92% which represents the variability of the Alprostadil, 0.5mg/ml, 1ml injection.

1.3 'Cost to the supply chain' attribute

Order line values, frequency of order lines and order line weights can be used to determine between expensive and affordable cost based on the procurement cost, holding cost, obsolescence cost and distribution cost. An order line is a part of an order on a bill which can be made up of one item or multiples of an item. The order line weight represents the number of order line items due for dispatch.

NB: *The distribution cost quoted excludes the transport cost.*

- In the procurement catalogue, if the price/unit is R60 with 15% price VAT being R9; minimum order quantity (MOQ) being 150 units; holding cost/unit = R2.10 at a facility; obsolescence cost/unit= R66; distribution cost/unit=R3 of the Dolutegravir 50mg x 30 tablets and the stated cost/MOQ compared to the expected performance benchmarked to the best practices of ISO 13485 is as given below:

	Procurement cost/MOQ	Distribution cost/MOQ	Holding cost/MOQ	**Obsolescence cost/MOQ=Total cost**
Currently	R9000	R450	R315	**R9 900**
Expected performance benchmarked to the best practices of ISO 13485	R9 000	R400	R300	**R9700**

- In the procurement catalogue, if the price/unit is R50 with 15% price VAT being R7.50; minimum order quantity (MOQ) being 100 units; holding cost/unit = R3 at a facility; obsolescence cost/unit= R58; distribution cost/unit=R5 of the Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity) and the stated cost/MOQ compared to the expected performance benchmarked to the best practices of ISO 13485 is as given below:

	Procurement cost/MOQ	Distribution cost/MOQ	Holding cost/MOQ	**Obsolescence cost/MOQ = Total cost**
Currently	R5 000	R500	R300	**R5 800**
Expected performance benchmarked to the best practices of ISO 13485	R5 000	R480	R300	**R5 780**

- In the procurement catalogue, if the price/unit is R7 000 with 15% price VAT being R1 050; minimum order quantity (MOQ) being 10 units; holding cost/unit = R2 at a facility; obsolescence cost/unit= R7 005; distribution cost/unit=R3 of the Alprostadil, 0.5mg/ml, 1ml injection and the stated cost/MOQ compared to the expected performance benchmarked to the best practices of ISO 13485 is as given below.

	Procurement cost/MOQ	Distribution cost/MOQ	Holding cost/MOQ	**Obsolescence cost/MOQ = Total cost**
Currently	R70 000	R30	R20	**R70 050**
Expected performance benchmarked to the best practices of ISO 13485	R60 000	R25	R15	**R60 040**

1.4 'Lead time to deliver' attribute

Pharmaceutical products that cannot be sourced nor replenished rapidly based on the supply cycle time, supply takt time and time service levels can constitute the long lead time, while the opposite is true for a short lead time. The Master Procurement Catalogue (MPC) usually provides the lead times to deliver for each product based on tenders, contracts and distribution plans. Therefore, each pharmaceutical product can be benchmarked against the median (quantity lying at the midpoint of a frequency distribution values) lead time of the rest of the products in the MPC.

- Consider that the Dolutegravir 50mg x 30 tablets has a lead time to deliver of 21 days and the median lead time of the rest of the products in the MPC is 14 days.
- Consider that the Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity) has a lead time of 7 days and the median lead time of the rest of the products in the MPC is 14 days.
- Consider that the Alprostadil, 0.5mg/ml, 1ml injection has a lead time to deliver of 10 days and the median lead time of the rest of the products in the MPC is 14 days.

1.5 'Lifecycle' attribute

Products that require a short end-to-end pipeline, rapid time to market and have short shelf life and life time can be considered to have a temporal life cycle, with the opposite being true for a lasting life cycle.

- Consider that the Dolutegravir 50mg x 30 tablets has an expiry date (lifetime) of 24 months from manufacture date and does not require a short end-to-end pipeline and rapid time to market.
- Consider that the Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity) has a shelf life of 12 months at 2 - 8°C and would require a short end-to-end pipeline and rapid time to market.

- Consider that the Alprostadil, 0.5mg/ml, 1ml injection has a shelf life of 12 months and would not require a short end-to-end pipeline and rapid time to market.

Please indicate the gradations of the described medicines as per the PDCL[2] product attributes taxonomy using an (x).

Medicine	Product		Demand		Cost to supply chain		Lead time		Lifecycle	
	S0-S4	*S5-S8*	*Volatile*	*Stable*	*Expensive*	*Affordable*	*Short*	*Long*	*Temporal*	*Lasting*
Dolutegravir 50mg x 30 tablets										
Vaccine: Influenza (inactivated) injection (0.5ml prefilled syringe antigenicity)										
Alprostadil, 0.5mg/ml, 1ml injection										

After determining the gradations of the PDCL[2] product attributes taxonomy, follow the overarching process flow of the Product Categorization framework as given in Figure 3.2 (page 14) of the pre-read document. Examine the supply chain profile recommended for each respective route of the medicines in question.

The conditions at the facilities to which the medicines are to be supplied are:

- Facility A: A district hospital with low storage capacity (though it is easily accessible).
- Facility B: A district hospital with high capacity and easily accessible.
- Facility C: A remote clinic not easily accessible, though the storage capacity is high.
- Facility D: A remote clinic not easily accessible and the storage capacity is low.

Questions:

3. Do you think the use of the Product categorization Framework and its tools is robust and sustainable for the South African public healthcare pharmaceutical supply chain in the context of the VAN supply planning?

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

4. Do you think the use of the Product categorization Framework and its tools is beneficial in enhancing sustainable availability of medicines in the South African public healthcare pharmaceutical supply chain in the context of the VAN supply planning?

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

Participant's name: …… Date:…../……/…