Evaluating packaging system performance and sourcing strategies of flexible packaging material in inbound supply, combined with the total cost of ownership impact analysis: A case study

by
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Research presented in fulfilment of the requirements for the degree of Masters of Commerce (Logistics Management) in the Faculty of Economic and Management Sciences at Stellenbosch University

Pectora roborant cultus recti

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December 2019

Declaration

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December 2019

Abstract

Packaging contributes to product value as it protects, markets and extends the life of the content of the product. Packaging is manufactured in all shapes and sizes and from various materials, with one of the main material types being polyethylene. Polyethylene forms part of the flexible packaging sector, and is a material, which requires specialist sourcing strategies. This study sets out to determine the packaging system performance and sourcing strategies of polyethylene at a case study company. The study further utilised the total cost of ownership model to consider the business impact of the recommendations from the study. Previous research failed to address both measurements and mainly considered sourcing or packaging system performance as a singular measurement.

Polyethylene contributes 70% of the material spend at the case study company. This, among other things, led to the need to understand and evaluate the current packaging system performance and sourcing strategies. There was a further need to develop implementable recommendations for the single-case study. Quantitative data and qualitative data was obtained through semi-structured interviews for the required input to the identified models. By using the packaging scorecard, the study was able to determine that the scorecard criterion of “stackabilty” was the worst performing criterion in the supply chain. The strategic sourcing investigation, using the Kraljic model, identified polyethylene as a “strategic product” and one which requires a “diversified sourcing strategy” to reduce its cost.

These findings were tested with the total cost of ownership model. The results indicated a total cost decrease when the stackability inefficiency is addressed by allowing polyethylene rolls to be double-stacked. The total cost of ownership model further illustrated a material spend decrease if the company considers polyethylene a strategic product and implements the recommended diversification sourcing strategy. Although the results of this study are only relevant for the case study company, this hybrid combination of approaches provide a holistic evaluation of a sourced commodity and some new supply chain insights (not necessarily possible by applying only the approach in isolation). The study recommends further exploration of the improvement potential of this hybrid approach as applied to multiple cases (supporting decision-making).

Opsomming

Verpakking dra by tot die waarde van `n produk deur die produk te beskerm en te bemark en die lewensduur van die produk te verleng. Verpakking word in alle vorme en groottes geproduseer en word van verskillende soorte materiaal gemaak. Een van die belangrikste soorte materiaal is poliëtileen. Poliëtileen maak deel uit van die sektor vir buigsame verpakking en is `n wispelturige materiaal wat gespesialiseerde verkrygingstrategieë vereis. Die studie het ten doel gehad om die prestasie van ŉ verpakkingstelsel en die verkrygingstrategie van poliëtileen by `n gevallestudie maatskappy te bepaal. Die studie het verder ook die totale totale koste van eienaarskap-model gebruik om die besigheids impak van die studie se aanbevelings te oorweeg. Vorige navorsing het nagelaat om beide metings gelyktydig te ondersoek en het hoofsaaklik verkryging of verpakkingsprestasie afsonderlik gemeet.

Poliëtileen is verantwoordelik vir 70% van die gevallestudiemaatskappy se materiaalkoste. Dit het aanleiding gegee tot die behoefte om die prestasie van die bestaande verpakkingstelsel en verkrygingstrategie te verstaan en te evalueer. Daar was `n verdere behoefte om implementeerbare aanbevelings vir die enkele gevallestudie te ontwikkel. Kwantitatiewe data en kwalitatiewe data is met behulp van semi-gestruktureerde onderhoude ingesamel vir die nodige insette tot die geïdentifiseerde modelle. Met behulp van die verpakkingstelkaart het die studie bepaal dat die telkaartkriterium van “stapelbaarheid” die maatstaf in die voorsieningkettingbestuur is wat die swakste presteer. Die strategiese verkrygingsondersoek, met behulp van die Kraljic-model, het poliëtileen geïdentifiseer as `n “strategiese produk” en een wat `n “gediversifiseerde verkrygingstrategie” benodig om die koste daarvan te verminder.

Hierdie aanbevelings is met behulp van die totale koste van eienaarskap-model getoets. Die resultate het `n kostevermindering aangetoon wanneer aan die ondoeltreffendheid van opstapeling aandag gegee word deur aan te beveel dat poliëtileenrolle dubbel gestapel word. Die totale koste van eienaarskap-model het verder `n kostevermindering van materiaal aangedui indien die maatskappy poliëtileen as `n strategiese produk beskou, en die gediversifiseerde verkrygingstrategie implementeer. Alhoewel die resultate van die studie net vir hierdie gevallestudiemaatskappy relevant is, voorsien die hibriede kombinasie van benaderings `n holistiese evaluering van ‘n verkrygde kommoditeit, en sommige nuwe voorsieningskettingbestuur-insigte (nie noodwendig moontlik deur die benadering slegs afsonderlik toe te pas nie). Die studie beveel verdere ondersoek na die verbeteringspotensiaal van die hibriede benadering, soos in verskillende gevalle toegepas (ondersteun besluitneming).

Acknowledgements

I would first like to thank and honour God for providing me with this opportunity. He gave me the necessary strength and determination to complete this thesis. This was pure undeserved grace.

I would like to thank my thesis supervisors Prof. Johan Louw and Me. Anneke de Bod of Stellenbosch University's Logistics Department. Their Skype lines were always open and provided expert guidance during my studies. Their knowledge of supply chain literature is significant and their willingness to share this knowledge unmatched.

To my amazing wife, Anél, thank you for allowing me to dream and providing me with the time to complete my studies. You have been a rock and your words of wisdom and encouragement has been so valuable. I appreciate all your support from proof reading, style editing to making the best rooibos tea.

To my sister, Marleen, thank you for being my unofficial editor and my academic voice of reason. Your countless points and suggestions helped me immensely and had a big contribution to the final product.

I would like to thank my parents, Martin and Hesta, for their unconditional love and support. Thank you for allowing me to be curious and providing the platform which allowed me to further my studies.

To my parents in law, Jan and Esther, thanks for your support and words of encouragement.

Finally, thanks to all my friends and family for their positive influence on my life and supporting me through this journey.

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List of acronyms and abbreviations

CEO	chief executive officer
CIPS	Chartered Institute of Procurement and Supply
EU	European Union
EVOH	ethylene vinyl alcohol copolymer
FG	finished goods
GDP	gross domestic product
HDPE	high-density polyethylene
ICFPA	International Council of Forest and Paper Associations
ISO	International Organisation for Standardisation
IT	information technology
KPI	key performance indicators
LCA	life-cycle assessment
LDPE	low-density polyethylene
LLDPE	linear low-density polyethylene
MWV	MeadWestvaco Corporation
NPO	non-profit organisation
NWASS	Normalised Weighted Average Satisfaction Score
OECD	Organisation for Economic Co-operation and Development
OTIF	on time and in full
PET	polyethylene terephthalate
PP	polypropylene
PPA	purchasing portfolio analysis
PPEM	packaging portfolio evaluation model
PS	polystyrene
PVC	polyvinyl chloride
RFQ	request for quote

ROI	return on investment
RQ	research questions
SLA	service-level agreements
SPA	sourcing portfolio analysis
SPAA	Sustainable Packaging Alliance of Australia
SPI	Society of Plastics Industry
SWOT	strength, weakness, opportunities, threats
TCO	total cost of ownership
ULDPE	ultra low-density polyethylene
VLDPE	very low-density polyethylene

Chapter 1
Introduction

1.1 Introduction and background

Packaging fulfils an important role in any supply chain as it supports the distribution and product information sharing activities. It is difficult to imagine the transportation of yogurt or electronic products without packaging. The need for packaging originated with human civilisation as products, such as water and fish, had to be transported and stored (Nilsson, 2016:280). Packaging and its functions are important to most products, and can be found in various shapes and sizes. It has six primary functions, namely containment, protection, apportionment, unitisation, convenience, and communication (Lockamy, 1995:52). These functions enable various companies and the public to operate on a daily basis.

Olsmats and Dominic (2003:9) refer to packaging as a system that adds value to a supply chain, and which acts as a key ingredient to the success of a business. This packaging system consists of three types of packaging, namely primary, secondary and tertiary (see **Section 2.1**). There are different types of material, which fulfil the primary functions of packaging, namely paper, glass, metal and plastic. These substrates are available globally and have evolved over time. Every one of the substrates has its own advantages and disadvantages and, depending on the application, the correct material type needs to be sourced and its performance in the supply chain evaluated (Cela & Kaneko, 2011:836).

There are various packaging system performance measurement models, which enable the evaluation of packaging system performance. Examples are the level of customer satisfaction (Kazanjian, 2013:82) and the cost of packaging as well as its value-adding ability (Hellström & Saghir, 2007:213). However, Olsmats and Dominic (2003:9) found that there is a need for a holistic approach when measuring packaging system performance due to the increased complexity in supply chains. This resulted in the development of a holistic packaging performance scorecard where the applicability of the criteria at each supply chain interface point is tested, indicated and its performance measured.

In addition to packaging system performance evaluation, the strategic sourcing of packaging should also be effective and efficient. 'Sourcing', in this study, refers to the process through which companies acquire resources from suppliers, which enables them to execute their operations and services (Wang, Webster & Zhang, 2010:310). 'Sourcing' can also be strategic, where strategic sourcing encourages companies to make supply management decisions with the purpose of creating distinctive value and a competitive advantage for a company and not merely be seen as a purchasing function (Ketchen, Crook & Craighead, 2014:165). Schneller (2010:22) further emphasises the outcome of strategic sourcing as a supply chain process, which manages risk and reduces cost.

When a company implements strategic sourcing, different possible strategies must be identified and evaluated. These strategies can be identified by using a sourcing methodology, such as purchasing portfolio analysis (Kraljic, 1983:110). As Gelderman and Van Weele (2002:30) state, the general aim of a purchasing portfolio analysis (PPA) is to develop and implement differentiated purchasing strategies. After considering various strategic sourcing strategies, a company is able to evaluate which one best fits in with its vision and business strategy, and then implements it in its business. Part of this evaluation is the understanding of the market within which the company operates. As the current study focused on the packaging industry, the evaluation of the packaging market was essential.

The global packaging sector is one of the fastest growing sectors in the manufacturing industry. It had a predicted global value of $770.5 billion in 2020, which illustrates the substantial growth in this sector, as the value was only $440 billion in 2006 (Economy Watch, 2010). The total value of the packaging industry in South Africa was estimated at $3.1 billion in 2012, which contributed 1.5% to the South African gross domestic product (GDP) (Mpact, 2019) and $4.96 billion (or 1.4%) in 2018 (Jhetam, 2019). These statistics emphasise the relevance and impact of packaging on the everyday life of global citizens.

To enhance this study further, a single-case study was used for this research, as recommended by Yin (2014:4). Due to the sensitivity of the research, the company in this study will be referred to as Poligistics. Poligistics is a privately-owned company, which produces packaging products in South Africa. The company started producing packaging material in the 1980s, supplying the South African market and later globally (Europe, Australasia and Asia). The company first produced dunnage bags, which led to the manufacturing of liquid liner bags and dry bags. The company currently (June 2019) produces between 15 000 and 30 000 liquid liner bags per month, comprising four types of bags, which vary in complexity. The liquid liner bags consist of various raw materials, with the largest component being polyethylene.

Due to the expected growth in the packaging industry, and in particular the plastics packaging industry, the purpose of this study was to investigate the packaging system performance and sourcing strategy of polyethylene at Poligistics. Polyethylene is the main raw material in liquid liner bags, and an important part of the company’s value chain; thus, Poligistics wants to ensure that it is viewed as such. To ensure this, the current research set out to investigate both concepts and to evaluate possible recommended practices through the total cost of ownership (TCO) model resulting in implementable recommendations.

1.2 Significance and motivation

The global plastic packaging market is expected to demonstrate growth over the next couple of years with an estimated market revenue of $375 billion in 2020 (Embree, 2016). Due to the likely growth of the middle class, there will be an increased demand for packaged consumer goods, such as beverages and processed foods, which will increase the demand for plastic packaging (liquid liners) produced from polyethylene (Lucintel, 2013; Smithers Pira, 2018).

The global development in strength and flexibility of polyethylene, as well as the movement from rigid packaging to flexible packaging, will lead to a greater demand for flexible material (Embree, 2016). This growth is expected to continue with an estimated annual growth rate of 4.3% until 2022 (Smithers Pira, 2018). In South Africa, there is similar growth potential with the plastics industry contributing 0.7% to the South African GDP in 2015 (BMi Research, 2016:124–136) whilst flexible packaging contributed 56.5% of the total market value. The growth in consumer packaging items will result in a higher demand for plastic raw materials. As Embree (2016) highlights, a key threat to the industry is the cost of raw material and the volatility associated with it. In order for Poligistics to position itself for this growth and demand, it is essential that the company understand how its packaging is performing and how polyethylene is being sourced.

McDonald (2016:209) argues that, when considering packaging, the packaging is symbiotically linked with the supply chain of a company. Saghir (2004) refers to this relationship as packaging logistics, which focuses on the synergies attained through the integration of the packaging as well as logistics systems. Hellström and Saghir (2007:199) found that supply chain effectiveness is affected by packaging as the latter represents an interface between the supply chain and the end user. The authors argue that packaging has a direct impact on lead times and delivery performance. Therefore, investigation of packaging system performance and its consequent improvement could lead to an increase in supply chain effectiveness for Poligistics.

Equally as important as polyethylene packaging system performance, is the sourcing of polyethylene. Manufacturing firms spend almost 50% (Arnold, Chapman & Clive, 2008:191) of their revenue on the purchasing of raw material while the Chartered Institute of Procurement and Supply (CIPS) believes it to be approximately 66% (CIPS, 2017). For Poligistics, polyethylene contributes 70% of the raw material cost of a liquid liner bag, which emphasises the importance of its sourcing activity, as liquid liner bags are its biggest cost-driving product. The correct strategic sourcing strategy can thus have a significant influence on the raw material cost spend of Poligistics.

While researching these two concepts, the researcher searched in various literature repositories for example EBSCOhost and Research Gate (through the Stellenbosch University Library), using key words. Two of these key words were ‘packaging system performance’ and ‘strategic sourcing’. This search returned limited results for books containing these titles, whilst the result for peer-reviewed articles was 24 065. These results however did not combine the two concepts in a single study, but rather discussed each concept individually, as seen in Hellström and Saghir (2007:197), Lockamy (1995:51), Hesping and Schiele (2016:101) and Kausik and Mahadevan (2012:78). Non-peered-review work provided similar results with these topics being discussed as independent research fields and not as combined in one study (Emmanson's Blog, 2010; Packaging Digest, 2019). The current study consequently found its significance in the limited studies available on packaging system performance and sourcing strategies in the South African packaging industry. The combination of packaging logistics (a relatively recent research field with the first literature provided by Lockamy [1995:51]) and strategic sourcing, an established research field, provided valuable insight into the subject field.

The study set out to add value to packaging literature as it not only considered packaging system performance or sourcing individually, but also investigated both fields of study simultaneously. The study further evaluated the impact of these concepts through the TCO model (see Ellram, 1995:10), which is described as a suitable model to drive major process changes. The study utilised a case study approach (see Yin, 2014:4), which gives the reader insight into the practical application of utilising both fields of study when investigating packaging.

1.3 Problem statement

As found in the current study, for Poligistics, polyethylene contributes 70% to the raw material cost of a liquid liner bag. This results in polyethylene being its single biggest raw material expenditure for the company. Poligistics wants to benefit from the expected growth in the packaging industry and the liquid liner industry. Therefore, the company questions whether it is viewing the packaging system performance and the sourcing of polyethylene strategically in the business.

Over-expenditure on polyethylene due to poor packaging quality or inadequate sourcing strategies negatively affects Poligistics directly. This has, therefore, led to the research problem identified in this study, namely to investigate and evaluate the packaging system performance and sourcing strategies used by Poligistics in terms of its main raw material component, polyethylene.

1.4 Research questions

This section lists the research questions (RQ) that were identified by the study and which formed the basis of the study.

- RQ1: To what extent is packaging system performance measured at Poligistics, and how is packaging performing based on criteria and set methods?
- RQ2: What is the current sourcing situation at Poligistics, and which sourcing strategy could enhance the sourcing of polyethylene?
- RQ3: What effect would an improved packaging system performance and appropriate sourcing strategy have on the total cost of ownership of polyethylene?

RQ4: Which recommended practices from packaging system, sourcing and TCO could be utilised by Poligistics to improve its current operation?

1.5 Research design and methodology

This study applied the research design and methodology as described by Saunders, Lewis and Thornhill (2009). This approach considers six perspectives in the research methodology and design process, namely philosophical stances, approaches, strategies, choices, time horizons and techniques. This section briefly describes the research design and methodology used by this study, whilst a detailed discussion follows in **Chapter 3**.

As this research study set out to investigate and evaluate the packaging system performance and sourcing strategies of polyethylene at Poligistics, it used the deductive research approach, which is based on existing theory (see Babbie, 2010:52). Deductive research is further described as starting with an expected pattern, which is then tested against observations (Babbie, 2010:52; Wilson, 2010:2–6). This approach was fitting for the objectives of this study, as the researcher utilised existing theories with expected patterns and tested the data through various observations.

A case study approach was chosen as strategy for this study as it allowed the researcher to focus on a specific case, and gave him the opportunity to conduct an in-depth investigation into the problem identified in this research (Rule & John, 2011:4; Yin, 2014:4). The case study approach further added value to the study as a limited amount of literature was available regarding the liquid liner industry, and by focusing on a case study, the researcher was able to explore a real-life bounded system (Creswell, 2013:73).

When considering the research methods of this study, the researcher considered the three principles of research design, namely empirical or non-empirical research, type of data used during the study, and the data source types (Babbie, 2010:92–94). Based on these principles, this study was defined as an empirical study, and therefore qualitative and quantitative research methods were used to investigate the packaging system performance and sourcing strategies of polyethylene. Numeric data is referred to as ‘quantitative data’ while textual data is referred to as ‘qualitative data’ and when both sources are used in one study, it is referred to as a mixed methods approach. This study utilised both data types as it required the gathering of data by using scientific models, as well as textual data (Alavi & Habek, 2016:62–63; Babbie, 2010:92–94).

The time horizon of this study was cross-sectional in nature as it only took a snapshot of the packaging system performance and sourcing strategy at Poligistics and did not observe these functions over an extended period. It further also gathered information from various subjects during the study and not repeatedly from the same subjects (Cherry, 2018).

1.6 Outline of the chapters

Chapter 1 provided an introduction to this thesis, and to the aim and motivation as well as the significance of the study. It further defined the problem statement of Poligistics and stated the four research questions. The chapter provided a brief background to the research design and methodology, and concludes with an outline of the remaining research document.

Chapter 2 consists of a literature review, which provides in-depth background to the main concepts of packaging system performance, sourcing and TCO. The packaging section describes the packaging functions and provides background to the four types of packaging material. This background comprises history of the material, its market overview as well as sustainability. Following this, packaging system performance including the packaging scorecard is discussed. After establishing the background to packaging, sourcing is comprehensively discussed.

Sourcing refers to background to strategic sourcing and PPA, which includes a detailed discussion of the Kraljic model. The section concludes with a discussion on various sourcing strategies. The penultimate section of **Chapter 2** provides background to TCO and how it can be utilised by decision-makers in a company. The model is discussed in detail with the TCO tree providing background to the various TCO elements. The chapter ends with a summary of all the conclusions based on the literature review.

Chapter 3 describes in detail the research design and methodology of the study. It discusses the research approach and research design with background to the research variables and unit of analysis of the study. It further describes the research methodology and how the data sampling was conducted as well as how the study aimed to provide reliable and valid data. It further discusses the limitations of the study and how the researcher gathered the necessary data to answer the research questions.

Chapter 4 contains the analysis and synthesis of the study and describes how the data was gathered and coded to answer the research questions. It provides background to Poligistics and the liquid liner industry, and starts to answer each research question. The findings of each research question are presented, and provide the necessary background to the conclusion and recommendations.

The final chapter (**Chapter 5**) contains the conclusion as well as recommendations of the study. The researcher brings to a close the literature review and the discussion of the methodology according to the major concepts discussed in the study, namely packaging system performance, sourcing and TCO. The researcher then ends the discussion on the various research questions before finally listing the recommendations in terms of the topic and possibilities for further research.

Chapter 2
Literature review

In the previous chapter, the research topic was introduced, and the aim and motivation for investigating this topic were discussed. **Chapter 2** focuses on providing in-depth background to the research topic. The chapter discusses packaging in detail, including the relevant types, performance measurements and sustainability factors. The chapter further discusses background to sourcing, the strategic importance of sourcing, and the various sourcing strategies as well as the TCO model. The chapter concludes with a summary of the conclusions based on the literature.

2.1 Packaging and the role of packaging in the supply chain

The global packaging market was valued at $589.9 billion in 2015 with a predicted total value of $770.5 billion in 2020 (Economy Watch, 2010; Technavio, 2019). This illustrates the growth in the sector and emphasises the relevance and impact of packaging on the everyday life of global citizens. In 2012, the South African packaging industry was worth $3.1 billion (Mpact, 2019), growing to $4.96 billion by 2018 (Jhetam, 2019). This resembles 60% growth in six years at an average of 10% per year. This data shows the growth in the packaging industry, but it is important to understand what this involves. Therefore, this section discusses the concept of packaging in detail.

Packaging can be described as a container which is in contact with the product itself (Ampuero & Vila, 2006:101), and can also be referred to as building-blocks where a small unit is placed within a larger unit (Murphy & Wood, 2011:215). Olsmats and Dominic (2003:9) refer to packaging as a system that adds value to a supply chain and which acts as a key ingredient to the success of a business. This packaging system adds value through marketing and logistics as well as by reducing the environmental impact of a business (Olsmats & Dominic, 2003:9). The environmental impact of a business can be reduced through improved packaging systems, which lessens the need for the use of packaging raw material or the recycling of eligible raw material.

The packaging system can be defined at three levels, namely primary, secondary and tertiary packaging. These three levels of packaging usually function in a complementary sense (Murphy & Wood, 2011:215). **Primary** packaging is in direct contact with the product, such as the can containing a soft drink. **Secondary** packaging may contain a couple of primary packages, and acts as a protective and informative barrier. Continuing with the soft drink analogy, this would be the polyethylene layer on the outside of a six-pack of soft drinks. **Tertiary** packaging acts as a further protection barrier as well as aiding the distribution of the product. This will therefore be the polyethylene layer holding four six-packs together (Ampuero & Vila, 2006:101). After establishing the packaging concept, the next section describes the various functions of packaging.

2.1.1 Packaging functions

Even though packaging plays an integral part in any product, it is often viewed as dispensable or readily available (Berger, 2005). Lockamy (1995:52) similarly states that packaging is often seen as a non-value-added cost with little strategic value. This should not be the case, as packaging plays a vital role in various industries, such as manufacturing, retail and agriculture. Packaging has several functions in these industries, and fulfils various needs (Lockamy, 1995:52). These functions include containment, protection, transport, facilitation and marketing.

Containment refers to the packaging's ability to contain a substance and, which forces the consumer to buy a certain amount or weight. Packaging protection refers to the ability of the packaging to act as a defensive line against contamination, theft and environmental damage. It simplifies transportation and facilitation through practical and comfortable designs, which ease handling. Packaging further carries colourful designs, which attract consumers and give them the necessary product information (Berger, 2005; Trending Packaging, 2015).

These different functions may sometimes come into conflict with each other. For instance, the need for the marketing of a new and innovative product could be in conflict with the practicality of transporting the product in a cost-efficient manner from the manufacturer to the distributor (Murphy & Wood, 2011:216). Lockamy (1995:51) states that traditionally, packaging had a primary function of protecting goods while it also served as a communication platform to consumers. It then developed as a marketing tool, through the development of printing technology, and in some instances, the traditional characteristics (i.e. protection and containment) were seen as secondary attributes. Lockamy (1995:51) further argues that the role of packaging is constantly expanding due to increased costs, improved packaging technology and enhanced environmental regulations. The expanding ability and packaging system performance are discussed in greater detail in **Section 2.1.3** while the following section will discuss the various types of packaging material and their history, the market overview and sustainability options.

2.1.2 Types of packaging material

Different types of packaging materials exist, such as paper, glass, metal and plastic. Each packaging substrate has its own unique characteristics with its own advantages and disadvantages. The different types of packaging material are discussed in more detail in the sub-sections below. These sub-sections describe the history of the packaging material type, providing its background and its function. The sub-sections further describe the market conditions globally as well as in South Africa, as well as the sustainability of the packaging material type. Sustainability has become a focus point for the packaging industry in recent years, and thus forms part of the background of this study.

2.1.2.1 Paper

The sub-section below provides background information about the history of paper and how it has evolved over time. It further discusses market conditions for the paper industry globally as well as in South Africa. The section concludes with a discussion of paper and its impact on sustainability.

a. History of paper

Papyrus is a plant that used to be readily available in Egypt (3000 BC) and was used to produce a thick, paper-type material. This is also where the word ‘paper’ originated (Packaging SA, 2017b). Berger (2005) states that the first country to produce paper in its current form was China. The Chinese used mulberry bark to wrap foods, and they were also responsible for developing and improving paper-making techniques. Paper making started in England in 1310, and was introduced to the American market in 1690, in Pennsylvania (Berger, 2005).

Paper was originally produced using cellulose fibres that were derived from flax, which is the same fibre that produces cloth. This became too expensive, and the process of producing cellulose fibre from wood pulp started. The first big stepping stone for commercialised paper packaging came in the form of paper bags, which were produced in 1844 (Berger, 2005). With the industrialisation of paper, the process of producing paper was standardised to three distinct steps, namely the growing or harvesting of material, pulping, and the final stage of conversion (PackagingSA. 2017b).

As stated above, cellulose fibre is produced from wood pulp. The two main sources of wood pulp are hardwood (gum trees) and softwood (pine trees) (PackagingSA, 2017b). Pulping refers to the removal of bark from wood. In the pulping process, the wood fibres are separated and refined, resulting in the pulp moving through rotating discs on machinery, which intertwines the fibres to create strong bonds. After the refining process, the pulp is converted by a paper, board or tissue machine, which creates a continuous, identical sheet of paper, board or tissue (PackagingSA, 2017b).

Through the development of paper, paperboard was developed in 1817 (Berger, 2005). **Paperboard** is the type of paper used to package a box of cereal, for instance. The Kellogg brothers were the first to use paperboard cartons in Michigan (Berger, 2005). Nowadays, paperboard is also used for products like milk cartons, shoeboxes and frozen food packaging (American Forest & Paper Association [AF&PA], 2017). Cardboard was developed in the 1850s (Berger, 2005) and its strength, lightness and low cost resulted in it being very useful for the shipping and storing market. **Cardboard** is made out of thin sheets of paperboard, which are moulded into a wavy shape and then glued between two flat sheets of paperboard. In today’s packaging industry, this is referred to as C-flute corrugated paperboard, and is commonly used to produce boxes (Berger, 2005).

b. *Market overview*

Several companies have tried to move away from paper and paperboard packaging with the main contributing factor being the development of flexible plastic packaging in the 1970–1980s (Berger, 2005). In 2006, paper and paperboard packaging accounted for 39% of the total packaging industry in the European Union (EU). This made paper the biggest contributor to the packaging market (Cela & Kaneko, 2011:836). The European Union consists of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom (Organisation for Economic Co-operation and Development [OECD], 2017).

In 2015, the South African paper and board packaging industry produced a total of 1 123 000 tons of product, which represents an increase of 2.5% from 2014. Of this total, 70.4% of product was contributed by the corrugated sector with carton board a distant second with 13.4%. In 2015, the industry contributed 0.5% to the South African GDP. Growth in this industry can be attributed to growth in end use markets, such as fruit and vegetables, and especially the corrugated sector is expected to grow on a yearly basis in the medium term (BMi Research, 2016:111–123).

c. Sustainability

Paper has a significant benefit in its recycling ability and, as the International Council of Forest and Paper Association (ICFPA) states (see ICFPA, 2019), paper recycling benefits are economic, environmental and social aspects (PackagingSA, 2017a). In 2015, the global paper recycling rate was 58% (CEPI, 2015) and with the estimated maximum attainable percentage being 75%, as certain paper products (books and archived documents) are kept for long periods. Other paper products are contaminated (e.g. cigarette paper), which also does not form part of recycling. Paper products can be recycled between five and seven times in their lifespan with the focus on the application of the product. The recycling of paper reduces the pressure on landfill and the energy consumption of processing plants as the steam created by the recycling process fuels the processing plant (PackagingSA, 2017a). All these factors increase the likelihood of the consumer continuing to support paper packaging.

2.1.2.2 Glass

This section discusses the history of glass, as well as the market factors influencing the glass industry. The section concludes with a discussion on the sustainability of glass.

a. History of glass

Glass-making began around 7000 BC as a different form of pottery, using limestone, soda, sand and silica (Berger, 2005). The ingredients were mixed together while they were hot, which resulted in the glass material. The first industrial production of glass occurred in Egypt 1500 BC, resulting in the rapid development of glass production. Different colours were easy to make, but only at the start of the Christian era did the first transparent glass make its appearance (Berger, 2005).

As with other packaging materials, glass only became affordable when the economies of scale were achieved through high production quantities (Berger, 2005). The first automatic rotary bottle-making machine was patented by Owens in 1889 (Berger, 2005). In the modern era, a bottle-making machine automatically produces 20 000 bottles per day. Glass bottles dominated the liquids packaging market in the 1900s – until the 1970s when the advantages of metal and plastic packaging gained popularity. Glass forms part of the rigid packaging family and is currently especially used when the aromas or flavours of the product needs to be protected (Berger, 2005).

b. Market overview

The industry currently comprises five main sectors, namely flat glass, container glass and domestic glass as well as continuous filament glass fibre and special glass. **Flat** glass is used in buildings (as windows) and the automotive industry (as windscreens). It is further used for solar-energy applications and in household furniture. **Container** glass is used in consumer products, such as food packaging, while **continuous filament glass fibre** is mainly used for the reinforcement of thermosetting and thermoplastic resins. This material is also known as **fibre-reinforced polymers** (see Wintour, 2015) where it is used in the transportation sector (airplanes). Drinking glasses, bowls and glass cookware are part of the *domestic* glass sector while the **special glass** sector consists of laboratory glassware, heat-resistant glass and extra thin glass for the electronics industry (Wintour, 2015).

Over 90% of glass products are sold to other industries, which underlines the dependability of the glass manufacturing industry on the building, automotive and food industries (Wintour, 2015). The global flat glass demand in 2009 was approximately 52 million tonnes (€22 billion) with China making out 50% of this demand (Wintour, 2015). Europe had the second highest flat glass demand with 16% (Wintour, 2015). The flat glass industry is capital-intensive with the estimated costs of setting up a flat glass manufacturing plant in 2010, between €70 million and €200 million. The Asia-Pacific region has the highest demand for container glass with 37% and Europe with 33% (Wintour, 2015). This sector had a value of $47.43 billion in 2012, and is expected to grow to $59.94 billion in 2019 (Wintour, 2015).

In 2015, the glass manufacturing industry contributed 0.2% to the South African GDP (BMi Research, 2016:152). This is a total market value of R6 785 million and a total tonnage of 923 000 tons. This was a 1.8% increase in volume from 2014, which reflects the challenges in the glass industry with competition from cans (metal) and rigid plastics (BMi Research, 2016:156). Domestic glass sector comprises the biggest sector in the glass manufacturing industry in South Africa. This demand is driven by all beverages and the wine industry as well as the food industry (BMi Research, 2016:148–156).

c. Sustainability

Glass has the highest recyclability rate from the four main packaging raw materials. Glass can be recycled an unlimited amount of times without losing its clarity or purity. Every one ton of glass that gets recycled, prevents the quarrying of 1.2 tons of raw materials (TGRC, 2018). This leads to a reduction in the costs of raw material, but also a smaller carbon footprint in terms of glass manufacturing due to a reduction in carbon dioxide gas release. Making new glass from recycled glass uses less energy and the energy saving from recycling one bottle will power a computer for 25 minutes (TGRC, 2018).

2.1.2.3 Metals

This section first describes the history of metal and how it has been transformed over centuries. Following this, the metal market is discussed as well as the sustainability factors of the metal industry.

a. History of metals

Modern metal packaging received its first breakthrough at the end of the eighteenth century and beginning of the nineteenth century. Various events led to this breakthrough with the first being the development of cheap and functional materials. An example of such a material is tin plate, which is produced from sheet iron. Germany was the first developer and user of tin plate, which was developed on a commercial scale in Wales through the development of the hot roll method (Hansen & Serin, 1999:309).

The second event occurred when Napoleon launched a competition regarding the preservation of food during war periods while also simplifying the transport of food (Hansen & Serin, 1999:310). The solution was the tin can as it was unbreakable, light and also non-toxic. At that stage, the tin can was a luxury item and only used by the military and luxury markets. However due to industrialisation and urbanisation it became more difficult to obtain fresh food and people had to buy preserved food, comprising the third event, which resulted in the need for a mass market (Hansen & Serin, 1999:310).

b. Market overview

The demand in the goods and beverage industry resulted in substantial growth for the metal packaging industry. The global market for metal packaging is projected to reach $135.69 billion by 2020 (Markets and Markets, 2017) and $150 billion by 2026 (Transparency Market Research, 2017). In 2015, the North American region made up a total of 34.4% of the total global market share in value terms, but countries, such as China and India, are estimated to show higher growth rates from 2015 to 2020 due to the higher level of urbanisation in these countries (Markets and Markets, 2017). Urbanisation led to an increase in the demand for packaged food, aerosol products and an increase in canned vegetables and foods. This coupled with the growth of the pharmaceutical and cosmetics industry will ensure that the metal packaging industry will see global growth until 2020 (Markets and Markets, 2017).

The South African metal industry currently have two main local suppliers with one company focusing on tin plate and cold rolled steel, while the other focuses on aluminium (BMi Research, 2016:137). In 2015, the industry contributed 0.2% to the South African GDP, while the industry produced a total of 249 220 tons of metal with a value of R6 035 million in the same year. The industry can be divided into three sectors, namely cans, closures and drums. **Cans** are the biggest contributor to the metal market (**Figure 2.1**) with a 76% market share, while **closures** (8%) and **drums** (16%) only account for the other 24% (BMi Research, 2016:137–147).

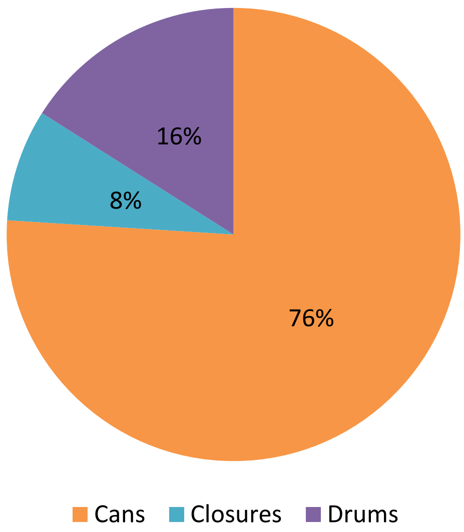


Figure 2.1 Market share of metal packaging in South Africa

Source: BMi Research (2016:138)

Cans are an important part of the metal market (see BMi Research, 2016:147) and in 2015 there was a shift from tin plate (ferrous metal) cans to aluminium (non-ferrous metal) cans (BMi Research, 2016:147). This, together with a weakened rand, led to an increase in the overall industry volume of 2.8% (BMi Research, 2016:147). Companies moved from the tin can to the aluminium can due to the high efficiency rate of aluminium recycling (Legget, 2018). The amount of costs saved through recycling aluminium is enough to cover the cost of collecting and recycling aluminium cans with an excess left after these costs had been recovered (Legget, 2018).

c. Sustainability

There are different steps in the recycling of metal, namely recovery, sorting, brokering, baling, shearing and smelting. Various companies perform these activities, and the recycled material may originate from manufactured scrap or from products that have passed their useful life. It is important to note that metal recycling is more environmentally friendly than extracting and processing virgin materials (Le Blanc, 2016).

The recycling of metal (secondary metal processing) has various advantages to the industry as well as different countries. It creates the opportunity for lower-priced material and is also an important job creator (United States Department of Labor, 2017). It also leads to a diversion of material from landfills, and reduces the amount of energy consumption. The recycling of one ton of steel leads to the non-use of 1 133 kilograms of iron ore, 635 kilograms of coal and 54 kilograms of limestone (Le Blanc, 2016).

The supply chain of metal recycling starts at the scrap metal collectors who pick up small quantities and sells these to scrapyards. Manufacturing plants add the biggest amount of scrap metal to the recycling process, and in 2014, an estimated 73 million metric tons of ferrous metal were recycled in the United States of America. Non-ferrous metal is not recycled to the same extent as ferrous metal, but due to its high value, it is aggressively recycled. In 2014, 7 million metric tons of non-ferrous metal were recycled in the United States, which had a value of $40 billion (Le Blanc, 2016).

2.1.2.4 Plastics

This section discusses the history of plastics and the different types of plastic. It further provides background to the manufacturing of flexible packaging as well as giving a market overview. It concludes with a discussion of plastics and its sustainability impact.

a. History of plastics

In 1988, the Society of Plastics Industry (SPI) (see PLASTICS, 2019) enabled consumers and recyclers to identify different types of plastic by establishing a classification system. This system outlines the seven types of plastics as described in **Table 2.1**.

Table 2.1 SPI classification of plastics

SPI classification	Plastic type	Properties	Common use
1	Polyethylene terephthalate (PET)	Heat resistance, clear, hard	Drink and beer bottles, pre-prepared food trays
2	High-density polyethylene (HDPE)	Chemical resistance, hard, strong, semi-flexible	Detergent bottles, milk bottles, crates, refuse bins
3	Polyvinyl chloride (PVC)	Transparency, good weathering ability	Credit cards, pipes and fittings
4	Low-density polyethylene (LDPE)	Flexible, low melting point, soft	Packaging films, refuse sacks, thick shopping bags
5	Polypropylene (PP)	Chemical resistance, high melting point, hard but flexible	Bottle tops, yogurt and margarine containers
6	Polystyrene (PS)	Glassy surface, affected by fats and solvents, brittle, rigid or foamed	Egg boxes, fast food trays, coat hangers
7	Other	Other polymers with a wide range of uses	Nylon, polycarbonate

Source: Ryedale District Council (2017)

Polyethylene has the highest demand in the plastics packaging sector with a yearly production total of 80 million tons (CIEC, 2017). As Risch (2009:8090) stated, various types of polyethylene are produced, namely low-density polyethylene (LDPE), high-density polyethylene (HDPE), linear low-density polyethylene (LLDPE), and very low-density polyethylene (VLDPE) also known as ultra low-density (ULDPE). Of these different types of polyethylene, LDPE was the first that was developed by Imperial Chemical Industries in 1933 (Risch, 2009:8090). LDPE and LLDPE are preferred for film packaging and insulation, while HDPE is used to produce containers for household chemicals or for piping applications (CIEC, 2017).

Lepoutre (2017) confirms Risch's (2009:8090) statement that polyethylene was first produced in the 1930s by scientists who discovered that ethylene gas can become a solid white object if it is heated at a very high pressure. This results in the polymerisation reaction which produces a wide distribution of molecule sizes. If this reaction is controlled, the size of a polymer granule can be determined. Part of the discovery was the realisation that LDPE is produced at a density range of 0.915 g/cm^3–0.930 g/cm^3. HDPE has a density range of 0.940 g–0.970 g cm^3, which results in a much stiffer material, which was also accidently discovered in 1952 (Lepoutre, 2017). The stiffness of the material was due to a lower level of branching as a result of straight chains of ethylene with a high average chain length. HDPE is produced at a lower pressure than LDPE, and in the 1950s, this low-pressure process was applied to LDPE, which created LLDPE. LLDPE is produced by copolymerising a small amount of another monomer (Lepoutre, 2017).

The base material for polyethylene is produced in small pellets with spherical or cylindrical shapes, which are also known as resins (Lepoutre, 2017). These resins can be used to produce polyethylene in a blown film or cast film extrusion process. In a blown film extrusion process, resins are fed with a gravity system from a hopper into the feed section of the extruder screw (**Figure 2.2**). The resins heat up as they move through the screw by means of friction and external barrel heaters, which results in the melting of the resin, creating a warm thick fluid. This warm substance then moves through the screw and past a screen pack and breaker plate (Lepoutre, 2017). The screen pack removes any foreign contaminants or inconsistencies while the breaker plate changes the plastic motion from rotational to longitudinal. The warm (bubble gum-like material) moves to the die, which is specifically designed for smooth and even plastic flow (Lincoln Plastics, 2017). After the substance has been forced through the die, it adopts the form of a circular tube as it is held in position by internal air pressure and externally cooled by an air ring. The bubble collapses at the nip rollers and is wounded in rolls, which can be used for flexible packaging (Lepoutre, 2017).

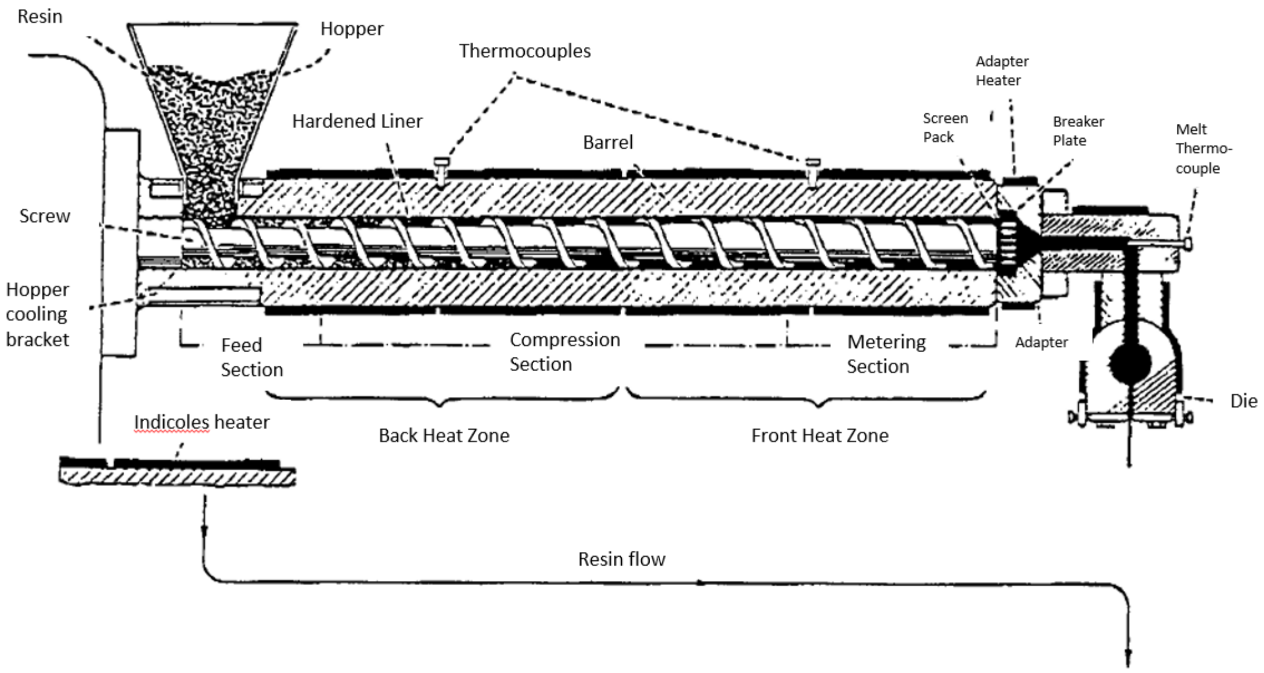


Figure 2.2 Cross-section of an extruder

Source: Lepoutre (2017)

In the cast film extrusion process, the resin is also fed to the extrusion screw by a hopper. From here, the warm substance moves through a flat die, which forms a thin film. The film is then kept in place (pinned to the surface) of a chilled roll by means of an air knife (**Figure 2.3**). The air and temperature of the air knife have to be controlled in order to solidify the film. From here, the film moves through rolls to the nip roller where it is wounded as a finished product. Advantages of cast film is improved film properties and clarity (University of Pune, 2019).

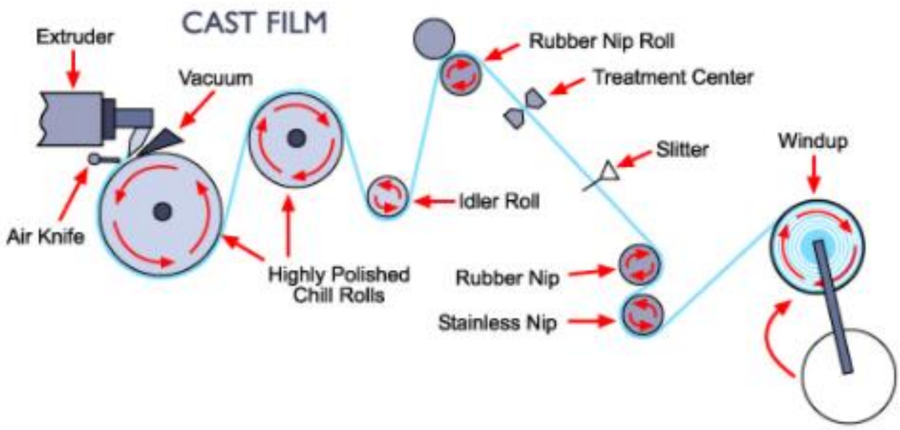


Figure 2.3 Example of the cast film extrusion process

Source: University of Pune (2019)

The film extrusion process can use a mono-extrusion or a co-extrusion machine. Mono-extrusion results in the production of one layer of film whereas co-extrusion is the simultaneous extrusion of two or more materials from a single die. The co-extrusion process is an important part of the plastics packaging industry, as the final application of the film demands characteristics, which are impossible to achieve with one layer of film. Food packaging applications for instance usually requires an oxygen barrier (ethylene vinyl alcohol copolymer – EVOH) and LDPE properties in one film. These co-extruded machines usually produce between five and seven layers with the market looking to increase this number (Macro 2017; ScienceDirect, 2019).

b. Market overview

The global plastic packaging market is expected to show good growth over the next couple of years with an estimated market revenue of $375 billion in 2020 (Embree, 2016). Due to the likely growth of the middle class, there will be increased demand for packaged consumer goods, such as beverages and processed foods, which will increase the demand for plastic packaging produced from polyethylene. The industry is highly fragmented with the North American and Asian Pacific markets dominating the industry (Lucintel, 2013). The industry is expecting most of its growth to come from the pharmaceutical industry due to the higher demand for healthcare plastic packaging (Embree, 2016).

Rigid packaging was the most important product segment for the industry in 2014, while flexible packaging is also important for the industry due to its high demand in food packaging (Embree, 2016). With the global development in strength and flexibility of polyethylene, and the movement from rigid packaging to flexible packaging, there will be a greater demand for flexible material, which in turn will increase the demand for polyethylene raw materials. One of the key threats to the plastics packaging industry is the cost of raw material and the specific volatility in this regard (Embree, 2016).

The South African plastics industry consists of rigid packaging plastics and flexible packaging plastics (BMi Research, 2016:126–137). Both these sectors use raw material from local suppliers and imported products. The rigid packaging sector comprises bottles, crates, bulk containers, drums and buckets. The main raw material used in bottles is PET, which has resulted in substantial growth for the beverage industry. The demand pool (number of people in the country) increases on a yearly basis, while bottles are becoming lighter in weight, which results in cost reductions (BMi Research, 2016:135). Crates are predominantly used in the agriculture and food industries while the demand for plastic drums are growing on a yearly basis due to the movement away from metal buckets for chemicals and paint (BMi Research, 2016:124–136).

In 2015, flexible packaging grew at a slower rate than rigid packaging in South Africa with one of the main contributing factors being the reduction in material weight of consumer products, which reduces the demand for raw materials to produce flexible packaging. The flexible packaging sector mainly consists out of woven sacks and different types of bags. Between 2014 and 2015, the woven sacks market grew by 5% in volume. More bags were produced in 2015 than in 2014 (see BMi Research, 2016:136) but the overall tonnage declined due to the light weighting of products. An increasing number of supermarket chains are launching initiatives to reduce the use of plastic shopping bags, which would further reduce the annual tonnage (Reuters, 2018). The total industry had a market volume of 807 000 tons in 2015 (see BMi Research, 2016:4) with rigid packaging making out 50.9% of this total (see BMi Research, 2016:4). Rigid and flexible packaging are thus equal in tonnage terms but flexible packaging contributed 56.5% of the market value in 2015, which was R3 643 million more than rigid packaging (BMi Research, 2016:127). In 2015, the plastics industry contributed 0.7% to the South African GDP (BMi Research, 2016:131).

c. Sustainability

Plastics are not as easily recyclable as metal and glass and have a relatively low monetary value due to the low density. Gu, Guo, Zhang, Summers and Hall (2017:1193) refer to three major routes to follow when disposing of waste plastics, namely mechanical recycling, energy recovery, and landfill. They further state that the recycling of plastics can represent a saving in the cost of raw material of between 20% and 50% if compared to virgin material. It also has been proved (see Gu et al., 2017:1193) that recycled plastics are an economically and technically viable alternative to virgin material. Ford announced in 2010 that they had used recycled plastics in a list of their automobile components, such as recycled PET in the seats of the Ford Focus Electric (Gu et al., 2017:1193).

After establishing the different types of material and their history, market overview and sustainability, it is imperative to investigate how the performance of the different materials is measured when in a packaging form. These measurements will enable companies to make informed decisions when deciding on a packaging form for their product. The various measurements in terms of performance are discussed in the next section.

2.1.3 Packaging system performance

Kaplan and Norton (1992) state that, if there are no measures there will be no improvement. This also applies to packaging system performance, while measurements further create information, which enables correct decision-making (Gunasekaran & Kobu, 2007:2820). Performance measurements enable organisations to evaluate their progress towards specific goals or objectives. A performance measurement system can be described as a systematic way of evaluating inputs, outputs and productivity, while the system includes performance criteria (relative elements, for example lead time) (Crawford, Cox & Blackstone, 1988:1561). This section discusses different performance measurement systems and the criteria used in assessing packaging system performance.

Packaging is an important part of various functions in an organisation, with one of the key areas being the logistics function. Here, the performance of a packaging system can lead to improvements in logistics costs and a reduction in time constraints. In order to measure packaging system performance, one has to consider various functions as explained by Lockamy (1995:52). He describes the customer, finance and business functions as factors which should be considered in the measurement. Lockamy (1995:56) argues that packaging has to be viewed from a strategic perspective as this will enable organisations to integrate packaging issues effectively into logistic plans. To view packaging strategically, performance measurement systems for the customer-, finance- and business-oriented functions are needed as these systems will generate the necessary information for making strategic packaging decisions (Lockamy, 1995:56).

The customer performance measurement system should include performance criteria, standards and measures, which are customer-driven, while the resource performance measurement system focuses on the effective use of organisational resources. Three performance criteria of this system are price or cost, quality, and lead time, and should be linked to the strategic objectives of the organisation. The financial performance measurement system uses the accounting data in terms of cost, profit, revenue, assets and liabilities (Lockamy, 1995:58). This system primarily drives investment decisions through return on investment (ROI), net present value and the internal rates of return data. Once these performance measurement systems have generated the necessary data, the organisation will be in a position to make sound strategic packaging decisions (Lockamy, 1995:58). Now that the performance measurement systems have been identified, possible packaging system performance criteria are discussed next.

2.1.3.1 Packaging system performance criteria

Packaging is the only form of customer communication which reaches 100% of shoppers (Zielinski, 2013). This results in the power to influence overall product satisfaction and the possibility of a repeat purchase by a customer (Zielinski, 2013). This insight came from a study (Packaging Matters) done by MeadWestvaco Corporation (MWV) (see Kazanjian, 2013:82), which measured packaging satisfaction of customers (Kazanjian, 2013:82).

The study investigated the performance of product packaging, and took into account shelf appeal, environmental friendliness and the ease of opening the product. The study further considered the ability of the packaging to uphold product integrity and to protect the product and the yield left after consumption.

The study found that the most important measure for packaging system performance for beauty products was the yield left after consumption. Consumers demanded value for money products and requested packaging to allow them to get to the very last drop of the product (Kazanjian, 2013:82). This measure forms part of the functional attributes of packaging, which have the potential to affect consumer opinion negatively. An example of this is found when a luxury perfume drips instead of sprays an even mist (Kazanjian, 2013:82). The other functional attributes (ease of opening or reclosing, maintaining product integrity and ease of pumping or dispensing) could lead to increased customer satisfaction in the later stages of the product life cycle. The look and form of a product thus influences a consumer’s preference to buy a product on the shelf while functionality plays an important role in repeat purchases (Kazanjian, 2013:82).

Unlike Kazanjian (2013:82), Hellström and Saghir (2007:198) did not focus on the packaging alone, but also reviewed packaging and logistics interactions in a retail supply chain environment. In this latter research, the researchers emphasised the importance of the packaging system and described the performance of the whole system as being reliant on the performance of the three individual levels in the system and the interactions between them. Furthermore, the researchers found that supply chain effectiveness is affected by packaging as packaging represents an interface between the supply chain and the end user. They argued that packaging has a direct influence on lead times and the delivery performance to a customer. This is due to the time it might take to complete the packaging operation (packaging a product, palletisation, wrapping) (Hellström & Saghir, 2007:199).

Hellström and Saghir (2007:211) also investigated the cost of packaging and its value-adding ability. Packaging is usually seen as a cost to a company, and thus an expense that needs to be minimised. This can be measured on a timely basis, but it should also be considered a competitive advantage opportunity and a possible source of profit. This opportunity can be realised when the packaging system is utilised in such a way that it adds value to all the supply chain members as well as the end consumer. This was researched by Olsmats and Dominic (2003:10) through the creation of a packaging scorecard.

2.1.3.2 Packaging scorecard

Nilsson (2016:294) states that it is important to measure and gain knowledge of the packaging system performance due to its physical influence on the product flow in a supply chain. Olsmats and Dominic (2003:9) found that there is a need for a holistic approach when measuring packaging system performance due to the increased complexity in supply chains. One such tool is the packaging portfolio evaluation model (PPEM), which provides insights into a specific market requirement and ways to adopt the best packaging solutions for this market (Nilsson, 2016:294). Olsmats and Dominic (2003:9) considered other holistic performance measurements in business, such as the balanced scorecard, which was developed by Kaplan and Norton (1996:191). The framework of the balanced scorecard comprises four perspectives with the first two being learning and growth and business processes. The next two perspectives are the customer and financial perspectives, which in combination enable a holistic approach to measuring business performance.

Based on this research, Olsmats and Dominic (2003:10) created a holistic packaging system performance scorecard which, according to Nilsson (2016:294), was developed to increase understanding and to act as a systematic tool to evaluate packaging system performance in a supply chain. The intention was to bring different supply chain actors together and create common goals to increase performance.

Nilsson (2016:294) describes the packaging scorecard as having three steps, with the first step mapping out the supply chain flow and relevant actors which come into contact with the packaging. In the second step, the applicability of each criterion, at each supply chain interface point is tested and indicated (**Table 2.2**). Following the applicability identification, each criterion is weighted to its relevant importance from 0% to 100% (by a supply chain actor), where 0% indicates complete unimportance and 100% represents most important (Nilsson, 2016:296). After establishing the relevant importance of a criterion, its performance needs to be rated. Each criterion point is rated on a scale of 0–4 where 0 is not applicable to the package and 4 indicates the criteria met the package performance excellently. In the final step, the normalised weighted score (in percentage format) is multiplied by the performance ratings (0–4) which then is summed to a normalised weighted average satisfaction score (NWASS).

Table 2.2 Packaging system performance criteria applicability

Criteria	Supplier	Transportation and distribution	Retail	Consumer
Machineability	x			
Product protection	x	x	x	x
Flow information	x	x	x	
Volume and weight efficiency	x	x	x	
Right amount and size		x	x	
Handleability		x	x	
Over value-adding properties	x			x
Product information				x
Selling capability			x	x
Safety			x	
Reduced use of resources	x			
Minimal use of hazardous substance	x			x
Minimal amount of waste			x	x
Packaging costs	x			

Source: Olsmats and Dominic (2003:10)

The combined NWASS results in a subjective but systematic packaging system performance indicator for each supply chain actor. This score not only represents the individual view per actor, but also the joint result between the actors for a certain level of the packaging system. This gives the actors an indication of where possible improvements or opportunities exist in the packaging system and also indicates which criteria are important to a certain supply chain interface point. The subjectivity of the result is a concern, but in order to nullify this, various respondents should be included in the case study (Olsmats & Dominic, 2003:11; Nilsson, 2016:296).

2.1.3.3 Packaging scorecard refinement

Building on the research conducted by Olsmats and Dominic in 2003, Pålsson and Hellström (2016:351) conducted a study which assessed the packaging system performance of 22 different cases by evaluating the individual performance of the primary, secondary and tertiary packaging levels. This resulted in a higher level of detail as the original study (see Olsmats & Dominic, 2003:9) only considered a functional packaging criterion and the satisfaction of the supply chain actors of a particular packaging system.

Six additional criteria were added to the original criteria, namely stackability, unwrapping, traceability, recyclability, reverse handling and packaging design. Pålsson and Hellström (2016:360) found that for secondary packaging and tertiary packaging, three supply chain actors (manufacturer, distribution centre, retailer) had the same view regarding the importance of certain criteria. However, for primary packaging, there were more diverse answers. When considering primary packaging, all three actors agreed that product protection, correct size, correct amount and packaging information are important. Manufacturers however ranked machinability (i.e. how effectively packaging material can be processed into a package (Nilsson, 2016:295)) as important, while retailers ranked selling capability as important (Pålsson & Hellström, 2016:359).

For secondary and tertiary packaging, all three actors agreed about the importance of product protection, flow information and the volume and weight efficiency. From a supply chain view, the single most important criterion of the packaging scorecard indicated by this study was product protection, while not one of the actors highlighted recyclability or reverse handling as important. Pålsson and Hellström (2016:366) encourage companies that intend being at the forefront of packaging systems design to integrate environmental considerations in their process. The study further indicated the relevance of the packaging scorecard and the need for further research in packaging system performance measurement tools.

Nilsson (2016:295) refined the packaging scorecard criteria and added to the original criteria points developed by Olsmats and Dominic (2003:10) stackability, user interaction, reverse handling and security concerns while he removed other value-adding activities as a criterion. This resulted in a total of 17 criterion points. In contrast to Pålsson and Hellström (2016:351), Nilsson (2016:295) did not add unwrapping, traceability, recyclability or packaging design to his criteria. Nilsson (2016:296) further suggests the use of interviews with selected staff from each supply chain actor in order to gather data to populate the packaging scorecard.

During his research, Nilsson (2016:297) found that, by using the scorecard, focus can be exerted on improving weak aspects of packaging, which would lead to higher business performance (Nilsson, 2016:297). Another factor to consider when focusing on business performance is the sustainability of the packaging. The environmental movement is part of the modern era its role and various considerations are discussed in the next section.

2.1.4 Sustainable packaging

The environmental movement started in the 1980s, and emphasises the importance of creating a sustainable environment and using sustainable products (Lockamy, 1995:55). Issues like recycling, hazardous waste and solid waste disposal have led to the formation of countless non-profit organisations (NPOs) and various environmental laws (Lockamy, 1995:55). The functionality of packaging is part of each person's daily life, but one of the main areas of concern is the recyclability of the material of the packaging product (Neil-Boss & Brooks, 2017). In recent years, consumers have been requesting producers to reduce the basis weight (material content of packaging), which is also referred to as down-gauging (Neil-Boss & Brooks, 2017). The reason here is the global movement to a more sustainable environment, which includes the packaging industry. The next section discusses packaging sustainability in more detail.

2.1.4.1 The four levels of sustainable packaging

The Sustainable Packaging Alliance of Australia (SPAA) defines sustainable packaging as comprising four levels. **Figure 2.4** depicts the four levels: society, packaging system, packaging material, and packaging component. These four levels consider the role of the packaging system and the entire life cycle of the product. In order to meet sustainable packaging and support this definition, certain principles need to be achieved. The **society** level refers to how effectively the package contains and protects the product in order to add value to society. The **packaging system** needs to be efficient in order to use both material and energy as efficiently as possible. It should be possible to recycle the **packaging material** through natural or technical systems on a continuous basis, and the **packaging components** should not pose any risks to human health or ecosystems (Sonneveld, James, Fitzpatrick & Lewis, 2014).

Nordin and Selke (2010:318) emphasise the above by describing sustainable packaging as the focus on improvement during the entire product life cycle in the supply chain. They further state that it is the process of evaluating all possibilities for the optimisation and transformation of the package which in turn aligns with the principles of sustainable development. The product life cycle can be assessed through the life cycle assessment (LCA), which is a systematic way of calculating the inputs (materials, energy and water), outputs (waterborne, solid and gaseous waste) and the environmental impacts of any service or product throughout its entire life cycle. Although this form of assessment has various benefits, it also has limitations as one critic argued that it is practically impossible to identify and measure all indirect sources of environmental problems (Arnold, 1993, as cited by Lewis, Verghese & Fitzpatrick, 2009:147–148).

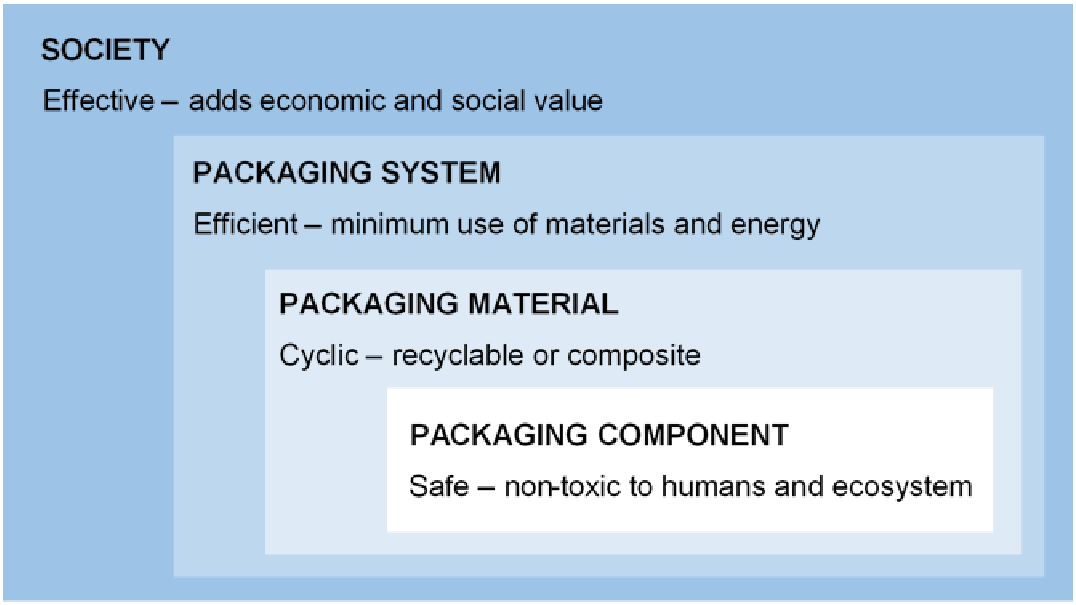


Figure 2.4 The four levels and principles of sustainable packaging definition

Source: Sonneveld et al. (2014)

2.1.4.2 Sustainable packaging challenges and solutions

Packaging is a vital part of the sustainable development process but poses significant challenges due to its high visibility partnered with its influence on distribution, marketing and the safe use of consumer products. The driving forces – consumer behaviour, spending trends and new packaging technologies – further routinely contradict the principles of sustainable development. Companies (who are the custodians of sustainable packaging) also have to consider marketing system complexity, the confirmation of competitive advantage in the market, and the cost of installing new technologies when implementing sustainable packaging (Nordin & Selke, 2010:319).

These challenges have to be overcome by sustainable solutions, which share all four levels of sustainable packaging as described by the SPAA (see **Section 2.1.4.1**). Lockamy (1995:53) describes one solution to reducing the amount of packaging being utilised as unitising loads. This entails packaging smaller boxes into bundles for shipping (Lockamy, 1995:53). The smaller boxes are packed into big boxes or bound together with plastic wrap when shipped. This technique reduces the number of corrugated boxes, paper and paperboard used in shipping.

Twede and Clarke (2004:8) investigated the possibility of using less packaging through the use of reusable containers and the possible advantages this could hold. The reusable containers that were investigated varied in size from manually handled totes to pallet-load-sized bulk containers. These containers are predominately made from plastic, and replace boxes produced from corrugated material, which were sent to a landfill once their contests had been depleted. The study found that, at the time, in the United States, automotive manufacturers predominately used reusable packing in the form of plastic pallets, bins and crates, and these were delivered directly to the assembly line. In the United Kingdom, grocery retailers participating in the research by Twede and Clarke (2004:10–

11) used reusable crates on wheeled racks to move their fresh produce from distribution centres to retailers.

These researchers conclude that the use of a reusable container has various economic and environmental advantages, such as reducing landfill waste, removing the cost of purchasing packaging, and destroying packaging after its contents had been depleted. The use of reusable containers however adds complexity to the supply chain as it is not a normal closed loop operation, such as the way milk bottles used to be collected and replaced by milk producers. The containers are interchangeable, and one container might move from one logistical system to another when its contents are depleted. In this scenario, it is very important to establish who will be the party responsible for the initial capital outlay of purchasing reusable containers and how the containers will be managed. This can be done either by an independent third party or by the owner through negotiating terms of ownership and policies of return and deciding who will be responsible to pay for the reusable containers (Twede & Clarke, 2004:22).

Nordin and Selke (2010:320) found that the economic and environmental factors (as described above) of sustainable packaging have been discussed in literature, but that the third factor, social considerations, still needed to be explored. Mourad, Jaime and Garcia (2014:869) acknowledged the social considerations of sustainable packaging and found that many manufacturers notice the need to have a better attitude towards society. Social considerations can be divided into two components, namely social equity (which forms part of sustainability) and consumer perceptions and interests. As the consumer is the final judge in terms of the success of sustainable packaging, it is important to understand consumers' perceptions and purchasing preferences. These perceptions and preferences are illustrated by consumer demand, which focuses on packaging system performance, convenience and price sensitivity (Nordin & Selke, 2010:320). The consumer generally wants a package that is sourced responsibly, designed to be effective and safe, produced efficiently with renewable energy but which also meets cost and performance criteria. The consumer further wants to be able to recycle or reuse the packaging after its contents had been depleted (Nordin & Selke, 2010:320).

Even though consumers have these requirements, it is important to note that Nordin and Selke (2010:322) found that there is a terminology gap between consumers and the packaging industry. They found that consumers view sustainable packaging as recyclable packaging, whilst industry relates it to cost-effectiveness and environmental footprint. This can explain why consumers recognise their responsibility towards the environment but assumes that the manufacturer has the responsibility to abide by all laws while they only have to recycle the used package (Nordin & Selke, 2010:322). The consumer's main focus is on package functionality and protection of products, which leads to sustainable features becoming secondary factors. Nordin and Selke's (2010:323) found that it is necessary to spend time and energy on educating consumers about sustainable packaging. There has however, been a change in recent years, due to the growth of social media and the globalisation of environmental issues. Consumers are more aware of sustainable packaging and participate in sustainability packaging programmes (Mourad, Jaime & Garcia, 2014:869).

2.1.4.3. Sustainable packaging design framework

Taking the environmental, economic and social considerations into account, Grönman et al. (2013:188) developed a framework for sustainable packaging design for food packaging, which could also be applied to other products. They found that, at the time, there were several guidelines in national laws, EU directives, CEN (European Committee for Standardization) Standards 13427–13432 and ISO (International Organisation for Standardization) packaging standards 18601–18606, which act as tools when designing packaging. The gap that was identified by Grönman et al. (2013:188) was that these guidelines were very broad. The packaging designer requires complete knowledge on sustainability and environmental impacts in order to choose the best packaging material to design the product with. In order to support the packaging designer, Grönman et al. (2013:190) created a framework.

Grönman et al. (2013:190) found that the simultaneous design of product and package minimises environmental impacts without compromising on the product. This simultaneous design, coupled with the key goals of packaging, should be emphasised by the package designer.

The first key goal is that the package should be safe to use and that its production and use should not have a negative impact on the environment, whilst the second refers to preventing product losses or product spoilage in the supply chain. When a trade-off occurs during the design process, it should be viewed with these key goals as background. The framework for sustainable food packaging design (**Figure 2.5**) includes all the levels of the packaging system (primary, secondary and tertiary) and was designed in such a way that it introduces different criteria and different methods in an order that allows designers to integrate various sustainability requirements in their work (Grönman et al., 2013:190).

The framework for sustainable food packaging design consists of five phases: specification and ideation phase, feasibility study, design phase, second specification phase and the follow-up phase (see **Figure 2.5**). There are six steps in this five-phase framework, which are discussed in more detail below (Grönman et al., 2013:191).

In the first phase, the **first step** that was identified, is the recognition of the minimum requirements of the product. General minimum requirements in the food packaging industry are high preservability, safety for the user and the environment, and the fulfilment of legislation requirements (Grönman et al., 2013:191).

Step two, which forms part of the first phase, is the preliminary selection of the packaging material for the product. This is done at all levels of the packaging system, and the designer could brainstorm various combinations to fulfil the minimum requirements of the package. **Step three** is the first step in the feasibility study phase, and is the identification of possible threats. This can be actioned by means of a SWOT (strengths, weaknesses, opportunities and threats) analysis (Grönman et al., 2013:192).

It is important to note the threats that are associated with the considered packaging material. The **fourth step** is the identification and testing of the packaging functionality criteria. These functionality criteria are based on the basic functions of the package, namely to protect, distribute and market the product. Grönman et al. (2013:195) note that it is important to develop product-specific functional criteria instead of using generalised criteria for all products.

The third phase includes **step five**, which is the detailed design of the package. After selecting the most appropriate material, the design can be finalised by the packaging designer. The **final step** requires a detailed LCA of the package, which will enable the measurement of the environmental impact of the product and packaging. The LCA should include product loss and the operational environment within which the package will be used. The fourth phase refers to the sustainable packaging combination for the product. The fifth and final phase is the follow-up phase, which ensures the continual optimisation of the packaging design (Grönman et al., 2013:196).

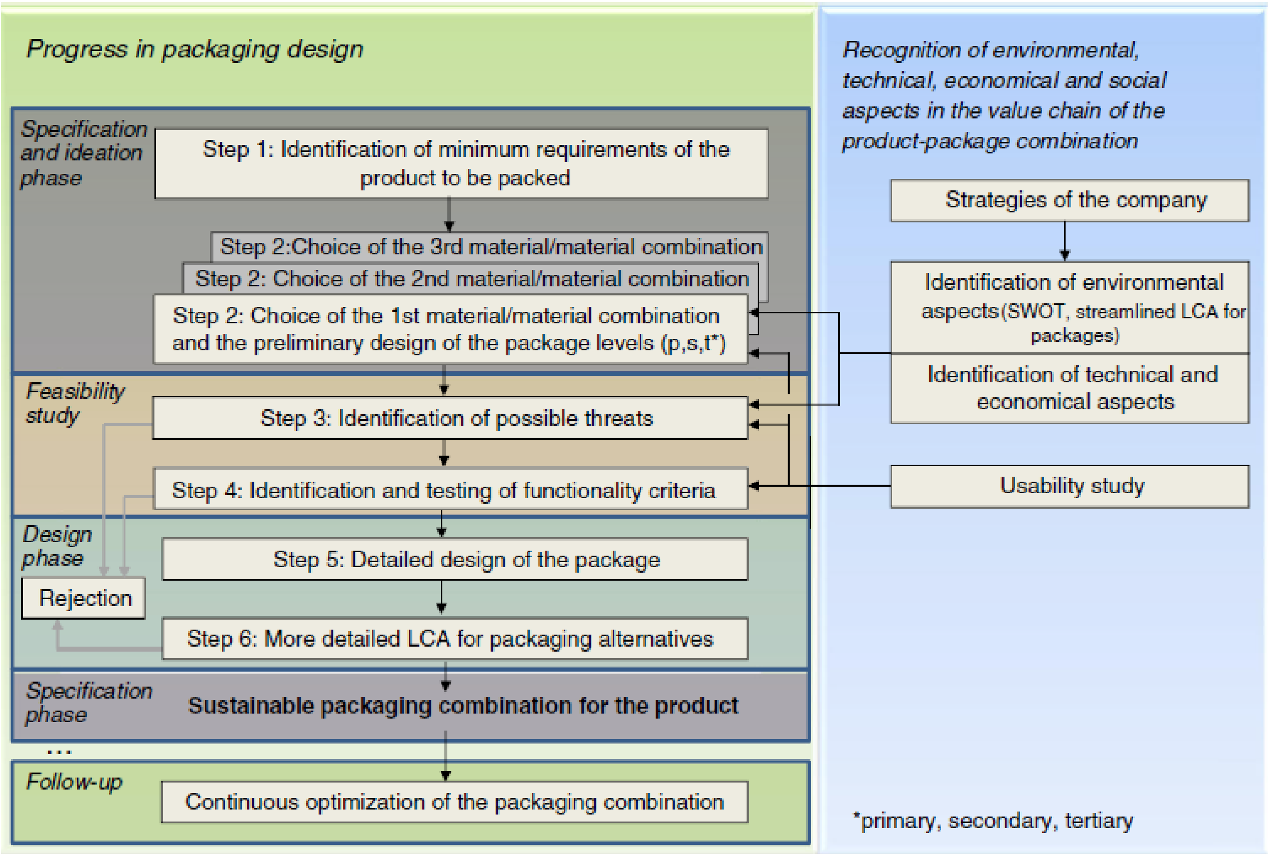


Figure 2.5 A framework for sustainable food packaging design

Source: Grönman et al. (2013:191)

2.1.5 Summary of findings from packaging literature

The packaging system can be defined with three levels, namely primary, secondary and tertiary packaging. These three types of packaging usually function in a complementary sense (Murphy & Wood, 2011:215). Packaging has several functions, which include containment, protection, transport, facilitation and marketing (Lockamy, 1995:52).

Paper is still the most commonly used packaging material, while glass has the highest recycling rate of all types of packaging material. Metal plays an important role in the preservation of food, and an increase in consumer usage of these products leads to a bigger demand for metallised packaging. In the plastics packaging sector, polyethylene shows the highest demand, and the film is produced through either a mono-extrusion or a co-extrusion machine. The growing demand for polyethylene is ascribed to the higher demand for flexible packaging, as consumers are moving from rigid packaging to more flexible products.

Packaging forms a strategic part of a business and should be considered a competitive advantage as it can be a profit-driver instead of a cost-reducer. The packaging scorecard is a relevant tool to measure the holistic performance of packaging, as it considers all actors in the supply chain. Previous studies, which measured packaging system performance, concluded that the most important packaging attribute is its ability to protect the product inside the package.

Sustainability is an important factor in modern packaging design, and the need to consider the entire life cycle of a product when investigating packaging sustainability was emphasised. The LCA is valuable as it quantifies the impact of the package from the point of raw material extraction to disposal or recovery. Furthermore, the need to consider economic, environmental and social factors when designing a sustainable package was discussed. After establishing the different types of packaging material, investigating different packaging system performance measurements, and viewing the role of sustainable packaging, the study also investigates how packaging material can be sourced. The next section gives background to various sourcing strategies and the available sourcing models.

2.2 Procurement and supply with a focus on strategic sourcing

According to the CIPS, procurement and supply management involve the purchasing of goods and services, which enable a company to operate. This might refer to the sourcing of raw materials that enable a company to produce goods for customers, or it might refer to the purchasing of services such as marketing, advertising or information technology (IT) (CIPS, 2017). Sourcing is seen as a key supply management function, which refers to the identification of suitable suppliers, negotiating terms and creating value through improvements, such as cost and risk reduction (Ketchen et al., 2014:165). Wang et al. (2010:310) describe sourcing as the process where companies acquire resources from suppliers, which enable them to execute their operations and services.

Arnold et al. (2008:191) indicate that manufacturing firms spend almost 50% of their revenue on the purchasing of raw material, while the CIPS believes it to be more than two thirds (CIPS, 2017). Kausik and Mahadevan (2012:78) estimated that companies spend over 70% on raw materials and services, which puts a special emphasis on procurement and sourcing. Sourcing thus has a large influence on the performance of a company, and it is thus imperative that a company adopt a professional sourcing approach (Padhi, Wagner & Aggarwal, 2012:1).

Sourcing has developed considerably over the last few decades due to globalisation (Gereffi & Lee, 2012:25). In the 1960s, US manufacturers started moving some of their assembly plants to offshore production facilities in order to reduce costs (see Gereffi & Lee, 2012:25), and in the 1970s and 1980s, retailers followed manufacturers in this trend of moving their facilities to off shore locations (see Gereffi & Lee, 2012:25). This led to a fundamental shift in supply chains that were "producer-driven" (Gereffi & Lee, 2012:25) to supply chains that are "buyer-driven" (Gereffi & Lee, 2012:25). These "buyer-driven" supply chains further emphasise the importance of sourcing in any company and the way sourcing affects the expenditure of the company (Gereffi & Lee, 2012:25).

2.2.1 Strategic sourcing

Sourcing has been viewed as a simple purchasing task for many years (Gelderman & Van Weele 2002:19; Ketchen et al., 2014:165). The idea of viewing sourcing as a strategic option was only considered in more recent times with the appointment of more specialised personnel and acceptance and agreement from top management (Ketchen et al., 2014:165). Strategic sourcing can be viewed as the action of making supply management decisions with the purpose of creating distinctive value and gaining a competitive advantage for a company and not merely serving a purchasing function (Ketchen et al., 2014:165). Kausik and Mahadevan (2012:79) describe strategic sourcing as a process which consists of the sub-processes planning, evaluating, implementing and controlling, which guide a company to realise its long-term goals. This, in turn, creates flexibility for a company to combat the uncertainties of today's global markets (Kausik & Mahadevan, 2012:79).

Schneller (2010:22) also emphasises the impact of strategic sourcing as a supply chain process for managing risk and reducing costs while referring to seven activities that form part of strategic sourcing, namely –

- category and spend analysis;
- market analysis;
- strategy development;
- supplier relationship strategy;
- supplier analysis;
- cost and price analyses; and
- fact-based negotiation.

These activities indicate that firms can create value not only by managing expenditure but also by collaborating with other supply chain actors, which could increase customer responsiveness and develop innovative products (Ketchen et al*.,* 2014:165).

To facilitate strategic sourcing, the different strategies must be identified and evaluated by means of a sourcing approach. There are various approaches found in literature, and the next section discusses and highlights some of these. After the sourcing approach has been identified, the various sourcing strategies will be elaborated on.

2.2.2 Purchasing portfolio analysis

Suppliers and sourcing play an integral part in supply chain management, and part of this is the segmentation of the supplier base through purchasing portfolio analysis (Kraljic, 1983:113). When the supplier base has been segmented, the company can match a sourcing strategy per supplier or product. One of the most effective ways of segmenting suppliers is the Kraljic model (Kraljic, 1983:111; see also **Section 2.2.2.1**). Peter Kraljic developed the Kraljic model in 1983. This model enables a company to segment its supplier base by mapping supply items against two key dimensions: risk and profitability. The 'risk' dimension refers to the possibility of an unexpected event (which disrupts the supply chain) occurring while the 'profitability' dimension refers to the impact of the supply item on the company's bottom line (Webb, 2017). Padhi et al. (2012:1) refer to the Kraljic model, containing these dimensions, as minimising supply vulnerability while also maximising buying power.

Gelderman and Van Weele (2002:30) state that the general aim of a purchasing portfolio model is to develop and implement differentiated purchasing strategies. Various purchasing models are discussed in literature, such as buyer–supplier relationships (see Faraz, Sanders, Zacharia & Gerschberger, 2018:6225) and power structures (see Cox, 2015:725) These models (including the Kraljic model) recommend generic strategies (see Cox, 2015:717; Gelderman & Van Weele, 2002:30) and tactics for different types of purchases with the purchasing chessboard being an example (see Schuh, Kromoser, Strohmer & Mariscotti, 2012). This latter approach wants to create a sophisticated purchasing positioning approach, and uses the power positions that were identified by the power matrix (see Cox, 2015:719) as a basis to do so (Cox, 2015:723). Following this, the approach uses the same sourcing strategies as the purchasing portfolio analysis (PPA) developed by Kraljic (1983:113) with 16 tactical levers per approach focused on cost reduction. As Cox (2015:719) points out, the power matrix was developed as criticism on the PPA and was therefore not the correct tool to be used in the purchasing chessboard.

Cox (2015:719) argues that the PPA developed by Kraljic (1983:110) was too simplistic and generic to add real value to practical applications. He thus developed his own model, sourcing portfolio analysis (SPA), which added two more product segmentation options (focusing on commercial and operational aspects), and uses the power matrix to identify suitable sourcing strategies. The focus of the SPA is to enable a buyer to move (by way of dynamic movement) from a less advantageous position to a more advantageous leverage position with its supplier (Cox, 2015:722).

All of these analyses have merit, but the Kraljic model is still the most used approach in purchasing portfolio management (Hesping & Schiele, 2016:101). Cox (2015:717) also acknowledges that since the 1980s, the Kraljic model approach has been the technique most commonly recommended to aid managerial actions. Padhi et al. (2012:1) emphasise this and state that the Kraljic model is an effective tool for discussing and visualising different sourcing strategies, and it has been characterised (by, for instance, Padhi et al, 2012:1)) as one of the best diagnostic and prescriptive tools for supply management and sourcing. Finally, Gelderman and Van Weele (2002:33) found that the important benefit of the Kraljic model is that, by using and customising it to a specific study, it results in a better understanding of strategic issues in the study.

2.2.2.1 The Kraljic model

Kraljic (1983:111) was the first person to introduce a comprehensive portfolio approach to be used in purchasing and supply management. The categorisation of products in a two-by-two matrix enable companies to derive guidelines about how to manage supplier relationships (Gelderman & Van Weele, 2002:30). The Kraljic model has four phases, namely

- purchase classification;
- market analysis;
- strategic positioning; and
- action planning (Kraljic, 1983:112).

During the first phase, the profit risk of certain items can be defined through the volume purchased or the percentage of the total purchase cost. The supply risk is assessed according to the availability, number of suppliers and the make-or-buy opportunities (Kraljic, 1983:117). The company uses this criterion to sort all purchased items into categories (see **Table 2.3)**, namely –

- strategic (high profit risk, high supply risk);
- bottleneck (low profit risk, high supply risk);
- leverage (high profit risk, low supply risk); and
- non-critical (low profit risk, low supply risk).

Each of these categories requires different sourcing techniques, which differ in complexity and resources (Kraljic, 1983:117).

Table 2.3 Classifying purchase material requirements

Classifying purchasing material requirements		
Procurement focus	**Required information**	**Decision level**
Strategic items	Detailed market data	Top level (Exco)
	Long-term supply and demand terms	
	Competitive intelligence	
	Industry cost curves	
Bottleneck items	Medium-term supply and demand terms	Higher level (head of department)
	Good market data	
	Inventory costs	
	Maintenance plans	
Leverage items	Good market data	Medium level (head buyer)
	Short- to medium-term planning	
	Accurate data	
	Price forecasts	
Non-critical items	Good market overview	Lower level (buyer)
	Short-term demand forecast	
	Economic order quantity	

Source: Adapted from Kraljic (1983:112)

The four categories are further illustrated in **Figure 2.6** as quadrants in a figure. The products in these categories have to be revisited on a regular basis due to the changing business environment (Kraljic, 1983:117). The two-by-two matrix developed by Kraljic (1983:117) does not utilise a numeric rating system to categorise a product. As a result, there are no calculating rules, which results in a ‘high’ or ‘low’ rating in this section, but the lack of objective measurement is a beneficial characteristic as the model utilises the expertise and knowledge of participants (Gelderman & Van Weele, 2002:33).

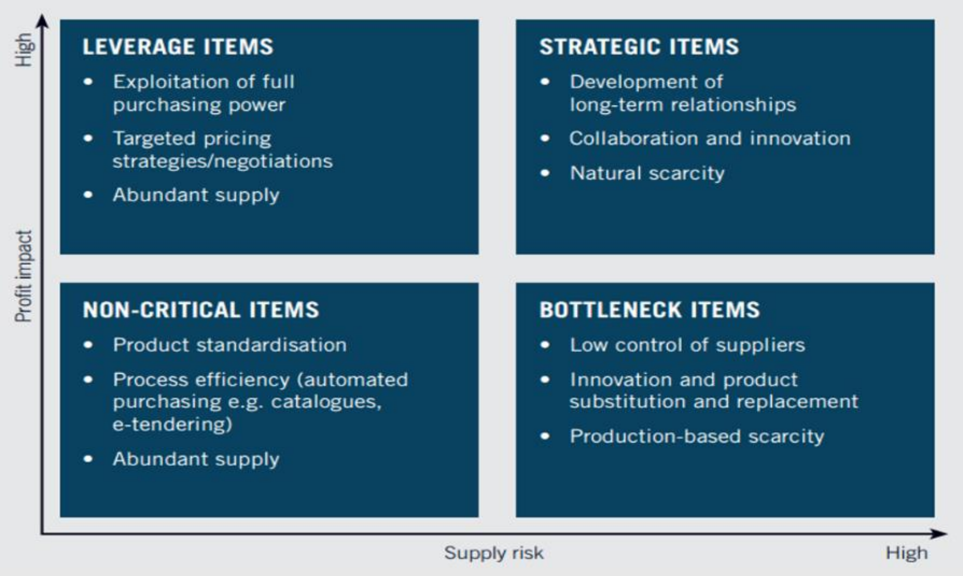


Figure 2.6 The quadrants of the Kraljic model

Source: Webb (2017)

The second phase requires the company to compare the bargaining power of its suppliers with its own bargaining power as a customer (see **Table 2.4).** This systematically assesses the supply market and evaluates the availability of strategic materials in terms of quality and quantity (Kraljic, 1983:113). The different criteria enable a company to assess where it can bargain with a specific supplier and on which qualities it cannot (Kraljic, 1983:113). For the supplier, the criteria include the market size versus the supplier capacity as well as the ROI. The criteria further compare market growth with the possible capacity growth of the business while company strength compares the purchasing volume of the company with the capacity of the main production units in the company. The company strength is further evaluated according to the cost and price structure and the cost of non-delivery (Kraljic, 1983:113).

Table 2.4 Comparing supplier strength and company strength

Purchasing portfolio evaluation criteria		
Number	**Supplier strength**	**Company strength**
1	Market size versus supplier capacity	Purchasing volume versus capacity of main units
2	Market growth versus capacity growth	Demand growth versus capacity growth
3	Capacity utilisation or bottleneck risk	Capacity utilisation of main units
4	Competitive structure	Market share versus main competition
5	Return on investment (ROI)	Profitability of main end products
6	Cost and price structure	Cost and price structure
7	Breakeven stability	Cost of non-delivery
8	Technological stability	Own production capability
9	Entry barrier	Entry cost for new sources versus cost for own production
10	Logistics	Logistics

Source: Kraljic (1983:114)

Another tool with which to compare the supplier and company strength is the five forces model created by Michael Porter (Cox, 2015:718; Porter, 1979:137) (see **Figure 2.7**). This model was developed to assess and evaluate the competitive strength and position of a company in a market (Porter, 1979:137). The model helps to identify where power lies in a business situation, which helps to understand the strength of the company in the current and possible future markets (CGMA, 2013). The model consists of five forces: supplier power, buyer power, competitive rivalry, threat of substitution, and threat of new entry. These five forces enable a company to understand the factors affecting profitability and could also inform decisions on whether or not to enter a specific industry.

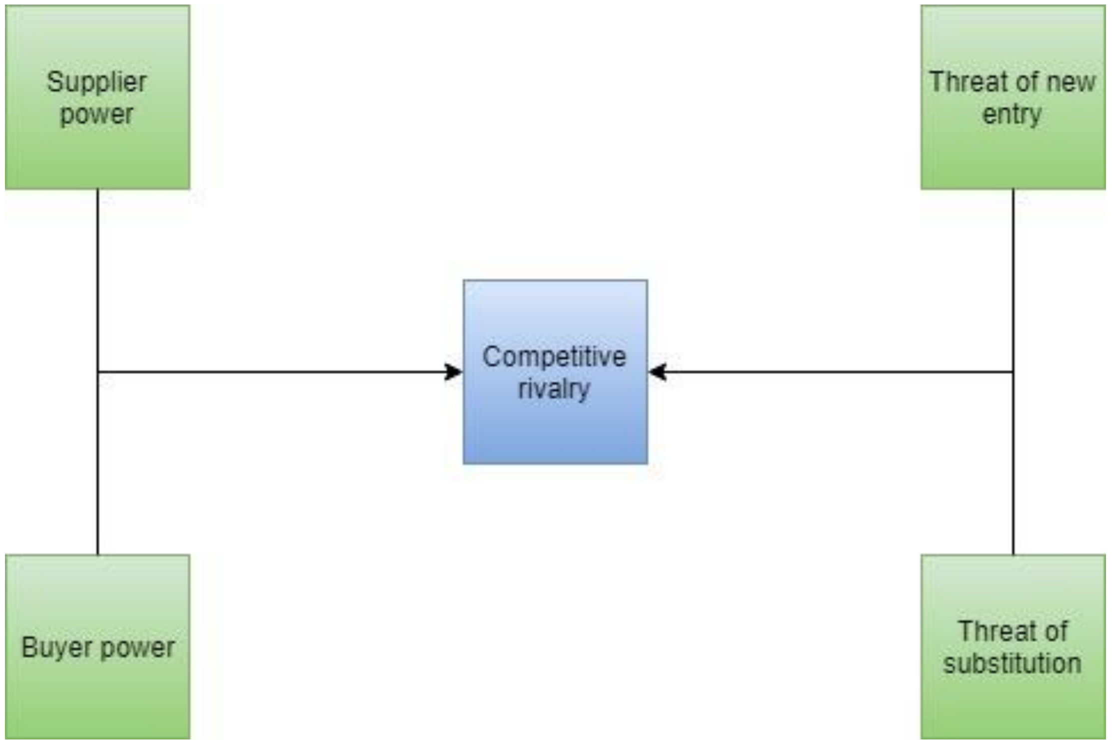


Figure 2.7 Porter's five forces model

Source: Adapted from CGMA (2013)

In the third phase of the Kraljic model, the company positions all the materials identified in the first phase as strategic in the purchasing portfolio matrix. Now areas of opportunity, vulnerability and supply risk can be identified through three basis risk categories (see **Figure 2.8**). Where the company plays a dominant role and a supplier's strength is medium or low, the exploit category is indicated. Where the company's role in the supply market is secondary, and the supplier has a strong presence, the company has to follow the diversify strategy and use material substitutes. If there is no real risk or real opportunity, the company should decide to follow the balanced strategy (Kraljic, 1983:114).

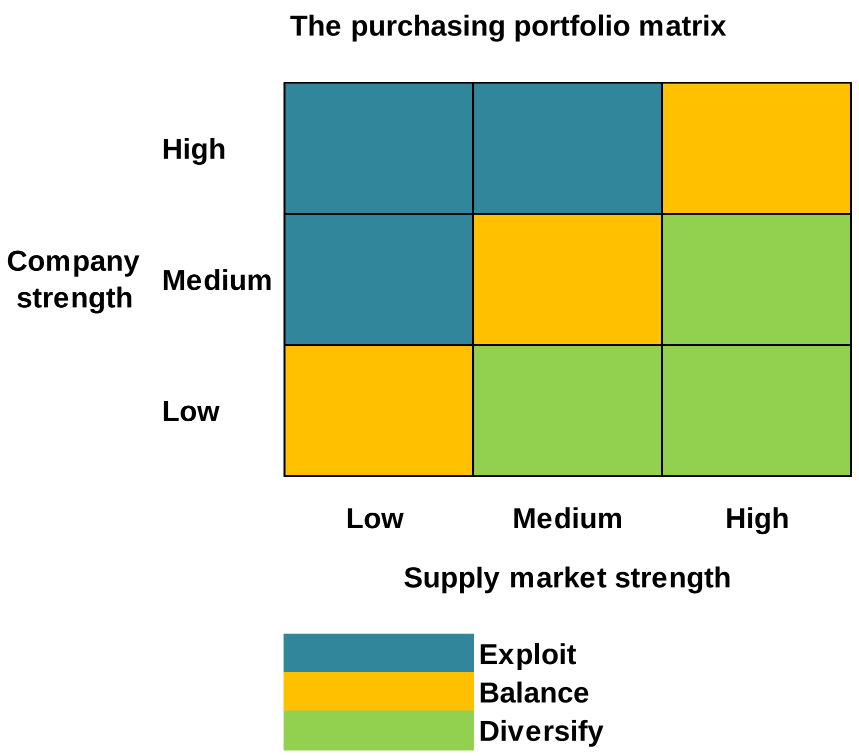
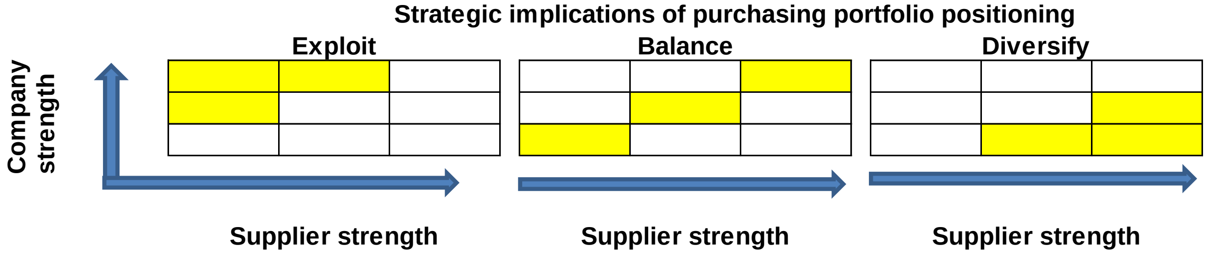


Figure 2.8 The purchasing portfolio matrix indicating the three risk categories

Source: Adapted from Kraljic (1983:114)

The fourth and final phase of the model requires the development of an appropriate action plan (see **Figure 2.9**). According to Kraljic (1983:114), when the strategic category for a certain material is diversification and the supplier has more strength than the company, the company should (in the short term) consolidate its supply position and cover its full volume through supply contracts. To reduce the long-term risk of a single source of supply, the company should seek alternative suppliers or consider backward integration to permit in-house production (Kraljic, 1983:114).

If the company is stronger than the supplier, it should spread its volume and exploit price advantages and reduce inventory levels (Kraljic, 1983:114). The company should conclude this phase by exploring a range of supply scenarios, which clearly define risks, costs and strategic implications. The company should then develop a preferred option with objectives, steps and responsibilities and wait for top management approval (Kraljic, 1983:114).



Policy issues

	Exploit	Balance	Diversify
Volume	Spread	Keep or shift carefully	Centralise
Price	Ask for reductions	Negotiate opportunistically	Keep low profile
Contractual coverage	Spot buying	Balance contracts and spot	Keep supply by contracts
New suppliers	Stay in touch	Selected vendors	Search vigorously
Inventories	Keep low	Use stock as buffer	Bolster stock
Own production	Reduce or do not enter	Decide selectively	Build up or enter
Substitution	Stay in touch	Pursue good opportunities	Search actively
Value engineering	Enforce on supplier	Perform selectively	Start own programme
Logistics	Minimise cost	Optimise selectively	Secure sufficient stock

Figure 2.9 The strategic action plan

Source: Adapted from Kraljic (1983:115)

The strategic levers which informs the action plan is depicted in **Table 2.5**. These levers also form part of the strategic sourcing strategy and act as guidelines for the management team when implementing the strategy. Kraljic (1983:115) recommends using these levers per quadrant but Hesping and Schiele (2016:105) found that using a blend of the various tactical sourcing levers are more practical than only using certain tactical levers per quadrant of the Kraljic model. Cox (2015:718) also refers to managers "cherry picking" tactical levers when implementing a sourcing strategy from the Kraljic model. Hesping and Schiele (2016:105) recommend grouping all the different levers into seven core tactical sourcing levers, namely –

- volume bundling (consolidation of demand);
- price evaluation (price targets);
- supply base extension (increase the number of suppliers);
- product optimisation (modifying the design/materials);
- process optimisation (efficient and effective);
- optimisation of supply relationships (positive relationships); and
- category-spanned optimisation which refers to balancing trade-offs among multiple purchasing categories.

Hesping and Schiele (2016:105) confirm that using these levers in a mixture per quadrant of the Kraljic model will result in the most optimal sourcing strategies. The original generic recommendations per quadrant made by the Kraljic model (see Kraljic, 1983:115) are important as they serve as spaces for debates but will probably not provide a conclusive answer to tactical problems.

Table 2.5 Strategic levers

Strategy	Lever	Strategy	Lever
Strategic	Long-term relationships	Leverage	Vendor selection
	Risk analysis		Exploit purchasing power
	Joint product development		Spot buying
	Detailed market research		Target pricing
	Vendor control		
	Contract staggering		
Non-critical	Efficient processing	Bottleneck	Volume insurance
	Product standardisation		Security of stock
	Consolidate volume		Control of vendors
	Inventory optimisation		

Source: Kraljic (1983:116)

As discussed in this section, Kraljic (1983:114) identifies three basic sourcing strategies, namely exploit (aggressive), balance (retaining the status quo), and diversify (engaging new suppliers). Cox (2015:718) argues that these are very generic sourcing strategies and that there is a need for detail in each strategy. Some of these, which may be considered, are supplier quote strategy, single sourcing, dual sourcing, multiple sourcing and insourcing (vertical integration). These strategies could form part of the Kraljic (1983:114) strategies, and are discussed in detail below.

2.2.3 Different sourcing strategies

This section provides background to some of the sourcing strategies available in literature.

2.2.3.1 Supplier quote strategy

Wang et al. (2010:311) considered the supplier quote strategy when purchasing a new product. This strategy involves the customer (manufacturer or producer) issuing a request for quote (RFQ) to one or multiple suppliers (see **Figure 2.10**). In the RFQ, the customer stipulates the product specification, quality expectations, payment terms and the desired lead times. The customer then requests the supplier to confirm which quantity and at what price they would be able to supply the product. This is due to the lack of knowledge from the customer about the suppliers cost structures (Wang et al., 2010:311).

The suppliers submit their product price–quantity schedules to the customer for review. From a customer perspective, the supply chain is transparent as customer can calculate the production cost of the supplier by investigating the number of units versus the cost and quantity for supplying the product. The advantage of this is that the customer can have multiple suppliers and procure the optimal quantity from each, due to the supply chain information being available. The disadvantage is that the supplier has limited information regarding the customer and the supplier might be unaware of the upstream part of the supply chain. (Wang et al., 2010:311).

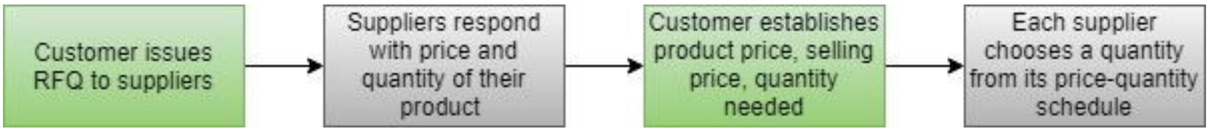


Figure 2.10 Request to quote process

Source: Wang et al. (2010:311)

2.2.3.2 Single sourcing strategy

As discussed in **Section 2.2.1**, sourcing decisions have become part of the strategic decisions of a company. Companies need to outperform competition, create cost-effectiveness and be quality conscious when producing or selling their products (Faes & Matthyssens, 2009:245). When companies must decide on a sourcing strategy, one possibility is single sourcing (see Faes & Matthyssens, 2009:246). This occurs when a source loyalty results in the use of only one supplier even though there are various suitable suppliers present in the market. Freeman and Cavinato (1990:7) describe this as the ultimate stage of full partnerships between a customer and supplier.

Single sourcing is the result of supplier base reduction initiatives, total cost-cutting strategies and reducing purchasing throughput time (Faes & Matthyssens, 2009:246). Single sourcing is often preferred to multiple sourcing due to its potential cost-reduction capability. Single supplier–purchaser relationships have cost advantages as the purchaser does not have to split its volumes between various sources, which in turn gives the purchaser the opportunity to negotiate improved purchasing conditions (Ellram & Billington, 2001:17; Faes & Matthyssens, 2009:246).

This strategy further leads to a reduction in warehousing costs. Because deliveries are only received from one supplier, deliveries can be planned more efficiently, and administrative costs are less when dealing with one supplier. Quality improvements are also imminent as the supplier has economies of scale and can thus devote more attention to developing solutions for technical or logistical problems (Faes & Matthyssens, 2009:246). Single sourcing also has some disadvantages. The major disadvantage is the dependency from both partners on one another. This strategy may lead to higher supplier switching costs and potentially less competitive cost structures. It may further lead to the purchaser losing its market feel, and its knowledge of supply alternatives might reduce (Faes & Matthyssens, 2009:246). To mitigate this, a purchaser might consider moving to a dual sourcing strategy.

2.2.3.3 Dual sourcing strategy

As Gereffi and Lee (2012:24) found in their study of global supply chains, it is common business practice for companies to have various supply sources with different levels of reliability in terms of on-time and in-full (OTIF) deliveries. When a company has these various supply uncertainties it is imperative to have a cost-efficient and effective sourcing strategy, which protects the company against fire accidents, earthquakes or any other natural or man-made disaster. To overcome these incidents, companies adopt a dual sourcing strategy, which means limiting the number of suppliers for one item to two (Faes & Matthyssens, 2009:246). Part of dual sourcing is parallel sourcing (see Faes & Matthyssens, 2009:246) in which a single source of supply is deliberately chosen for one specific product, but then a second supplier is introduced on a related component, which puts pressure on the single supply source to constantly improve performance (Faes & Matthyssens, 2009:246).

Silbermayr and Minner (2013:37) refer to real-world examples when dual sourcing could lead to improved supply chain management. In 2011, various global companies had to rebuild their supply chains due to an unforeseen earthquake in Japan (Zhu, 2015:191). BMW stopped production in three German plants in 2010 due to the non-availability of electronic components as result of the ash cloud, from the erupted volcano in Iceland, hanging over the European skyline resulting in the grounding of all flights. These examples indicate the importance of using a dual sourcing strategy as it reduces risk in the procurement process and closely matches supply with demand (Zhu, 2015:191).

Zhu (2015:192) studied the combined impacts of disruption at source, disruption in the availability of information and in lead times and costs on a dual sourcing strategy. He considered a scenario where a company sources from both a local and an overseas supplier. When considering cost performance from these two suppliers, the researcher investigated whether local disruption will always have a bigger impact on the business than overseas disruption. He further considered the possible cost-saving opportunity of having disruption information before disruption occurs. His final research question was the effect of different lead times from two suppliers on the customer. Zhu (2015:192) refers to these questions as the key issues that a firm must manage when adopting a dual sourcing strategy.

Zhu (2015) consequently found that supply disruption at the local source has a bigger impact on cost-efficiencies than disruption at the overseas source. This also indicates that the information in terms of the local source is more valuable than that relating to the overseas source. Complete information availability could further result in a 9% cost saving should the company procure from a local and overseas supplier (Zhu, 2015:198).

Using computational experiments, Silbermayr and Minner (2013:41) found that the benefit of dual sourcing over single sourcing is especially high when there are high penalty costs and long disruption periods. Watts, Kim and Hahn (1995:2) found that dual souring enables the best purchasing results in the service buying and high-tech markets.

2.2.3.4 Multiple sourcing strategy

Multiple sourcing can be defined as purchasing an identical product or service from two or more suppliers (Linthorst & Telgen, 2017). These sources will then produce and deliver the same item to one purchaser who must make the decision on how an order will be divided between various suppliers (Linthorst & Telgen, 2017). An order can be static (fixed total per supplier), semi-static (a fixed percentage per order, which is decided by chance), dynamic (decided on previous performances) or a combination of these (Linthorst & Telgen, 2017). The multiple sourcing strategy is used when a purchaser does not want to put all its eggs in one basket and needs more flexibility in its supply chain. Multiple sourcing further mitigates the possibility of vendor lock-in and simplifies the management of supplier contracts with fewer specifications per contract (Yu, 2014).

In their study, Faes and Matthyssens (2009:252) found that companies moved from a single sourcing strategy to a multiple sourcing strategy for products deemed strategic. Kraljic (1983:112) describes these products as having a high supply risk and requiring substantial investment. In their study, Faes and Matthyssens (2009:252) further found that the markets where these products were being used were still on route to maturity and had room for product improvements. Building on this, Linthorst and Telgen (2017) state that multiple sourcing could lead to a reduction in cost per product due to supplier competition while it simultaneously ensures independency from said suppliers.

Furthermore, multiple sourcing ensures supply continuity, as a single disaster with one supplier does not have a detrimental effect on the purchaser's business, and multiple sourcing gives wide access to different technologies and markets. While the continuation of supply is secured through multiple sourcing, it does lead to higher administrative and transaction costs due to multiple suppliers. It also leads to less loyalty between purchaser and supplier, which may result in no clear transparency in the relationship. Multiple sourcing further reduces any scale of economy benefits, as the purchaser is unable to offer all its business to one supplier (Linthorst & Telgen, 2017). When a purchaser realises that neither single, dual or multiple sourcing is the potential strategy for its company, vertical integration might be an option.

2.2.3.5 Vertical integration

Frohlich and Westbrook (2001:186) state that the most successful manufacturing companies are the ones that can link their processes with suppliers and with customers in a unique supply chain. This section focuses on suppliers, and the different possibilities in a supplier–buyer relationship.

Lazzarini, Chaddad and Cook (2001:7) stated that vertical interdependencies require a systemic understanding of resource allocation and information flow between companies engaged in sequential stages of production. Value chain analysis is an approach that describes a set of sequential activities creating value within companies, and it has been extended to activities between companies (Lazzarini, Chaddad & Cook 2001:7).

This value creation occurs in a supplier–buyer relationship, which can be referred to as a form of integration (Guan & Rehme, 2012:187). There are different forms of integration – either **hybrid forms**, referring to different companies collaborating in the procurement of raw material or finished goods, or **vertical integration** (Guan & Rehme, 2012:187). Hybrid integration is a combination of vertical integration and outsourcing and Wilson (1995:14) describes a hybrid operation as one that uses networks of relationships that are built on power and trust to manage the flow of material and information. Frohlich and Westbrook (2001:187) state that the higher the level of integration with suppliers, the greater the potential benefits for the supply chain.

Vertical integration is defined by Harrigan (1985:397) as a variety of decisions, which lead to an organisation providing goods through its business units or purchasing such goods from outsiders. Vertical integration can further be described as the degree to which business activities in a value chain which are brought together and which are reported to the management of a single company (Majumdar & Ramaswamy, 1994:119). There are two forms of vertical integration, namely upstream and downstream integration. **Upstream** integration refers to a manufacturing company integrating with its raw material supplier. The company positions itself in the upstream part of the supply chain, where it is closer to its material than its customer (Guan & Rehme, 2012:188). This integration can result in two scenarios. The company can either acquire a raw material supplier or said company can start a new division in its operation where it manufactures its own raw material. An example of this is Samsung who was originally a component manufacturer for smartphones, but now designs and manufactures phones and its components (Tuttle, 2016:8).

Downstream integration refers to the integration between the manufacturing company and its distribution partner (Guan & Rehme, 2012:188). The company positions itself in the downstream section (facing the customer) of a supply chain. This form of integration enables a company to secure distribution channels for its products, and leads to efficiency gains in the supply chain. Downstream integration requires companies to expand their focus from operational excellence to being a close ally of its end customer (Guan & Rehme, 2012:188).

Upstream vertical integration has various advantages in supply chain management, and is a sourcing strategy that especially works well in companies that view time as their most important determinant (Darneille, 2011:25). The reason for this is that time can be saved at every step of the supply chain in a vertically integrated company (Darneille, 2011:26). In the cotton industry, if a textile mill can spin its own cotton, it does not have to wait for deliveries. Mills that are able to produce their own cotton, do not have to wait for a local producer to deliver it. This further decreases the amount of quality testing to be conducted as most manufacturers redo quality checks, which take place at source. Upstream integration also reduces time spent on design and construction as a new concept does not have to be explained numerous times for the designer to comprehend the design (Darneille, 2011:26).

Vertical integration is not without risks for a company. One of these risks is a company’s ability to defer costs during a recall process (Tuttle, 2016:8). As the supplier of the raw material is also the manufacturer of the product, the company does not have another entity to turn to in order to offset reputational or financial damage (Tuttle, 2016:8). This then results in a magnified risk for the company, and one which Samsung experienced with the release of the Galaxy Note 7 Smartphone (Tuttle, 2016:8). As Samsung was the battery supplier as well as the phone manufacturer, there was no opportunity to defer recall costs to its supplier when the phones started exploding in 2016 (Tuttle, 2016:8).

There are various driving forces in vertical integration, and these are discussed from an economic, marketing and strategic management perspective (Guan & Rehme, 2012:189). From an economic and strategic view, Mahoney (1992:560) indicates that there are four driving forces for vertical integration, namely transaction cost considerations, strategic considerations, output or input price advantages, and cost or price uncertainties. Majumdar and Ramaswamy (1994:120) simplified these four driving forces and created two theoretical frameworks: the traditional and the transactional frameworks. The **traditional** framework sees vertical integration as a reaction to technological interdependencies between two successive stages in a supply chain (Majumdar & Ramaswamy, 1994:120). The **transactional** framework states that, if there are high profits in a supply chain, an integrated firm will perform better than a non-integrated firm (Majumdar & Ramaswamy, 1994:120). These driving forces are indicators to a company in terms of when they should consider vertical integration as a strategic sourcing option (Majumdar & Ramaswamy, 1994:120).

In one of the most popular vertical integration case studies, Fisher Body supplied automobile bodies to General Motors (Roider, 2006). During the period of 1919 to 1924, the two companies had exclusive supply contracts, but in 1925, General Motors experienced an increase in demand and requested Fisher Body to build a new plant close to a new General Motors facility. Fisher Body refused, which led to General Motors experiencing automobile body shortages, resulting in a reduction in scheduled production. The General Motors chief executive officer (CEO) at the time stated that full vertical integration with Fisher Body was not an option but a must for General Motors. This integration took place in 1926, and General Motors announced that they would develop their own automobile body-building facility the next day (Roider, 2006). This shows how vertical integration can have consequences on the transaction cost between companies but also on strategic decision-making. It can further also have an influence on the market outcomes of a product, such as its final price or quality (Guan & Rehme, 2012:189).

In their study of purchaser–supplier relationships, Dubois and Gadde (1996:806) found that for one product, various sourcing strategies might be used depending on the circumstances in which the product needs to be procured. Some of these circumstances might be the specifications from the customer, standardisation efforts and cost-saving initiatives or structural changes in the supply market. This means a purchaser should also take these into account when deciding on a purchasing strategy.

2.2.4 Summary of findings from sourcing literature

Sourcing is seen as a key supply management function, which refers to the identification of suitable suppliers, negotiating terms and creating value through improvements, such as cost and risk reduction (Ketchen et al., 2014:165). Sourcing has only recently been seen as a strategic consideration, and Ketchen et al. (2014:165) describe it as the action of making supply management decisions with the purpose of creating distinctive value and a competitive advantage for a company, and not merely a purchasing function.

The Kraljic model is the most used approach in purchasing portfolio management (Hesping & Schiele, 2016:111). Cox (2015:717) also acknowledges that from the 1980s, the Kraljic model approach has been the technique most commonly recommended to aid managerial decisions. The Kraljic model has four phases, namely –

- classifying all materials according to profit risk and supply risk;
- analysing the supply market of the material;
- identifying the overall strategic supply position of the company; and
- developing material strategies and action plans (Kraljic, 1983:110).

After establishing the strategic importance of a product, the sourcing strategy must be decided. Supplier quote strategy, single sourcing and dual sourcing were discussed above. Multiple sourcing and vertical integration were also discussed in detail in this section. A cost measurement will allow for the quantification of a sourcing decision. The next section discusses possible quantifiable measures, which will indicate whether a business sourcing decision was the correct one.

2.3 Total cost of ownership (TCO): Aiding with impact analysis

As mentioned in 2.2.1, strategic sourcing has been identified as one of the vehicles to create competitive advantage through cost-effectiveness, innovative capability and improved quality (Faes & Matthyssens, 2009:246). Strategic sourcing can be measured through various performance measurements, such as supplier performance management, operational excellence, procurement value and the monetary value associated with a new sourcing strategy (Lindstrom, 2010). As described in the packaging section of this chapter (**Section 2.1.3**), packaging system performance can be measured through tools such as the packaging scorecard and various key performance indicators (KPI), such as cost of material, quality and supplier performance.

To gauge the potential value of using the correct packaging system performance, and reviewing the sourcing strategies of Poligistics, a comprehensive measuring tool is needed. Various tools are found in literature, including life cycle costing, which primarily focuses on capital or fixed assets and tend to de-emphasise pre-transactions costs (Ellram, 1995:5). The balanced scorecard (measuring financial, customer, process and employee growth) is another possible tool, as is the TCO (Kaplan & Norton, 1996:191).

The term 'total cost of ownership' (TCO) refers to all the costs that relate to the procurement and use of a product. These costs include the end-to-end cost of the product, including the costs of disposing of the product at the end of its life cycle, and can be viewed individually or in a broad sense throughout the entire supply chain (Burt, Petcavage & Pinkerton, 2010:304). Ellram (1995:6) states that TCO is a purchasing tool and a philosophy of which the purpose is to comprehend the true cost of purchasing a product or service from a certain supplier. McCrea (2013) concurs and describes the TCO model (see **Section 1.2**) as enabling buyers to develop a comprehensive cost view for a product and also to indicate how much the product will cost in the long term. Burt et al. (2010:312–313) state that TCO should be a constant concept in the mind of a supply management professional and that the overemphasis on the purchase price of a product or service usually results in failure to address ownership and post-ownership costs.

In her TCO study, Ellram (1995:10) found that there are three primary uses of TCO model, namely supplier selection, supplier evaluation or ongoing monitoring of supplier performance, and driving major process changes. The companies in Ellram's study who used TCO to drive major process changes, used a broad approach to TCO analysis, which not only focused on purchasing-related issues but also on broad strategic make-or-buy decisions (Ellram, 1995:5). TCO can further be seen as an analytical tool, which supports management decision-making (Burt et al., 2010:315). The TCO approach can be modified to support major purchase decisions or to be used as part of a strategic cost analysis to support decisions, which require an analysis on cost over time (Burt et al., 2010:315). This further supports the decision by the current researcher to use TCO as a tool to test improved packaging system performance and strategic sourcing.

When using the TCO model, the company must decide between two approaches: dollar-based or value-based (Ellram, 1995:11). The **dollar-based** approach uses actual cost data for each TCO element and enables the company to track the costs of each item that makes up the total TCO of a product (Ellram, 1995:11). The **value-based** approach combines the cost data with performance data, which is not easily quantifiable. This approach is more complex than the dollar-based approach due to qualitative data being transformed to quantitative data (Ellram, 1995:11). Both these approaches use historical data and future cost estimates to calculate the TCO (Ellram, 1995:11). When the approach has been decided on, the company must decide between a unique and a standard model. A **unique** model can be created for a specific product or one-time purchase, whereas a **standard** model is used for repetitive buys (Ellram, 1995:11).

2.3.1 TCO tree

After establishing the approach and model, the TCO tree can be developed (see **Figure 2.11**). The TCO tree consists out of the buckets, elements, KPIs, levers and possible actions (Louw, 2017). The **buckets** represent the four TCO cost considerations of direct spend, indirect spend, internal costs and opportunity costs. By explaining and discussing the buckets, the elements in the tree are identified. This is followed by a **KPI** per element, which in turn unlocks certain levers. Examples of **levers** to reduce the TCO are a specification change, reduced usage and reduced inventory. The final step assigns possible **actions** to each lever to reduce the total TCO of the product (Louw, 2017).

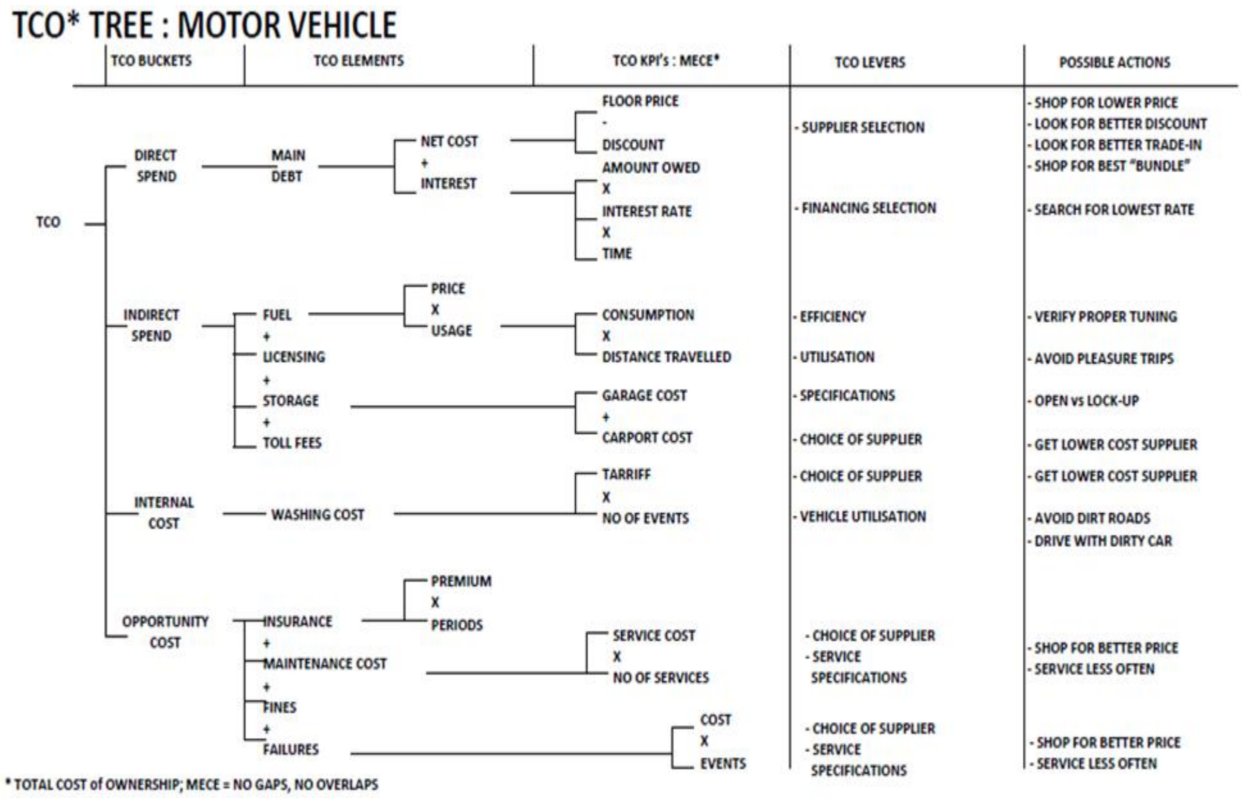


Figure 2.11 TCO tree for a motor vehicle

Source: Louw (2017)

Companies are reluctant to use TCO because of its various barriers and disadvantages (Ellram, 1995:14). The lack of data in many companies is one of the major barriers as well as the complexity of the model itself. There is also no standard approach to the model as it differs from company to company and in some cases within a company. TCO also requires a cultural change (in purchasing) from price orientation to cost understanding. Furthermore, TCO is situation-specific, which means that the cost needed for decision-making purposes may vary due to the importance of a specific purchase. Even though these barriers are active, there are also various advantages to the TCO model (Ellram, 1995:14).

One of the major advantages of the TCO model is its ability to create a consistent supplier evaluation tool, which improves the value of supplier performance comparisons. The evaluation tool creates clarity between the company and the supplier regarding the supplier performance expectations. The data created by the evaluation tool can also be used as a basis during supplier negotiations, and provides an opportunity to justify initial high prices on higher-quality products as this might result in lower total costs in the long term. TCO further enables a company to identify opportunities for cost savings through the identification of which supplier performance areas would be most beneficial to the company (Ellram, 1995:14).

2.3.2 Summary of findings from TCO literature

There are various tools to use when evaluating the impact of a process change, but the current study found TCO to be the most suitable tool. TCO enabled the study to view and compare the entire cost of polyethylene with the suggested improvements. The term 'total cost of ownership' (TCO) refers to all the costs, which relate to the procurement and the use of a product (Burt et al., 2010:304). TCO consists out of buckets, elements, items, KPIs, levers and actions and are situation-specific (Louw, 2017). There are both advantages and disadvantages to TCO. The former comprises the enablement of consistent supplier evaluations and the clarification of supplier expectations between the purchaser and supplier. The latter comprises the complexity of the model and the availability of data Ellram, 1995:14).

2.4 Deductions from literature review

This chapter set out to discuss the literature pertaining to the current research study. In this chapter, the researcher discussed packaging and the role of packaging in the supply chain. The discussion referred to the packaging functions and packaging system. The packing system consists of three levels, namely primary, secondary and tertiary (Murphy & Wood, 2011:215). In addition, the packaging material types – paper, glass, metal and plastics – were discussed.

The various material types were discussed with a focus on their history, market overview and sustainability impact. Packaging not only consists of material types, but is also a measurable material. In **Section 2.1.3**, the researcher discussed various packaging system performance models with a focus on the packaging scorecard. The packaging scorecard model enables the holistic measuring of packaging system performance. Following the discussion on packaging system performance, the sustainability of packaging was considered. The literature indicated that there is a need to take the entire life cycle of a product into account when investigating packaging sustainability. This allows the quantification of the environmental impact of packaging from the point of raw material extraction to its disposal or recovery.

Following the discussion on packaging, the literature review provided background to sourcing with a focus on strategic sourcing. This section referred to strategic sourcing and how sourcing has developed into a sophisticated action. It further discussed purchasing portfolio analysis (PPA) and various sourcing models. The Kraljic model was identified as one of the most trusted and used models in literature, giving rise to the identification of best-suited sourcing strategies. This section concluded with a discussion of various sourcing strategies and their advantages and disadvantages.

The final section in this chapter discussed the TCO model and how it can aid a business in its cost decision-making. The TCO tree was discussed, as well as the advantages and disadvantages of using the TCO model to determine the total costs of a product or service. To review all the key concepts discussed in this chapter, **Figure 2.12** illustrates the relationships between these key concepts in the form of a summarised concept map. The map depicts the relationships between the different concepts and the way they relate to one another. It illustrates how the packaging system has an influence on packaging system performance and how the material type of the packaging has an impact on its sourcing. This concept map provides an outline of this chapter and forms the basis of **Chapter 3** where the research design and methodology are discussed in detail. **Chapter 3** further illustrates and discusses the approach and methods applied during the study and the methods used to gather valid and reliable data.

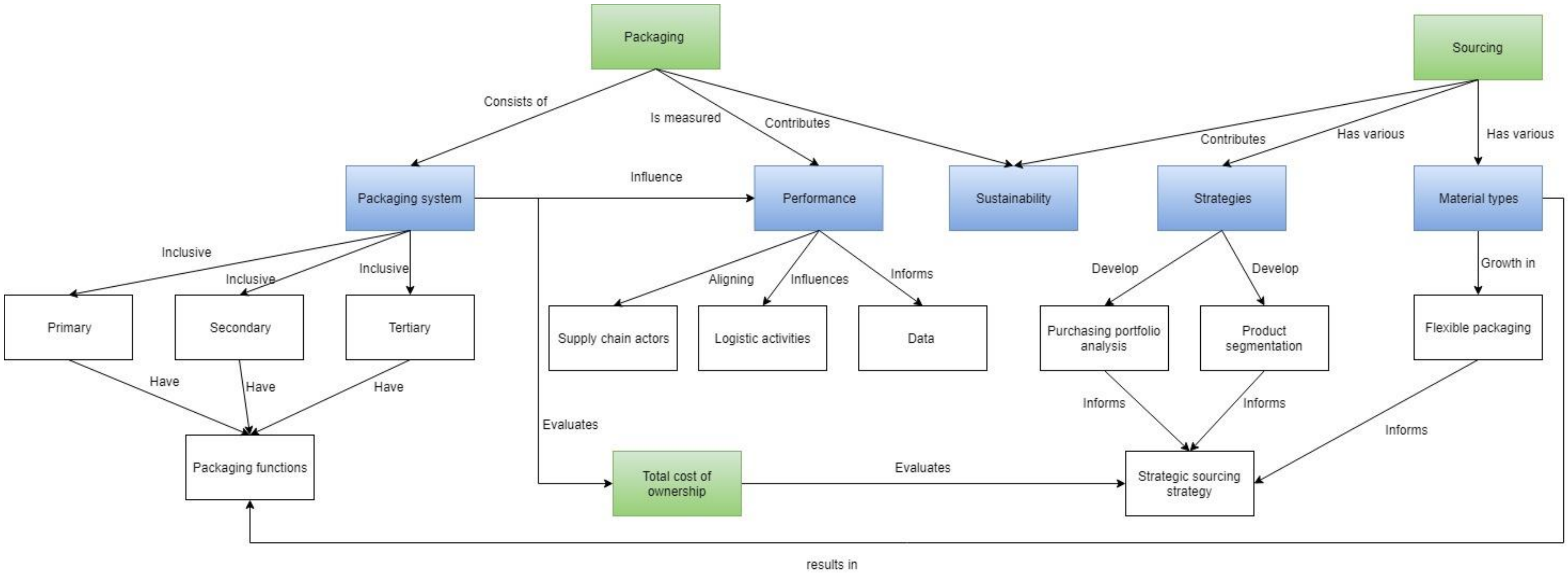


Figure 2.12 Literature review summary (as a concept map)

Chapter 3
Research design and methodology

3.1 Introduction

Chapter 2 discussed the packaging industry, types of packaging, packaging system performance measurements and sustainable packaging. It further considered sourcing and the various sourcing models, as well as strategic sourcing strategies. The chapter concluded with a discussion on total cost of ownership (TCO) and how this measurement is used in global business practice. **Chapter 3** presents the research approach, research design and methodology. It further presents the strategy of enquiry used in this study, as well as the data processing and analysis methods, which were employed. Measures to ensure the reliability and validity of the research are considered, whilst the limitations to the study will also be noted.

To assist in introducing the research design and methodology, the conceptual framework of the study is depicted in **Figure 3.1**. This framework maps the major concepts of the study as well as the research methods and their application. The framework illustrates the different variables identified in the study and how they were operationalised and analysed (Regoniel, 2015). The blue blocks indicate the main concepts of the study, while the green blocks highlight the research methodology of the study and the orange blocks show how the data was analysed and operationalised. The conceptual framework illustrates the cyclical nature of the methodology. As a concept is researched and analysed, the process reverts to the start to identify further areas of improvement.

3.2 Research approach

Using the approach described by Saunders et al. (2009), to formulate the research design and methodology, enabled the researcher to use a structured research methodology approach. The purpose of this approach is to ensure a consistent and logical research flow as it is integral to the development of a suitable and logical research design that can be justified and explained (Saunders & Tosey, 2012).

The philosophical stance of the research can be one of the following: positivism, realism, interpretivism, objectivism, constructivism and pragmatism (Saunders & Tosey, 2012). The philosophical stance is the researcher’s view of the world and affects how a research question is understood. As this research study was based on a single-case study of Poligistics, the researcher used the pragmatic philosophical stance. This stance is used when the practical implications of the research are important and feed into a research design where reliable and credible data can be collected to inform the study (Saunders & Tosey, 2012).

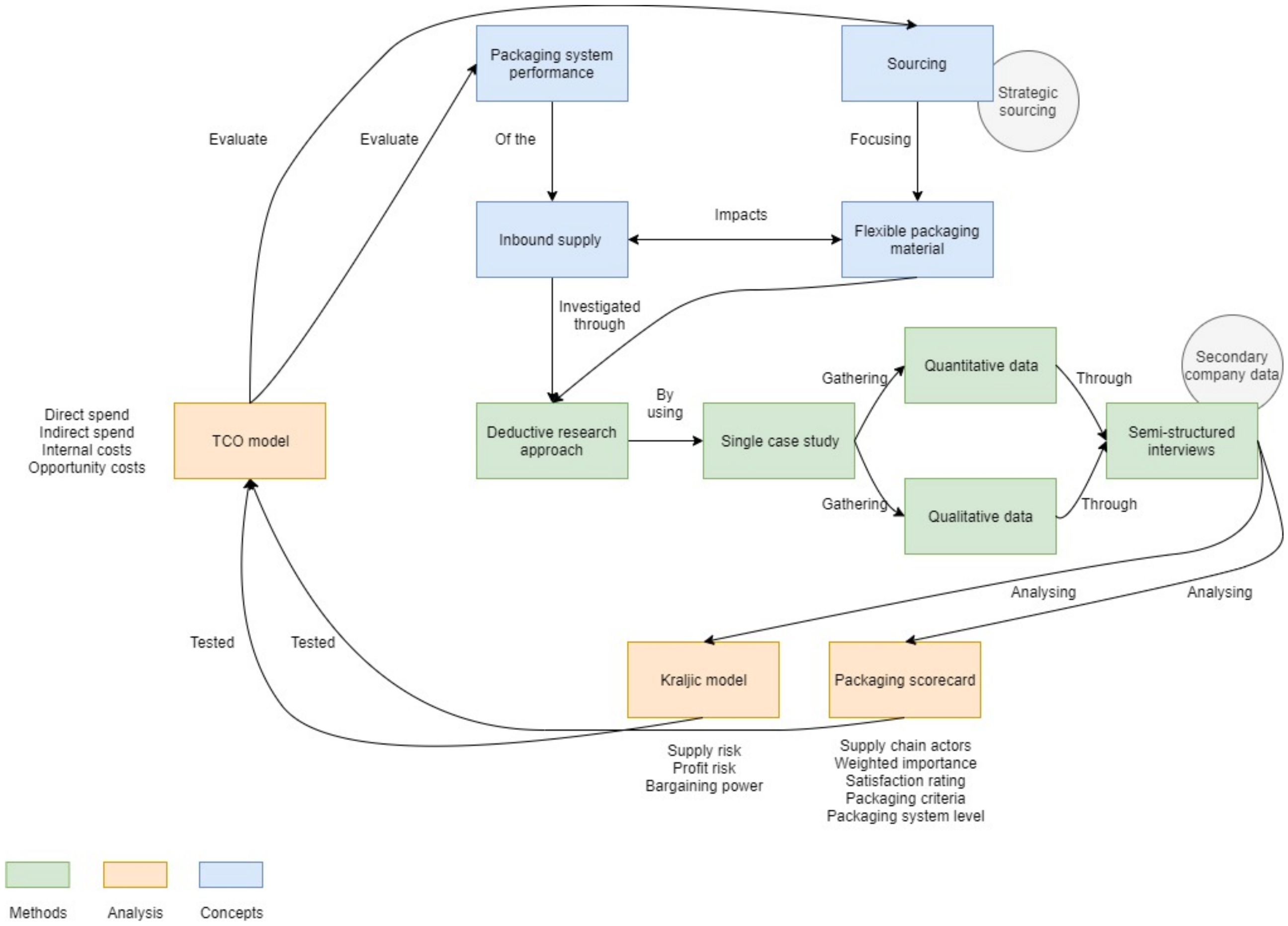


Figure 3.1 Conceptual framework

Source: Researcher's own compilation

Part of the research approach is to determine whether the research conducted is deductive or inductive. Trochim (2006) refers to **deductive** research as beginning with general reasoning and ending with specifics, whilst Creswell and Plano Clark (2007:23) refer to deductive research as working from the "top down". Alternatively, **inductive** research is referred to as working from the "bottom up" while using participants to build broader themes (Creswell & Plano Clark, 20017:23). Wilson (2010:2–6) notes that the deductive approach is concerned with the development of a hypothesis based on existing theory, and then designing a research strategy to the stated hypothesis. The research in the current study therefore followed a deductive approach as current theories and concepts were investigated and tested.

In addition, the case study approach was used to investigate current theories and concepts. A case study allows researchers to focus on a case while retaining a holistic and real-world perspective (Yin, 2014:4). Furthermore, Rule and John (2011:4) state that a case study is an in-depth and systematic investigation of a situation in its original context. As the study will consider the situation in its original context, this statement from Rule and John (2011:4) supported the need to utilise a case study strategy in the current research. Creswell (2013:73) further defines case study research as an approach where the investigator explores a real-life bounded system (a case) over time and through detailed data collection, which comprises multiple sources of information (Creswell, 2013:73).

The case study used in this study was based on a key information method (Gelderman & Van Weele, 2002:33). This resulted in a selected number of experts from Poligistics being interviewed in terms of sourcing where various stakeholders were interviewed in terms of the packaging system performance metrics. The specific experts were chosen due to their specialised knowledge of and experience with packaging system performance and sourcing. Following the establishment of the research strategy, a decision on the research method had to be taken. The following section describes the design of this study, comprising of the variables and unit of analysis.

3.3 Research design

Babbie (2010:91) describes research design as the researcher's plan to find something out. This plan stipulates what the researcher will analyse and observe to reach a conclusion to the research questions. Flick (2014:112) refers to the research design as a plan to gather and analyse sets of data, which enable the researcher to answer the research question. Three principles were identified by Babbie (2010:92–94) to classify research design.

The first principle distinguishes between empirical and non-empirical studies, while the second principle considers primary and secondary data. Primary data refers to data that was collected by the researcher and is also known as 'new' data, whereas secondary data already existed when the study started (Hox & Boeije, 2005:593). The main difference between these two data sources is the level of control the researcher has. With primary data, the researcher has a degree of control over the data collection, while secondary data was produced by another source (Babbie, 2010:92–94). The current study utilised both primary and secondary data as primary data was collected by the researcher and secondary data was obtained from the case study company in the form of knowledge sharing and financial information.

The third and final principle made by Babbie (2010:92–94) was between the types of data sources. These can be classified into two main categories, namely numeric (numbers, statistics) and textual data (documents, interview transcripts). Numeric data is referred to as 'quantitative data' while textual data is referred to as 'qualitative data' and, when both sources are used in one study, it is referred to as the mixed methods approach (see Greene, Caracelli & Graham, (1989:256) also Bryman, (2008:164). This form of research is also known as the "third path", the "methodological movement" or the "third research paradigm" (Alavi & Habek, 2016:62–63).

Of these different data sources, quantitative data is the dominant form of research in management sciences (Alavi & Habek, 2016:62). Qualitative data became especially popular during the second half of the twentieth century (Alavi & Habek, 2016:62). The mixed methods approach can be traced back to 1959 when it was used as a multi-method approach, but researchers only started using it on a regular basis in the 1990s (Alavi & Habek, 2016:62). Greene, Caracelli and Graham (1989:256) define the mixed methods approach as one where at least one quantitative method and one qualitative method is used and neither one is linked to an inquiry pattern. Bryman (2008:164) states that, when using the mixed methods approach, the researcher should clearly state the reasons for using a mixed methods approach and the advantages of it. Pope and Mays (2006:102) found that using a mixed methods approach enables the researcher to establish the "what" of the problem through quantitative methods, and the "why" and "how" through qualitative methods.

Alavi and Habek (2016:63) refer to the mixed methods approach as being a strong and precise research tool in the field of management research Therefore, the mixed methods approach was identified as the best suited approach for this study. The mixing of the two methods complements each other rather than compete with one another (Creswell & Plano Clark, 2007:10; Flick, 2014:16, 48). As an added value to the current study, parallel and complementary information was identified

3.3.1 Research variables

Three different concepts were investigated through the mixed methods approach. The first concept relates to the evaluation of the packaging system performance of polyethylene rolls. The packaging performance scorecard was used as the measurement tool for this concept and utilised quantitative data. The measurement included five variables, namely supply chain actors, weighted importance of a criterion, satisfaction rating, packaging criteria and packaging system level (see **Table 3.1**).

Another concept in this study was TCO. The TCO model was used for the evaluation of packaging and sourcing. The following variables form part of the TCO model: direct spend, indirect spend, internal costs and opportunity costs (see **Table 3.1**). In the current study, the TCO model utilised quantitative data in its cost calculation of packaging and sourcing. According to Soiferman (2010), quantitative research translates into the use of statistical analysis, and enables the researcher to make a connection between what is known and what can be learned through research. Quantitative analysis also enables the researcher to represent data visually through graphs, plots, charts and tables. It further enables researchers to draw conclusions based on logic and evidence (Trochim, 2006). Based on these reasons, the quantitative approach was applied for the packaging system performance evaluation and TCO model.

The final concept evaluated by this study was the strategic sourcing strategy. The evaluation method was the Kraljic model (see **Section 2.2.2.1**). The variables considered here were supply risk, profit risk and the bargaining power of the company (see **Table 3.1**).

In the current study, the qualitative approach enabled in-depth understanding of the sourcing strategies employed by Poligistics at the time of the research. Creswell (2013:36) describes qualitative research as collecting data at the site where a specific issue is being studied. With this research, respondents did not have to visit a laboratory, nor did they have to complete surveys. Instead, the researcher gathered information by conversing with people and observing their behaviour and actions within their natural environment (Creswell, 2013:37). Babbie (2010:296) concurs with Creswell (2013:36), and states that the main aim of qualitative research is to have an in-depth description and understanding of actions in a natural setting for the social actors.

Table 3.1 Variables and their descriptions

Variable	Data field descriptions	QN/QL data*	Data record (example)
Packaging system performance			
Supply chain actors	Actors who are active in the supply chain	QL	Supplier
Weighted importance	Relevant importance of a criterion (0%–100%)	QN	80
Satisfaction rating	Level of performance of criterion (0–4)	QN	2
Packaging criteria	Criteria were measures of packaging performance	QL	Protection
Packaging system level	A primary, secondary or tertiary system	QL	Primary system
Kraljic model			
Supply risk	The raw material availability, number of suppliers and the make-or-buy opportunities	QL	High
Profit risk	Volume purchased or percentage of total purchase cost	QL	Low
Bargaining power	Bargaining power of suppliers versus own bargaining power as a customer	QL	High
TCO model			
Direct spend	Direct spend on raw material	QN	R100 000
Indirect spend	Indirect spend on raw material	QN	R20 000
Internal costs	Costs to operate the company	QN	R10 000
Opportunity costs	Possible savings due to improvements	QN	R35 000

Note: *QN: Quantitative data; QL: Qualitative data

Source: Author's own compilation

The researcher wanted to evaluate the current sourcing strategy at Poligistics by using the Kraljic model, and the advantages of qualitative research enabled him to get an in-depth view of the current sourcing function at Poligistics. Following the establishment of the research choices, as specified by Saunders et al. (2009), the researcher considered the time frame of the study. The current study only took a "snapshot" of the variables (of the three concepts) and data, and did not observe them over an extended period of time (see Saunders & Tosey, 2012). The researcher also utilised various subjects instead of utilising the same subjects repeatedly. These elements resulted in the study being cross-sectional in nature (see Saunders & Tosey, 2012).

The researcher found that the mixed methods approach, with its focus on a specific case study, provided an appropriate research plan to answer the identified research questions (see **Section 1.4**). The study required in-depth investigation and understanding of packaging and sourcing at Poligistics. Thus, to summarise the quantitative design of the mixed methods approach investigated the packaging system performance and TCO model of polyethylene (see **Section 2.1.3** also **Section 2.3**) whilst the qualitative design explored sourcing through the Kraljic model (see **Section 2.2.2.1**) in a cross-sectional time frame.

3.3.2 Unit of analysis

The unit of analysis of a study forms an important part of the research design and data analysis. In social research, 'unit of analysis' refers to, for example, individuals, groups, organisations, social interactions and social artefacts (Babbie, 2010:98). To identify the unit of analysis of a study, the researcher should first consider the variables (see **Section 3.3.1**).

The three concepts of packaging system performance, TCO model and the strategic sourcing strategy with their variables were described in detail in **Section 3.3.1**. These variables were used to analyse the unit of analysis, Poligistics. Yin (2014:31–35) warns against confusion between the unit of analysis and the unit of data collection. Even though data collection might rely heavily on information gathered during interviews with individuals, conclusions cannot be based entirely on this information Yin (2014:31–35). To combat this, questions should be about the organisation and not about individuals working at the organisation. All questions should refer to the identified unit of analysis, namely the organisation (Yin, 2014:31–35).

3.4 Research methodology

Bryman (2008:160) describes the term 'methods' as the techniques used by researchers to conduct their research. These methods can refer to forms of data collection, such as interviews, observations or questionnaires, or they might refer to tools used to analyse data, such as statistical techniques. 'Methods' can further refer to aspects of the research process, such as sampling (Bryman, 2008:160). This explains 'methodology' as being the study of methods in research. Hagan (2014:432) states that the major concern with the selection of instruments is that they might not be best suited to quantify the theoretical or conceptual framework. Considering this, the data gathering instrument used in the current study was semi-structured interviews (as recommended Wilson, 2012). This technique enabled the researcher to gather the relevant and adequate quantitative and qualitative information to answer the research questions.

When a researcher needs to understand human issues, and when it is necessary to explore a trend and search for themes in data, an interview is a considered a good data gathering technique (Wilson, 2012). There are three types of interviews (see **Figure 3.2**), namely structured interviews, semi-structured interviews and unstructured interviews. With structured interviews, all respondents are asked the same set, whereas with semi-structured interviews, the interviewer has a set of guiding questions but can follow topics of interest with individual interviewees. In unstructured interviews, there is a high level of flexibility, and the interview is a conversation between two parties (Wilson, 2012).

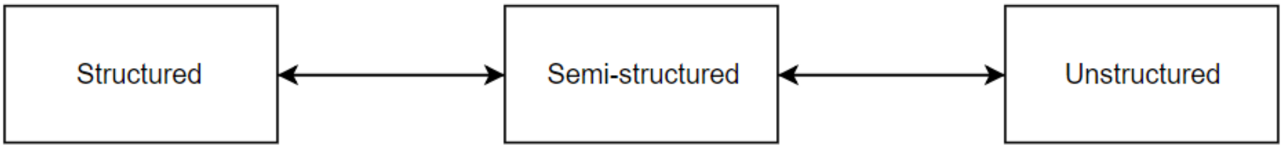


Figure 3.2 The structure of different interview types

Source: Welman and Kruger (2001:158–159)

Welman and Kruger (2001:161) state that a semi-structured interview offers a versatile way of collecting data and utilises an interview guide, which comprises a list of topics related to the research theme. This enables the researcher to formulate and adapt questions to suit the educational level and background of respondents (Welman & Kruger, 2001:161). In the current research study, interviews were conducted with various employees of Poligistics and respondents working in the flexible packaging industry. Semi-structured interviews allowed the researcher to extract all the necessary information from respondents, as well as the opportunity to explain certain terminologies used during the interview, as explained by Welman & Kruger (2001:161). This led to comprehensive and more reliable data, as the respondents were able to answer the question to the best of their ability.

There are various advantages to interviews (Welman & Kruger, 2001:158–159). The key advantage is the control the interviewer has over the interview situation. The interviewer can clear up any misunderstandings and is able to follow up on any incomplete or vague responses. Due to the interviewer physically being at the interview, there is a high response rate as regards data gathering (Welman & Kruger, 2001:158–159).

There are however also certain limitations to conducting interviews (Welman & Kruger, 2001:159). The physical presence of the interviewer can be a potential challenge, and there are high costs associated with the preparation, application and conducting of interviews. These costs include the time it requires of researchers and respondents, as well as their travelling costs. Further to this, the reduction in the possibility of anonymity of respondents or of the interviewer might lead to incorrect information as the respondents might respond in a way they think the interviewer expects of them rather than what applies to them (Welman & Kruger, 2001:159).

To combat this, the researcher ensured that respondents were interviewed at a convenient time and place, and that all respondents were participating voluntarily with no expectation of compensation, reward or possible future limitations in their careers. Respondents were also aware that they could withdraw from the interviews at any time should they need to, and anonymity was maintained at all times.

3.5 Sampling and population

Respondents to assist with data gathering were identified by the researcher through the use of sampling. Babbie (2010:191–197) describes sampling as the process of selecting observations. There are two types of sampling, namely probability and non-probability sampling. **Probability** sampling comprises a selection of typical or representative units of the population it represents. **Non-probability** sampling occurs when probability sampling is not practical or appropriate and, in the process, not all the individuals in the population has an equal chance of being selected. Individuals are rather selected on their accessibility or purposive personal judgment to the researcher (Babbie, 2010:192; Explorable, 2019).

There are four types of non-probability sampling, namely reliance on available subjects, purposive sampling, snowball sampling, and quota sampling. Using non-probability sampling, the current study applied purposive and snowball sampling. When the researcher has vast knowledge of the population and its elements, the purposive sampling method is applicable (Babbie, 2010:192–196). De Vos, Strydom, Fouché and Delport (2011:232) concur and state that with the purposive sampling model, the researcher uses his or her expertise to select subjects from the studied population.

In this instance, the researcher had knowledge of the population as well as access to the respondents, which is in line with how Monette, Sullivan and Dejong (2005:148) describe purposive sampling. These authors described purpose sampling as choosing respondents who possess the characteristics or information necessary for the study and who are accessible to the researcher. In addition to purposive sampling, the snowball sampling technique was used during the study. This method refers to the process of accumulation where identified respondents suggest other respondents (Babbie, 2010:193). This sampling method was applicable to the current research because there were a limited number of respondents available, and the possibility existed that the knowledge of certain respondents might lead to the identification of further potential respondents.

3.6 Reliability and validity

Reliability is an important part of a research study and, depending on the type of instrument, can be measured in multiple ways (Hagan, 2014:431). It is the degree of consistency with which an instrument measures the attribute it is designed to measure (Polit & Hungler, 1993:448). There are three common measurements of reliability, namely test–retest, internal consistency and scorer reliability (Hagan, 2014:431). **Test–retest** refers to the comparison of responses from the same respondents but at different time intervals. **Internal** consistency refers to the comparison of responses between respondents, while **scorer** reliability compares one reviewer with another reviewer (Hagan, 2014:431).

Reliable information means researchers can assume that the scores or data obtained through various methods are dependable and consistent. If inconsistent, there might be a problem with the items or reviewers, which will need to be examined and addressed. 'Validity' is used to describe the extent to which a measuring instrument measures what it is intended to measure. Research instruments are not inherently valid; validity must rather be established for specific contexts and populations (Endacott, Benbenishty & Seha, 2010:65). To evaluate the validity of the research, problems first need to be addressed. Without reliability, validity cannot exist (Hagan, 2014:431–432). The validity can further be confirmed by triangulation, where findings from different analytical approaches are compared with each other (Bryman, 2008:163).

The researcher allowed sufficient time for an in-depth literature review and thorough data gathering. Data was deemed trustworthy as only the researcher was responsible for conducting the semi-structured interviews. To maintain the reliability of the research instrument, the researcher disassociated himself from ambiguous items, questions, which combined three or more factors in one, and he also refrained from posing sensitive or threatening questions. Data was further collected in a neutral, private location where respondents were free of disturbances, such as interruptions, a lack of privacy or sudden noises. All respondents participated voluntarily in the interview process and anonymity was maintained by using pseudonyms. Validity was ensured by the consistent use of the various analytical approaches, and all concepts were explained in such a manner that a less-informed citizen could understand it.

3.7 Limitations to this study

The researcher used a specific single-case study and therefore findings cannot be generalised to all packaging companies. Furthermore, as certain respondents might not have reacted truthfully, there may exist a limitation on the information gathered by the researcher. The study further only focused on the sourcing and performance of polyethylene packaging and did not consider other packaging material types.

This chapter established that the pragmatic philosophical stance was used in the study while the deductive research approach was identified as the research approach. The strategy of the current study was that of a single-case study while utilising the mixed methods research methodology. Semi-structured interviews were used to gather data while the interviewees were identified through purposive and snowball sampling. The next chapter discusses the preparation of this data and the analysis and synthesis conducted.

Chapter 4
Analysis and synthesis

The first section of this chapter discusses the data gathering and analysis of this study. It further reflects on the data preparation and the coding that was needed for the analysis. It also provides background to the liquid liner industry and Poligistics. **Section 4.3** provides feedback to the various research questions and relays the information as found during the research process. As discussed in **Chapter 3**, a mixed methods approach was used to gather data by using semi-structured interviews as a data gathering instrument. This enabled the application of the packaging scorecard, the Kraljic model and the TCO model.

4.1 Data gathering, coding and analysis

This section of the study describes how the data was gathered, as well as the sampling methods used. The section further discusses the data gathering instruments used and the data preparation and coding required to analyse the data.

4.1.1 Data gathering

To investigate the packaging system performance and sourcing strategies at Poligistics, data gathering was required. Data gathering enabled the researcher to apply the packaging scorecard, the Kraljic model and TCO model in the study to evaluate polyethylene at Poligistics from a packaging system performance and sourcing strategy view, which led to implementable recommendations.

Quantitative data was gathered for the packaging scorecard and for the population of the TCO model. Qualitative data was gathered for the Kraljic model and for the background to the liquid liner industry and Poligistics. Both data types were prevalent in the study and thus a mixed methods approach was utilised to gather the required data.

4.1.2 Sampling methods used

For the purpose of this study, non-probability sampling was used to identify respondents. The specific non-probability sampling techniques used were purposive and snowball sampling. Purposive sampling resulted in the identification of three supplier respondents, one service provider respondent and seven customer respondents. Further snowball sampling led to the identification of three supplier respondents and two service provider respondents who supplied data for the packaging scorecard. This resulted in a total of 16 respondents (9 males and 6 females) used to gather data to populate the packaging scorecard.

Purposive sampling was further used to identify the respondents needed to populate the Kraljic model relating to the sourcing research question, TCO model and to provide background to the liquid liner industry and Poligistics. Six respondents with the necessary knowledge and skills were selected to partake in the sourcing research and TCO model part of the study. These respondents as well as the customer respondents participating in the packaging scorecard also supplied the necessary data to populate the TCO model and gave background to the liquid liner industry and Poligistics. Another respondent only provided background information to the liquid liner industry and Poligistics. Most respondents used in this study had vast knowledge of the flexible packaging industry, while all respondents were seen as experts in their respective positions. Respondents varied from a general worker to managerial level, allowing the researcher to gain a holistic view of the gathered data. These two elements (expert knowledge and representation at different levels) combined and resulted in the researcher gathering reliable and valid data from the respondents.

Semi-structured interviews were conducted with all respondents, and this occurred at a location and time convenient to them. The researcher travelled to the respondents and insured that all respondents were comfortable with no expectation of any compensation or possible disadvantages regarding their careers. Respondents participated voluntarily and were able to leave the interview at any stage. However, all respondents completed their interviews and provided the required data.

4.1.3 Data preparation: Coding and analysis

The data gathered during the semi-structured interviews was used to populate the various models in the study. The sub-sections below describe data preparation, reshaping and coding for each model.

4.1.3.1 Packaging scorecard

A total of 16 respondents formed the sample group providing information to populate the packaging scorecard. These respondents formed the sample group of the supplier, service provider and customer supply chain actor groups. All the respondents were selected based on their competence and knowledge in their respective positions. The respondents' job titles varied from general worker to managerial level and ensured realistic and reliable data. The data was gathered by way of semi-structured interviews and Interview Guide 1 (**Appendix A**). Respondents supplied background to the current packaging system performance measurements used in their area of work and their current view of its performance.

The next step was to explain the supply chain of a polyethylene roll and the logistic activities associated with it (**Figure 4.1**). After establishing each respondent (supply chain actor) position in the supply chain and the difference between the packaging types, the semi-structured interview progressed to the packaging scorecard. Respondents were required to make three decisions regarding each criterion in the packaging scorecard.

- Participants first had to decide whether the criteria were applicable to their part of the supply chain.
- Second, they had to rate the importance of each criterion on a scale of 0–100%.

- Finally, the respondents had to rate the performance of the criterion on a scale of 0–4 where 0 meant not applicable to the packaging and 4 meant the packaging was performing excellently.

Each respondent supplied the data according to his or her view on the packaging type and its performance with regard to a specific criterion point. The respondents viewed this from their role in the supply chain (supplier, service provider, customer). The gathered data (**Appendix B)** had to be combined in order to determine which criteria points were performing well at the time and which were performing poorly. The data required preparation and reshaping in order to reach the required conclusions, as in its current state, the data was not able to give a holistic view of the packaging system performance.

The preparation and reshaping included calculating the normalised weighted average satisfaction score (NWASS) per criterion point. This score comprises the satisfaction scores and weight of each criterion point and can be calculated in either Microsoft Excel or Tableau (via a calculated field). In the current study, the data was structured in a tabular form (**Appendix C**), which reflects columns for the criteria point, score and weight. This data was then used to calculate the aggregated NWASS in Tableau by using the following formula, as recommended by Nilsson (2016:296):

$$\text{NWASS} = \sum(\text{[Satisfaction scores] X [Weight]}) / \sum(\text{[Weight]})$$

The data enabled the researcher to create histograms, bar charts and divergent stacked bar charts to analyse the data. In answering the first research question, the first level of analysis indicated that the primary packaging system was the top performing packaging system while service providers only interacted with tertiary packaging (see **Section 4.3.1**). Minimal use of hazardous substances and security concerns were some of the best performing criteria while stackability was one of the worst performing criteria (see **Section 4.3.1**).

4.1.3.2 Kraljic model

Six respondents took part in the semi-structured interviews that populated the Kraljic model. These respondents had vast knowledge of the flexible packaging industry with a combined total of 59 years of experience in the industry. The interview included questions regarding background to the flexible packaging industry, and explaining the the Kraljic model. As the data was qualitative in nature, all the required data was captured during the semi-structured interviews.

This data gathering activity used the Kraljic model as a framework. After establishing the background to the flexible packaging industry, respondents were required to rate the supply risk and profit risk of polyethylene on a scale of 1–10, where 1 was very low and 10 was very high. The supply risk values were plotted on the x-axis while profit risk was plotted on the y-axis (see graph in **Figure 4.8**). This resulted in the purchasing classification of polyethylene.

Market analysis of polyethylene was the next step and required qualitative data. Porter's five forces model was applied to conduct the market analysis as the model helps to understand the strength and weaknesses of a company (CGMA, 2013). Respondents gave their views on the factors 'competitive rivalry', 'supplier power', 'buyer power', 'threat of substitution' and 'threat of new entry' for Poligistics. When preparing and shaping this data, the researcher looked for common themes in respondent views on these various topics. Possible patterns were identified which provided coherent results (see **Figure 4.10**).

The data gathering, and preparation enabled the researcher to populate the Kraljic model. During the first level of analysis of the second research question (see **Section 1.4**) and based on the model, it was indicated that polyethylene is a strategic product for Poligistics. All respondents agreed that there is a high supply and profit risk associated with the product. In addition, the five forces model indicated that price volatility is prevalent in the flexible packaging industry and that Poligistics is a price taker in the market. There is a high barrier of entry to the industry due to the need for expert knowledge and a required customer base (Expert 1; Expert 6).

4.1.3.3 Total cost of ownership model

The TCO model was used to evaluate the impact of possible improvements in the packaging system performance or sourcing of polyethylene at Poligistics. To populate this model, data was gathered during the semi-structured interviews with the same six respondents who provided the data to populate the Kraljic model and the customer respondents in the packaging scorecard. The interviewees supplied the primary data, which enabled the researcher to conduct calculations to populate the TCO model.

The TCO model consists of four main buckets, namely direct spend, indirect spend, internal costs and opportunity costs (see Louw, 2017; see also **Section 2.3.1**). These main buckets consist of various individual calculations, which summarises to the cost per bucket (**Appendix D).** A certain polyethylene size, which the respondents confirmed was used on a monthly basis (2 200 mm and 100 micron) at the time, was used for the purpose of the calculations. The respondents further confirmed that an average of eight tons of this product was used monthly, which allowed the researcher to conduct the TCO calculations. The data gathered for the TCO calculation was applicable for the first quarter of the year 2018.

The four costs per bucket were added together to determine the TCO of the polyethylene. After gathering data from respondents, the researcher used Microsoft Excel to plot all the various numbers (**Appendix D**). By using the multiply and sum function, the researcher was able to calculate the various costs for TCO. The first level of analysis indicated that, at the time, the TCO for 96 tons of polyethylene equated to R802 214 per annum with the biggest contributor being the direct spend bucket (77%), with the second highest cost bucket was indirect spend with 12%.

4.2 Background to the liquid liner industry and Poligistics

As described in **Chapter 3** of this thesis, semi-structured interviews were used to gather the relevant data for this study. All interviewees were specialists in their positions and had a wealth of experience in the business unit within which they were functioning, as well as in the liquid liner industry. The information in this section regarding the liquid liner industry and Poligistics was gathered during the semi-structured interviews with the six identified experts for the Kraljic model as well as one expert who only provided background to the liquid liner industry and Poligistics.

4.2.1 Background

The liquid liner bag industry originated as a result of the need for battery acid to keep all the vehicles in the Second World War running (Expert 7). As bottles were not in abundant supply and the military needed more acid, the need developed for an alternative solution. Plastic bags were used to replace bottles and they fitted inside a storage unit. After the Second World War, the need for battery acid reduced but it was found that other liquid products could also be transported in these liner bags inside a storage unit (Expert 7).

Storage units were previously used for the transportation of food products but were replaced by cheaper storage units containing liquid liner bags (Expert 1; Expert 7). The original storage units were expensive and extremely product sensitive (Expert 1; Expert 7). This resulted in the need for thorough cleaning after use before it could be reused again. Liner bags presented the opportunity to use a cheaper storage unit, which reduced the logistics cost per litre, as the distributor was able to put more product into the storage unit than in the bottles and reduce the cleaning cost (Expert 7).

The liquid liner bag further eliminated the need to move empty storage units from one point to another, as the bag could be recycled immediately, and the unit reused. Improved packaging integrity was a sub-benefit as the bag reduced the amount of air in the storage unit, which could compromise the product (Expert 6; Expert 7). Customers were however not aware of the product that preceded their product in an original storage unit. This led to cross-contamination in some cases, whereas when using one-off liquid liner bags no possibility of such contamination existed (Expert 6; Expert 7).

4.2.2 Liquid liner bag functionality

Liquid liners are predominately used in a business-to-business environment (Expert 2). Reasons for this include the volume of waste generated by the packaging and the size of the product shipment (Expert 2). Traditionally, businesses do not have excess space on their premises. The volume of waste generated by flexible packaging versus rigid packaging (containers standing on the premises) results in businesses opting for flexible packaging. However, consumer goods do not use flexible packaging regularly, with the most prominent product type being wine (Expert 1; Expert 2; Expert 6). To satisfy the various demands, liquid liner bags are produced in various shapes and sizes but Poligistics predominately (90%) produces 1 000-ℓ bags.

The first 1 000-ℓ bags were used in 1970s when products were transported from Australia to other countries (focusing on fruit industry products) (Expert 1; Expert 7). One of the first international voyages was from Australia to England in the 1980s. Today, the most packaged or transported product in a liquid liner bag is tomato sauce due to its short processing time but high storage capability. Tomato sauce is moved between the main plant and smaller plants in 1 000-ℓ bags, where it is then placed in smaller bags (3ℓ, 5ℓ, 10ℓ) for businesses such as fast food outlets, hotels and hospitals (Expert 1; Expert 7).

4.2.3 Economics and challenges

The global liquid liner industry currently generates roughly $2.5 billion per year (small and big bags) (Expert 7). In the 1 000-ℓ bag industry, there are 10 big competitors and another 40–50 smaller competitors (Expert 1; Expert 6). Industry growth is seen in the fast food industry (especially in the developing world) with the other industry driver being the oil industry (Expert 1; Expert 2; Expert 6). These two market drivers are predominately found in developed countries due to the lack of infrastructure in the developing world. To grow the market in the developing countries, infrastructure is needed with good logistics systems and capital investments by governments (Expert 7).

By 2050, the industry is expected to be much bigger with more products moving over to the use of liquid liner bags (Expert 7). Due to the economic advantages of flexible packaging, most rigid packaging containers will move to flexible packaging (Expert 7). One of the challenges facing the industry is the robustness of the packaging itself (Expert 7). Due to the large quantity of products moved at any one time, one tear in a bag results in thousands – even millions – of rands worth of damages. A further challenge is possible stringent laws regarding plastic packaging and how the industry will be able to deal with this (Expert 7).

4.2.4 Poligistics

Poligistics is a privately-owned company, which started producing packaging material in the 1980s, supplying the global markets (Expert 5; Expert 6). The company first produced dunnage bags, which resulted in an understanding of the packaging industry as well as its opportunities. One of these opportunities was the identification of the flexible packaging liquid liner industry. The company identified itself as a competitive, growing market, which could compete with the best manufacturers in the world. This opportunity resulted in a movement away from the manufacturing of dunnage bags, with the company currently only producing liquid liner bags and dry bags. Dry bags (see Sandax, 2019) are used as a moisture absorber in containers, but this study focused on liquid liner bags only.

The company transformed itself into an innovative company, which focuses on new products and which helps customers move their products safely. The company currently produces between 15 000 and 30 000 liquid liner bags per month, comprising four types of bags, namely drum liners, pillow liners, form-fit liners and high viscosity liners. These liners vary in complexity with the drum liner being the least complex liner and the high viscosity liner being the most complex liner. ‘Complexity’ refers to the complexity of producing the bag and its different features. Drum liners and pillow liners are commodity products (i.e. they are readily available in the market), whereas form-fit liners and high viscosity liners are part of the company's premium product range which provide added value opportunities to customers.

The major component of a liquid liner is polyethylene, which is extruded by flexible packaging companies (Expert 3). Poligistics currently procures polyethylene from four different suppliers, with lead times ranging from three to six weeks. The current supply base is scattered across the world with the main suppliers situated in South Africa. After establishing the background to the liquid liner industry as well as Poligistics, **Section 4.3** discusses the findings of the packaging system performance measurements.

4.3 Packaging system performance

Section 4.3 to **Section 4.5** will start to answer the research questions of the current study (see **Section 1.4**). The fourth research question regarding the recommended practices will be discussed in detail in **Section 5.1.3.4**. This section will however start to answer RQ1:

To what extent is packaging system performance measured at Poligistics, and how is packaging performing based on criteria and set methods?

Section 2.1.3 discussed packaging system performance and referred to 'performance' as measurements enabling organisations with the evaluation of their progress towards specific goals or objectives (Crawford et al., 1988). The goal of this research question was to understand the current packaging system performance model utilised by Poligistics, the actors in its supply chain, and finally, to evaluate the performance of the packaging system.

To understand the packaging system performance, the supply chain with its logistic activities had to be defined. This enabled the researcher to identify the specific supply chain actors responsible for each logistic activity. **Figure 4.1** illustrates the supply chain and logistics activities of a polyethylene roll, from where it is extruded to where it is converted into a liquid liner bag. The activities in the green segments are the responsibility of external parties, while the blue segments indicate the activities for which Poligistics is responsible. The current study's supply chain is divided in activities namely suppliers, receiving, storage and issuing, production, packaging, distribution and finished goods delivery. **Figure 4.1** illustrates how Poligistics controls most activities in the supply chain, but that it does not have direct control over the production of polyethyelene rolls or the distribution of the final liquid liner bags.

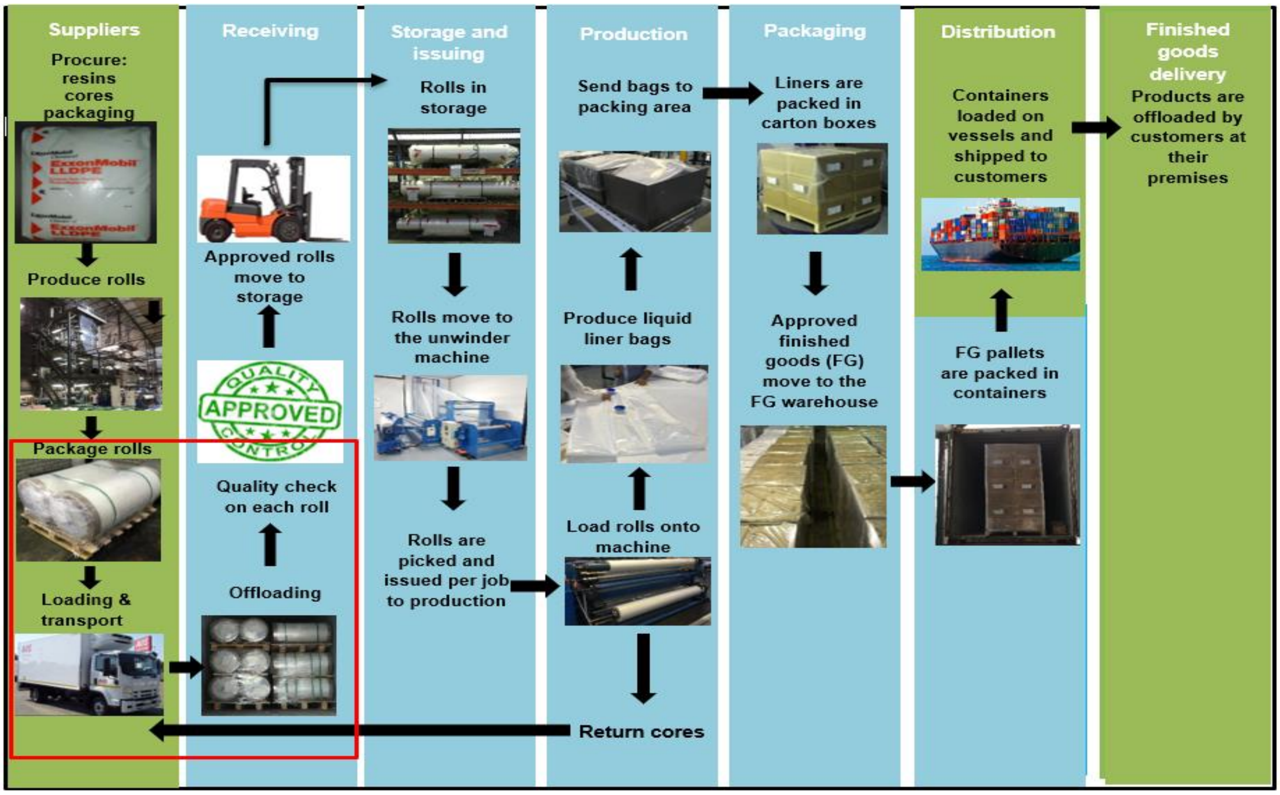


Figure 4.1 Supply chain activities: Polyethylene roll

For this study, the inbound supply logistic activities for only this supply chain, namely the packaging of the roll, its transportation, offloading and quality checks, were considered (**Figure 4.2**). These activities led to the identification of the supply chain actors who had to be included in the study. There were three supply chain actors present, namely the supplier, the service provider (transport) and the customer (Poligistics). Following the identification of these actors, the packaging system performance measurement could commence.

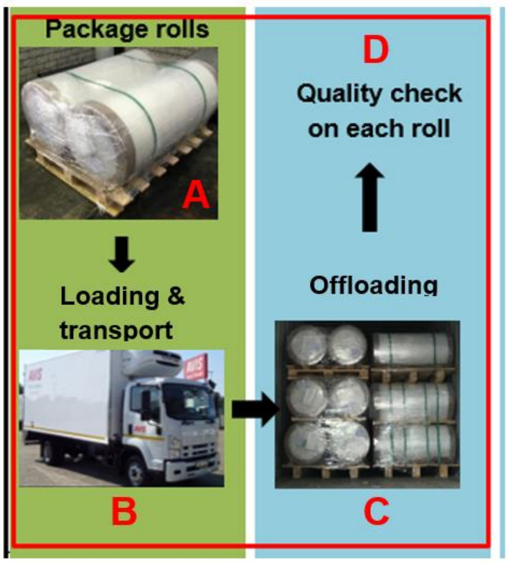


Figure 4.2 Activity flow focus (abstracted from **Figure 4.1**)

4.3.1 Packaging scorecard

A total of 16 respondents participated in the semi-structured interviews regarding packaging system performance. Of these respondents, six were part of the supplier actor group, three were service providers and seven were customers, with all respondents seen as competent in their respective positions. These positions varied from managerial level to general worker and the packaging scorecard criteria that were used in this study were as explained by Nilsson (2016:295).

All 16 respondents individually participated to populate the packaging scorecard (**Appendix B**). Semi-structured interviews enabled the researcher to explain each criterion in detail to respondents, which resulted in accurate scoring. The first step in the process was to understand the current packaging system performance measurement. At the time of the interviews, all 16 respondents agreed that there was no formal measurement, with the customer group referring to a physical check of polyethylene upon arrival at Poligistics as the packaging performance check. After this confirmation, all respondents individually populated the packaging scorecard, where they considered the relevant packaging system with which they came into contact and whether the relevant criteria were applicable to the packaging. If deemed applicable, a weight of importance (0–100%) was assigned to a criterion point and its performance (0 – Not applicable to the package, 1 – Not approved, 2 – Approved, 3 – Well approved, 4 – Met excellently) indicated.

After the collection of this data (**Appendix C**) and the calculation of the NWASS (as described in **Section 2.1.3.2**), the data was as follows. The overall packaging NWASS for this section of the polyethylene supply chain was 2.9. This is out of a total possible point of 4, and indicates that the packaging in this supply chain was performing relatively well. **Figure 4.3** indicates the aggregated NWASS per packaging system. All respondents agreed that secondary packaging was not used in this supply chain and was not rated. The primary packaging of the polyethylene roll consists of the core and first polyethylene layer which acts as a cover for the roll. The tertiary packaging consists of stretch wrap, carton corners, strapping and a pallet. The respondents rated primary packaging (3.0) as performing 0.2 points better than tertiary packaging (2.8).

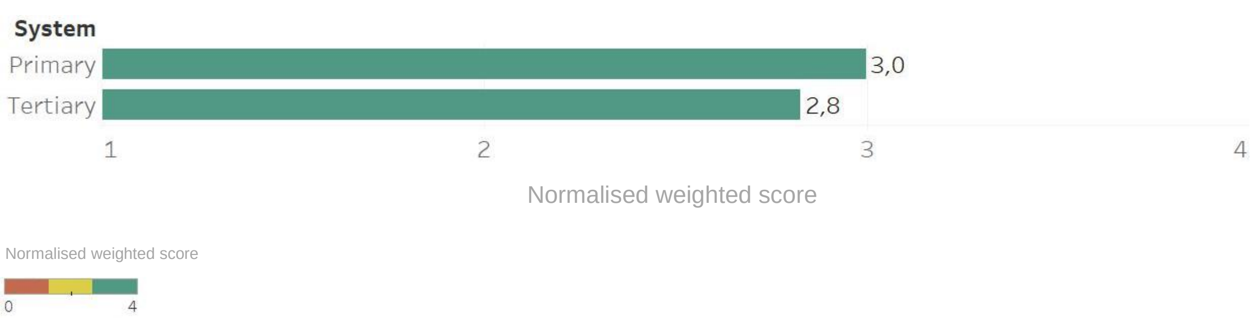


Figure 4.3 The aggregated NWASS per packaging system

After establishing the overall NWASS for each packaging system, **Figure 4.4** illustrates the NWASS per packaging system, but seen from each supply chain actor's point of view. Suppliers and customers interact with primary and tertiary packaging; both groups of actors therefore scored both packaging systems. The secondary packaging system is not present in this supply chain and thus none of the actors were able to rate this system (see **Section 2.1**). Suppliers rated the NWASS per packaging system the same as the overall rate, namely 3.0 for the primary system and 2.8 for the tertiary system. Customers scored the tertiary packaging system 2.9, which was 0.1 higher than the suppliers, while the customer also scored the primary system 3.0. The service providers only interacted with the tertiary packaging of the product, and gave the system an NWASS of 2.9.

Figure 4.4 NWASS per packaging system and supply chain actor

The NWASS represents the quantitative measurement of the packaging scorecard (see **Section 3.3.1**), while **Figure 4.5** illustrates the qualitative measurement on a diverging bar chart. The figure indicates the percentage of respondents who selected a certain level of satisfaction per criterion. The figure further illustrates how minimal use of hazardous substances were deemed the best performing criteria and reverse handling, second best. Stackability was deemed the criterion in which the supply chain was performing the worst at the time. The second worst performer was the tracking information of the product while respondents were also not pleased with the volume and weight efficiency of the products packaging.

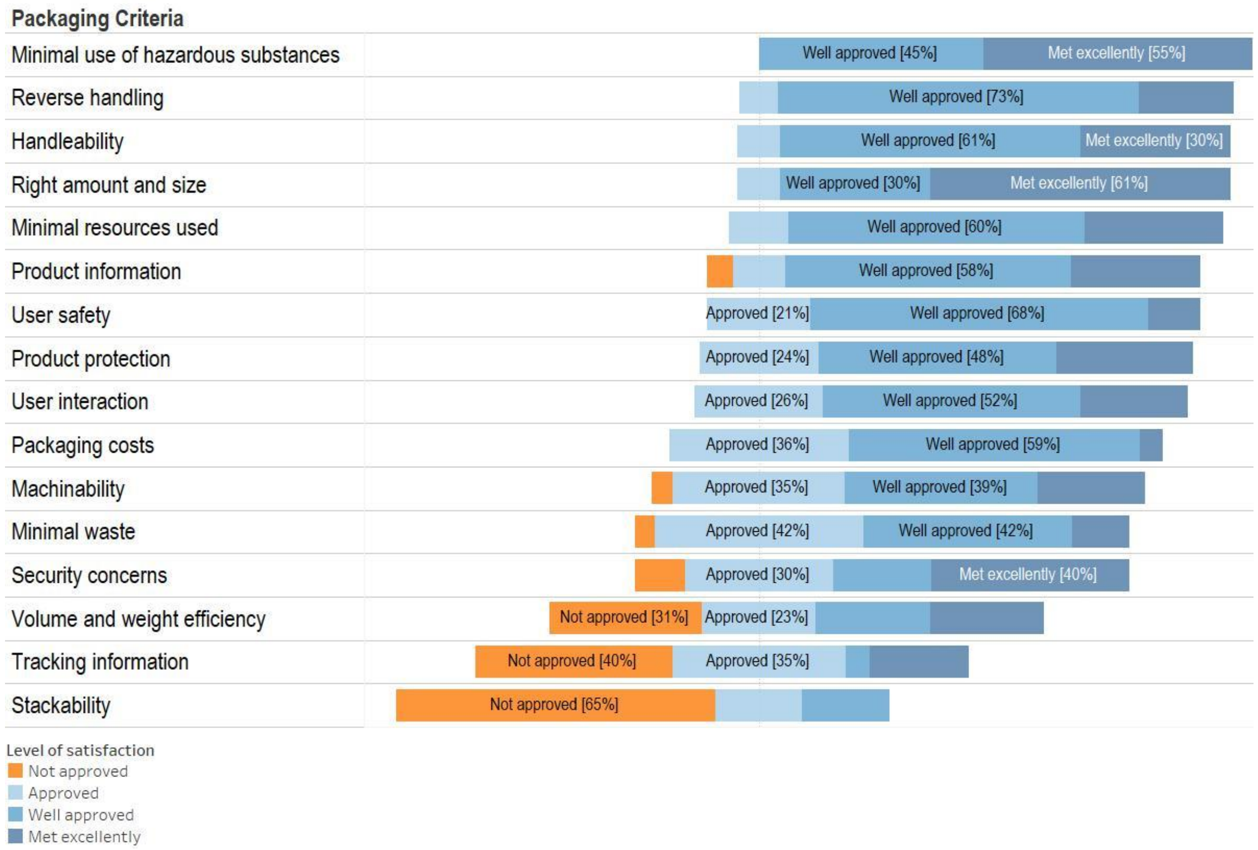


Figure 4.5 Packaging criteria results (viewed in a divergent bar chart)

After establishing the overall NWASS ratings as well as viewing the satisfaction level per criterion, **Figure 4.6** indicates the NWASS rating per criterion with the ratings indicated by the green, yellow and red bars. The green bars indicate the criterion was well approved or met the expectation excellently, while the yellow bars indicate the performance of the criterion was approved. Furthermore, the red bars indicate the performance of the criterion was not approved.

In the primary packaging system, suppliers rated the performance of security concerns the highest with a NWASS of 4, whereas the customer respondents rated “right amount and size” as the best performing criterion with an NWASS of 3.6. When rating the primary packaging, suppliers viewed tracking information (2.3) and volume and weight efficiency (1.5) as potential areas where the packaging is not performing as expected. The customers felt that user volume and weight efficiency (2.0) and stackability (1.7) were areas that did not perform adequately at the time. Customer 1 stated that stackability was not performing at all, as there was no stacking of polyethylene by local suppliers at the time, while customer 3 noted that packaging was not strong enough to stack the rolls.

Figure 4.6 further illustrates the NWASS for the tertiary packaging system. As mentioned earlier in this section, tertiary packaging received a lower NWASS than primary packaging. The top performing criterion according to suppliers was security concerns (4.0) while service providers deemed the minimal use of hazardous substances (4.0) as well as right amount and size (4.0) as the best performing criteria. Service provider 2 indicated that the configuration of two 250-kg polyethylene rolls per pallet was perfect and an increase in size would decrease its movement efficiency. The customers concurred with service providers as they also listed right amount and size (3.7) as the top performing criterion. Suppliers listed tracking information (1.2) and stackability (1.1), while service providers listed stackability (2.2) and user interaction (2.0) as the worst performing criteria. Customers noted the same criteria as suppliers with tracking information (2.1) and stackability (1.2) being scored the lowest.

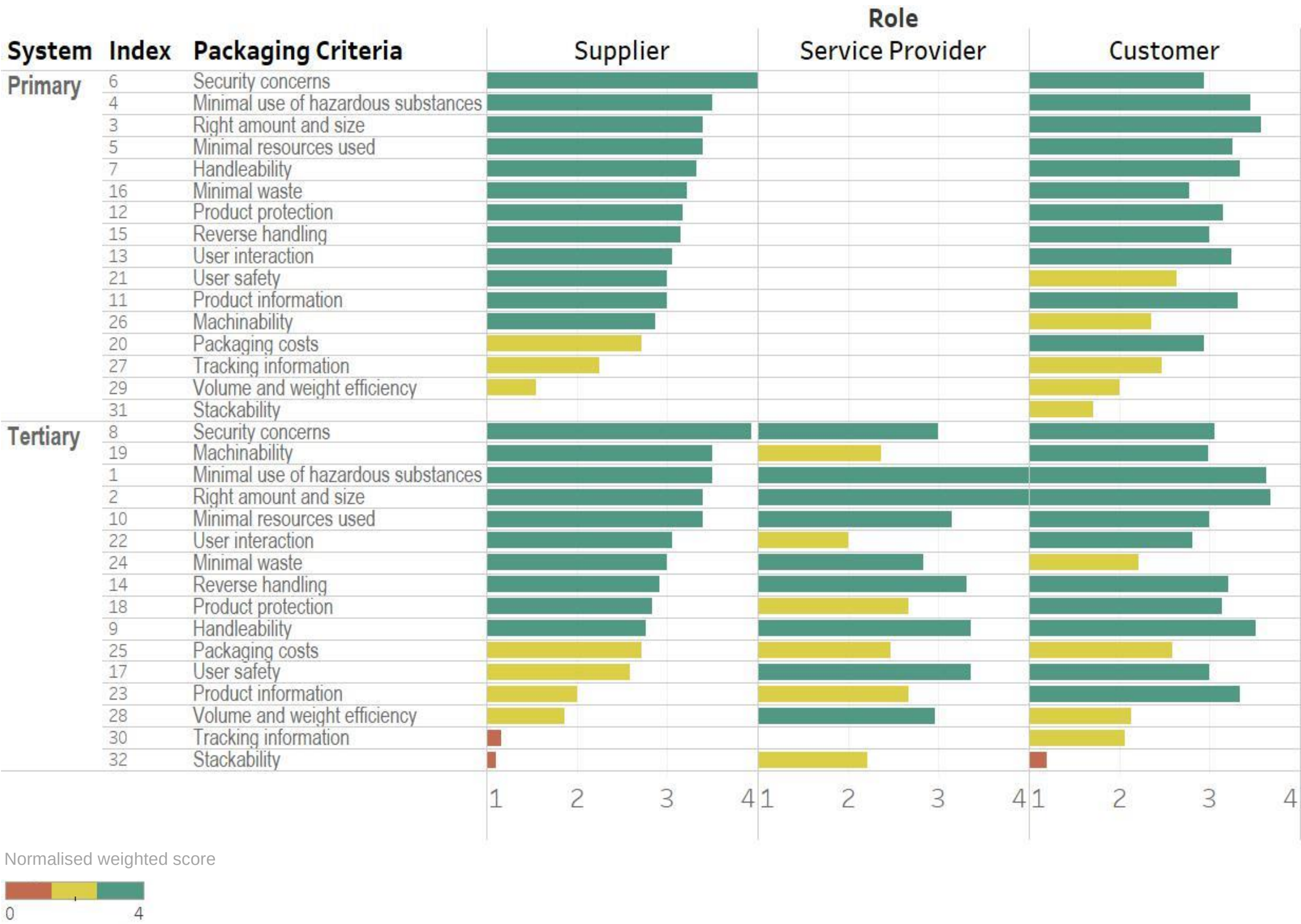


Figure 4.6 NWASS per packaging system, packaging criteria and supply chain actor (viewed per satisfaction rating in a bar chart)

As Figure 4.6 indicated the NWASS per criterion, **Figure 4.7** provides detail on how all respondents rated each criterion by using the level of satisfaction in a diverging bar chart (Not approved, Approved, Well approved, Met excellently). The orange areas in the figure indicate criteria which were deemed not approved by respondents while dark blue areas indicate that the criterion was met excellently. **Figure 4.7** illustrates that suppliers rated the ability of the primary packaging system to facilitate stackability as not approved, while customers felt equally strongly about this in the tertiary system. The service providers indicated that tracking information was the criterion which they approved the least.

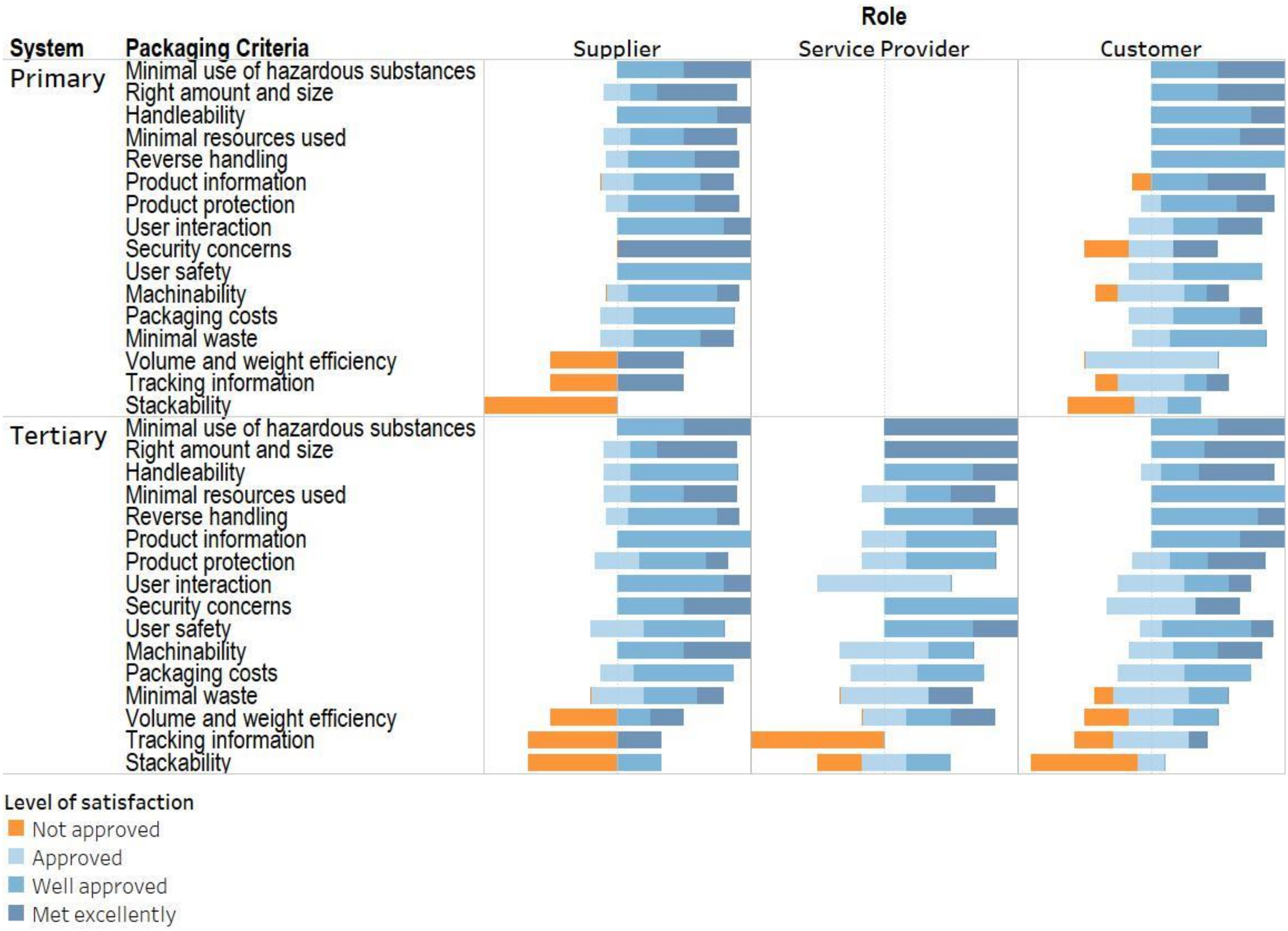


Figure 4.7 Packaging scorecard results per packaging system, packaging criteria and supply chain actor (viewed in a divergent bar chart per level of satisfaction)

These figures indicate the respondents' view on the performance of the packaging system used in the supply chain of a polyethylene roll. The NWASS provided a quantitative view on the performance while the diverging bar charts represent a qualitative view. All supplier and customer respondents rated the primary and tertiary packaging systems while the service providers only rated the tertiary packaging system. Following the findings of the packaging scorecard, the next section will provide insight into the sourcing of polyethylene.

4.4 Sourcing

This section starts to answer RQ2:

> What is the current sourcing situation at Poligistics, and which sourcing strategy could enhance the sourcing of polyethylene?

Companies procure large quantities of raw materials and various products, works and services to fulfil their operational responsibilities (Padhi et al., 2012:1). This entail significant time and money of a company as well as carrying a significant amount of risk (Padhi et al., 2012:1). As described in **Section 2.2.2.1** of this thesis, the Kraljic model is one of the most used techniques for managerial actions in the purchasing (Cox, 2015:717). The current study also utilised this model to understand sourcing at Poligistics and to identify possible opportunities.

To gather the relevant data and populate the Kraljic model, six experts were interviewed using semi-structured interviews. These experts had a combined total of 59 years' experience in the packaging industry and vast knowledge of the sourcing strategies as well as the market and industry conditions within which Poligistics was competing at the time of the study. The researcher interviewed experts who formed a cross-functional team as they were part of the supply chain, quality and sales departments at Poligistics (Gelderman & Van Weele, 2002:33).

The experts concurred that raw material costs accounted for 50% of the cost of a liquid liner bag at the time, while polyethylene contributed 70% of this raw material cost. This therefore contributed 37.5% to the overall cost of a liquid liner bag. This was the highest single cost contributor for Poligistics at the time, and underlined the importance of the purchasing strategy used to procure polyethylene. According to Expert 1, sourcing was seen as important at Poligistics, while Expert 5 felt that it was not viewed as important enough. All the experts described the Poligistics sourcing strategy at the time as one which solely focused on price and quality. These two attributes were pivotal to the business and the purchasing team had the mandate to procure polyethylene at the cheapest cost but for the best possible (acceptable) quality. Some of the main supplier challenges identified by the experts were the quality of the delivered polyethylene and a lack of technical knowledge from suppliers. They further identified packaging of the polyethylene rolls, the lead time as well as price volatility as concerning issues. These issues provided important background before the commencement of the population of the Kraljic model.

4.4.1 Purchase classification

As discussed in **Section 2.2.2.1**, the Kraljic model has four steps, namely purchase classification, market analysis, strategic positioning and action planning. The current section reports on the results of the interviews with the experts in these four Kraljic model steps.

The first step was to identify how polyethylene was rated according to its supply and profit risk (see **Figure 2.6**). Supply risk (x-axis) will be high when there are few suppliers, the material is scarce, or when the supply could be affected by government instability. On the y-axis, profit risk is high when the item adds substantial value to the output of the company (Oakley, 2017).

The Kraljic model utilises a subjective measurement to determine the 'high' or 'low' supply risk and profit risk rating. The measurement is based on respondent's experience and/or knowledge of the company and the industry within which it competes. Due to the vast experience and knowledge of the experts in this study, this measurement was applicable. To plot the experts' view on a diagram, the researcher used a scale of 1–10 to determine the specific point to which the expert was referring to with 1 representing the smallest possible risk and 10, the absolute biggest risk. **Table 4.1** indicates how the six experts rated supply risk and profit risk.

Table 4.1 The expert's view of supply risk and profit risk

Expert	**Supply risk**	**Profit risk**
Expert 1	7	9
Expert 2	10	10
Expert 3	9	9
Expert 4	7	10
Expert 5	6	7
Expert 6	10	10

The experts' rating is further visually illustrated in **Figure 4.8** in a scatter diagram. Expert 5 gave the lowest rating to both variables whereas expert 6 and expert 2 gave the highest ratings. According to all six experts' ratings, polyethylene was classified as a strategic product according to the Kraljic model. Strategic products deserve the most attention from managers (Oakley, 2017). For a strategic item, companies can develop long-term supply relationships and analyse risk regularly. Furthermore, they can plan for contingencies and consider integrating the product vertically into the company (Oakley, 2017).

In **Figure 4.9,** the experts' ratings are further depicted. This figure shows the critical impact of polyethylene procurement on profit for Poligistics. Three of the experts rated the profit risk higher than supply risk, while the other three scored the two risks as being equal. This further underlines the strategic importance of polyethylene for Poligistics, and supports the classification by the Kraljic model as it being a strategic product.

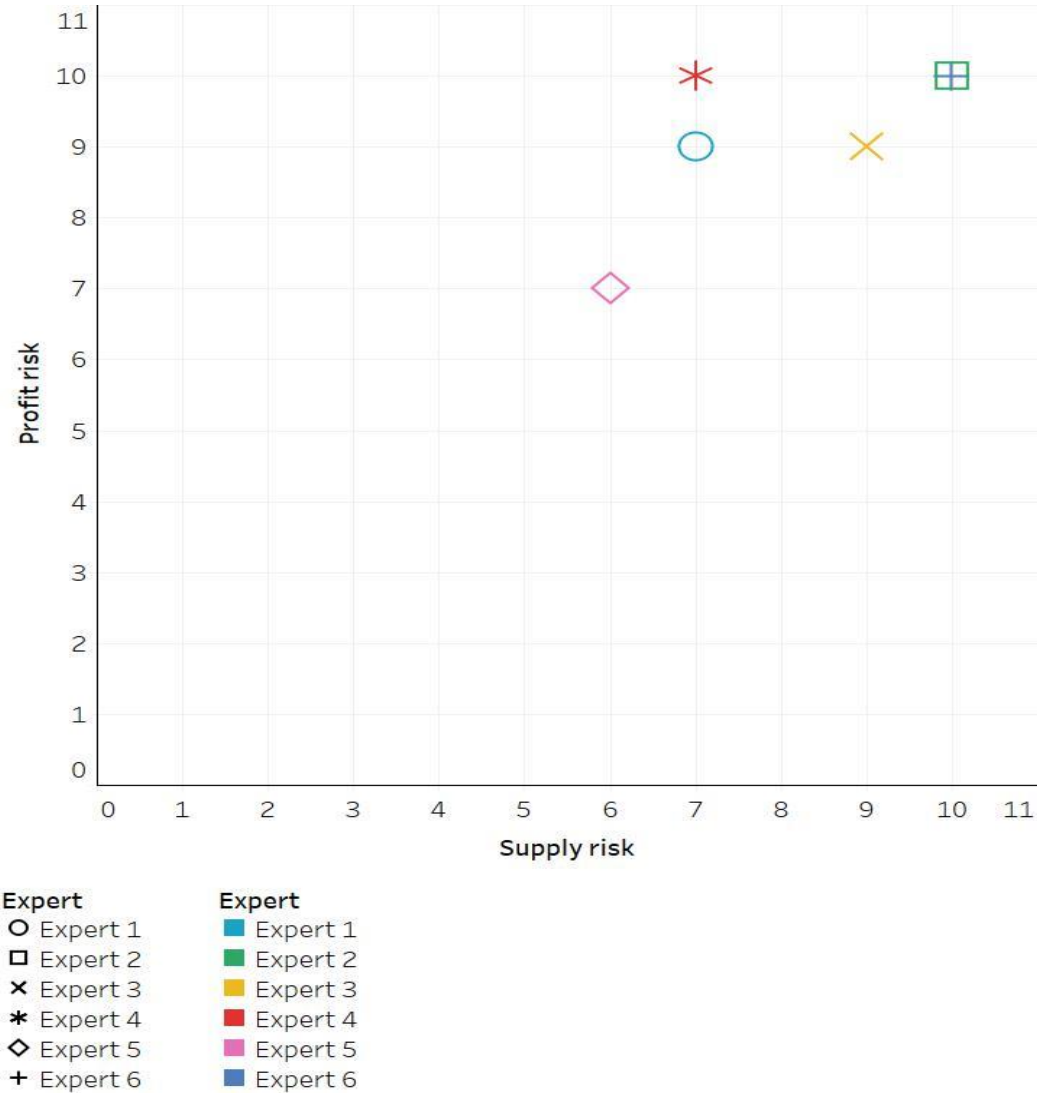


Figure 4.8 The six experts view on the Kraljic model

Figure 4.9 Profit risk versus supply risk

4.4.2 Market analysis

During the second step of the Kraljic model, the market conditions need to be investigated. This step determines the bargaining power of the buyer and supplier, and gives an indication of the position of the company in the market. As discussed in **Section 2.2.2.1**, Porter's five forces model can be used as an alternative to the list of metrics listed by the Kraljic model. The current study utilised the five forces model as it is a simpler model with fewer metrics, which suited the semi-structured interviews with the experts. This section will report all the information received during the interviews with the experts, through the utilisation of five forces model.

4.4.2.1 Buying power

Poligistics has between 30 and 40 clients globally with 95% of them residing outside South Africa (Expert 6). One of these customers attributes to 30% of all sales, while the second biggest customer represents 14%, and the third placed customer 12% of all sales. According to expert 2, every client roughly procures four different product lines from Poligistics, which leads to a possible monthly order from each customer.

Customers are extremely price sensitive (especially in the commodity market) while the premium products are less price sensitive. All customers are aware of the market conditions, and when there are grounds for a decrease in price, they will request it, according to expert 6. Poligistics only entertains price decreases when it makes economic sense for the company. Expert 4 elaborated on this, and felt that Poligistics was in most instances a price taker (see CFI, 2019) in the market.

One of the main challenges for Poligistics is that it does not sell its product to the end user but rather to a distributor of the product. If there is an opportunity for a supplier change, the distributor will dictate these terms. The customer can easily switch between suppliers regarding commodity products but not in terms of premium products. There is not another offering from a competitor to the premium product offer from Poligistics.

There are customer differences. In developed countries, customers are interested in the value of the product and the full sales offering, while in developing countries, customers focus on the price of the product (Expert 1). Poligistics however has loyal customers who had supported them during difficult periods, according to expert 6. A further challenge was identified by expert 3. The liquid liner bag can only be used on a once-off basis as it then has to be discarded or recycled. This is a potential challenge as the world is becoming more cognisant of the impact of plastics on the environment, and certain countries have started to ban single-use plastic products (Expert 3).

4.4.2.2 Supplier power

Experts 1, 2 and 3 felt that it is very easy for a supplier to increase the price of polyethylene due to the relative size of suppliers versus Poligistics. The suppliers are always bigger (in turnover, volume) than Poligistics, which impacts price negotiations. There are five potential suppliers in South Africa, and an infinite number globally (Expert 1). The high-quality suppliers with the best technology are in the United States and Europe while the better-priced suppliers are in the developing world (India, China) according to expert 1.

It will be expensive for Poligistics to move to other suppliers as the move will involve supplier development. Expert 3 emphasised that this move would depend on the skill level of the new supplier. If a supplier does not have the necessary in-house knowledge, development of the resulting supplier will be expensive for Poligistics. Expert 2 stated that it would be best to switch suppliers when current supply is sufficient and there is no demand pressure to move to a new supplier. An attempt to substitute the use of polyethylene in a liquid liner bag would be difficult. There are possibilities to move from LLDPE to HDPE or polypropylene, but this will need extensive research and development.

4.4.2.3 Competitive rivalry

At the time of this research in 2018, Poligistics did not have any competitors in South Africa while there were multiple in the United States, Australia, Europe and Asia (Expert 6). Most of Poligistics' competitors do not focus on 1 000-ℓ liquid liner bags but rather offers a variety of liquid liner solutions (Expert 6). The difference between these competitors and Poligistics, is that they are a 'local phone call away', as they are located in the same country as the customer, while Poligistics is most probably in another time zone, which affects immediate communication.

Expert 4 stated that he had seen liquid liner bags from competitors in the market, and that they had the same quality characteristics as the liquid liner bags produced by Poligistics. He further explained that Poligistics had gained opportunities in the market due to quality issues experienced by competitors. However, the top manufacturers in the market have a high level of automation which reduces quality problems, according to expert 5.

4.4.2.4 Threat of new entry

To enter the liquid liner industry, the entrant will require specialist knowledge of the business. Expert 4 indicated that this is especially important due to the complexity of the production of the product as well as its raw material. The capital outlay (to start with) will be between R3 million and R5 million, according to expert 6, but it will depend on the required level of automation. One of the biggest challenges would however be to build relationships with customers, according to expert 1.

Relationships with customers as well as distributors are important as one of the barriers to entry into the market would be the offering of a value-added service to a potential customer. Another barrier to enter this market is the time it takes to launch a product (from trialling a new product to introducing it to the production line). This time delay could place a significant constraint on the cash flow of a business.

4.4.2.5 Threat of substitution

Expert 6 stated that, at the time of the study, there was a definite threat of substitution for commodity products, especially from China and India. The premium products did not have a like-for-like substitution possibility, especially regarding value and price. Expert 1 stated that, at the time, Poligistics was the cheaper alternative for customers in this segment. Expert 3 indicated that there would possibly be 'greener' substitutes in the future as Europe has recently passed a bill (see Watkiss, 2019) to reduce the amount of single use plastic bags or containers. In **Figure 4.10,** a summary of Poligistics' five forces model is depicted.

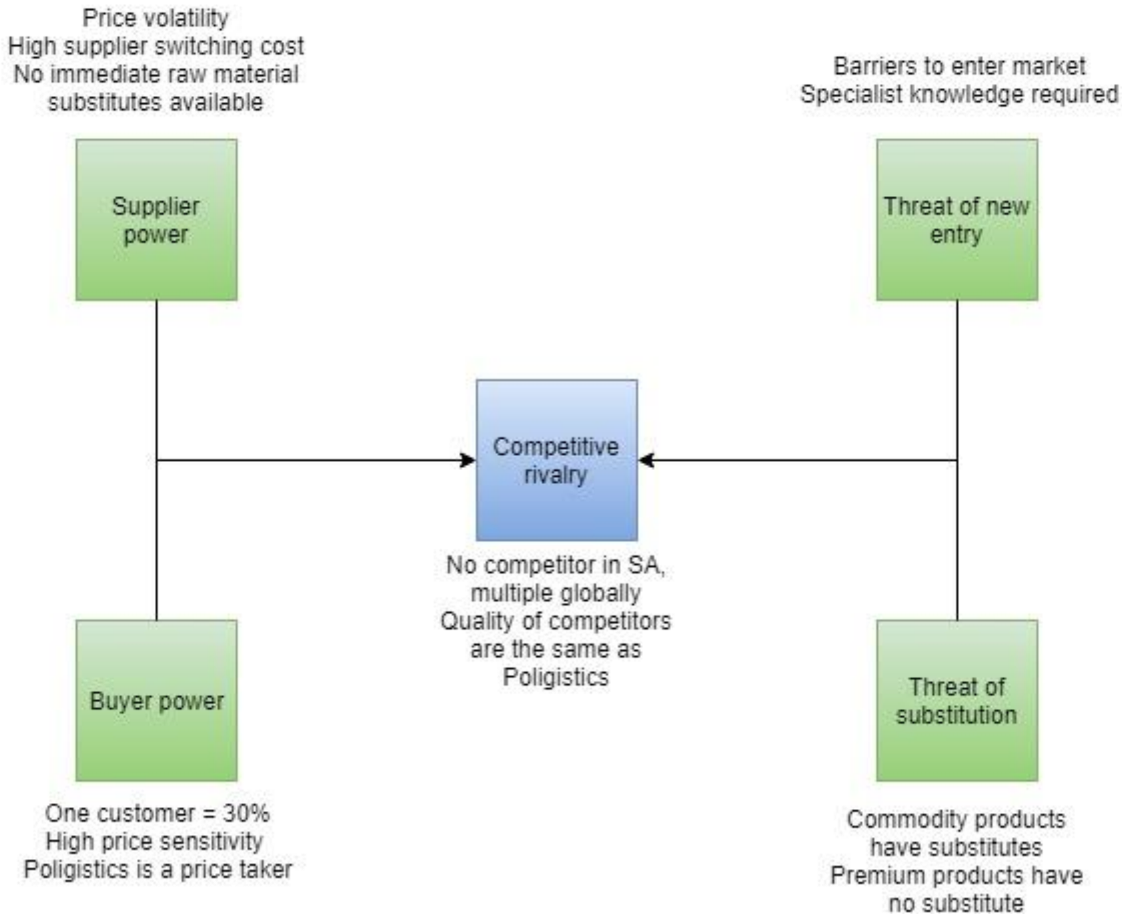


Figure 4.10 Summary of the Poligistics market analysis

4.4.3 Strategic positioning

As mentioned in **Section 2.2.2.1**, the third step of the Kraljic model requires the researcher to plot all strategic products according to their relative company strength and relative supply market strength. Polyethylene was classified as a strategic product in the first step of this model, and therefore the researcher could continue with plotting the strategic position. This position is based on a high, medium or low scale, where high means the company or supply market dictates the terms, and low results in the company or supply market adhering to any requests or terms stipulated by the other party.

4.4.3.1 Company buying strength

As stated by expert 1, Poligistics is predominately a price taker in the market, due to the size of its suppliers and relatively small volume purchases. The company further requests high quality levels with short lead times, which results in a reduction in possible suppliers and an increase in cost. Based on these points, Poligistics did not have a high level of buying power with its suppliers at the time of the research, and the company buing strength is indicated as 'low' in **Figure 4.11**.

4.4.3.2 Supply market strength

Expert 2 indicated that, at the time of this research, there were a limited number of suppliers in South Africa who were able to produce polyethylene complying with the required standard for Poligistics. This was further enhanced by the cost of polyethylene as local suppliers are not averse to market conditions (slow growth, exchange rate, inflation), which results in volatile prices, which Poligistics could not influence.

The size of the suppliers (locally as well as globally) is also in the supplier's favour with the Poligistics polyethylene orders at the time not translating into multiple production hours on an extruder, according to expert 1. Suppliers decide when a production run for Poligistics will occur and also in which sequence a specific order will run. This further emphasis the strength of suppliers in the relationship with Poligistics, as seen in **Figure 4.11**. Supplier strength was high while the buying strength of Poligistics was low resulting in low bargaining power for the company. This is illustrated in **Figure 4.11** as the intersection point is in the diversify procurement strategy block.

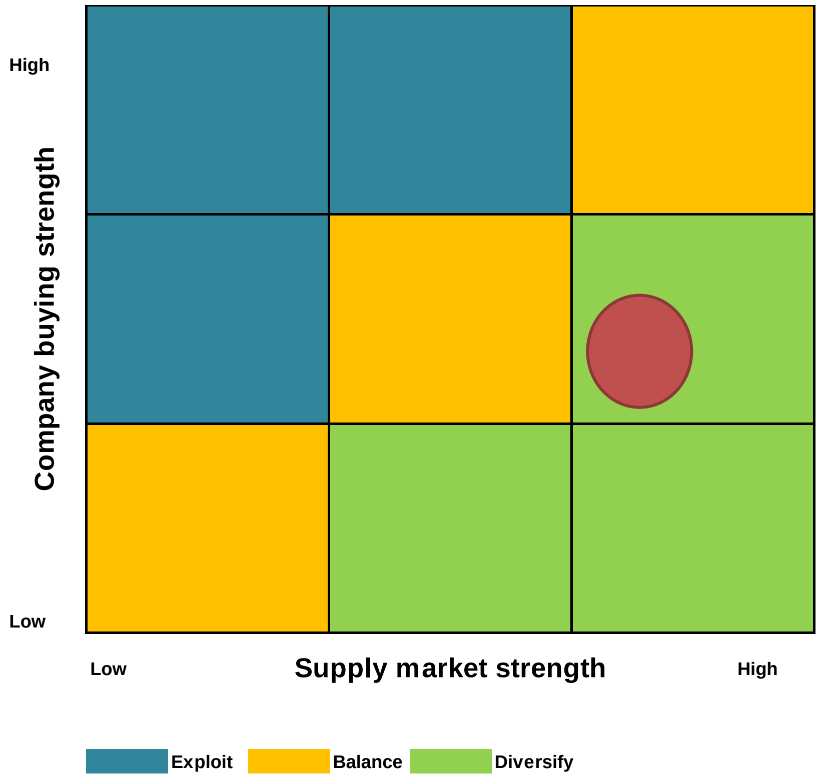


Figure 4.11 Supplier strength versus buyer strength

The third step in the Kraljic model was used to evaluate the supply market strength and, as indicated in **Section 2.1**, once the recommended purchasing strategy has been identified through the supplier strength versus buyer strength figure, an action plan needs to be developed.

4.4.4 Action planning

When developing the action plan, the previous three steps of the Kraljic model are considered. In this instance, the three steps determined that Poligistics requires a diversified purchasing strategy when procuring polyethylene. The diversify strategy seeks to reduce the supply risk through searching for alternative suppliers or possible alternative products. As discussed in **Section 2.2.3.4** of this thesis, a multiple sourcing strategy is often used for strategic products. This occurs when a strategic product is procured from multiple sources to mitigate the possibility of vendor lock-in and simplifies the management of supplier contracts with fewer specifications per contract. This resonates with Kraljic's diversification strategy, and comprises important supplier policy points to consider when developing the action plan.

Kraljic (1983:115) considered nine policy issues when creating an action plan for a specific sourcing strategy. **Table 4.2** depicts the action plan for Poligistics based on the Kraljic model and information gathered during this study. This plan includes nine action points, which Poligistics could consider when sourcing polyethylene. The execution of these actions may lead to improvements in the sourcing of polyethylene for Poligistics.

Table 4.2 Action plan for Poligistics

Policy issue	Actions for Poligistics
Volume	Polyethylene volume should be supplied by a limited number of suppliers
Price	Negotiate carefully and adhere to supplier's requirements
Contractual coverage	Only procure from suppliers where supply contracts are in place, which stipulate the pricing, volume and lead time parameters
New suppliers	Constantly search for alternative supply sources
Inventories	Keep high stock levels
Own production	Investigate the possibility of vertical integration and be self-sustaining through the production of polyethylene
Substitution	Search actively for possible substitutions
Value engineering	Begin own programme to identify areas where value engineering could add value to the business
Logistics	Ensure enough polyethylene is in stock to combat extended lead times

Source: Author's own compilation

This section discussed polyethylene as a strategic product for Poligistics, and one which needs to be procured in a market where supplier strength is higher than buying strength. It was established that there is a barrier to enter this market and that Poligistics relies on certain key customers for consistent orders. The section concluded with a possible action plan for Poligistics. In **Section 4.5**, the TCO model is used to consider the possible business impact of improved packaging system performance and sourcing.

4.5 Total cost of ownership

In this section, RQ3 is discussed:

> What effect would an improved packaging system performance and appropriate sourcing strategy have on the total cost of ownership of polyethylene?

TCO is designed to enable companies to make informed decisions (Ellram, 1995:5). TCO not only considers the purchasing price of a product, but also the complete cost from the point of purchase to disposal (Reh, 2018). As this study considered polyethylene, the TCO of a certain roll of polyethylene (2 200 mm and 100 micron) was calculated (**Appendix D**).

Figure 4.12 indicates the current TCO tree for polyethylene.

- The **direct** spend bucket consists of the cost per kilogram and the amount (in kilogram) procured, while the **indirect** spend bucket considers the cost of supplier development, handling and warehousing.
- The **internal** cost bucket refers to the cost of the cores and plastic pallets, which are used per roll.
- The **opportunity** cost bucket comprises the roll rejections and delayed production time due to non-delivery.

Possible TCO levers are indicated and include efficiency improvements as well as space utilisation. Possible actions are indicated in **Figure 4.12**, namely investigating alternative suppliers, developing supplier contracts, and the possible increasing of polyethylene roll stacking. The TCO is measured on an annual basis, and Poligistics sources 96 tons of this LLDPE/mLLDPE polyethylene roll during this period.

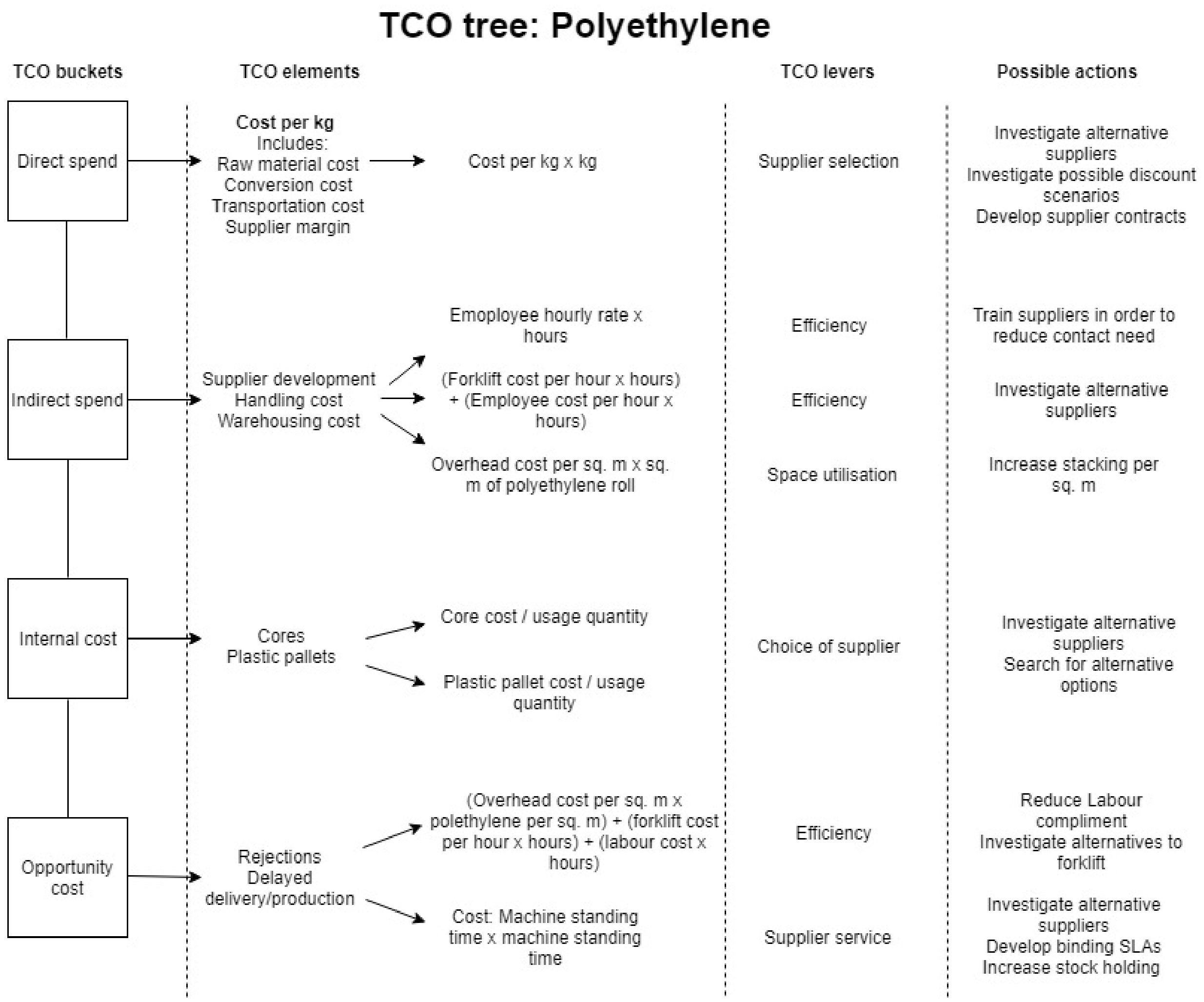


Figure 4.12 TCO tree: Polyethylene

At the time of this research, the TCO for this type of polyethylene was R802 204 for 96 tons of product per annum (**Appendix D**). **Figure 4.13** illustrates how the TCO buckets contributed to the TCO of polyethylene. Direct spend contributed 77%, while indirect spend was the second highest contributor with 12% and opportunity costs were 11%. **Figure 4.14** provides detail about the TCO as it indicates the cost allocation per TCO element. The cost per kilogram contributed to direct spend while supplier development cost (8.16%) was the biggest contributor to indirect spend. Internal costs were a very small portion of the TCO while the production delay costs calculated to 7.56% and rejection costs, 2.96%.

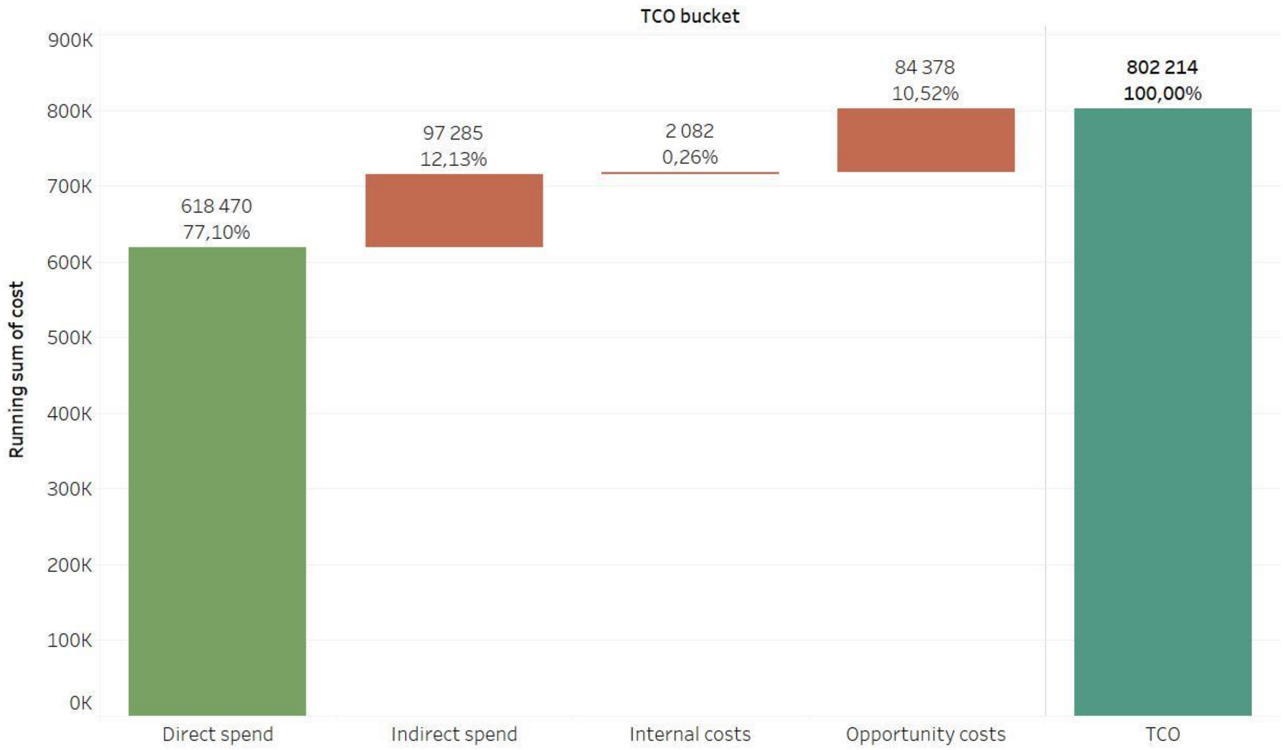


Figure 4.13 TCO at the time of the study: TCO buckets

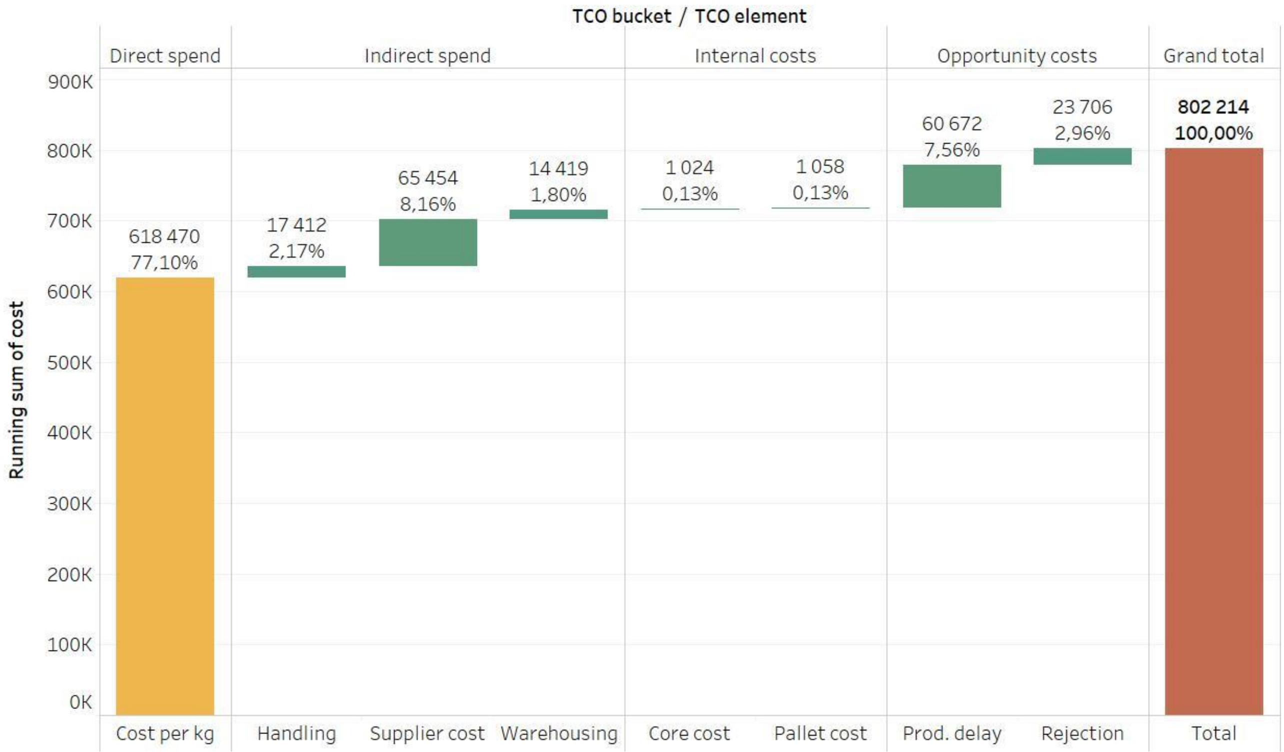


Figure 4.14 TCO at the time of the study: TCO elements

4.5.1 TCO: Improved packaging

As the packaging system performance measurement indicated, one of the key areas of improvement for packaging would be to increase the stackability of the product. This would also have an effect on the TCO of polyethylene, as Poligistics was spending R97 285 on indirect costs, including handling of this product, at the time of this research. **Figure 4.15** indicates the area of possible improvement (indirect spend bucket) when stackability improves. At the time of this research, Poligistics was storing two polyethylene rolls per square meter, but improved packaging could double this to four rolls and also half the time spent on handling the product (see **Section 4.3.1**). Moreover, the cost of the rolls should not increase as a result of increased packaging, as suppliers would reduce the number of delivery trips to Poligistics. Thus, the cost of improved packaging would be absorbed and result in a TCO reduction for Poligistics.

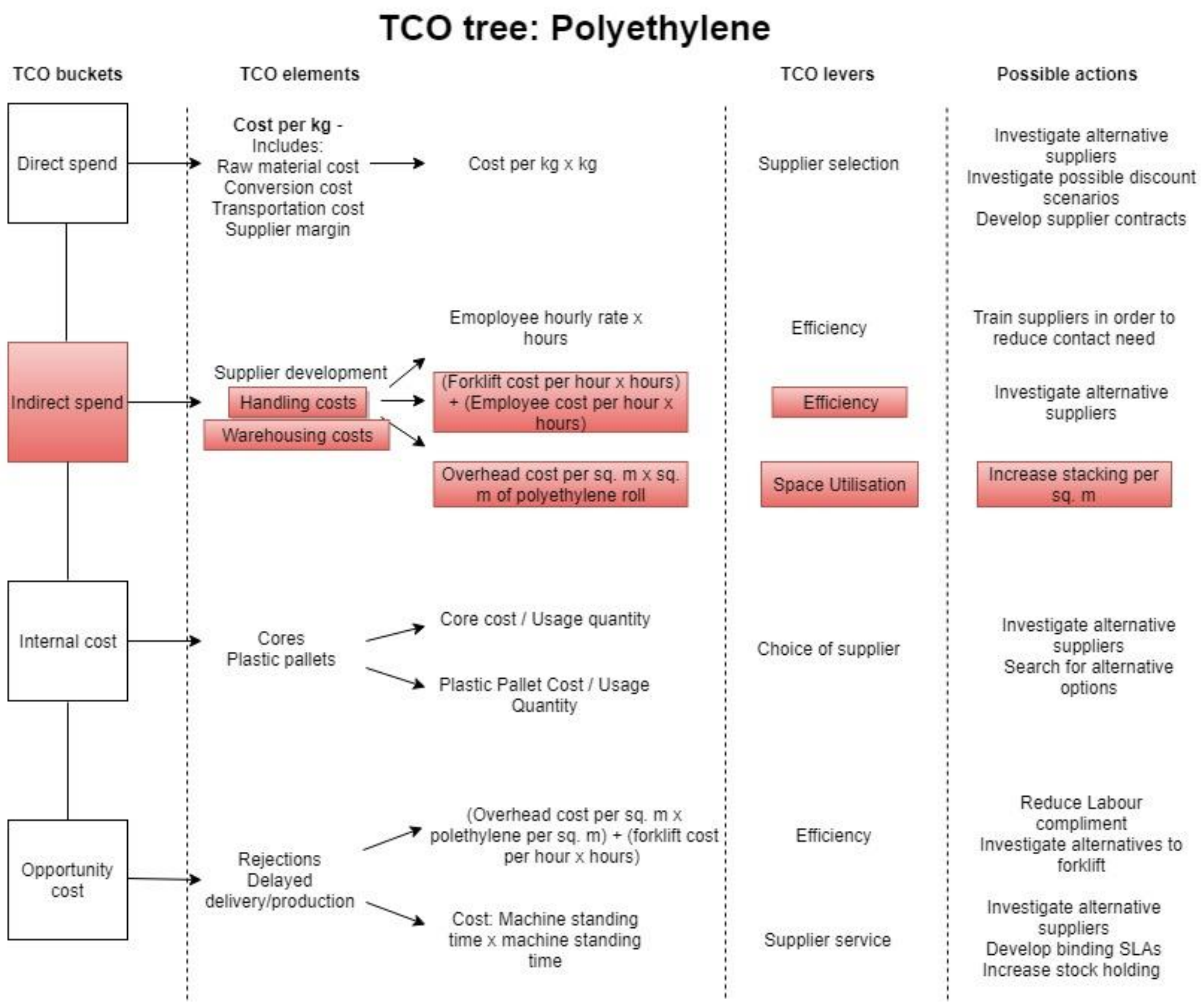


Figure 4.15 TCO: Packaging improvement

When increasing the stackability of polyethylene from two rolls to four rolls per square meter, the impact on the TCO is seen in **Figure 4.16**. The higher stackability rate reduces the handling and warehousing costs per roll, as the company is now able to store, and handle double the number of rolls than it previously did. This improvement will lead to a reduction in indirect costs of R15 915 and results in an almost 2% TCO saving for Poligistics.

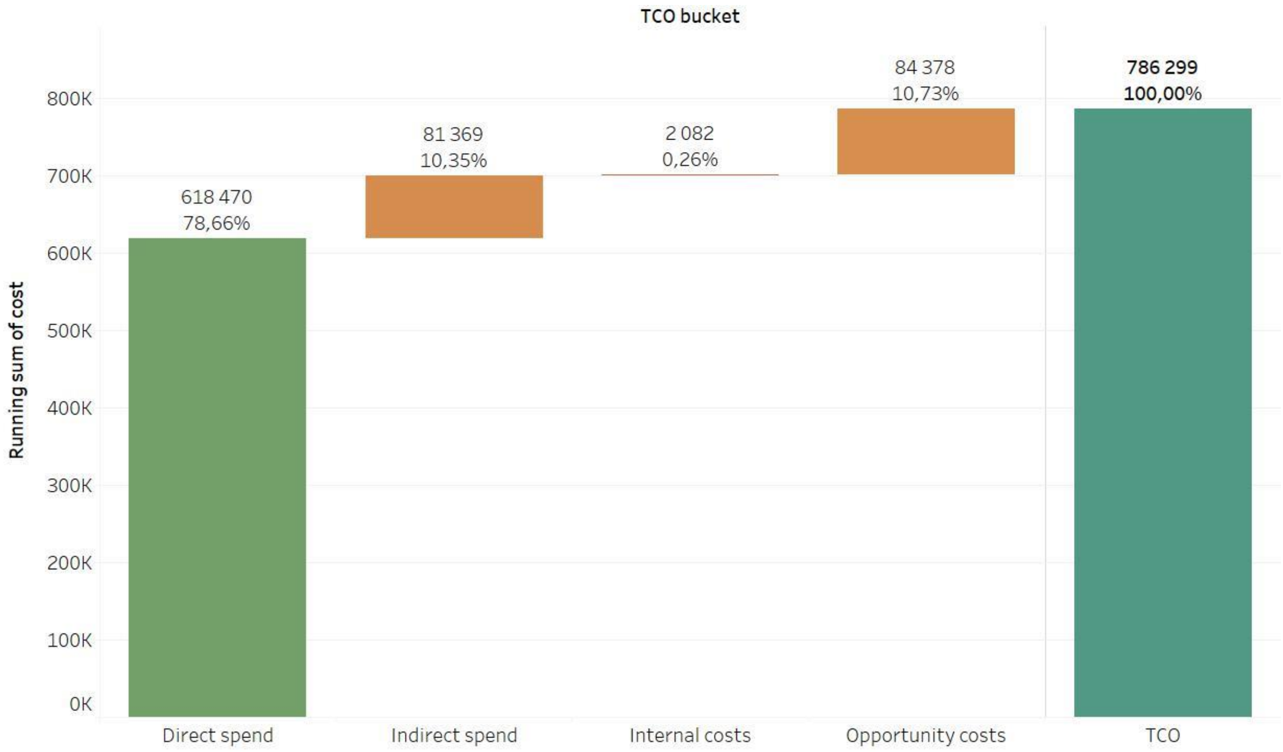


Figure 4.16 TCO after stackability improvement

4.5.2 TCO: Improved sourcing

Supplier improvements for Poligistics were identified by using the Kraljic model. The TCO at the time of this research (**Figure 4.13**) also indicated that there was an opportunity for the company in the opportunity cost bucket for polyethylene. This bucket is driven by quality rejections as well as machine standing time (Expert 6). At the time of this research, Poligistics was paying R84 377 per annum in opportunity costs for this specific polyethylene roll due to supplier non-delivery or quality challenges (Expert 1; Expert 3; Expert 6). **Figure 4.17** indicates the area of possible improvement (opportunity cost bucket), elements and possible levers which Poligistics can use to reduce TCO.

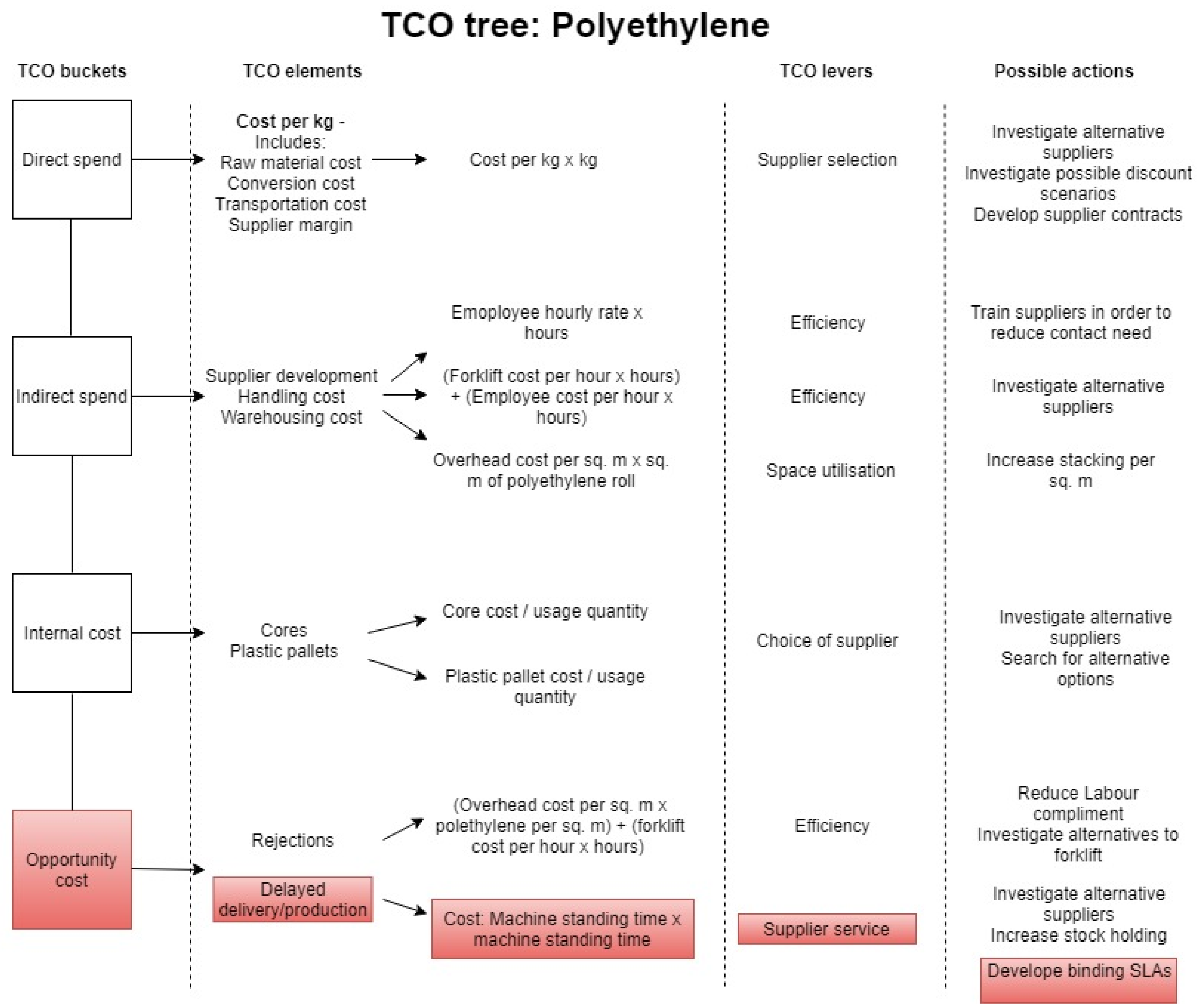


Figure 4.17 TCO**:** Sourcing improvement

The impact of late delivery results in the production line either standing or reducing in output rate. For the purposes of this calculation, and through the sourcing interviews, late deliveries were estimated at 5% at the time of this research. As 96 tons of polyethylene results in 384 rolls of 250 kg each, 5% resulted in the late delivery of 19.2 rolls per annum (Expert 1).

As the sourcing action plan indicated, one of the key actions Poligistics could incorporate is binding service level agreements (SLAs) with their suppliers. The SLA should include strict lead and delivery times with penalties associated to each. To calculate the possible TCO impact, a 50% improvement (from 5% to 2.5%) on deliveries is estimated. This would reduce the number of rolls that are delivered late to 9.6 per annum and would reduce the TCO with R30 366 (3.78%) per annum (**Figure 4.18**).

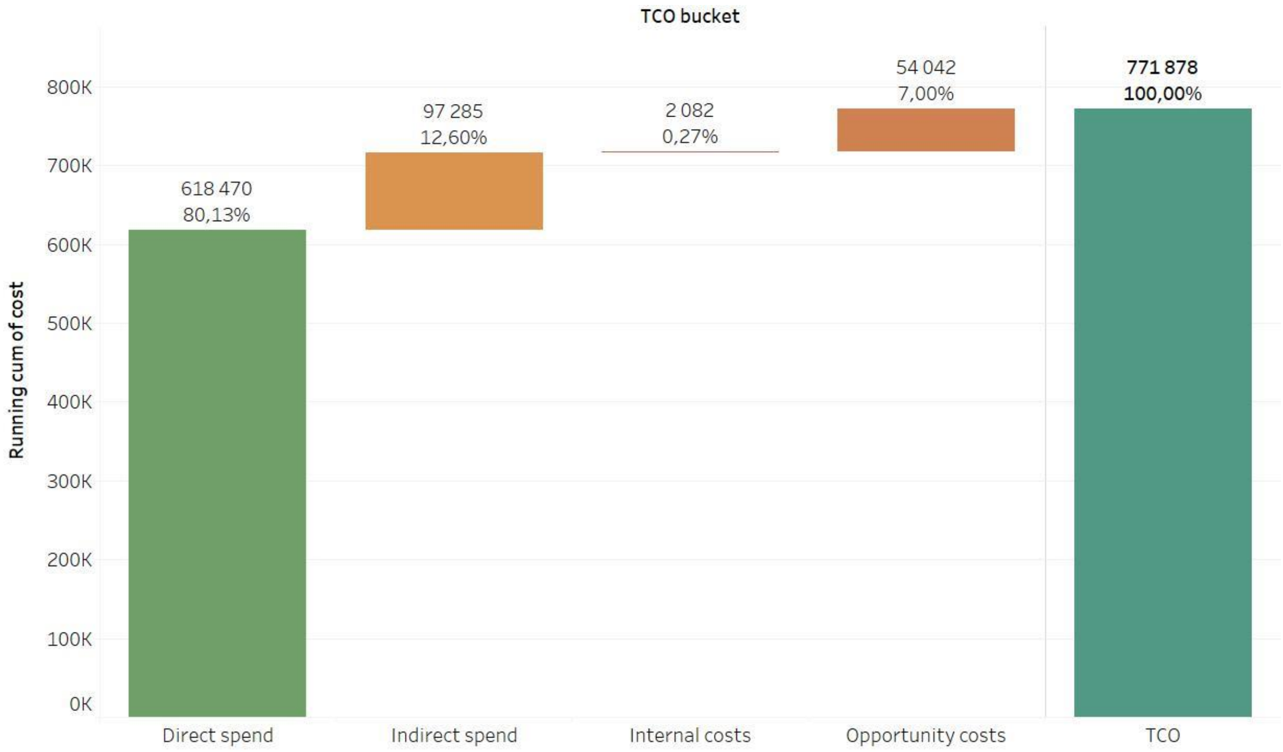


Figure 4.18 TCO: Sourcing improvement

The various TCOs and their final costs are illustrated in **Figure 4.19**. The TCO will reduce when the stackability is improved, but the biggest TCO reduction will be the improvement in sourcing which results to a TCO reduction of 3.78%. **Figure 4.20** illustrates the cost improvement after the sourcing implementation on the TCO element level. The production delay costs reduced from a total TCO contribution of 7.56% to 3.93% or R30 336.

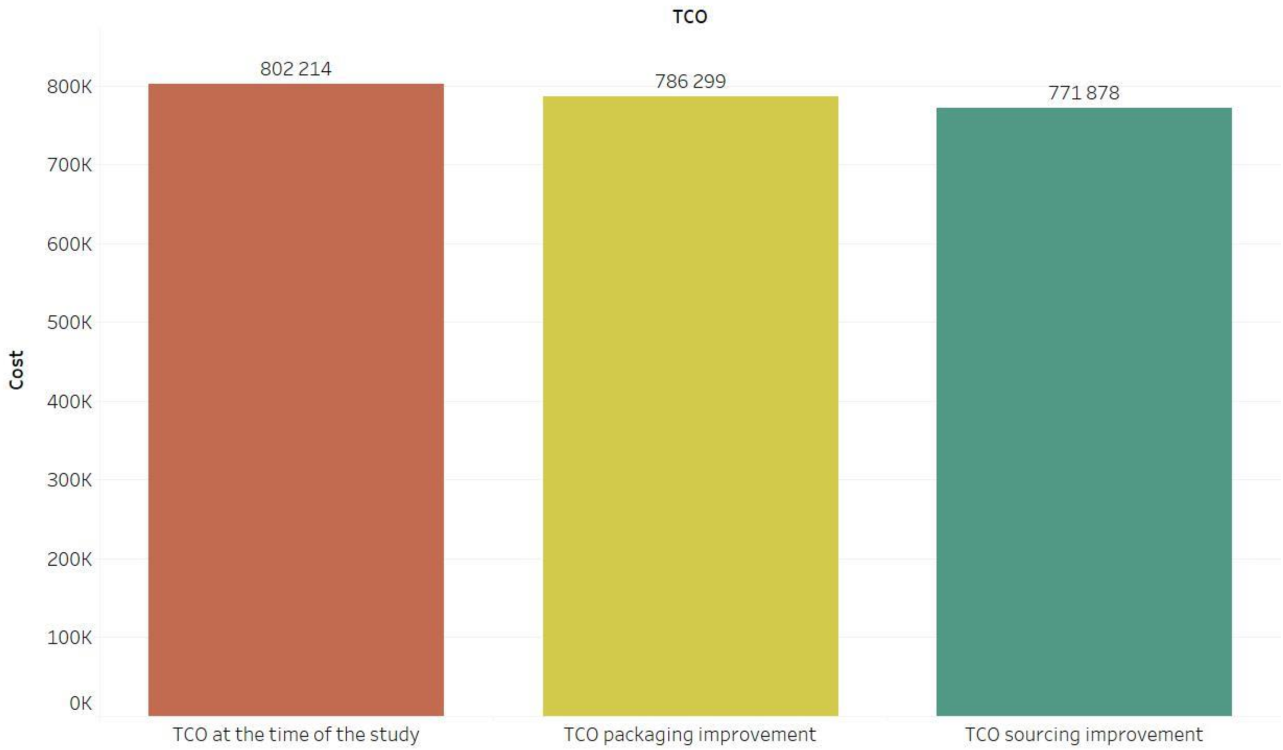


Figure 4.19 TCO comparison

Figure 4.20 TCO elements after the implementation of sourcing improvement

As discussed in **Section 2.3.1** of this thesis, one of the major advantages of the TCO model is its ability to create a consistent supplier evaluation tool. Using the TCO model, Poligistics would be able to indicate to its suppliers the outcome of supply chain improvements. This will provide clarity between the supplier and Poligistics regarding the supplier's performance and also the performance expectations from Poligistics.

4.6 Summary of findings

The first section of this chapter discussed the data gathering and preparation in order to start with the analysis. This included a discussion of the sampling methods used as well as the coding and analysis of the data. The next section (**Section 4.2**) gave background to the liquid liner industry and Poligistics. This information was obtained through semi-structured interviews with respondents. The industry is expecting to grow in the future due to a global movement towards flexible packaging. Poligistics is described as a packaging company that distributes its products globally, and which focuses on innovation. They produce liquid liner bags in various sizes with a focus on the manufacturing of 1 000-ℓ liquid liner bags.

Following the background to Poligistics, the chapter started presenting the findings on packaging system performance. It was found that, at the time of this research, Poligistics was not measuring its packaging system performance. The current measurement was therefore the first of its kind at the company. The packaging scorecard was used to establish the packing system performance of the inbound logistic activities in the supply chain. This resulted in quantitative data (NWASS) and qualitative data (diverging bar charts) compiled from data gathered through semi-structured interviews.

The overall NWASS of the packaging system was calculated at 2.9 while the primary system received a NWASS rating of 3, and the tertiary system a rating of 2.8. All three supply chain actors rated packaging performance of the inbound supply chain. The service providers did not rate the primary packaging system as they only interacted with the tertiary packaging system. The section provided further in-depth ratings per criterion with stackability being identified by the NWASS as well as by divergent bar charts as the worst performing criterion.

Section 4.4 presented the findings reported on sourcing. The Kraljic model was used to determine the most appropriate sourcing strategy for Poligistics when sourcing polyethylene. Through a purchase classification exercise, it was found that polyethylene should be seen as a strategic product in the company. This was due to respondents rating it as a product that has high supply and profit risk. The market analysis, through the five forces model, found that Poligistics has relatively low bargaining power. This results in the diversification sourcing strategy as being the best suited sourcing strategy for Poligistics on account of its low bargaining power and the strategic value of polyethylene. The section concluded with an action plan, which Poligistics could use to improve their purchasing of polyethylene.

The final section (**Section 4.5)** reported on the use of the TCO of 96 tons of polyethylene to determine the possible cost reductions when implementing packaging system performance and sourcing strategy improvements. It provided the costs to the TCO buckets as well as TCO elements while illustrating the TCO levers and possible actions. Overall, the sourcing improvement would have a bigger cost implication through the reduction of production standing time, which in turn would result in a TCO reduction of 3.78% per annum. Following the review of the packaging system performance, sourcing and TCO of Poligistics, **Chapter 5** will conclude this thesis by presenting a summary and possible recommendations.

Chapter 5
Conclusion and recommendations

Chapter 4 described how the data was gathered during this study, and provided background to Poligistics and the liquid liner industry. It presented the findings of this study, namely the findings from the packaging scorecard, Kraljic model and TCO model. **Chapter 5** closes this thesis by presenting an overall conclusion on literature used in the study, the methodology used to gather the necessary data as well as an answer to each research question. The chapter ends by providing possible recommendations and identifying potential areas for further research.

5.1 Conclusion

The thesis provided in-depth background, findings and analysis on packaging system performance, strategic sourcing and TCO. This section draws this research report to an end and the sub-sections follow the order of the key concepts and research questions used throughout this thesis.

5.1.1 Conclusion on literature

This sub-section reports whether there was sufficient literature available to support the research questions of the current study. Section summarises the packaging system performance, strategic sourcing and TCO literature.

5.1.1.1 Packaging system performance

Research Question 1 of this study focused on whether packaging system performance was measured at Poligistics and what the performance of the packaging was. This resulted in the development of the first main concept of this study, namely packaging. The literature on packaging provided background to packaging, its functions, types of material, packaging system performance, and considered its environmental impact. Olsmats and Dominic (2003:9) as well as Murphy and Wood (2011:215) describe a packaging system as a system that works in a complementary sense to fulfil the various packaging functions. Lockamy (1995:52) defines these functions as containment, protection, transportation, facilitation and marketing.

Even with all these functions, packaging was seen as a non-value-add product and easily dispensable (Berger, 2005). This view was altered by Lockamy (1995:51) who identified the potential impact of packaging on logistic activities. Following this research, the literature contributed to especially packaging system performance measurement. Here, Olsmats and Dominic (2003:9), Hellström and Saghir (2007:198), Pålsson and Hellström (2016:351) and Nilsson (2016:294) provided valuable insight. The development of a holistic packaging measurement tool by Olsmats and Dominic (2003:9), termed the “packaging scorecard”, resulted in the ability to identify packaging improvement opportunities in a supply chain.

Pålsson and Hellström (2016:351) further refined the packaging scorecard and, whilst the original study of Olsmats and Dominic (2003:9) only considered a single packaging system, their study focused on multiple packaging systems. Nilsson (2016:295) attributes a further six additional criterion points to Olsmats and Dominic's (2003:9) list of criteria. (see **Section 1.4**). It further showed that there is consensus in literature regarding the packaging system and the advantages of measuring packaging system performance. The research provided by these studies provided enough background to answer the first research question

5.1.1.2 Sourcing

Sourcing and the various strategies associated with it were also considered in the study. Ketchen et al. (2014:165) noted that sourcing has been discussed in literature for many years, but that it has only received focused attention in recent years. Schneller (2010:22) and Kausik and Mahadevan (2012:79) describe the advantages of strategic sourcing as creating flexibility for a company and reducing its risk. The importance of strategic sourcing was initially discussed in 1983 by Peter Kraljic through his development of the Kraljic model. This model is seen as a purchasing portfolio analysis (PPA). According to Padhi et al. (2012:1), Kraljic argued that this model enabled companies to minimise supply vulnerabilities while simultaneously capitalising on their buying power.

Other purchasing portfolio models have been developed, such as the purchasing chessboard (Schuh et al., 2012) and the sourcing portfolio analysis (SPA) (Cox, 2015:719). The SPA was created as criticism on Kraljic's model as this latter model was seen as too simplistic and generic (Cox (2015:719). Despite this criticism, the Kraljic model is the most used sourcing approach in purchasing portfolio management (Cox, 2015:717; Hesping & Schiele, 2016:101; Padhi et al., 2012:1). The literature on sourcing continued by providing in-depth background to different sourcing strategies (see Faes & Matthyssens, 2009:246; Wang et al., 2010:311). The literature provided advantages and disadvantages of using certain sourcing strategies like vertical integration (see **Section 2.2.3.5**) and described the necessary conditions to implement such a strategy (see **Section 2.2.3.5**). The sourcing literature provided sufficient background to answer the sourcing research question of this study and supported the use of the Kraljic model for evaluation.

5.1.1.3 Total cost of ownership

Literature reports on various tools to measure the cost implications of a process change in a company (see **Section 2.3**), such as the life cycle costing model, the balanced scorecard and the TCO model. The TCO model accounts for all costs that relate to the procurement of the product, from the point of inception to the end of the life cycle of the product. This results in a comprehensive cost overview of the product or process and supports major process changes (Burt et al., 2010:304; Ellram, 1995:5; Kaplan & Norton, 1996:191; McCrea, 2013).

In **Chapter 2**, the comprehensive cost view of the product was illustrated by the TCO tree. This tree comprises buckets, TCO elements, KPIs, levers and actions and these components follow one another when determining the TCO of a product (Louw, 2017). The TCO model is an analytical tool, which informs management decision-making and provides an analysis of total costs over time (Burt et al., 2010:315). The literature provided enough support to use the TCO model as a measurement in the evaluation of the recommended process improvements and in answering the research questions.

5.1.2 Conclusion on approach

This section summarises the approach used to gather the data for the packaging system performance, sourcing and TCO measurements.

5.1.2.1 Packaging system performance

The methodology and techniques used to gather the data to populate the packaging scorecard were found to be sufficient for the purpose of this study. The use of semi-structured interviews allowed the researcher to explain the scorecard to all respondents, as well as to determine the packaging system performance measurements used at Poligistics at the time of this study. The packaging scorecard however provided two challenges to the researcher.

The first challenge was that the scorecard consisted of 17 criterion points, which were found to be excessive for this study. Not all 17 points were applicable to each packaging function meaning that certain criteria were deemed as not applicable. The second challenge was the rating of these criterion points in the scorecard as it is the researcher’s opinion that performance rating is skewed towards a positive rating. The ratings of 0 – Not applicable to the packaging, 1 – Not approved, 2 – Approved, 3 – Well approved, and 4 – Met excellently could result in an unbalanced packaging system performance rating (Nilsson, 2016:296). This might lead to inflated performance ratings when using the packaging scorecard and not an accurate rating of the packaging for a specific criterion.

The researcher noted that a new rating scale has been introduced in recent literature by Pålsson (2018:36). In his model, the satisfaction level is measured on a 1–5 scale where 1 – Very low, 2 – Below average, 3 – Average, 4 – Above average, and 5 – Very high. This scale can be used in future research to improve the imbalance in the current ratings.

5.1.2.2 Sourcing

To populate the Kraljic model, semi-structured interviews were conducted with six respondents. To assist in structuring these interviews, the researcher followed the four-phase model as set out by Kraljic:

- classifying all materials according to profit risk and supply risk;
- analysing the supply market of the material;
- identifying the overall strategic supply position of the company; and
- developing action plans (Kraljic, 1983:110).

The first step of the Kraljic model requires respondents to rate the supply risk and profit risk of the product. Due to the subjectivity of the rating and instead of utilising the high or low rating (typical of this model), the researcher utilised a scale of 1–10 in order to simplify the rating for respondents. This enabled the accurate plotting of the respondents' results on the portfolio matrix (see **Figure 4.8**). The second step in the Kraljic model sets out to determine supplier strength versus buying strength. The researcher found Kraljic's evaluation criteria too structured for semi-structured interviews, and thus used the five forces model to complete this step (Porter, 1979:137).

The five forces model help to create the guidelines for the semi-structured interviews and allowed respondents to discuss the market position of Poligistics freely, whereas Kraljic's criteria were found to be too strict and might have led to a smaller amount of data. The Kraljic model, with minor changes by the current researcher, acted as a valuable framework to determine which sourcing strategy would benefit Poligistics.

5.1.2.3 Total cost of ownership

The methodology used to gather the necessary data to populate the TCO model comprised semi-structured interviews. These interviews provided enough information to populate and execute the TCO model. The respondents were, however, not certain about each individual costing; all respondents however were more than 85% confident in their costing. This resulted in the possibility of skewed costings, as the cost could might have been inflated or deflated. The researcher found this to be acceptable due to the goal of the measurement not being to identify the exact cost implications, but rather the outcome of the process changes.

5.1.2.4 Reliability, validity and analytical approach

The data gathered in this study was reliable as it was seen as consistent between respondents and only the researcher conducted the semi-structured interviews. Reliability was further ensured through conducting interviews in a neutral and safe environment, and respondents participated on a voluntary basis. The data was deemed valid as the researcher consistently used the same research models and explained the research models to the respondents in such a way that they could understand it (see **Section 3.6**).

The analytical approach was sufficient to gather the necessary data to answer the research questions posed by the study. The researcher developed a hybrid approach, which combined three approaches not used previously (i.e. packaging scorecard, Kraljic model and TCO model) and consolidated them into one case (see **Section 3.3** and **Section 3.4**). These approaches were not competing against each other and supported the research study to answer the research questions (see **Section 3.6**).

5.1.3 Conclusion on research questions

This section summarises the four research questions (RQ1, RQ2, RQ3 and RQ4) that were posed in this study and provides an interpretation of the findings.

5.1.3.1 RQ1: To what extent is packaging system performance measured at Poligistics, and how is packaging performing based on criteria and set methods?

Through the semi-structured interviews, it was determined that packaging system performance was not measured at Poligistics at the time of this research and that the packaging scorecard measurement was the first of its kind for the company. The overall packaging system performing was calculated with the aid of the NWASS formula and scored 2.9 out of a maximum of 4 points. This indicated that the packaging was performing relatively well at the time of this research. This rating was only for the primary and tertiary packaging systems as the secondary packaging system was not present in the identified supply chain. The respondents rated primary packaging (3.0) as performing 0.2 points better than tertiary packaging (2.8).

The measurement further resulted in the identification of specific criterion points in the supply chain, which should be addressed by Poligistics. This was identified by using the NWASS and qualitative diverging bar charts. From this quantitative as well as qualitative data it was concluded that stackability is the criterion with the lowest satisfaction level (performance level). All the supply chain actors concurred with this result. The minimum use of hazardous material and security concerns were identified as the best performing criteria.

5.1.3.2 RQ2: What is the current sourcing situation at Poligistics, and which sourcing strategy could enhance the sourcing of polyethylene?

This research question prompted the researcher to investigate sourcing of polyethylene at Poligistics at the time of the research and to identify a possible sourcing strategy, which would enhance this function. It was established that Poligistics was not utilising a specific sourcing strategy at the time. The Kraljic model was then used to answer the research question regarding the sourcing of polyethylene. Through this model, it was established that polyethylene should be classified as a strategic product by Poligistics. The five forces model also describes the market conditions in which Poligistics operated at the time, and provided in-depth background to the supplier strength in the market versus the buying strength of Poligistics.

The higher supplier strength rating resulted in the diversified sourcing strategy being identified as the most suitable sourcing strategy for when Poligistics procures polyethylene. The strategy requires the diversification of the supply base from the company. This could include limiting the amount of polyethylene supplied by a certain supplier and ensuring supply contracts have been signed with all approved suppliers. It also requires the constant search and identification of new suppliers while also keeping bigger stock quantities for inconsistent supply.

5.1.3.3 RQ3: What effect would an improved packaging system performance and appropriate sourcing strategy have on the total cost of ownership of polyethylene?

This third research question was applicable to the study as it provided a test of the possible enhancements in the packaging system performance and sourcing of polyethylene. The study used a specific polyethylene roll size of 2 200mm and 100 micron, and 96 tons of material for its calculation. The TCO of the roll was calculated at R802 204 per annum at the time with direct spend contributing 77%, indirect spend 12% and opportunity costs 11% of the TCO.

Through the packaging system performance enhancement, a total of 2% of TCO will be saved on 96 tons of polyethylene per annum, while the sourcing enhancement could lead to a possible TCO reduction of 3.78%. These figures support the applicability of the research question as it enabled the researcher to compare two separate concepts and their possible enhancements in one measuring model. It further provided tangible results for Poligistics as the costs of a product is a tangible concept to them.

5.1.3.4 RQ4: Which recommended practices from packaging system, sourcing and TCO could be utilised by Poligistics to improve its current operation?

By using the packaging scorecard, the Kraljic model and the TCO model, recommended practices were identified which Poligistics could implement in its business. The packaging scorecard illustrated the value of a packaging system performance measurement in a business. Not only can it lead to a cost reduction, but it also aids in the identification of supply chain improvement areas due to its holistic approach. The packaging system performance measurement further results in the identification of the supply chain actors in a supply chain, which leads to improved communication between these actors as all actors pursue a common goal.

The Kraljic model emphasise the importance of classifying each raw material product according to its supply risk and profit risk. This is an important practice to conduct in a company as it results in the identification of the correct sourcing strategy per product. The model further underlined the value of market analysis, especially when negotiating supply contracts when it is important to be aware of the buying strength of the company versus supplier strength.

The TCO model reinforce the practice of using an objective measurement when measuring different concepts. This measurement also underlined the value of measuring the end-to-end cost of a product, from its inception to its point of disposal. This model further supports the recommended practice to identify hidden opportunity costs in the business. To conclude, this question was answered by the study as various recommended practices were identified through the course of the study.

5.2 Recommendations

This section presents the recommendations related to packaging system performance and sourcing enhancements, which arose from the study. It further provides areas of possible further research, which were identified during the study.

As mentioned in **Section 5.1.2.4**, this study combined three individual analytical approaches and used them in conjunction with one another. This hybrid combination of approaches provided a holistic evaluation of polyethylene at Poligistics as well as of valuable supply chain insights. The study recommends that researchers utilise this approach when searching for a comprehensive and holistic approach to evaluate a strategic product at a company. The approach provides quantitative as well as qualitative data and an all-encompassing evaluation, which could support key decision-making by the company.

5.2.1 Packaging system performance enhancements

As established during the semi-structured interviews with respondents, Poligistics was not measuring packaging system performance in its supply chain at the time of this research. As Kaplan and Norton (1992) state, if an action is not measured, it will not be able to improve. It is thus the recommendation of this study that the packaging system performance of polyethylene be measured on an annual basis. By conducting the measurement on an annual basis, sufficient time will be allowed to improve on identified areas before the next measurement.

The study further calculated the NWASS and level of satisfaction for each criterion and packaging system through the packaging scorecard. The packaging system performance rating per criterion of 1–4 was identified as possibly leading to inflated ratings as the ratings structure was skewed towards a positive result. The study recommends that this rating can be increased to a balanced ordinal scale (1 – very low, 3 – average, 5 – very high), which should enable respondents to provide more accurate ratings.

Using the packaging scorecard measurement resulted in the identification of the stackability criterion as the worst performing criterion. All supply chain actors participating in this study concurred that stackability is the criterion with the lowest level of satisfaction. It is thus recommended that Poligistics should start a project to investigate the available stackability options for polyethylene rolls. As seen in the TCO measurement (**Section 4.4.1**), by increasing the rolls per square meter from two to four, a potential saving of 2% in TCO can be achieved.

5.2.2 Sourcing enhancements

Respondents indicated that polyethylene is seen as a critical raw material at Poligistics, but that no previous sourcing model was used to determine the applicable sourcing strategy when sourcing the material. By using the Kraljic model, it was determined that polyethylene is a strategic product, and a diversification sourcing strategy should be used when sourcing the product. The study further utilised the TCO model to determine the potential value of using the diversification sourcing strategy.

The study found that production standing time due to late polyethylene deliveries is one of the major contributors to the TCO opportunity costs (see **Section 4.5.2**). Based on this, the researcher recommends that Poligistics use the nine-point action plan as discussed in **Section 4.4.4** above, with a specific focus on sourcing from multiple suppliers and contractual coverage. The recommendation is to develop supply contracts with all polyethylene suppliers, which should stipulate pricing, volume and lead time parameters. This will enable Poligistics to recoup any money lost due to machine standing time, as well as on-time deliveries from suppliers.

As the Kraljic model indicated that polyethylene is a strategic product for Poligistics and that in the supplier–buyer relationship, high supplier strength and low bargaining power for Poligistics is evident, it is further recommended that the possibility of producing polyethylene be investigated. Such vertical integration will allow Poligistics to own the entire supply chain and be less reliant on suppliers, whilst also producing polyethylene to the quality standard, which Poligistics require.

It is further recommended that a similar sourcing exercise be conducted for other raw material products in order to use the correct sourcing strategy when needed. This will result in the classification of raw material products and will support key sourcing decisions. Due to market forces and industry changes, it is recommended that this exercise be conducted on an annual basis, or when supply contracts are close to their expiry date.

Finally, the Kraljic model utilises a subjective rating of high and low to determine the supply risk and profit risk of a certain product. In order to classify the products accurately on a diagram, numbers are needed. The researcher utilised a 1–10 rating to identify the position of the product correctly (see **Table 4.1**). This had a positive outcome, and it is recommended that a similar numeric approach be used to determine the product position in future research.

5.2.3 Further research

This sub-section identifies key elements, which the study was unable to investigate further. This study utilised a single case study approach where further research could use multiple case studies instead of focusing on a single case. This will result in testing of the same approach but across multiple companies and could lead to more comprehensive results.

This study further focused on the inbound section of the supply chain at Poligistics. There would be value in evaluating an entire supply chain according to the approach used instead of only focusing on one section of the supply chain. This could especially focus on packaging system performance evaluation, where the outbound packaging systems could be evaluated to provide a comprehensive rating of the supply chain packaging system performance. This might provide in-depth background to decision-makers and help to identify areas of improvement in the entire supply chain.

With the evaluation of the packaging system performance through the packaging scorecard, the researcher noted the challenge of the current satisfaction rating scale of 0–4. As mentioned in **Section 5.1.2.1**, new findings by Pålsson (2018:36) gave rise to a new satisfaction rating scale of 1–5. Further research could utilise the new scale by Pålsson (2018:36) and compare these results with the current 0–4 ratings in a study.

Reference list

Alavi, H. & Habek, P. 2016. Addressing research design problem in mixed methods research. *Management Systems in Production Engineering*, 1(21):62–66.

American Forest & Paper Association. 2017. *Paper-based packaging* [Online]. Available: http://www.afandpa.org/our-products/paper-based-packaging [2019, April 1].

Ampuero, O. & Vila, N. 2006. Consumer perceptions of product packaging. *Journal of Consumer Marketing,* 23(2):100–112.

Arnold, J., Chapman, S. & Clive, L. 2008. *Introduction to materials management*. Upper Saddle River, NJ: Pearson Prentice Hall.

Babbie, E.R. 2010. *The practice of social research*. Twelfth edition. Belmont, CA: Wadsworth Cengage Learning.

Berger, K. 2005. *A brief history of packaging* [Online]. Available: http://ufdc.ufl.edu/IR00001524/00001 [2019, March 31].

BMi Research. 2016. *Overview of the South African packaging industry*. Bedfordview.

Bryman, A. 2008. Of methods and methodology. *Qualitative Research in Organisations and Management*, 3(2):159–168.

Burt, D., Petcavage, S. & Pinkerton, R. 2010. *Supply management*. New York, NY: McGraw-Hill.

Cela, E. & Kaneko, S. 2011. Determining the effectiveness of the Danish tax policy: The case of paper and paperboard packaging imports. *Resources Conservation and Recycling,* 55(9):836–841.

CEPI (Confederation of European Paper Industries). 2015. *Global Forest and Paper Industry Releases Policy Statement on Paper Recycling* [Online]. Available: http://www.cepi.org/news/global-forest-and-paper-industry-releases-policy-statement-paper-recycling [2019, June 12].

CFI (Corporate Financial Institute). 2019. *Price taker* [Online]. Available: https://corporatefinanceinstitute.com/resources/knowledge/economics/price-taker/ [2019, June 16].

CGMA (Charted Global Management Accountant). 2013. *Porter's five forces of competitive position analysis* [Online]. Available: https://www.cgma.org/resources/tools/essential-tools/porters-five-forces.html [2019, March 31].

Cherry, K. 2018. *Cross-sectional research method: How does it work?* [Online]. Available: https://www.verywellmind.com/what-is-a-cross-sectional-study-2794978 [2019, January 30].

CIEC (Centre for Industry Education Collaboration). 2017. *Poly(ethene) (Polyethylene)* [Online]. Available: http://www.essentialchemicalindustry.org/polymers/polyethene.html [2019, April 1].

CIPS (Chartered Institute of Procurement & Supply). 2017. *What is procurement?* [Online]. Available: https://www.cips.org/en-za/membership/why-join-cips/what-is-procurement-and-supply/ [2017, October 19].

Cox, A. 2015. Sourcing portfolio analysis and power positioning: Towards a “paradigm shift” in category management and strategic sourcing. *Supply Chain Management: An International Journal,* 20(6):717–736.

Crawford, K., Cox, J. & Blackstone, J. 1988. *Performance measurement systems and the JIT philosophy: Principles and cases*. Falls Church, VA: APICS.

Creswell, J.W. 2013. *Qualitative inquiry and research design: Choosing among five approaches.* London: Sage.

Creswell, J.W. & Plano Clark, V.L. 2007. *Designing and conducting mixed methods research*. Thousand Oaks, CA: Sage.

Darneille, W. 2011. Regionalism returns via vertical integration. *Cotton International Magazine*, 5 December: 24.

De Vos, A.S., Strydom, H., Fouché, C.B. & Delport, C.S.L. 2011. *Research at grass roots: For the social sciences and human service professionals*. Fourth edition. Pretoria: Van Schaik.

Dubois, A. & Gadde, L.E. 1996. Purchasing behaviour during three decades. *Proceedings of the 12th Annual IMP Conference*, 1(1):805–807.

Economy Watch. 2010. *Packaging industry report* [Online]. Available: http://www.economywatch.com/world-industries/packaging/report.html [2018, May 7].

Ellram, L. 1995. Total cost of ownership. *International Journal of Physical Distribution & Logistics Management*, 25(8):4–23.

Ellram, L. & Billington, C. 2001. Purchasing leverage considerations in the outsourcing decision. *European Journal of Purchasing and Supply Management,* 7(1):15–28.

Embree, K. 2016. *Global plastics packaging market to hit $375 billion by 2020* [Online]. Available: https://www.plasticstoday.com/packaging/global-plastics-packaging-market-hit-375-billion-2020/23800481624973?cid=nl.x.plas08.edt.aud.plas2day.20160801 [2019, March 31].

Emmanson’s Blog. 2010. *Purchasing and supply chain management* [Online]. Available: https://emmansonme.wordpress.com/2010/05/04/purchasing-and-supply-chain-managment-4-pp111/ [2019, February 24].

Endacott, R., Benbenishty, J. & Seha, M. 2010. Preparing research instruments for use with different cultures. *Intensive and Critical Care Nursing*, 26(1):64–68.

Explorable. 2019. *Non-probability sampling* [Online]. Available: https://explorable.com/non-probability-sampling [2019, June 15].

Faes, W. & Matthyssens, P. 2009. Insights into the process of changing sourcing strategies. *Journal of Business & Industrial Marketing*, 24(4):245–255.

Faraz, A., Sanders, N., Zacharia, Z. & Gerschberger, M. 2018. Monitoring type B buyer–supplier relationships. *International Journal of Production Research*, 56(18): 6225–6239.

Flick, U. 2014. *An introduction to qualitative research*. London: Sage.

Freeman, V. & Cavinato, J. 1990. Fitting purchasing to the strategic firm: Frameworks, processes and values. *Journal of Purchasing and Materials Management*, 26(4):6–10.

Frohlich, M.T. & Westbrook, R. 2001. Arcs of integration: An international study of supply chain strategies. *Journal of Operations Management*, 19(2):185–200.

Gelderman, C.J. & Van Weele, A.J. 2002. Strategic direction through purchasing portfolio management: A case study. *International Journal of Supply Chain Management*, 38(2):30–38.

Gereffi, G. & Lee, J. 2012. Why the world suddenly cares about global supply chains. *Journal of Supply Chain Management*, 48(3):24–32.

Greene, J., Caracelli, V. & Graham, W. 1989. Toward a conceptual framework for mixed method evaluation design. *Educational Evaluation and Policy Analysis*, 11(3):255–274.

Grönman, K., Soukka, R., Järvi-Kääriänen, T., Katajajuuri, J., Kuisma, M., Koivupuro, H., Ollila, M., Pitkänen, M., Miettinen, O., Silveneius, F., Thun, R., Wessman, H. & Linnanen, L. 2013. Framework for sustainable food packaging design. *Packaging Technology and Science,* 26(1):187–200.

Gu, F., Guo, J., Zhang, W., Summers, P. & Hall, P. 2017. From waste plastics to industrial raw materials: A life cycle assessment of mechanical plastic recycling practice based on a real-world case study. *Science of Total Environment*, 601/602:1192–1207.

Guan, W. & Rehme, J. 2012. Vertical integration in supply chains: Driving forces and consequences for a manufacturer's downstream integration. *Supply Chain Management: An International Journal,* 17(2):187–201.

Gunasekaran, A. & Kobu, B. 2007. Performance measures and metrics in logistics and supply chain management: A review of recent literature (1995–2004) for research and applications. *International Journal of Production Research*, 45(12):2819–2840.

Hagan, T.L. 2014. Measurements in quantitative research: How to select and report on research instruments. *Oncology Nursing Forum*, 41(4):431–433.

Hansen, A. & Serin, G. 1999. Materials and strategies for successful innovation and competition in the metal packaging industry. *Technology in Society*, 21(3):307–322.

Harrigan, K.R. 1985. Vertical integration and corporate strategy. *Academy of Management Journal,* 28(2):397–425.

Hellström, D. & Saghir, M. 2007. Packaging and logistics interactions in retail supply chains. *Packaging Technology and Science*, 20:197–216.

Hesping, F.H. & Schiele, H. 2016. Matching tactical sourcing levers with the Kraljix matrix: Empirical evidence on purchasing portfolios. *International Journal of Production Economics,* 177(1):101–117.

Hox, J.J. & Boeije, H.R. 2005. *Data collection, primary vs. secondary* [Online]. Available: http://www.joophox.net/publist/ESM_DCOL05.pdf [2019, June 14].

ICFPA (International Council of Forest and Paper Association). 2019. *Home* [Online]. Available: https://icfpa.org/ [2019, June 12].

Jhetam, S. 2019. Packaging SA website enquiry. E-mail to M. Engelbrecht, 14 January. Available e-mail: engelbrechtmarnus@gmail.com.

Kaplan, R. & Norton, D. 1992. *The balanced scorecard: Measures that drive performance* [Online]. Available: https://hbr.org/1992/01/the-balanced-scorecard-measures-that-drive-performance-2 [2018, November 9].

Kaplan, R. & Norton, D. 1996. *The balanced scorecard: Translating strategy into action*. Boston, MA: Harvard Business School Press.

Kausik, U. & Mahadevan, B. 2012. A review of strategic sourcing literature during 1997–2010: Trends and emerging issues for research. *South Asian Journal of Management*, 19(2):78–98.

Kazanjian, S. 2013. Packaging matters. *GCI*, September: 82–83.

Ketchen, D., Crook, R. & Craighead, C. 2014. From supply chains to supply ecosystems: Implications for strategic sourcing research and practice. *Journal of Business Logistics*, 35(3):165–171.

Kraljic, P. 1983. Purchasing must become supply management. *Harvard Business Review*, 61(5):109–117.

Lazzarini, S., Chaddad, F. & Cook, M. 2001. Integrating supply chain and network analyses: The study of netchains. *Journal on Chain and Network Science*, 1(1):7–22.

Le Blanc, R. 2016. *About metal recycling* [Online]. Available: https://www.thebalance.com/about-metal-recycling-2877921 [2017, July 12].

Legget, R. 2018. *The difference between aluminium & tin can* [Online]. Available: http://sciencing.com/difference-between-aluminum-tin-can-8596036.html [2019, April 1].

Lepoutre, P. 2017. *The manufacture of polyethylene* [Online]. Available: https://docplayer.net/24119564-The-manufacture-of-polyethylene.html [2019, April 1].

Lewis, H., Verghese, K. & Fitzpatrick, L. Evaluating the sustainability impacts of packaging: The plastic carry bag dilemma. *Packaging Technology and Science*, 23(1):145–160.

Lincoln Plastics. 2017. *Five steps to plastic extrusion* [Online]. Available: http://www.lincoln-plastics.com/five-steps-plastic-extrusion [2019, March 31].

Lindstrom, M. 2010. *Measuring strategic sourcing and procurement maturity within indirect spend* [Online]. Available: https://www.instituteforsupplymanagement.org/files/Pubs/Proceedings/2010ProcED-Lindstrom.pdf [2019, April 1].

Linthorst, M. & Telgen, J. 2017. *Public purchasing future: Buying from multiple suppliers* [Online]. Available: https://www.utwente.nl/en/bms/tms/staff/telgen/scientific%20journal%20papers/2006%20Jo

PP%20-%20Public%20purchasing%20future%20-buying%20from%20multiple%20suppliers%20(met%20ML).pdf [2019, April 1].

Lockamy, A. III. 1995. A conceptual framework for assessing strategic packaging decisions. *The International Journal of Logistics Management*, 6(1):51–60.

Louw, J.J. 2017. Honours procurement management [study notes]. Stellenbosch University.

Lucintel. 2013. *Growth opportunities in the global plastic packaging market* [Online]. Available: http://www.lucintel.com/plastic-packaging-market-2018.aspx [2019, April 1].

Macro. 2017. *Fundamentals of cast film extrusion technology* [Online]. Available: http://www.macroeng.com/fundamentals-of-cast-film-extrusion-technology.php [2019, March 31].

Mahoney, J.T. 1992. The choice of organizational form: Vertical financial ownership versus other methods of vertical integration. *Strategic Management Journal*, 13(8):559–584.

Majumdar, S.K. & Ramaswamy, V. 1994. Explaining downstream integration. *Managerial and Decision Economics*, 15(2):119–129.

Markets and Markets. 2017. *Metal packaging market worth $135.69 billion by 2020* [Online]. Available: http://www.marketsandmarkets.com/PressReleases/metal-packaging.asp [2019, April 1].

McCrea, B. 2013. *5 reasons to use total cost of ownership* [Online]. Available: https://www.digikey.co.za/en/articles/techzone/2013/jul/5-reasons-to-use-total-cost-of-ownership [2018, August, 26].

McDonald, C. 2016. Integrating packaging and supply chain decisions: Selection of economic handling unit quantities*. International Journal of Production Economics*, 180:208–221.

Monette, D.R., Sullivan, T.J. & Dejong, C.R. 2005. *Applied social research: A tool for the human services*. Sixth edition. Belmont, CA: Thomson Brooks.

Mourad, A., Jaime, S. & Garcia, E. 2014. Sustainability & ethics: Key issues for packaging trends. In *Proceedings of the 9th International Conference on Life Cycle Assessment in the Agri-Food Sector* [Online]. Available: https://pdfs.semanticscholar.org/9456/60457ff1e2fd07a46bec0262a761f941c88a.pdf [2019, June 12].

Mpact. 2019. *The carbon footprint of packaging* [Online]. Available: http://www.mpcsa.co.za/carbon-footprint-of-packaging.php [2019, January 9].

Murphy, P.R. & Wood, D.F. 2011. *Contemporary logistics*. Tenth edition. Upper Saddle River, NJ: Pearson Education.

Neil-Boss, N. & Brooks, K. 2017. *Unwrapping the packaging industry: Seven success factors* [Online]. Available: https://www.ey.com/Publication/vwLUAssets/Unwrapping_the_packaging_industry_%E2%80%93_seven_factors_for_success/$FILE/EY_Unwrapping_the_packaging_industry_-_seven_success_factors.pdf [2019, April 1].

Nilsson, F. 2016. Packaging – the supply chain enabler. In W.J. Pienaar & J.J. Vogt (eds.). *Business logistics management: A value chain perspective.* Fifth edition. Cape Town: Oxford University Press Southern Africa, 280–305.

Nordin, N. & Selke, S. 2010. Social aspect of sustainable packaging. *Packaging Technology and Science*, 23(1):317–326.

Oakley, S.J. 2017. *The Kraljic Portfolio Purchasing Model: Assessing risk and maximizing profits* [Online]. Available: https://www.linkedin.com/pulse/kraljic-portfolio-purchasing-model-assessing-risk-profits-oakley [2018, July 19].

OECD (Organisation for Economic Co-operation and Development). 2017. *Glossary of statistical terms* [Online]. Available: https://stats.oecd.org/glossary/detail.asp?ID=6805 [2019, April 1].

Olsmats, C. & Dominic, C. 2003. Packaging scorecard: A packaging system performance evaluation method*. Packaging Technology and Science*, 16(1):9–14.

Packaging Digest. 2019. *Search results: Packaging performance and strategic sourcing* [Online]. Available: https://www.packagingdigest.com/search/node/packaging%20performance%20and%20strategic%20sourcing [2019, February 24].

PackagingSA. 2017a. *Statement on paper recycling* [Online]. Available: http://www.packagingsa.co.za/info-library/packaging-types/paper-and-printing/international-council-of-forest-and-paper-associations-statement-on-paper-recycling-2/ [2019, April 1].

PackagingSA. 2017b. *The story of paper* [Online]. Available: http://www.packagingsa.co.za/info-library/packaging-types/paper-and-printing/the-story-of-paper/ [2019, April 1].

Padhi, S., Wagner, S. & Aggarwal, V. 2012. Positioning of commodities using the Kraljic Portfolio Matrix. *Journal of Purchasing & Supply Management*, 18(1):1–8.

Pålsson, H. 2018. *Packaging logistics*. London: Kogan Page.

Pålsson, H. & Hellström, D. 2016. Packaging logistics in supply chain practice – current state, trade-offs and improvement potential. *International Journal of Logistics Research and Applications,* 19(5):351–368.

PLASTICS (Plastics Industry Association). 2019. *This is plastics* [Online]. Available: https://www.thisisplastics.com/ [2019, June 12].

Polit, D.F. & Hungler, B.P. 1993. *Nursing research: Principles and methods*. Third edition. Philadelphia, PA: Lippincott.

Pope, C. & Mays, N. 2006. *Qualitative research in health care*. Oxford: Blackwell.

Porter, M. 1979. How competitive forces shape strategy. *Harvard Business Review*, 57(2): 137–146.

Regoniel, P. 2015. *Conceptual framework: A step by step guide on how to make one* [Online]. Available: https://simplyeducate.me/2015/01/05/conceptual-framework-guide/ [2019, February 15].

Reh, F.J. 2018. *A guide for managers to understand total cost of ownership (TCO)* [Online]. Available: https://www.thebalancecareers.com/total-cost-of-ownership-tco-2276009 [2018, August 30].

Reuters. 2018. *Woolworths to trial plastic bag free store* [Online]. Available: https://www.iol.co.za/business-report/international/woolworths-to-trial-plastic-bag-free-store-17400635 [2019, June 12].

Risch, S.J. 2009. Food packaging history and innovations. *Journal of Agricultural and Food Chemistry*, 57(1):8089–8092.

Roider, A. 2006. *Fisher Body revisited: Supply contracts and vertical integration* [Online]. Available: https://www.amherst.edu/system/files/media/0054/Roider%2520FisherBody.pdf [2019, April 1].

Rule, P. & John, V. 2011. *Your guide to case study research*. Pretoria: Van Schaik.

Ryedale District Council. 2017*. Different types of plastics and their classification* [Online]. Available: https://www.ryedale.gov.uk/attachments/article/690/Different_plastic_polymer_types.pdf [2019, March 31].

Saghir, M. 2004. *The concept of packaging logistics* [Online]. Available: https://www.researchgate.net/publication/228799386_The_Concept_OF_Packaging_Logistics [2018, May 10].

Sandax. 2019. *Container desiccant* [Online]. Available: https://www.sandax.de/en/container-desiccant.html [2019, June 16].

Saunders, M., Lewis, P. & Thornhill, A. 2009. *Research methods for business students*. Fifth edition. Harlow: Pearson Education.

Saunders, M. & Tosey, P. 2012. *The layers of research design* [Online]. Available: https://anlp.org/files/research-onion-layers_42_357.pdf [2019, February 4].

Schneller, E. 2010. A guide to successful strategic sourcing. *Materials Management in Health Care,* 19(6):22–26.

Schuh, C., Kromoser, R., Strohmer, M.F. & Mariscotti, F. 2012. *The purchasing chessboard* [Online]. Available: http://www.middle-east.atkearney.com/documents/787838/788065/Purchasing+Chessboard+-+English.pdf/e4a9dc5e-5229-47b5-b02c-47de726dcf2b [2018, November 4].

ScienceDirect. 2019. *Coextrusion* [Online]. Available: https://www.sciencedirect.com/topics/materials-science/coextrusion [2019, June 12].

Silbermayr, L. & Minner, S. 2013. A multiple sourcing inventory model under disruption risk. *International Journal of Production Economics,* 149(1):37–46.

Smithers Pira. 2018. *What's causing a shift from traditional materials to flexible packaging types?* [Online]. Available: https://www.smitherspira.com/resources/2018/january/shift-to-flexible-packaging [2019, June 11].

Soiferman, K. 2010. *Compare and contrast inductive and deductive research approaches* [Online]. Available: https://files.eric.ed.gov/fulltext/ED542066.pdf [2018, March 29].

Sonneveld, K., James, K., Fitzpatrick, L. & Lewis, H. 2014. *Sustainable packaging: How do we define and measure it?* [Online]. Available: https://www.researchgate.net/profile/Helen_Lewis9/publication/228737738_Sustainable_packaging_how_do_we_define_and_measure_it/links/54a333440cf256bf8bb0e127.pdf [2019, April 1].

Technavio. 2019. *Top 20 companies in the global packaging industry 2019* [Online]. Available: https://blog.technavio.com/blog/top-20-companies-global-packaging-market [2019, June 12].

TGRC (The Glass Recycling Company). 2018. *Facts about glass* [Online]. Available: https://theglassrecyclingcompany.co.za/facts-about-glass/ [2018, May 9].

Transparency Market Research. 2017. *Metal packaging market* [Online]. Available: http://www.transparencymarketresearch.com/metal-packaging-market.html [2019, April 1].

Trending Packaging. 2015. *Functions of packaging* [Online]. Available: https://www.trendingpackaging.com/functions-of-packaging/ [2019, January 20].

Trochim, W.M.K. 2006. *Research methods knowledge base* [Online]. Available: http://index-of.co.uk/Various/Social%20Research%20Methods%20Knowledge%20Base.pdf [2019, April 1].

Tuttle, H. 2016. Samsung's vertical integration challenge. *Forefront Magazine*, November: 6–8.

Twede, D. & Clarke, R. 2004. Supply chain issues in reusable packaging. *Journal of Marketing Channels*, 12(1):7–26.

United States Department of Labor. 2017. *Scrap metal recycling* [Online]. Available: https://www.osha.gov/SLTC/recycling/recycling_scrap_metal.html [2019, April 1].

University of Pune. 2019. *Introduction* [Online]. Available: http://shodhganga.inflibnet.ac.in/bitstream/10603/87835/10/10_chapter1.pdf [2019, March 31].

Wang, C., Webster, S. & Zhang, S. 2010. A comparison of two sourcing tactics for a new component. *European Journal of Operational Research*, 211(2):310–317.

Watkiss, C. 2019. *EU finally seals ban on single-use plastics by 2021* [Online]. Available: http://www.climateaction.org/news/eu-finally-seals-ban-on-single-use-plastics-by-2021 [2019, June 16].

Watts, C., Kim, K. & Hahn, C. 1995. Linking purchasing to corporate competitive strategy. *International Journal of Purchasing and Materials Management,* 31(1):2–8.

Webb, J. 2017. *What is the Kraljic Matrix?* [Online]. Available: https://www.forbes.com/sites/jwebb/2017/02/28/what-is-the-kraljic-matrix/#6832c147675f [2019, April 1].

Welman, J.C. & Kruger, S.J. 2001. *Research methodology for the business and administration sciences*. Second edition. Cape Town: Oxford University Press Southern Africa.

Wilson, D.T. 1995. An integrated model of buyer-seller relationships. *Journal of the Academy of Marketing Science*, 23(4):335–345.

Wilson, J. 2010. *Essentials of business research: A guide to doing your research project*. London: Sage.

Wilson, V. 2012. *Research methods: Interviews* [Online]. Available: https://doi: 10.18438/B89P5B [2018, May 9].

Wintour, N. 2015. *The glass industry: Recent trends and changes in working conditions and employment relations* [Online]. Available: http://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/publication/wcms_442086.pdf [2017, July 16].

Yin, R. 2014. *Case study research: Design and methods*. Fifth edition. Thousand Oaks, CA: Sage.

Yu, E. 2014. *Multi-sourcing offers benefits, but complex to manage* [Online]. Available: http://www.zdnet.com/article/multi-sourcing-offers-benefits-but-complex-to-manage/ [2017, December 17].

Zhu, S.X. 2015. Analysis of dual sourcing strategies under supply disruptions. *International Journal of Production Economics*, 170:191–203.

Zielinski, L. 2013. *If the consumer isn't happy with packaging, nobody's happy* [Online]. Available: https://www.brandpackaging.com/articles/84432-if-the-consumer-snt-happy-with-packaging-nobodys-happy [2018, November 4].

Appendix A

Interview Guide 1

RQ1: To what extent is packaging system performance measured at Poligistics, and how is packaging performing based on criteria and set methods?

Background

Packaging and its functions are important to most products and can be found in various shapes and sizes. It has six primary functions namely (1) containment, (2) protection, (3) apportionment, (4) unitisation, (5) convenience, and (6) communication. These functions enable various businesses and the general public to operate on a daily basis. Packaging can be seen as a system which consists of three types of packaging, namely primary, secondary and tertiary. The aim of this interview is to test the packaging performance at Poligistics, through the use of a packaging scorecard

Consent

Verbally confirm with the respondent that they are comfortable with their participation in this research study and that they are participating voluntarily without an expectation of compensation or reward. Also confirm that he/she may withdraw from the interview at any stage.

Guiding questions

Explain how polyethylene rolls are packaged?

What are some of the packaging requirements at your company?

Do you currently measure the performance of packaging and if so, with which instrument?

Map the supply chain of a polyethylene roll with the respondent.

Does the respondent know of any product-specific challenges?

Packaging scorecard

Explain the packaging scorecard including the process as well as the meaning of each criterion point.

Is the criteria point applicable to your part of the Supply Chain?

How would you rate the importance (0% non-important – 100% very important) of each of the following criteria per packaging level (list all 17 Criteria).

How would you rate the performance of each criteria (per packaging level) from 0-4?

Final Thoughts

What else would you like to share with regard to packaging system performance?

Interview Guide 2

RQ#2 What is the current sourcing situation at Poligistics and which sourcing strategy could enhance the sourcing of polyethylene?

Background

Sourcing is seen as a key supply management function and it refers to the identification of suppliers, contract term negotiations and quality agreements. It has a high impact on the material expenditure of a business and directly affects the bottom line. It has received more strategic attention in recent times with companies identifying it as a competitive advantage opportunity as well as a risk mitigation activity. This interview sets out to determine the current sourcing strategy used by Poligistics when procuring polyethylene and test which sourcing strategy should be used through the use of the Kraljic Model.

Consent

Verbally confirm with the respondent that they are comfortable with their participation in this research study and that they are participating voluntarily without an expectation of compensation or reward. Also confirm that he/she may withdraw from the interview at any stage.

Guiding Questions

Please describe the current process of sourcing polyethylene at Poligistics?

Please share some of the challenges with your current sourcing strategy?

Describe the amount of polyethylene purchased on a monthly basis and the percentage of this cost to the total product cost?

Kraljic Model

What is the supply and profit risk of polyethylene?

Describe the bargaining power between Poligistics and its suppliers?

Please share some details regarding your current polyethylene suppliers (pricing, lead time, amount)?

What are the market growth possibilities for Poligistics and the possibilities of bottlenecks at suppliers?

How would you describe possible growth opportunities for Poligistics and is there space for development?

Are there new entries in the market or a threat of substitution?

Final Thoughts

What else would you like to share with regard to the sourcing of polyethylene?

Appendix B

Packaging scorecard gathered data

Suppliers

Supplier 1						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	x	x				
Tracking information	x	x				
Machinability	x					
Volume and weight efficiency	x	x				
Stackability	x	x				
Minimal resources used	x	x				
Minimal use of hazardous substances						
Right amount and size	x	x				
Packaging costs	x	x				
Selling capability						
Minimal waste	x	x				
Product information						
User interaction	x	x				
Reverse handling	x	x				
Security concerns						
User safety						
Handleability	x	x				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	80	80				
Tracking information	50	50				
Machinability	30					
Volume and weight efficiency	90	90				
Stackability	90	90				
Minimal resources used	100	100				
Minimal use of hazardous substances						
Right amount and size	50	50				
Packaging costs	70	70				
Selling capability						
Minimal waste	80	80				
Product information						
User interaction	20	20				
Reverse handling	80	80				
Security concerns						
User safety						
Handleability	50	50				
Total						

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	3	3				
Tracking information	4	4				
Machinability	4					
Volume and weight efficiency	1	1				
Stackability	1	1				
Minimal resources used	4	4				
Minimal use of hazardous substances						
Right amount and size	4	4				
Packaging costs	3	3				
Selling capability						
Minimal waste	3	3				
Product information						
User interaction	4	4				
Reverse handling	3	3				
Security concerns						
User safety						
Handleability	3	2				

Applicability of criteria	Supplier 2					
	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	x	x				
Tracking information		x				
Machinability	x					
Volume and weight efficiency						
Stackability						
Minimal resources used	x	x				
Minimal use of hazardous substances	x	x				
Right amount and size	x	x				
Packaging costs						
Selling capability						
Minimal waste	x	x				
Product information		x				
User interaction	x	x				
Reverse handling	x	x				
Security concerns						
User safety	x	x				
Handleability	x	x				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	100	100				
Tracking information		100				
Machinability	100					
Volume and weight efficiency						
Stackability						
Minimal resources used	40	40				
Minimal use of hazardous substances	100	100				
Right amount and size	100	100				
Packaging costs						
Selling capability						
Minimal waste	20	20				
Product information		100				
User interaction	100	100				
Reverse handling	100	80				
Security concerns						
User safety	90	90				
Handleability	80	80				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	4	4				
Tracking information		4				
Machinability	3					
Volume and weight efficiency						
Stackability						
Minimal resources used	2	2				
Minimal use of hazardous substances	3	3				
Right amount and size	4	4				
Packaging costs						
Selling capability						
Minimal waste	2	2				
Product information		4				
User interaction	3	3				
Reverse handling	3	3				
Security concerns						
User safety	3	3				
Handleability	3	3				

Supplier 3						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	x	x				
Tracking information		x				
Machinability	x					
Volume and weight efficiency		x				
Stackability						
Minimal resources used	x	x				
Minimal use of hazardous substances	x	x				
Right amount and size	x	x				
Packaging costs	x	x				
Selling capability						
Minimal waste		x				
Product information	x	x				
User interaction	x	x				
Reverse handling	x	x				
Security concerns		x				
User safety		x				
Handleability	x	x				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	100	100				
Tracking information		80				
Machinability	100					
Volume and weight efficiency		90				
Stackability						
Minimal resources used	100	100				
Minimal use of hazardous substances	100	100				
Right amount and size	100	100				
Packaging costs	100	100				
Selling capability						
Minimal waste		60				
Product information	100	100				
User interaction	80	80				
Reverse handling	100	60				
Security concerns		8				
User safety		80				
Handleability	80	80				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	3	3				
Tracking information		1				
Machinability	3					
Volume and weight efficiency		1				
Stackability						
Minimal resources used	3	3				
Minimal use of hazardous substances	4	4				
Right amount and size	4	4				
Packaging costs	2	2				
Selling capability						
Minimal waste		2				
Product information	3	3				
User interaction	3	3				
Reverse handling	4	4				
Security concerns		3				
User safety		2				
Handleability	3	3				

Supplier 4						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	x	x				
Tracking information						
Machinability	x	x				
Volume and weight efficiency		x				
Stackability		x				
Minimal resources used	x	x				
Minimal use of hazardous substances						
Right amount and size	x	x				
Packaging costs	x	x				
Selling capability						
Minimal waste						
Product information	x					
User interaction						
Reverse handling	x	x				
Security concerns	x	x				
User safety		x				
Handleability		x				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	100	100				
Tracking information						
Machinability	100	100				
Volume and weight efficiency		100				
Stackability		10				
Minimal resources used	100	100				
Minimal use of hazardous substances						
Right amount and size	100	100				
Packaging costs	100	100				
Selling capability						
Minimal waste						
Product information	100					
User interaction						
Reverse handling	80	80				
Security concerns	100	100				
User safety		100				
Handleability		100				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	4	2				
Tracking information						
Machinability	2	3				
Volume and weight efficiency		3				
Stackability		3				
Minimal resources used	4	4				
Minimal use of hazardous substances						
Right amount and size	3	3				
Packaging costs	3	3				
Selling capability						
Minimal waste						
Product information	2					
User interaction						
Reverse handling	3	3				
Security concerns	4	4				
User safety		2				
Handleability		3				

Supplier 5						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	x	x				
Tracking information	x	x				
Machinability	x	x				
Volume and weight efficiency	x	x				
Stackability	x	x				
Minimal resources used						
Minimal use of hazardous substances	x	x				
Right amount and size	x	x				
Packaging costs						
Selling capability						
Minimal waste	x	x				
Product information	x	x				
User interaction	x	x				
Reverse handling	x	x				
Security concerns						
User safety	x	x				
Handleability	x	x				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	100	100				
Tracking information	70	70				
Machinability	100	100				
Volume and weight efficiency	20	20				
Stackability	90	90				
Minimal resources used						
Minimal use of hazardous substances	100	100				
Right amount and size	80	80				
Packaging costs						
Selling capability						
Minimal waste	80	80				
Product information	100	100				
User interaction	50	50				
Reverse handling	100	100				
Security concerns						
User safety	100	100				
Handleability	100	100				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	2	2				
Tracking information	1	1				
Machinability	3	4				
Volume and weight efficiency	4	4				
Stackability	1	1				
Minimal resources used						
Minimal use of hazardous substances	3	3				
Right amount and size	2	2				
Packaging costs						
Selling capability						
Minimal waste	4	4				
Product information	3	3				
User interaction	3	3				
Reverse handling	2	2				
Security concerns						
User safety	3	3				
Handleability	4	2				

Supplier 6						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	x	x				
Tracking information						
Machinability	x					
Volume and weight efficiency						
Stackability						
Minimal resources used	x	x				
Minimal use of hazardous substances	x	x				
Right amount and size						
Packaging costs	x	x				
Selling capability						
Minimal waste	x	x				
Product information	x					
User interaction	x	x				
Reverse handling	x	x				
Security concerns						
User safety		x				
Handleability		x				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	100	100				
Tracking information						
Machinability	90					
Volume and weight efficiency						
Stackability						
Minimal resources used	70	70				
Minimal use of hazardous substances	100	100				
Right amount and size						
Packaging costs	80	80				
Selling capability						
Minimal waste	90	90				
Product information	100					
User interaction	90	90				
Reverse handling	80	80				
Security concerns						
User safety		70				
Handleability		70				

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection	3	3				
Tracking information						
Machinability	3					
Volume and weight efficiency						
Stackability						
Minimal resources used	3	3				
Minimal use of hazardous substances	4	4				
Right amount and size						
Packaging costs	3	3				
Selling capability						
Minimal waste	3	3				
Product information	4					
User interaction	3	3				
Reverse handling	4	3				
Security concerns						
User safety		3				
Handleability		3				

Service providers

Service Provider 1						
Applicability of criteria	**Supplier**		**Service Provider**		**Customer**	
	Primary	**Tertiary**	**Primary**	**Tertiary**	**Primary**	**Tertiary**
Product protection				x		
Tracking information				x		
Machinability				x		
Volume and weight efficiency				x		
Stackability				x		
Minimal resources used				x		
Minimal use of hazardous substances						
Right amount and size						
Packaging costs				x		
Selling capability						
Minimal waste				x		
Product information				x		
User interaction				x		
Reverse handling				x		
Security concerns				x		
User safety				x		
Handleability				x		

	Supplier		**Service Provider**		**Customer**	
	Primary	**Tertiary**	**Primary**	**Tertiary**	**Primary**	**Tertiary**
Product protection				100		
Tracking information				100		
Machinability				100		
Volume and weight efficiency				100		
Stackability				90		
Minimal resources used				100		
Minimal use of hazardous substances						
Right amount and size						
Packaging costs				80		
Selling capability						
Minimal waste				20		
Product information				100		
User interaction				100		
Reverse handling				100		
Security concerns				70		
User safety				90		
Handleability				90		

	Supplier		**Service Provider**		**Customer**	
	Primary	**Tertiary**	**Primary**	**Tertiary**	**Primary**	**Tertiary**
Product protection				3		
Tracking information				1		
Machinability				2		
Volume and weight efficiency				3		
Stackability				2		
Minimal resources used				3		
Minimal use of hazardous substances						
Right amount and size						
Packaging costs				2		
Selling capability						
Minimal waste				2		
Product information				2		
User interaction				2		
Reverse handling				3		
Security concerns				3		
User safety				3		
Handleability				3		

Serivce Provider 2						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection				X		
Tracking information				X		
Machinability				X		
Volume and weight efficiency				X		
Stackability				X		
Minimal resources used				X		
Minimal use of hazardous substances				X		
Right amount and size				X		
Packaging costs						
Selling capability						
Minimal waste				X		
Product information				X		
User interaction						
Reverse handling				X		
Security concerns						
User safety				X		
Handleability				X		

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection				100		
Tracking information				100		
Machinability				100		
Volume and weight efficiency				90		
Stackability				100		
Minimal resources used				70		
Minimal use of hazardous substances				100		
Right amount and size				90		
Packaging costs						
Selling capability						
Minimal waste				50		
Product information				100		
User interaction						
Reverse handling				80		
Security concerns						
User safety				100		
Handleability				100		

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection				2		
Tracking information				1		
Machinability				3		
Volume and weight efficiency				4		
Stackability				3		
Minimal resources used				4		
Minimal use of hazardous substances				4		
Right amount and size				4		
Packaging costs						
Selling capability						
Minimal waste				4		
Product information				3		
User interaction						
Reverse handling				4		
Security concerns						
User safety				4		
Handleability				4		

Service Provider 3						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection				X		
Tracking information						
Machinability				X		
Volume and weight efficiency				X		
Stackability				X		
Minimal resources used				X		
Minimal use of hazardous substances				X		
Right amount and size				X		
Packaging costs				X		
Selling capability						
Minimal waste				X		
Product information				X		
User interaction						
Reverse handling				X		
Security concerns						
User safety				X		
Handleability				X		

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection				100		
Tracking information						
Machinability				70		
Volume and weight efficiency				100		
Stackability				50		
Minimal resources used				40		
Minimal use of hazardous substances				100		
Right amount and size				100		
Packaging costs				70		
Selling capability						
Minimal waste				50		
Product information				100		
User interaction						
Reverse handling				80		
Security concerns						
User safety				90		
Handleability				90		

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection				3		
Tracking information						
Machinability				2		
Volume and weight efficiency				2		
Stackability				1		
Minimal resources used				2		
Minimal use of hazardous substances				4		
Right amount and size				4		
Packaging costs				3		
Selling capability						
Minimal waste				2		
Product information				3		
User interaction						
Reverse handling				3		
Security concerns						
User safety				3		
Handleability				3		

Customers

Customer 1						
Applicability of criteria	**Supplier**		**Service Provider**		**Customer**	
	Primary	**Tertiary**	**Primary**	**Tertiary**	**Primary**	**Tertiary**
Product protection					x	x
Tracking information					x	x
Machinability						x
Volume and weight efficiency						x
Stackability					x	x
Minimal resources used						
Minimal use of hazardous substances					x	
Right amount and size					x	x
Packaging costs					x	x
Selling capability						
Minimal waste					x	x
Product information					x	
User interaction					x	x
Reverse handling						
Security concerns					x	x
User safety					x	
Handleability						x

	Supplier		**Service Provider**		**Customer**	
	Primary	**Tertiary**	**Primary**	**Tertiary**	**Primary**	**Tertiary**
Product protection					90	90
Tracking information					100	100
Machinability						60
Volume and weight efficiency						100
Stackability					80	100
Minimal resources used						
Minimal use of hazardous substances					30	
Right amount and size					100	100
Packaging costs					100	100
Selling capability						
Minimal waste					20	10
Product information					100	
User interaction					80	95
Reverse handling						
Security concerns					20	20
User safety					70	
Handleability						100
Total						

	Supplier		**Service Provider**		**Customer**	
	Primary	**Tertiary**	**Primary**	**Tertiary**	**Primary**	**Tertiary**
Product protection					3	4
Tracking information					4	4
Machinability						4
Volume and weight efficiency						2
Stackability					3	1
Minimal resources used						
Minimal use of hazardous substances					4	
Right amount and size					4	4
Packaging costs					4	3
Selling capability						
Minimal waste					2	1
Product information					4	
User interaction					4	2
Reverse handling						
Security concerns					1	2
User safety					2	
Handleability						4

Customer 2						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					x	x
Tracking information					x	x
Machinability					x	x
Volume and weight efficiency					x	x
Stackability					x	x
Minimal resources used					x	x
Minimal use of hazardous substances					x	x
Right amount and size						
Packaging costs					x	x
Selling capability						
Minimal waste					x	x
Product information					x	
User interaction					x	x
Reverse handling					x	x
Security concerns						
User safety						x
Handleability					x	x

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					100	100
Tracking information					90	90
Machinability					100	70
Volume and weight efficiency					50	50
Stackability					80	80
Minimal resources used					60	60
Minimal use of hazardous substances					90	90
Right amount and size						
Packaging costs					30	30
Selling capability						
Minimal waste					50	50
Product information					50	
User interaction					60	40
Reverse handling					30	80
Security concerns						
User safety						100
Handleability					90	90
Total						

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					2	2
Tracking information					3	2
Machinability					1	3
Volume and weight efficiency					2	1
Stackability					1	1
Minimal resources used					3	3
Minimal use of hazardous substances					3	3
Right amount and size						
Packaging costs					2	2
Selling capability						
Minimal waste					2	2
Product information					1	
User interaction					2	2
Reverse handling					3	3
Security concerns						
User safety						3
Handleability					3	3

Applicability of criteria	Customer 3					
	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					x	x
Tracking information					x	x
Machinability					x	
Volume and weight efficiency						x
Stackability						x
Minimal resources used					x	x
Minimal use of hazardous substances						x
Right amount and size					x	x
Packaging costs					x	x
Selling capability						
Minimal waste					x	x
Product information					x	
User interaction					x	x
Reverse handling					x	x
Security concerns						
User safety					x	x
Handleability					x	x

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					100	100
Tracking information					50	60
Machinability					90	
Volume and weight efficiency						80
Stackability						80
Minimal resources used					20	20
Minimal use of hazardous substances						20
Right amount and size					80	80
Packaging costs					50	70
Selling capability						
Minimal waste					30	60
Product information					100	
User interaction					50	30
Reverse handling					60	60
Security concerns						
User safety					20	30
Handleability					50	80

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					3	2
Tracking information					1	1
Machinability					2	
Volume and weight efficiency						3
Stackability						1
Minimal resources used					4	3
Minimal use of hazardous substances						3
Right amount and size					3	3
Packaging costs					3	2
Selling capability						
Minimal waste					3	2
Product information					3	
User interaction					3	3
Reverse handling					3	3
Security concerns						
User safety					3	3
Handleability					3	2

Customer 4						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					x	x
Tracking information					x	x
Machinability					x	x
Volume and weight efficiency						
Stackability						
Minimal resources used					x	x
Minimal use of hazardous substances					x	x
Right amount and size					x	x
Packaging costs					x	x
Selling capability						
Minimal waste					x	x
Product information					x	x
User interaction					x	x
Reverse handling					x	x
Security concerns						
User safety						x
Handleability					x	x

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					100	100
Tracking information					100	100
Machinability					90	100
Volume and weight efficiency						
Stackability						
Minimal resources used					40	40
Minimal use of hazardous substances					80	80
Right amount and size					100	100
Packaging costs					100	100
Selling capability						
Minimal waste					50	50
Product information					100	100
User interaction					100	100
Reverse handling					50	80
Security concerns						
User safety						100
Handleability					100	100

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					3	3
Tracking information					2	2
Machinability					2	2
Volume and weight efficiency						
Stackability						
Minimal resources used					3	3
Minimal use of hazardous substances					4	4
Right amount and size					4	4
Packaging costs					2	2
Selling capability						
Minimal waste					3	3
Product information					3	3
User interaction					4	4
Reverse handling					3	4
Security concerns						
User safety						2
Handleability					4	4

Customer 5						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					x	x
Tracking information					x	x
Machinability					x	x
Volume and weight efficiency						
Stackability						
Minimal resources used					x	x
Minimal use of hazardous substances					x	x
Right amount and size					x	x
Packaging costs					x	x
Selling capability						
Minimal waste					x	x
Product information					x	x
User interaction					x	x
Reverse handling					x	x
Security concerns					x	x
User safety						x
Handleability					x	x

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					100	100
Tracking information					100	100
Machinability					100	100
Volume and weight efficiency						
Stackability						
Minimal resources used					50	50
Minimal use of hazardous substances					100	100
Right amount and size					60	60
Packaging costs					100	100
Selling capability						
Minimal waste					60	60
Product information					100	100
User interaction					50	50
Reverse handling					60	60
Security concerns					60	60
User safety						100
Handleability					60	60

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					4	4
Tracking information					2	2
Machinability					4	4
Volume and weight efficiency						
Stackability						
Minimal resources used					3	3
Minimal use of hazardous substances					4	4
Right amount and size					3	3
Packaging costs					3	3
Selling capability						
Minimal waste					3	2
Product information					4	4
User interaction					3	3
Reverse handling					3	3
Security concerns					2	2
User safety						4
Handleability					3	3

Customer 6						
Applicability of criteria	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					x	x
Tracking information						x
Machinability					x	x
Volume and weight efficiency						
Stackability					x	x
Minimal resources used					x	x
Minimal use of hazardous substances					x	x
Right amount and size					x	
Packaging costs						
Selling capability						
Minimal waste					x	x
Product information					x	x
User interaction					x	x
Reverse handling					x	x
Security concerns						
User safety						x
Handleability						x

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					100	100
Tracking information						100
Machinability					90	90
Volume and weight efficiency						
Stackability					100	100
Minimal resources used					60	60
Minimal use of hazardous substances					100	100
Right amount and size					80	
Packaging costs						
Selling capability						
Minimal waste					30	30
Product information					100	100
User interaction					30	30
Reverse handling					100	100
Security concerns						
User safety						100
Handleability						100

	Supplier		Service Provider		Customer	
	Primary	Tertiary	Primary	Tertiary	Primary	Tertiary
Product protection					3	3
Tracking information						1
Machinability					3	3
Volume and weight efficiency						
Stackability					1	1
Minimal resources used					4	3
Minimal use of hazardous substances					3	4
Right amount and size					3	
Packaging costs						
Selling capability						
Minimal waste					3	3
Product information					3	3
User interaction					2	2
Reverse handling					3	3
Security concerns						
User safety						3
Handleability						4

Customer 7						
Applicability of criteria	**Supplier**		**Service Provider**		**Customer**	
	Primary	**Tertiary**	**Primary**	**Tertiary**	**Primary**	**Tertiary**
Product protection					x	x
Tracking information					x	x
Machinability					x	x
Volume and weight efficiency						
Stackability					x	x
Minimal resources used					x	x
Minimal use of hazardous substances					x	x
Right amount and size					x	x
Packaging costs					x	x
Selling capability						
Minimal waste					x	x
Product information					x	
User interaction						
Reverse handling					x	
Security concerns					x	x
User safety					x	x
Handleability						x

	Supplier		**Service Provider**		**Customer**	
	Primary	**Tertiary**	**Primary**	**Tertiary**	**Primary**	**Tertiary**
Product protection					100	100
Tracking information					70	70
Machinability					70	70
Volume and weight efficiency						
Stackability					90	90
Minimal resources used					80	80
Minimal use of hazardous substances					60	60
Right amount and size					90	90
Packaging costs					90	90
Selling capability						
Minimal waste					70	70
Product information					100	
User interaction						
Reverse handling					90	90
Security concerns					90	90
User safety					100	100
Handleability						100

	Supplier		**Service Provider**		**Customer**	
	Primary	**Tertiary**	**Primary**	**Tertiary**	**Primary**	**Tertiary**
Product protection					4	4
Tracking information					2	2
Machinability					2	2
Volume and weight efficiency						
Stackability					2	2
Minimal resources used					3	3
Minimal use of hazardous substances					3	3
Right amount and size					4	4
Packaging costs					3	3
Selling capability						
Minimal waste					3	2
Product information					4	
User interaction						
Reverse handling					3	3
Security concerns					4	4
User safety					3	3
Handleability						4

Appendix C

Packaging scorecard criteria with its importance and performance ratings

Tracking Number	Actor	System	Criteria Number	Packaging Criteria	Score	Weighting
1	Supplier 1	Primary	1	Product protection	3	80
2	Supplier 1	Primary	2	Tracking information	4	50
3	Supplier 1	Primary	3	Machinability	4	30
4	Supplier 1	Primary	4	Volume and weight efficiency	1	90
5	Supplier 1	Primary	5	Stackability	1	90
6	Supplier 1	Primary	6	Minimal resources used	4	100
7	Supplier 1	Primary	8	Right amount and size	4	50
8	Supplier 1	Primary	9	Packaging costs	3	70
9	Supplier 1	Primary	11	Minimal waste	3	80
10	Supplier 1	Primary	13	User interaction	4	20
11	Supplier 1	Primary	14	Reverse handling	3	80
12	Supplier 1	Primary	17	Handleability	3	50
13	Supplier 2	Primary	1	Product protection	4	100
14	Supplier 2	Primary	3	Machinability	3	100
15	Supplier 2	Primary	6	Minimal resources used	2	40
16	Supplier 2	Primary	7	Minimal use of hazardous substances	3	100
17	Supplier 2	Primary	8	Right amount and size	4	100
18	Supplier 2	Primary	11	Minimal waste	2	20
19	Supplier 2	Primary	13	User interaction	3	100
20	Supplier 2	Primary	14	Reverse handling	3	100
21	Supplier 2	Primary	16	User safety	3	90
22	Supplier 2	Primary	17	Handleability	3	80
23	Supplier 3	Primary	1	Product protection	3	100
24	Supplier 3	Primary	3	Machinability	3	100
25	Supplier 3	Primary	6	Minimal resources used	3	100
26	Supplier 3	Primary	7	Minimal use of hazardous substances	4	100
27	Supplier 3	Primary	8	Right amount and size	4	100
28	Supplier 3	Primary	9	Packaging costs	2	100
29	Supplier 3	Primary	12	Product information	3	100
30	Supplier 3	Primary	13	User interaction	3	80
31	Supplier 3	Primary	14	Reverse handling	4	100
32	Supplier 3	Primary	17	Handleability	3	80
33	Supplier 4	Primary	1	Product protection	4	100
34	Supplier 4	Primary	3	Machinability	2	100
35	Supplier 4	Primary	6	Minimal resources used	4	100
36	Supplier 4	Primary	8	Right amount and size	3	100
37	Supplier 4	Primary	9	Packaging costs	3	100
38	Supplier 4	Primary	12	Product information	2	100
39	Supplier 4	Primary	14	Reverse handling	3	80
40	Supplier 4	Primary	15	Security concerns	4	100
41	Supplier 5	Primary	1	Product protection	2	100
42	Supplier 5	Primary	2	Tracking information	1	70
43	Supplier 5	Primary	3	Machinability	3	100
44	Supplier 5	Primary	4	Volume and weight efficiency	4	20
45	Supplier 5	Primary	5	Stackability	1	90
46	Supplier 5	Primary	7	Minimal use of hazardous substances	3	100
47	Supplier 5	Primary	8	Right amount and size	2	80
48	Supplier 5	Primary	11	Minimal waste	4	80
49	Supplier 5	Primary	12	Product information	3	100
50	Supplier 5	Primary	13	User interaction	3	50
51	Supplier 5	Primary	14	Reverse handling	2	100
52	Supplier 5	Primary	16	User safety	3	100
53	Supplier 5	Primary	17	Handleability	4	100
54	Supplier 6	Primary	1	Product protection	3	100
55	Supplier 6	Primary	3	Machinability	3	90
56	Supplier 6	Primary	6	Minimal resources used	3	70
57	Supplier 6	Primary	7	Minimal use of hazardous substances	4	100
58	Supplier 6	Primary	9	Packaging costs	3	80
59	Supplier 6	Primary	11	Minimal waste	3	90
60	Supplier 6	Primary	12	Product information	4	100
61	Supplier 6	Primary	13	User interaction	3	90
62	Supplier 6	Primary	14	Reverse handling	4	80
63	Supplier 1	Tertiary	1	Product protection	3	80
64	Supplier 1	Tertiary	2	Tracking information	4	50
65	Supplier 1	Tertiary	4	Volume and weight efficiency	1	90
66	Supplier 1	Tertiary	5	Stackability	1	90
67	Supplier 1	Tertiary	6	Minimal resources used	4	100
68	Supplier 1	Tertiary	8	Right amount and size	4	50
69	Supplier 1	Tertiary	9	Packaging costs	3	70

Tracking Number	Actor	System	Criteria Number	Packaging Criteria	Score	Weighting
70	Supplier 1	Tertiary	11	Minimal waste	3	80
71	Supplier 1	Tertiary	13	User interaction	4	20
72	Supplier 1	Tertiary	14	Reverse handling	3	80
73	Supplier 2	Tertiary	1	Product protection	4	100
74	Supplier 2	Tertiary	2	Tracking information	0	100
75	Supplier 2	Tertiary	6	Minimal resources used	2	40
76	Supplier 2	Tertiary	7	Minimal use of hazardous substances	3	100
77	Supplier 2	Tertiary	8	Right amount and size	4	100
78	Supplier 2	Tertiary	11	Minimal waste	2	20
79	Supplier 2	Tertiary	12	Product information	0	100
80	Supplier 2	Tertiary	13	User interaction	3	100
81	Supplier 2	Tertiary	14	Reverse handling	3	80
82	Supplier 2	Tertiary	16	User safety	3	90
83	Supplier 2	Tertiary	17	Handleability	3	80
84	Supplier 3	Tertiary	1	Product protection	3	100
85	Supplier 3	Tertiary	2	Tracking information	1	80
86	Supplier 3	Tertiary	4	Volume and weight efficiency	1	90
87	Supplier 3	Tertiary	6	Minimal resources used	3	100
88	Supplier 3	Tertiary	7	Minimal use of hazardous substances	4	100
89	Supplier 3	Tertiary	8	Right amount and size	4	100
90	Supplier 3	Tertiary	9	Packaging costs	2	100
91	Supplier 3	Tertiary	11	Minimal waste	2	60
92	Supplier 3	Tertiary	12	Product information	3	100
93	Supplier 3	Tertiary	13	User interaction	3	80
94	Supplier 3	Tertiary	14	Reverse handling	4	60
95	Supplier 3	Tertiary	15	Security concerns	3	8
96	Supplier 3	Tertiary	16	User safety	2	80
97	Supplier 3	Tertiary	17	Handleability	3	80
98	Supplier 4	Tertiary	1	Product protection	2	100
99	Supplier 4	Tertiary	3	Machinability	3	100
100	Supplier 4	Tertiary	4	Volume and weight efficiency	3	100
101	Supplier 4	Tertiary	5	Stackability	3	10
102	Supplier 4	Tertiary	6	Minimal resources used	4	100
103	Supplier 4	Tertiary	8	Right amount and size	3	100
104	Supplier 4	Tertiary	9	Packaging costs	3	100
105	Supplier 4	Tertiary	14	Reverse handling	3	80
106	Supplier 4	Tertiary	15	Security concerns	4	100
107	Supplier 4	Tertiary	16	User safety	2	100
108	Supplier 4	Tertiary	17	Handleability	3	100
109	Supplier 5	Tertiary	1	Product protection	2	100
110	Supplier 5	Tertiary	2	Tracking information	1	70
111	Supplier 5	Tertiary	3	Machinability	4	100
112	Supplier 5	Tertiary	4	Volume and weight efficiency	4	20
113	Supplier 5	Tertiary	5	Stackability	1	90
114	Supplier 5	Tertiary	7	Minimal use of hazardous substances	3	100
115	Supplier 5	Tertiary	8	Right amount and size	2	80
116	Supplier 5	Tertiary	11	Minimal waste	4	80
117	Supplier 5	Tertiary	12	Product information	3	100
118	Supplier 5	Tertiary	13	User interaction	3	50
119	Supplier 5	Tertiary	14	Reverse handling	2	100
120	Supplier 5	Tertiary	16	User safety	3	100
121	Supplier 5	Tertiary	17	Handleability	2	100
122	Supplier 6	Tertiary	1	Product protection	3	100
123	Supplier 6	Tertiary	6	Minimal resources used	3	70
124	Supplier 6	Tertiary	7	Minimal use of hazardous substances	4	100
125	Supplier 6	Tertiary	9	Packaging costs	3	80
126	Supplier 6	Tertiary	11	Minimal waste	3	90
127	Supplier 6	Tertiary	13	User interaction	3	90
128	Supplier 6	Tertiary	14	Reverse handling	3	80
129	Supplier 6	Tertiary	16	User safety	3	70
130	Supplier 6	Tertiary	17	Handleability	3	70
131	Service Provider 1	Tertiary	1	Product protection	3	100
132	Service Provider 1	Tertiary	2	Tracking information	1	100
133	Service Provider 1	Tertiary	3	Machinability	2	100
134	Service Provider 1	Tertiary	4	Volume and weight efficiency	3	100
135	Service Provider 1	Tertiary	5	Stackability	2	90
136	Service Provider 1	Tertiary	6	Minimal resources used	3	100
137	Service Provider 1	Tertiary	9	Packaging costs	2	80
138	Service Provider 1	Tertiary	11	Minimal waste	2	20
139	Service Provider 1	Tertiary	12	Product information	2	100

Tracking Number	Actor	System	Criteria Number	Packaging Criteria	Score	Weighting
140	Service Provider 1	Tertiary	13	User interaction	2	100
141	Service Provider 1	Tertiary	14	Reverse handling	3	100
142	Service Provider 1	Tertiary	15	Security concerns	3	70
143	Service Provider 1	Tertiary	16	User safety	3	90
144	Service Provider 1	Tertiary	17	Handleability	3	90
145	Service Provider 2	Tertiary	1	Product protection	2	100
146	Service Provider 2	Tertiary	2	Tracking information	1	100
147	Service Provider 2	Tertiary	3	Machinability	3	100
148	Service Provider 2	Tertiary	4	Volume and weight efficiency	4	90
149	Service Provider 2	Tertiary	5	Stackability	3	100
150	Service Provider 2	Tertiary	6	Minimal resources used	4	70
151	Service Provider 2	Tertiary	7	Minimal use of hazardous substances	4	100
152	Service Provider 2	Tertiary	8	Right amount and size	4	90
153	Service Provider 2	Tertiary	11	Minimal waste	4	50
154	Service Provider 2	Tertiary	12	Product information	3	100
155	Service Provider 2	Tertiary	14	Reverse handling	4	80
156	Service Provider 2	Tertiary	16	User safety	4	100
157	Service Provider 2	Tertiary	17	Handleability	4	100
158	Service Provider 3	Tertiary	1	Product protection	3	100
159	Service Provider 3	Tertiary	3	Machinability	2	70
160	Service Provider 3	Tertiary	4	Volume and weight efficiency	2	100
161	Service Provider 3	Tertiary	5	Stackability	1	50
162	Service Provider 3	Tertiary	6	Minimal resources used	2	40
163	Service Provider 3	Tertiary	7	Minimal use of hazardous substances	4	100
164	Service Provider 3	Tertiary	8	Right amount and size	4	100
165	Service Provider 3	Tertiary	9	Packaging costs	3	70
166	Service Provider 3	Tertiary	11	Minimal waste	2	50
167	Service Provider 3	Tertiary	12	Product information	3	100
168	Service Provider 3	Tertiary	14	Reverse handling	3	80
169	Service Provider 3	Tertiary	16	User safety	3	90
170	Service Provider 3	Tertiary	17	Handleability	3	90
171	Customer 1	Primary	1	Product protection	3	90
172	Customer 1	Primary	2	Tracking information	4	100
173	Customer 1	Primary	5	Stackability	3	80
174	Customer 1	Primary	7	Minimal use of hazardous substances	4	30
175	Customer 1	Primary	8	Right amount and size	4	100
176	Customer 1	Primary	9	Packaging costs	4	100
177	Customer 1	Primary	11	Minimal waste	2	20
178	Customer 1	Primary	12	Product information	4	100
179	Customer 1	Primary	13	User interaction	4	80
180	Customer 1	Primary	15	Security concerns	1	20
181	Customer 1	Primary	16	User safety	2	70
182	Customer 2	Primary	1	Product protection	2	100
183	Customer 2	Primary	2	Tracking information	3	90
184	Customer 2	Primary	3	Machinability	1	100
185	Customer 2	Primary	4	Volume and weight efficiency	2	50
186	Customer 2	Primary	5	Stackability	1	80
187	Customer 2	Primary	6	Minimal resources used	3	60
188	Customer 2	Primary	7	Minimal use of hazardous substances	3	90
189	Customer 2	Primary	9	Packaging costs	2	30
190	Customer 2	Primary	11	Minimal waste	2	50
191	Customer 2	Primary	12	Product information	1	50
192	Customer 2	Primary	13	User interaction	2	60
193	Customer 2	Primary	14	Reverse handling	3	30
194	Customer 2	Primary	17	Handleability	3	90
195	Customer 3	Primary	1	Product protection	3	100
196	Customer 3	Primary	2	Tracking information	1	50
197	Customer 3	Primary	3	Machinability	2	90
198	Customer 3	Primary	6	Minimal resources used	4	20
199	Customer 3	Primary	8	Right amount and size	3	80
200	Customer 3	Primary	9	Packaging costs	3	50
201	Customer 3	Primary	11	Minimal waste	3	30
202	Customer 3	Primary	12	Product information	3	100
203	Customer 3	Primary	13	User interaction	3	50
204	Customer 3	Primary	14	Reverse handling	3	60
205	Customer 3	Primary	16	User safety	3	20
206	Customer 3	Primary	17	Handleability	3	50
207	Customer 4	Primary	1	Product protection	3	100
208	Customer 4	Primary	2	Tracking information	2	100
209	Customer 4	Primary	3	Machinability	2	90

Tracking Number	Actor	System	Criteria Number	Packaging Criteria	Score	Weighting
210	Customer 4	Primary	6	Minimal resources used	3	40
211	Customer 4	Primary	7	Minimal use of hazardous substances	4	80
212	Customer 4	Primary	8	Right amount and size	4	100
213	Customer 4	Primary	9	Packaging costs	2	100
214	Customer 4	Primary	11	Minimal waste	3	50
215	Customer 4	Primary	12	Product information	3	100
216	Customer 4	Primary	13	User interaction	4	100
217	Customer 4	Primary	14	Reverse handling	3	50
218	Customer 4	Primary	17	Handleability	4	100
219	Customer 5	Primary	1	Product protection	4	100
220	Customer 5	Primary	2	Tracking information	2	100
221	Customer 5	Primary	3	Machinability	4	100
222	Customer 5	Primary	6	Minimal resources used	3	50
223	Customer 5	Primary	7	Minimal use of hazardous substances	4	100
224	Customer 5	Primary	8	Right amount and size	3	60
225	Customer 5	Primary	9	Packaging costs	3	100
226	Customer 5	Primary	11	Minimal waste	3	60
227	Customer 5	Primary	12	Product information	4	100
228	Customer 5	Primary	13	User interaction	3	50
229	Customer 5	Primary	14	Reverse handling	3	60
230	Customer 5	Primary	15	Security concerns	2	60
231	Customer 5	Primary	17	Handleability	3	60
232	Customer 6	Primary	1	Product protection	3	100
233	Customer 6	Primary	3	Machinability	3	90
234	Customer 6	Primary	5	Stackability	1	100
235	Customer 6	Primary	6	Minimal resources used	4	60
236	Customer 6	Primary	7	Minimal use of hazardous substances	3	100
237	Customer 6	Primary	8	Right amount and size	3	80
238	Customer 6	Primary	11	Minimal waste	3	30
239	Customer 6	Primary	12	Product information	3	100
240	Customer 6	Primary	13	User interaction	2	30
241	Customer 6	Primary	14	Reverse handling	3	100
242	Customer 7	Primary	1	Product protection	4	100
243	Customer 7	Primary	2	Tracking information	2	70
244	Customer 7	Primary	3	Machinability	2	70
245	Customer 7	Primary	5	Stackability	2	90
246	Customer 7	Primary	6	Minimal resources used	3	80
247	Customer 7	Primary	7	Minimal use of hazardous substances	3	60
248	Customer 7	Primary	8	Right amount and size	4	90
249	Customer 7	Primary	9	Packaging costs	3	90
250	Customer 7	Primary	11	Minimal waste	3	70
251	Customer 7	Primary	12	Product information	4	100
252	Customer 7	Primary	14	Reverse handling	3	90
253	Customer 7	Primary	15	Security concerns	4	90
254	Customer 7	Primary	16	User safety	3	100
255	Customer 1	Tertiary	1	Product protection	4	90
256	Customer 1	Tertiary	2	Tracking information	4	100
257	Customer 1	Tertiary	3	Machinability	4	60
258	Customer 1	Tertiary	4	Volume and weight efficiency	2	100
259	Customer 1	Tertiary	5	Stackability	1	100
260	Customer 1	Tertiary	8	Right amount and size	4	100
261	Customer 1	Tertiary	9	Packaging costs	3	100
262	Customer 1	Tertiary	11	Minimal waste	1	10
263	Customer 1	Tertiary	13	User interaction	2	95
264	Customer 1	Tertiary	15	Security concerns	2	20
265	Customer 1	Tertiary	17	Handleability	4	100
266	Customer 2	Tertiary	1	Product protection	2	100
267	Customer 2	Tertiary	2	Tracking information	2	90
268	Customer 2	Tertiary	3	Machinability	3	70
269	Customer 2	Tertiary	4	Volume and weight efficiency	1	50
270	Customer 2	Tertiary	5	Stackability	1	80
271	Customer 2	Tertiary	6	Minimal resources used	3	60
272	Customer 2	Tertiary	7	Minimal use of hazardous substances	3	90
273	Customer 2	Tertiary	9	Packaging costs	2	30
274	Customer 2	Tertiary	11	Minimal waste	2	50
275	Customer 2	Tertiary	13	User interaction	2	40
276	Customer 2	Tertiary	14	Reverse handling	3	80
277	Customer 2	Tertiary	16	User safety	3	100
278	Customer 2	Tertiary	17	Handleability	3	90
279	Customer 3	Tertiary	1	Product protection	2	100

Tracking Number	Actor	System	Criteria Number	Packaging Criteria	Score	Weighting
280	Customer 3	Tertiary	2	Tracking information	1	60
281	Customer 3	Tertiary	4	Volume and weight efficiency	3	80
282	Customer 3	Tertiary	5	Stackability	1	80
283	Customer 3	Tertiary	6	Minimal resources used	3	20
284	Customer 3	Tertiary	7	Minimal use of hazardous substances	3	20
285	Customer 3	Tertiary	8	Right amount and size	3	80
286	Customer 3	Tertiary	9	Packaging costs	2	70
287	Customer 3	Tertiary	11	Minimal waste	2	60
288	Customer 3	Tertiary	13	User interaction	3	30
289	Customer 3	Tertiary	14	Reverse handling	3	60
290	Customer 3	Tertiary	16	User safety	3	30
291	Customer 3	Tertiary	17	Handleability	2	80
292	Customer 4	Tertiary	1	Product protection	3	100
293	Customer 4	Tertiary	2	Tracking information	2	100
294	Customer 4	Tertiary	3	Machinability	2	100
295	Customer 4	Tertiary	6	Minimal resources used	3	40
296	Customer 4	Tertiary	7	Minimal use of hazardous substances	4	80
297	Customer 4	Tertiary	8	Right amount and size	4	100
298	Customer 4	Tertiary	9	Packaging costs	2	100
299	Customer 4	Tertiary	11	Minimal waste	3	50
300	Customer 4	Tertiary	12	Product information	3	100
301	Customer 4	Tertiary	13	User interaction	4	100
302	Customer 4	Tertiary	14	Reverse handling	4	80
303	Customer 4	Tertiary	16	User safety	2	100
304	Customer 4	Tertiary	17	Handleability	4	100
305	Customer 5	Tertiary	1	Product protection	4	100
306	Customer 5	Tertiary	2	Tracking information	2	100
307	Customer 5	Tertiary	3	Machinability	4	100
308	Customer 5	Tertiary	6	Minimal resources used	3	50
309	Customer 5	Tertiary	7	Minimal use of hazardous substances	4	100
310	Customer 5	Tertiary	8	Right amount and size	3	60
311	Customer 5	Tertiary	9	Packaging costs	3	100
312	Customer 5	Tertiary	11	Minimal waste	2	60
313	Customer 5	Tertiary	12	Product information	4	100
314	Customer 5	Tertiary	13	User interaction	3	50
315	Customer 5	Tertiary	14	Reverse handling	3	60
316	Customer 5	Tertiary	15	Security concerns	2	60
317	Customer 5	Tertiary	16	User safety	4	100
318	Customer 5	Tertiary	17	Handleability	3	60
319	Customer 6	Tertiary	1	Product protection	3	100
320	Customer 6	Tertiary	2	Tracking information	1	100
321	Customer 6	Tertiary	3	Machinability	3	90
322	Customer 6	Tertiary	5	Stackability	1	100
323	Customer 6	Tertiary	6	Minimal resources used	3	60
324	Customer 6	Tertiary	7	Minimal use of hazardous substances	4	100
325	Customer 6	Tertiary	11	Minimal waste	3	30
326	Customer 6	Tertiary	12	Product information	3	100
327	Customer 6	Tertiary	13	User interaction	2	30
328	Customer 6	Tertiary	14	Reverse handling	3	100
329	Customer 6	Tertiary	16	User safety	3	100
330	Customer 6	Tertiary	17	Handleability	4	100
331	Customer 7	Tertiary	1	Product protection	4	100
332	Customer 7	Tertiary	2	Tracking information	2	70
333	Customer 7	Tertiary	3	Machinability	2	70
334	Customer 7	Tertiary	5	Stackability	2	90
335	Customer 7	Tertiary	6	Minimal resources used	3	80
336	Customer 7	Tertiary	7	Minimal use of hazardous substances	3	60
337	Customer 7	Tertiary	8	Right amount and size	4	90
338	Customer 7	Tertiary	9	Packaging costs	3	90
339	Customer 7	Tertiary	11	Minimal waste	2	70
340	Customer 7	Tertiary	15	Security concerns	4	90
341	Customer 7	Tertiary	16	User safety	3	100
342	Customer 7	Tertiary	17	Handleability	4	100

Appendix D

Poligistics TCO model

		Monthly cost	Yearly cost
Direct spend	**Cost per kg**	51 539,14	618 469,63
	Cost per kg x weight		
Indirect Spend	**Supplier development**	5 454,48	65 453,76
	Employee hourly rate x Hours worked		
	Handling Cost	1 450,99	17 411,93
	(Forklift hourly rate x Handling time) + (Employee hourly rate x Handling time)		
	Warehousing Cost	1 201,60	14 419,20
	Overhead cost per sq. m x sq. m space rolls		
Internal Costs	**Core Cost**	85,33	1 024,00
	(Core cost/Core usage) x Amount of cores		
	Pallet Cost	88,18	1 058,13
	(Pallet Cost/Pallet usage) x Amount of pallets		
Opportunity Costs	**Rejection Cost**	1 975,46	23 705,56
	(Overhead sq. m cost x sq. m space rolls) + (Forklift hourly rate x Rejection time) + (Employee hourly rate x Rejection time)		
	Delayed Production Cost	5 056,00	60 672,00
	(Machine standing cost x Rejection time)		
	TCO	**66 851,19**	**802 214,22**