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Optimisation of logistics and distribution of parcels in local courier services in South Africa

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Declaration

I hereby declare that this submission is my own and to the best of my knowledge, it neither contains material previously published nor written by another person, nor material that to a major extent has been accepted for the award of any other degree at Durban University of Technology or any other educational institution. I also declare that the intellectual content of this thesis is a product of my work. Every source that was used for the research is referenced under "References" and cited within the text.

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Date: 26 February 2024

Dedication

I dedicate my thesis work to my parents Sibahle Msomi and Qiniso Biyela, as well as my younger sister Owami Biyela. You have continued to show me love and encouraged me to achieve more in life. It is a true blessing to have you all as my pillars in this journey of life, you are the reason why I wake up every morning and strive to be a better person. To the Msomi and Biyela family, thank you for all the love and support you have shown me from the time I was a child, to now as an adult, you are appreciated.

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Abstract

Distribution logistics is a highly integrated supply chain network that generally focuses on the optimal movement of goods and services from consignor to consignee. Given the importance of logistics distribution, courier services suffer a severe problem of experiencing parcel damage which leads to customer complaints and packaging claims. The cardboard packaging for National Logistics Company (NLC) was found to be easily prone damage when in transit and the courier endured consequences such as claim costs that continued to rise every financial year. The aim of the study is to optimise the logistics and distribution of parcels in courier services in terms of cardboard package damages. The data of package damages was drawn from an Enterprise resource planning (ERP) system used at the NLC, together with measurements that were conducted on site. The study adopted a quantitative research approach, and the data was used to reveal the impact of damaged goods to NLC organisation.

A fish-bone diagram was developed to represent the potential root-cause of parcels being damaged in the distribution network, and the results revealed that specifications such as packaging size, weight of parcel, internal content packaging utilization, flute corrugated size used for the package and manpower struggling with heavy parcels were potential root-cause of breakages. Furthermore, a value stream map was developed to analyse the operational steps and collect data of the cross-docking performance for a one-month period. Data collection revealed a lower than anticipated throughput capacity, throughput results varied from day-to-day operations which depict low reliability of distributing parcels. Correlation analysis was then used to examine the correlation between packaging weight, size, internal packaging utilization, and flute corrugated size used for a box. The correlation between these variables was ascertained to be moderate.

To optimise package size based on weight, dimensions, item and flute size, a regression model was developed to derive the optimal package for items using the Simplex linear programming of the Solver function in Excel. The model revealed that for an item to have an optimal package size, an addition of 2cm must be added to the original size of an item. Furthermore, training solutions were developed to optimize package handling in the logistics and distribution of parcels. The approach for developing training solutions

included loading and offloading strategies, methods of staging and sorting cardboard in a vertical flute direction which is also support by the packaging pictorial markings, and the type of equipment to be considered to reduce breakages. The outcome of the research revealed a significant improvement in the overall logistics process and the financial performance of the organisation. Future studies will look at logistics activities of manufacturing cardboard packaging and the development of standard optimal packages which will be derived from supplier product design.

Table of Contents

List of Tables

List of Figures

List of Acronyms

B2C	Business to Consumer
C2C	Consumer to Consumer
DC	Distribution Centre
ERP	Enterprise resource planning
FIFO	First in, First Out
GRG	Generalized Reduced Gradient
IHC	Inventory Holding Cost
JIT	Just in Time
KPI	Key Performance Indicators
LP	Linear Programming
LMS	Logistics Management System
NLC	National Logistics Company
NNM	Nearest Neighbour Method
OEE	Overall Equipment Effectiveness
OJT	On the Job Training
OTD	On Time Deliveries
PDCA	Plan, Do, Check, Action
PHES	Parcel Handling Evaluation Sheet
PID	Parcel Inspection Document
POD	Proof of Delivery
PLT	Production Lead Time
PPE	Personal Protective Equipment
PPM	Packaging Pictorial Markings

PSDs	Power Spectral Densities
QC	Quality Check
SIPOC	Supplier, Input, Product, Output, Customer
TPS	Toyota Production System
VAT	Value Added Time
VFD	Vertical Flute Direction
VSM	Value Stream Map
WIP	Work in Progress
WMS	Warehouse Management System

CHAPTER 1: BACKGROUND

1.1 Introduction

The transportation service has continued to expand over the past years, and movement of goods has become an essential service across the entire world. Distribution logistics is a joint term that describes the processes and procedures that characterise successful order fulfillment services, and is an element of the broader logistics industry. This study was conducted at National Logistics Company (NLC) in Southern Africa, which is one of the prosperous logistics service providers that is involved in world-class distribution, linehaul and warehousing solutions for retailers. It is an intermediate link that distributes finished goods from business to consumer (B2C) and consumer to consumer (C2C). It was indicated by Kuczyńska-Chałada, Furman and Poloczek (2018) that such features can be used to characterize the supply chain, a process object that includes the goals, objectives, functional scope, and areas in which the cooperating entities participate. The field of logistics is a detailed industry that refers to the movement, storage, and flow of goods, services, and information inside and outside the organisation.

However, logistics involves a high level of inventory management to ensure that the goods arrive on time, unharmed and with the expected units at the consignee. High fuel costs are a known business threat in logistics; in reality, they are now ranked among the top 10 challenges facing the truck transport sector (Gurtu, Jaber and Searcy 2015). Additionally, the most important and significant role in the courier services supply chain for items is the business process operations design. Not much research has been conducted to optimise logistics and distribution of parcels in terms of reducing package damages which increase expense cost such as packaging claims in the distribution network, and thus this research seeks to add that niche to the body of knowledge. The roadmap for this chapter commences with a brief overview of the research problem, aim of the study, objectives of the study, research questions as well as the motive of the study. It also embraces the research methodology which was followed to achieve results, significance of the study, scope and delimitations of the study, structure of the dissertation and conclusion. It is worth noting that the words package and parcel, damages and breakages will be used interchangeably in the research study.

1.2 Research Problem

Courier companies can only manage internal controllable factors such as transportation equipment's used, internal storage of goods, trailer loading strategies and parcel handling methods applied in the warehouse as well as last-mile delivery. Several authors revealed that packaging performs two basic functions and should fulfil various demands in terms of marketing and logistics (Khademi Kord and Pazirandeh 2008; Dominic 2011). Courier delivery process needs cartons, fillers, plastic bags, and other packaging materials. The case study organisation is facing challenges in measuring factors that contribute to package damages that lead to poor service delivery, excessive claims and increase in operational expenses. Some of the factors that could contribute to packaging damages are specifications such as environmental conditions, warehouse conditions, packaging size and shape, methods of handling, machine or human error, internal packaging utilization and flute corrugated size used on the cardboard packaging.

Among these contributing factors, the damage caused by mis-handling could be the most vital one to examine. Packaging design aims to give the necessary protection to the product against impacts due to mishandling by considering "cushioning design". The objective of the cushion design is to prevent external impacts and to protect the products inside the packaging. Poor logistics service delivery can lead to a decline in resources and a loss in business revenue through excessive claims that result from unpleased customers.

The negligent handling of packaging either from the sender or the courier itself affects the physical damage of the package, whereas the other cause of physical damage could be caused by weather disturbance, or enclosed spaces due to moisture. Other factors that result in physical damage are improper weight distribution and false labeling of packaging. Placing heavyweight on the package can cause complete damage to the parcel, and false labelling can reduce awareness of fragile and non-fragile items. It is against the backdrop of these contributing factors that it was imperative to investigate the factors that hindered optimal logistics operations and distribution of parcels to reduce customer packaging claims, customer complaints and increase business revenue for NLC.

1.3 Aim of the Study

This study is aimed at optimising logistics operations and distribution of parcels by reducing customer packaging claims, customer complaints and increase business revenue in a local courier service based in South Africa.

1.4 Objectives of the Study

The objectives of the study are as follows:

- To analyse the process for logistics and distribution of parcels;
- To identify process parameters which are resulting in breakages;
- To optimise controllable factors for reduction of packaging claims; and
- To develop training solutions to empower employees for sustained optimisation of logistics and distribution of parcels.

1.5 Research questions

This research will pursue to answer the following questions:

- What tools can be used to analyse the current process for logistics and distribution of parcels?
- In order to reduce the amount of packaging claims, how will process parameters resulting in breakages be identified in logistics operations?
- Is the Plan Do Check Action (PDCA) principle appropriate for application in logistics optimisation and if so, how can NLC implement the PDCA principles in their processes to improve controllable factors for reduction of packaging claims?
- What effect does employee empowerment and engagement have on logistics operations optimization?

1.6 Research Methodology

A quantitative research methodology will be adopted for the study. The Deming's Plan-Do-Check-Action (PDCA) system will be used to analyse the framework of the NLC, and the value stream map (VSM) will be used to analyse and measure the cross-docking performance to improve, and control operational processes continuously. The PDCA is the most effective technique to look for better effects or improvement (Patel and

Deshpande 2015). Chakraborty (2016) reported that this method was used by a small automobile manufacturing company to secure continuous improvement for the processes at the company. A fish-bone diagram will also be used to represent the potential root-cause with an aim of fixing the main cause first time around. The fishbone, its form has a similarity to a fish, which has a head (as an effect) and a body in the form of bones, illustrated as causes of known problems (Slameto 2016).

1.7 Significant of the study

The results of this study will add to the body of knowledge significantly for those organisations in the logistics sector that are striving to revitalize their processes to operate optimally. It is also anticipated that the study will result in substantial cost savings and better sustainability of the case study organisation, thereby saving jobs that would have been lost if the company wound up due to poor performance. Developing solutions for the current state of package damage experienced during the supply of goods will not only positively impact the organisation financially but will also enhance the relationship between the consumers and the suppliers.

1.8 Scope and delimitations of the study

The study will focus on a local courier service based in South Africa in relation with local consumers. This research was limited only to improving controllable factors contributing to packaging damages which were method of handling packaging, conveyor system operations, package size and stacking corrugated packaging in a vertical flute direction to offer best stacking strength. The study is restricted from improving non-controllable factors such as the manufacturing process of corrugated cardboard and the choice of package type based on product design.

1.9 Structure of the dissertation

To assist the readers in navigating through the dissertation, the study is represented as follows:

Chapter 1: Introduction

This chapter commences with a brief background of the study, followed by research questions, significance of the study and the structure of the dissertation.

Chapter 2: Literature Review

This chapter focuses on the review of the current literature on the processes for logistics and distribution of parcels. Furthermore, the literature on tools for identifying process parameters resulting in breakages will be explored. Thereafter, the literature review focuses on optimisation of logistics operations and distribution of parcels by eliminating customer packaging claims, customer complaints and increase business revenue in a local courier service. It further elaborates on the ability to improve the financial performance of the business, by improving parcel handling methods used and developing training solutions to empower employees for sustained optimisation of logistics and distribution of parcels.

Chapter 3: Research Methods

This chapter provides a clarification on the methods used, data collection method, root cause analyses techniques, the correlation analysis, mathematical models and the data analysis on factors contributing to packaging damages.

Chapter 4: Process for National Logistics Company

This chapter represents the process of the NLC in depth overview. The VSM tool will be used to reveal both material and information flow of NLC while measuring the cross-docking performance.

Chapter 5: Results and Discussion

This chapter presents the results of the study, commencing with the process parameters for breakages, followed by optimisation of controllable factors for reduction of packaging claims. The development of regression model to optimise packaging size for items using the Solver Add-in on Excel was discussed in this chapter. The discussion also included parcel handling methods, stacking strength guides that influence optimisation of logistics and distribution of parcels and the employee empowerment after the development of training solutions.

Chapter 6: Conclusion and Recommendations

This chapter shows the conclusions and recommendations based on the study findings and provides direction for future studies. The logistics activities of manufacturing

cardboard packaging were not thoroughly examined in this study and future studies can focus on the development of standard optimal packages which can be derived from supplier product design.

1.10 Conclusion

This chapter presented the general introduction and the structure of the study. The sections covered were introduction, research problem, aim of the study, objectives of the study, research questions, research methodology, significance of the study, scope and delimitations of the study, structure of the dissertation and conclusion. It was noted that poor service delivery negatively impacts the organisation financially and will also affect the relationship between the consumers and the suppliers. Improving and controlling operational processes continuously will result in cost savings and reduction of claims caused by breakages.

CHAPTER 2 : LITERATURE REVIEW

2.1 Introduction

A literature review is a systematic method used for identifying and evaluating completed work produced by researchers (Dubey and Gunasekaran 2015). It is crucial to evaluate the crux of the logistics process and gain understanding of the existing research. Once the knowledge is gained, the right tools and potential solutions can be easily identified and implemented. The objectives of the study served as guidelines in gathering the literature that is relevant to the study.

2.2 Processes for logistics and distribution of parcels

Completed goods are distributed by NLC, an intermediary service provider, between B2C and C2C. Couriers pick up shipments for numerous recipients at a single shipment location, thus leading to the implementation of B2C service (Coyle, Bardi and Langley 2010). The distribution leg may be long such as when exporting abroad or short, such as when it occurs in the same city. Reliable packaging, however, is essential to the supply chain and is crucial to the distribution process. Pongrácz (2007) asserts that packaging is the only means of connecting production and consumption. Furthermore, Pongrácz (2007) noted that packaging will be very important because product transportation will be essential during urbanization. Furthermore, according to Gunasekaran (2012), packaging is crucial to the business world due to globalization, where businesses are constantly competing with one another.

Furthermore, as explained by Gunasekaran (2012), packaging does not always get the attention it deserves. However, packaging becomes a problem when a shipment is received by a customer and is wasted or destroyed (Pongrácz 2007). This study will focus on improving controllable factors that influence reduction of packaging claims.

Dominic (2011) mentioned that excellent and reliable packaging is mandatory to protect goods during transportation. Moreover, courier service internal staff are responsible for handling stock with care until the last mile delivery (Lindh *et al.* 2016). This study focused on the problem of cardboard packaging damage that led to poor service delivery, excessive claims and an increase in operational expenses.

Reverse logistics can also be recognised as optimisation because it refers to the reverse logistics system, the layout of the various logistics facilities and transport facilities between the arrangements. The distribution of transport nodes using transport logistics makes it possible to reduce transport difficulty. In relation to freight transport the reduction of transport as well as shipping happens (Stopka, Černá and Zitrický 2016). Operations research can be understood as a resource to find an optimal solution while evaluating various factors (Ľupták, Gašparík and Chovancová 2017), for example the routes can be chosen for several vehicles from the same location or from several independent locations (Jagelčák and Kubasáková 2014).

2.2.1 Logistics distribution

In logistics, distribution refers to the overall management of goods transported from their development to the point of sale. Gołąbek *et al.* (2021) indicates that integrating and coordinating logistic systems of enterprises is today considered to be the essence of modern logistics management. Distribution in logistics joins various processes, with an aim of ultimately achieving optimal distribution and smooth movement of finished goods to recipients. It is supported by Gołembska (2009) that through logistics competencies, companies can gain a competitive advantage, not only in the local but also in the global economy. Rushton, Croucher and Baker (2022) described logistics as a combination of material management plus distribution, where material management constitute of activities concerning material processed and distribution represent the process of making the product available to the end consumer or the business.

Logistics is considered an indicator of the economy, it can exploit raw materials in the world and their flow. This is supported by Karcz and Slusarczyk (2016) who contend that transport is also recognised as one of the most important factor affecting the development of economic activity and overall economic development.

Nurprihatin *et al.* (2021) further described cross-docking as logistics technique which eliminates the need to store and pick up goods from warehouses. When compared to alternative product distribution methods, cross-docking offers a number of benefits in terms of both the environment and the economy. Numerous factors, including a level of product demand, the expense of stock-outs, and the distance between suppliers and buyers, affect cross-docking decisions.

2.2.2 Packaging related factors in distribution centres

The manufacturing of the packaging is the first step in the packaging process and it is crucial that when designing packaging, the manufacturing process must be taken into consideration. This is supported by Saghir (2004) who explained that the first step of the packaging logistics journey throughout the retail supply chain begins at the manufacturer where the product meets the primary packaging, which is considered a unified and single unit. The primary packaging information is aimed at the consumer, whereas secondary and tertiary packaging information is used within the retail supply chain.

Rundh (2005) stated that the manufacturer of packaging material and packaging machinery is core of the packaging industry. Several decisions regarding package design must be made to develop an effective package that supports the product's positioning and is consistent with other elements of the marketing strategy. The size of packaging, convenience and printing are the new demand in the market, therefore they should be considered during packaging phase.

Secondary and tertiary packaging are handled at the distribution center (DC) and may consist of corrugated cardboard with an envelope bottom that prevents it from being handled automatically on the conveyor belt in the DC. This results to manual labor in a highly automated DC (Pålsson and Hellström 2016). Since there is so much manual handling in a DC, labor is usually the greatest cost (Hellström and Saghir 2007).

In the cross-docking process the efficient flow of inventory is fundamental. This is achieved by receiving packages inbound and sorting according to their final destinations immediately. The sorting process involves arranging and temporarily storing packages using the first-in, first-out (FIFO) method to improve inventory control and distribute packages more effectively. As a result of using this method, unnecessary losses

throughout the supply chain can be avoided, thereby minimizing economic losses, while clients can be better served by providing them with products that meet their needs (Hertog *et al.* 2014).

2.2.3 Supply chain network

Supply chain is a very competitive environment where customers are highly impatient, therefore the network need to be reactive and fast while keeping the prices low (Ladier and Alpan 2016). Rushton, Croucher and Baker (2022) illustrate that in the business area, supply chain covers a broader scope, which includes the supply of raw materials, components, and delivery of products to the end customer. A supply chain is the network of all the organisations, people, assets, activities, and technologies included within the creation and sale of an item or a product. It is a quick and responsive system connected and guided by the customer selection mechanism, aiming to achieve the highest satisfaction and maximize profit for the companies within the supply chain. This is further echoed by Kaminsky and Simchi-Levi (2003) when they point out that the supply chain is a network of manufacturers, suppliers, warehouses, and retailers intending to produce and distribute goods in the right place, time and in the right quantity, to minimize overall costs while meeting service level requirements.

In spite of the significance of networks for demonstrating complex adaptive systems, Halldorsson *et al.* (2007) indicated that the latest developments of networks related to supply chain adopted a relational exchange view or retained the linear view. However, a supply chain can be viewed as connector that links firms together with an aim of creating products or services (Hearnshaw and Wilson 2013).

2.2.4 Courier services

A courier is an organisation that delivers packaging from one place to another. Courier companies typically offer courier services on a commercial contract basis. The growth rate of companies in the courier industry is staggering, Taylor and Hallsworth (2000) support this by indicating that courier services have developed rapidly in the last three decades. This was also supported by Otsetova and Dudin (2017) who emphasized that in Bulgaria, courier services had a stellar performance in the past ten years and the market is becoming increasingly competitive advantage. The activities of courier services

should be organized so that the cost and quality of services can be better controlled. It is predominant that courier operators optimise the distribution processes to meet changing customer demands and continuously adapt to new technologies.

The NLC adopted a cross docking system which means they handle high volume stock in a short period of time. Cross docking is ideal for businesses that distribute large volumes goods and serve a large number of stores (Yu and Egbelu 2008). A typical process flow in a cross-docking system generally operates as follows:

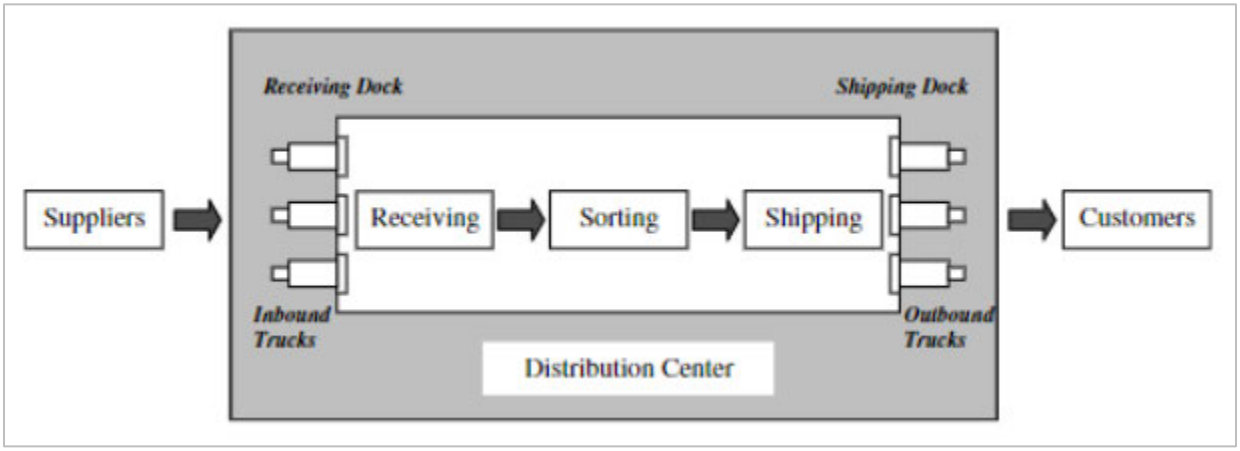


Figure 2.1: Cross-docking system

Source: (Yu and Egbelu 2008)

As shown in Figure 2.1,

i. Products (cardboard cartons, packages) are received at the distribution centre and parcels are scanned and verified. Volumizer system is also used to weigh and size the received products.
ii. Products are sorted by customer destination.
iii. Products are processed to shipping locations and leave the distribution centre.

The cross-docking process reveals that packages can be processed efficiently while reducing the need for storage. Cross docking has a potential to eliminate storage and retrieval, which are considered the two most expensive warehousing operations.

2.2.5 Measuring machine efficiency

When it comes to logistics industries, the most commonly used machinery are conveyor systems, folk lifts and pallet trucks. Since investing in this machinery is expensive, logistics companies aim to maximize the machine capability to increase in return on investments (ROI). Overall equipment effectiveness (OEE) is the best practice that identifies the accurate operating percentage rate of a machine under a planned production time. This is supported by Braglia, Frosolini and Zammori (2008) who contend that OEE has been adopted as the principal efficiency metric by several industrial fields. This calculation tool consolidates common sources of productivity losses and represents them into three clear categories, which are availability, performance and quality. The combination of availability, performance, and quality into a one OEE score provides a comprehensive measure of machine efficiency (Subramaniam *et al.* 2008).

2.2.5.1 Availability

Availability considers downtime loss, which includes any events preventing the production process for an extended period of time. This includes failures of equipment, material shortages, and changeover time. Since changeover time is a type of downtime, it is included in OEE analysis. Actual operation time refers to the remaining available time, as shown in (2.1). The available time is calculated as follows:

$$Availability = \frac{Actual\ Operating\ Time}{Planned\ Opeerating\ Time} \qquad (2.1)$$

2.2.5.2 Performance

Performance considers speed loss, which includes any factors that cause the process to run at less than the maximum possible or rated speed. This includes machine wear, poor materials, misfeeds, and inefficient operators. Actual operation time refers to the remaining available time. So, performance is defined as the ratio of actual operation time to planned operation time, considering speed loss. Machine ideal cycle time is the shortest cycle time that a given process can be expected to achieve under optimal conditions. Machine performance is calculated as follows:

$$Performance = \frac{(Machine\ Ideal\ Cycle\ Time \times Total\ Packages\ Processed)}{Planned\ Operating\ Time} \qquad (2.2)$$

2.2.5.3 Quality

Quality considers quality loss, which accounts for cardboard packages that do not meet quality standards, including packages that require rework. The remaining time is referred to as actual productive time. Quality is the ratio of actual productive time (time for good packages processed) to planned operation time (time for total packages). Quality is calculated as follows:

$$Quality = \frac{Good\ Packages\ Processed}{Total\ Packages\ Processed} \quad (2.3)$$

2.3 Tools for identifying process parameters resulting in breakages

Courier companies need to discover ways of reducing breakages within the distribution network and develop consistent strategies with an aim of being competitive advantage in the logistics industry. Package breakages enquired in logistics can be caused by various factors resulting in excessive claims and a decrease in business revenue. However, the selection of the “best packaging” is usually connected with considerations involving cost reduction and improved sales (García-Arca, González-Portela Garrido and Prado-Prado 2017). Understanding the impact of packaging and the nature cause of breakages increases the ability to identify the root cause of packaging damage.

Packaging has a huge influence in distribution services and plays an enormous role in product securement to reduce the risk of damage and theft. This is supported by Rundh (2016) who claims that during distribution in a supply chain, packaging provides protection, tamper resistance, and a variety of physical and biological needs. The foundation point for parcel damage prevention is packaging, considering that each product requires different packaging materials. Hence, it is vital to take precautions when choosing the ideal packaging for a particular type of product, for it to reach the customer in perfect condition. Schaefer and Cheung (2018) also indicated that the primary purpose of packaging is to protect a product from deterioration caused by exposure to and usage in the external environment.

2.3.1 Fish-bone diagram

A fish-bone diagram, well known as the Ishikawa cause and effect diagram is used to illustrate potential root cause of a specific problem. The fish-bone diagram provides a

systematic method of analyzing the cause and effect of the identified problem (Ilie and Ciocoiu 2010). This is further echoed by Mahto and Kumar (2008) who contend that a root cause is an important component of a thorough understanding of “what happened”.

As a possible solution, process methodologies such as Ishikawa cause and effect diagram may be implemented to identify many possible causes for an effect or a problem. A cause-and-effect diagram was used as a tool to identify and display possible causes for packaging breakages.

2.3.2 Plan-Do-Check-Action

The PDCA (plan do check action) cycle is a basic popular procedure of the TQM (total quality management), it is scientific summarization to the continuous and spiral improvement. However, these four phases cannot be separated otherwise the circulation cannot be formed (Du *et al.* 2008). To identify process parameters resulting in breakages in the distribution network aiming to optimising logistics operations, the PDCA tool can be used to define and continuously improve on parameters resulting in breakages. Several actions are produced by the PDCA to troubleshoot process challenges temporarily and permanently. This is supported by Isniah, Purba and Debora (2020) who indicated that PDCA produces permanent actions which consist of eliminating the root cause whereas temporary measures aim to correct interim problems.

Liu and Li (2006) further explained that the principle behind PDCA cycle is that everything operates as P (Plan), D (Do), C (Check), A (Action). Table 2.1 represents phases and steps of PDCA cycle in more detail.

Table 2.1: Four phases and eight steps of PDCA cycle

Phase	Step	Content
Plan	1	Analyses the current conditions and finds out the existent problems.
	2	Finds out various causes resulting in those problems.
	3	Identifies the major factors from various causes.
	4	Works out the solution and improvement plan according to the major factors.
Do	5	Carries out the plan and measures.
Check	6	Checks the implements according to requirements of the plan.
Action	7	Summarizes experiences and consolidates achievements.
	8	Turns problems that haven't been solved or appear newly into the next cycle.

Source: (Du et al. 2008)

2.3.3. Value Stream Mapping

Value stream mapping (VSM) is the process of mapping the material and information flows of all components and sub-assemblies in a value stream that includes manufacturing, suppliers, and distribution to the customer (Seth* and Gupta 2005). VSM is a powerful tool that combines material processing steps with information flow and other important related data. This tool enables users to develop a solid implementation strategy that makes the most of their available resources. In VSM, the value stream is the point at which value is added to the product or service by changing the market form or function to meet the needs of the customer (Manos 2006).

The concept of value stream mapping (VSM) emerged in the late 1990s as a tool to assist organizations in identifying and eliminating waste in their manufacturing processes (Rother and Shook 2003). Setiawan, Tumanggor and Purba (2021) eluded that the VSM tool is one of the most effective lean tools for identifying waste in business processes, it is useful for eliminating and identifying or streamlining steps with added value, as well as eliminating steps with no added value. There are several benefits for the company if VSM is implemented, which include improving the flow of information that is not feasible, decreasing excessive waiting times, and increasing the overall efficiency of the business process.

According to Rother and Shook (2003), value stream mapping is a method of visualizing the flow of a manufacturing process or service, as well as the overall flow of information, in order to produce a single type of product or service. Not only in each work area but at the overall level of production, as well as identifying value-added and non-value-added activities.

While VSM has its roots in the manufacturing industry, it has been implemented in a wide range of industries, including courier services and logistics allowing them to identify and eliminate steps that do not add value to their customers since VSM is a visualization technique that maps out the flow of materials and information through a process. Furthermore, Harris, Mcadam and Reid (2005) higlights that one of the key benefits of VSM is its ability to provide a clear and concise overview of an organization's processes, which makes it easier for the cooperate to identify areas for improvement.

Supply chain being a competitive enivorment where customers are demanding and require quick service delivery, VSM has been a tool used to identify and eliminate waste in the process. It creates a visual map of every supply chain involved in the flow of materials and information in the value chain of a product, and provides an exposure of the current situation of a supply chain by observing its material and information flow, as well as the volume and on-time deliveries (OTD) variables (Suarez-Barraza, Miguel-Davila and Vasquez-García 2016). Applying VSM in supply chain allows companies to visualize the disruptions and gaps during the supply of goods and further manage relationships with suppliers and customers within the supply chain.

2.4 Optimising controllable factors resulting in breakages

Consumers are no longer willing to accept poor service offerings (Mat *et al.* 2018). Service failures arise when perceptions of performance are lower than expectations, resulting in dissatisfaction (Setiawan and Setyohadi 2018; Li *et al.* 2020). With the current state of increase in number of customer complaints and packaging claims due to parcels being damaged within the network, distribution services continue to lose on revenues every financial year since logistical packaging affects the cost of every activity within the network and has a significant impact on the operation systems. Courier companies are not always the cause of packaging being damaged but are still held accountable, some

failures can be associated with the courier services whereas some failures are out of the courier services control.

Santoso (2022) compiled a brief research that explained the Liability for Damage to Goods in Expedition Services One Night Service at the Kilat Courier Company (TIKI). The study revealed that carriers are responsible for any damage to products that have been accepted for transit unless it is caused by circumstances beyond their control or by the negligence or fault of the sender. Failures that can be associated with the courier are specifically, packaging specifications, type of goods handled, weight of goods, type of cardboard packaging flute, type of adhesive used, which are all contributing factors towards the durability of a packaging during movement.

Providing a closer view of packaging effect on operational cost, the influences could be categorized as direct and indirect. The direct influences are cost for material packaging used, storage, method of loading trailer and internal handling of packaging. The indirect influences are activities such as volume utilization during transition with an aim of reducing transportation cost, while maximizing the chances of breakages during transition due to packaging design and poor road conditions. Packaging plays an enormous role in the logistics industry and does not receive as much attention as it deserves. It is only brought into attention once it reaches the consumer destroyed or wasted.

2.4.1 Correlation analysis

Correlation analysis refers to working with relationships between variables (Xiao *et al.* 2017). Methods of correlation analysis such as Pearson correlation are used to measure the strength of the linear relationship between two variables. Zou, Tuncali and Silverman (2003) supported this by stating that the purpose of correlation analysis is to measure and interpret the strength of a linear relationship between two variables. Therefore, understanding the relationship between any two variables can be used to determine the critical parameters accurately to optimise controllable factors resulting in breakages in the distribution network.

Pearson correlation coefficient absolute values are always between 0 and 1. The correlation between two variables is more significant once the absolute value of their Pearson correlation coefficient is higher, while there is no correlation between the two

variables if the absolute value is approximate to 0 (Tzamalis, Panagiotakos and Drosinos 2016). Correlation analysis will be used to examine the significance between packaging size and internal packaging utilization, packaging weight and flute corrugated size used on a cardboard package. Flute corrugated size refers to the material size contained between liner boards of the cardboard box which makes the package more durable and able to resist pressure.

2.4.2 Optimisation models through Excel

Optimization models consist of multiple constraints that specify the interactions between the system characteristics and variables, as well as an objective function that must be maximized or minimized (Loucks 2022). Zakwan (2016) indicates that Microsoft Excel provides an optimization tool called Excel Solver, which has the ability to resolve both nonlinear and linear optimization problems. The Excel solver includes the following functions: the Generalized Reduced Gradient (GRG) solver for smooth non-linear optimization problems, the Evolutionary solver for non-smooth non-linear optimization issues, and the Linear Programming (LP) solver for linear optimization problems.

Developed by Leon Lasdon and Allan Waren, the GRG solver is essentially a nonlinear optimization algorithm that has been found to be a powerful nonlinear optimization tool to estimate the parameters of nonlinear equations (Zakwan 2016).

Since version 2010, the evolutionary solver has been a component of Microsoft Excel's Solver Add-in. The evolutionary solver supports non-smooth constraints and a non-smooth objective function, in contrast to the simplex, general-reduced-gradient, and branch-and-bound algorithms (Trautmann and Gnägi 2015). A popular and well researched pivoting method for solving linear programs is the simplex LP method, which is a local improvement strategy that works by pivoting between fundamentally feasible solutions (Fearnley and Savani 2015).

Linear regression is a statistical analysis technique that applies regression analysis in mathematical statistics to find the quantitative relationship between two or more variables (Zou *et al.* 2019). In a study conducted by Jayabal, Natarajan and Sekar (2011), a regression model was developed to show how certain drilling parameters, like drill bit diameter, spindle speed, and feed rate, interact with one another and their effects on

responses, like thrust force, torque, and tool wear, when drilling glass-coir fiber reinforced hybrid composites. The results revealed that feed rate had a greater impact on the responses than the other two variables.

2.4.3 Packaging utilization

In the recent past, the dominating environmental issues have been material use and recycling possibilities when considering package (Williams and Wikström 2011). The word packaging refers to any material that is used for the containment of another product (Jones 2004). Aboura et al. (2004) quoted that the package must protect what it sells and must sell what it protects. Saghir and Jönson (2001) defined packaging as a means of ensuring safety of the goods in a sound condition to the ultimate consumer, supplemented by reuse of packaging at a minimum cost. According to Johnsson (2000), and Saghir and Jönson (2001) who pointed out that there is a need for methods of measuring the performance of packaging logistics to identify crucial areas in packaging development process where improvements will add value to the supply chain. Compression strength testing is one of the methods used to measure the performance of a box package. Frank (2014) defined the compression strength as a fundamental to estimate the package performance during its service, a more precise measurement in the lab produces a more accurate prediction of performance in the real world. Furthermore, Grönman *et al.* (2013) indicated that from the environmental and operational point of view, the most significant task of the package is to protect the product, which is vital to concede in the packaging design process. A packaging that failing to protect the product inside will lead to unnecessary waste due to damages of the packed products (Katajajuuri *et al.* 2010).

Optimising logistics in terms of packaging content utilization means filling the internal space of the package to it maximum capacity depending on the size of the cardboard and applying quality methods of handling packaging.

2.4.4 Package handling

Handling packaging with care is an essential operation in distribution and requires precise skill and attention to optimise package handling and reduce breakage occurrences. Communication (package pictorial markings) is one of the attributes that can be used to facilitate and allow safe handling. Zhong *et al.* (2016) supported this by stating that

pictorial marking offers the best possibility of conveying the consignor's intention. The scope of packaging pictorial markings (PPM) portrait symbols which convey handling instructions. The following Table 2.2 represents examples of PPM.

Table 2.2: Examples of packaging pictorial markings

Description	Pictorial markings
'FRAGILE HANDLE WITH CARE'	 (Indicates the item content is fragile)
'KEEP DRY'	 (Indicates package should be kept dry at all times)
'PACKAGE MAY TIP OVER EASILY'	 (Indicates that package is top heavy and might fall easily)
'DO NOT USE LIFT TRUCK FOR HANDLING'	 (Indicates that the package must not be handled with Hyster)

Source: (Singh and Singh 2005)

The packages are normally named with handling instructions in the language of the country of origin to make it easier for the user to comprehend and handle according to precautionary information provided by the PPM.

2.4.5 Failures associated with the courier services

Ghatak and Pal (2016) claim that failures impact the service quality of the business, however prioritizing the service failures brings discipline in implementing service recovery actions. Services are becoming increasingly dominant and competitive in the global economy between service organisations. Packaging failures such as breakages that occur during distribution by courier service results to poor business performance and customer dissatisfaction. Sureshchandar, Rajendran and Anantharaman (2002) indicated that the relationship between service quality and customer satisfaction has received

academic attention over the past years and the results show that the two constructs are independent yet closely related, implying that their relationship is directly proportional since an increase in one will probably lead to an increase in another. Therefore, it is essential for courier services to eliminate failures to improve service deliveries as this will positively impact the business operations and enhance customer satisfaction.

2.4.5.1 Road Conditions

Poor weather conditions result in poor road conditions. Sometimes there is no indication of the road hazards and accidents may occur due to these circumstances. Kilpeläinen and Summala (2007) stated that road accident risk is elevated during adverse weather and road conditions. It is vital for the driver to be aware of markings such as animals on the road, poor road conditions, lane markers, marked speed bumps and excessive speeds to increase visibility and awareness during transportation of goods.

To simulate package testing for parcel delivery, Böröcz and Singh (2018) conducted a study on measurement and analysis of delivery van vibration levels and provided an understanding of vibration levels that occur during van transportation that can be used to pre-shipment test new packages to prevent damage. The measured acceleration-time data were analyzed in terms of power spectral densities (PSDs) and presented with statistical data to provide an understanding of the variability of intensity. The separated and averaged vibration levels that were measured in this study were compared with the American Society of Testing and Materials and the International Safe Transit Association vibration profiles for pickup and delivery vehicle in the form of PSD spectrums. Based on the analyzed data of this study, PSD spectra were provided for various route conditions as well as composite spectra, which can be used to simulate the measured vibration conditions representing van shipments.

2.4.5.2 Weather

Cataldi, Profaizer and Bayer (2019) mentioned that an exposure to water or humidity is highly destructive toward cardboard mechanical properties. Water-soaked corrugated cardboard can easily collapse with irreversible shape distortions. During the supply-chain of goods, a package might temporarily stay on the ground while being processed and humidity has an effect during transit, especially for non-refrigerated goods.

An assessment was conducted by Savchenko *et al.* (2021) to evaluate the financial and environmental consequences of using a combination of vehicle, motorcycle, bicycle, and pedestrian courier to deliver small packages in urban areas during inclement weather. The study revealed that it is less convenient to make use of motorcycles, bicycles and pedestrian couriers than using vehicles during poor weather conditions. It is cost effective to use motorcycles since they can navigate around the traffic with ease, however, it will be affected during poor weather conditions. Whereas, the vehicle is not affected by weather conditions, it can travel through snow and rain without damaging its courier.

2.4.5.3 Warehousing conditions

Ye and Abe (2012) defined natural disasters as one of the cause of disruptions to supply chain as they result in widespread damage to several firms and facilities at the same time. This has a huge impact and significant time is required to recover from natural disasters. Natural disasters such as fire, floods and earth movement can occur when least expected similarly to any smaller incidents, such as theft and robbery.

A study was conducted by Đurđević, Andrejić and Pavlov (2022) to offer safety improvement and methodical approach to warehouse management. This method included nine basic steps that involve; Identification of the need for safety management, analysis of the current situation, identification of risk generators and hazards posed by generators, risk analysis, preventive and corrective measures, investments and investment effects, training staff, and periodic and continuous checks of system. The recommendations for risk reduction and elimination included removal of hazardous materials from the workplace, substituting a high-risk situation with low-risk situation and making use of personal protective equipment (PPE).

2.4.5.4 Size and shape of the package

Dominic (2011) mentioned that excellent and reliable packaging is mandatory to protect goods during transportation. However, methods of handling packaging are vital since a courier generally has different types of parcels that differ in shape and size within the same vehicle for dispatch. Therefore, each package is somehow exposed to distortion, especially when not protected and packed properly (bigger and heavier boxes might damage the smaller ones that don’t have sturdy packaging).

Singh *et al.* (2014) conducted a major damaged assessment study to examine challenges products endure during transportation and handling in mixed-loads. Products of various weights and sizes are loaded into trailers using a variety of mechanical and human techniques, as well as different algorithms to determine how best you can weigh a trailer efficiently. However, poor loading and insufficient load security within the trailer might harm the packages and the goods they hold, which increases the risk of accidents during unloading.

2.4.5.5 Method of loading parcels into trucks

The research on methods of packing and load securing cargo on trucks to reduce the risk of damages was conducted by Abdul Hanan *et al.* (2017). The aim of this research was to investigate the potential impact of load securement and packaging techniques on the risk of cargo freight damage in trucks. Improperly secured cargo was discovered to have the potential to cause serious accidents, vehicle damage, cargo loss, and environmental dangers. However, lack of load securement and improper loading inside the trailer can result in damage to both packages and the items they contain and may result in further damage while unloading. Furthermore, packaging can be defined as a coordinated system of preparing goods for transport, warehousing, logistics, sale, and end user. It also refers to the technology of enclosing or protecting things for distribution, storage, sale, and usage.

Singh *et al.* (2014) described some of the common methodologies used when loading parcels into trucks, which are; ensuring large and heavy parcels are placed on the bottom, trailers should be loaded tightly while avoiding void spaces in both lateral and longitudinal directions inside closed vehicles or containers. A stair-case technique may be utilized to step down the parcels to the trailer's rear when it is only partially loaded. Depending on industry standards that provide safe loading techniques, extra devices such dunnage, airbags, or friction rubber mats may be used to improve loading methods. It is crucial to realize that most loads will generally shift to some extent as a result of the many movements that take place inside a container or trailer. However, proper load securement techniques are essential to prevent damage and potential injuries to people handling items and packages during loading and unloading.

Singh *et al.* (2014) extends this and emphasized that improper loading and lack of load securement inside the trailer can result in damage to both packages and the products they contain. Even though most of the time, trucks usually go fully loaded, the packages may move inside. The shape of the parcel determines how well they can be stacked or stored. For example, the courier can stack a rectangular box without wasting too much space between the dispatches, but unusually shaped packages could still move around a little.

2.4.5.6 Improper packaging and reused boxes

Grönman *et al.* (2013) stated that the dominating environmental issues in the recent past have been material used and the possibility of recycled packages. Packaging is only given attention when a breakage occurs, whereas the main task of packaging is to protect and distribute the right parcel to the right user in a safe condition. The foundation point of preventing parcel damage is the packaging, keeping in mind that each good requires different packaging materials.

Packaging is crucial to many facets of the food business as well as to industries such as electronics, manufacturing, cosmetics, and so forth. A product needs a container to make handling, transporting, stacking, storing, and distribution easier, even if it is handled as bulk (Ait-Oubahou, Hanani and Jamilah 2019). Additionally, packaging serves to protect its contents from unfavorable climatic factors like rain, dust, extreme heat or cold, low relative humidity, external odors, and pests. Therefore, In order to meet consumer expectations, creative and innovative packaging container development must be taken into consideration. Tolstunova (2019) supported this and stated that poor packaging will lead to failures and ultimately to loss of the company. Packaging is one of the most significant elements in the efficient performance of the organization, which should comply with all the company's stated requirements.

2.4.5.7 Machine or human error

Senders and Moray (2020) explained that human error can occur in the design, operation, management, and maintenance of the complex systems. Behind each dispatch, there is a team of individuals and advanced machinery. Courier companies sort out the parcels mechanically (which can also cause damage), and the package handlers happen to be

only humans – sometimes people make mistakes. Heavy packages can accidentally end up on the floor before they finally reach their destination. Kletz (2018) extends this and argues that human errors are the nature of humans, therefore instead of trying to persuade people not to make errors, it is important to accept individuals as they are and try to remove opportunities for error by changing the work situation, such as the design of the equipment or the method of performing a task.

2.4.6 Key performance indicators affecting an organisation's logistics costs

In organizations, performance indicators are critical managerial decision-making tools (Gunasekaran *et al.* 2015). Key performance indicators (KPIs) have a significant impact on an organization's logistics costs. According to Martí, Puertas and García (2014), logistics costs is estimated to range between 2% and 15% of total organisation turnover. These indicators help measure the efficiency and effectiveness of logistics operations, enabling businesses to identify areas for improvement and cost optimization.

2.4.6.1 Transportation Costs

This KPI measures the costs of transporting goods from one location to another. It considers factors such as fuel costs, freight rates, carrier fees, and transportation mode efficiency. Pajić, Radivojević and Kilibarda (2021) established that transportation cost can be distinguished into internal and external cost. Internal costs include the costs of product delivery, insurance, driver salaries, fleet maintenance and fuel. Whereas external transportation costs, includes climate change, air pollution and accidents (Mostert and Limbourg 2016). Monitoring transportation costs allows organizations to identify opportunities for route optimization, shipment consolidation, and negotiating better rates with carriers.

2.4.6.2 Inventory Holding Costs

Inventory holding costs (IHC) are the expenses incurred to maintain inventory levels. Traditionally, IHC are considered to be a combination of several costs and is determined by adding these cost components (Odedairo, Alaba and Edem 2020). These expenses include storage, warehousing, insurance, taxes, obsolescence, and depreciation. Implementing efficient inventory management techniques such as just-in-time (JIT)

inventory, demand forecasting, and stock rotation strategies can help to reduce inventory holding costs.

2.4.6.3 Warehouse Utilization

Warehouse utilization evaluates factors such as space utilization, picking and packing productivity, and inventory accuracy to determine the efficiency of warehouse operations. Gu, Goetschalckx and McGinnis (2007) performed an extensive review on warehouse operation problems and classified them according to basic warehouse functions such as receiving, storage, order picking, and shipping. Efficient warehouse operations can help reduce labor costs, minimize storage expenses, and enable faster order fulfillment. Implementing warehouse management systems (WMS), optimizing layout design, and utilizing automation technologies can improve warehouse utilization and reduce logistics costs.

2.5 Training solutions for optimisation of logistics

There are many packaging handling points in NLC network, stock is received from various customers, sorted, staged, and loaded for inter-branch transport or last mile deliveries to stores. The NLC is accountable for ensuring stock is handled with care and delivered in the right condition to the end customer. Training is the organized way in which organisations provide development and enhance quality of new and existing employees (Jehanzeb and Bashir 2013). Therefore, developing training solutions and awareness will empower NLC employees with the skills needed to handle stock in the best way to achieve commitment to customers and operational procedures to optimise logistics. Organisations that invest in training and development of employees tend to achieve both short and long-term benefits, thus for organisations to achieve maximum returns from their investments they need to manage training and development programmes (Nda and Fard 2013).

Tien *et al.* (2020) indicated that according to a survey conducted by the Research and Development Institute of the National Economics University, up to 80.26% of the labor force in logistics companies are still mainly trained through daily work, 23.6% of workers take part in domestic training courses, 6,9% hire foreign experts to train, while those attending training courses abroad account for only 3.9%. Sarkar and Shankar (2021)

extends this and elude that implementing Industry 4.0 has the potential to increase port efficiency by 15 to 20%, therefore employees should learn additional skills and competencies for implementing advanced technologies because it is time-consuming and difficult for them. Proper training and domain knowledge are essential or else it will act as a barrier. In Industry 4.0, effective training requires not only learning but also unlearning and it creates a problem for the organization to cope with this change.

2.5.1 Optimisation of operational logistics procedures

The NLC is customer focused and solutions driven, hence optimising procedures is vital to have competitive advantage and meet customer demand. Taniguchi, Thompson and Yamada (2004) defined city logistics as a process of optimising the logistics and transport activities by private organisations with the support of advance information systems in urban areas considering traffic environment, congestion, safety, and energy savings within the framework of a market economy. According to Tseng, Yue and Taylor (2005), city logistics is an idea of trying to form the existing resources to solve difficulties incurred in the urban areas caused by increase in population and vehicle ownership.

Transport logistics is concerned with the scheduling and operation of the transportation network, the role of transportation logistics is to coordinate and optimize shipment movements. Optimisation of operational logistics activities include shortening of run routes, which is the most effective utilization of transportation, human resources and technologies (Pečený *et al.* 2020). Techniques to optimise logistics activities include effective route planning. Effective routes can be started by implementing the Nearest Neighbour Method (NNM). This method has simple rules and is not overly complicated, making it suitable for determining optimized routes.

2.5.2 Implementing outbound loading strategies

Wei and Leung (2011) state that when different kinds of products are to be loaded on the same truck, loading a truck can be difficult. This is supported by Singh *et al.* (2014) who echoed that the type of freight to be distributed is dependent on what the customer provides the courier. Thus, loading various types of freight, which are all packaged differently, together on one trailer is a challenge. As a result, the truck has to wait long at the loading points blocking other trucks that are also in the process. During the peak

season, the normal operations are affected due to limited loading area and traffic further weakens the loading efficiency (Wei *et al.* 2009). However, cross-docking is one innovative warehouse strategy which has potential for controlling logistics and distribution cost while simultaneously maintaining the level of customer service (Apte and Viswanathan 2000).

Vanderroost *et al.* (2017) conducted a study on how to improve the efficiency of logistics operations on food packages to reduce food loss, and the research revealed that cross docking is a practice that aims to reduce or completely eliminating storage allocation by directly loading incoming parcels in outbound transport vehicles, hereby reducing the related risks of damaging food packages. Implementing outbound loading strategies will optimise logistics operations while reducing package breakages. Outbound logistics is essential to a company's interactions with customers since reliable partnerships keep communication clear and workflows function efficiently. This aspect of the shipping cycle receives more attention as companies seek to improve customer satisfaction and loyalty rates, since consumer expectations and delivery volumes are always rising. Vakulenko et al. (2019) supported this by conducting an analysis which revealed that service innovation in the e-customer journey increases customer expectations.

Optimizing outbound logistics requires effort to build relationships and engage in negotiations, furthermore technology can be used to organize schedules, analyze routes, discover distribution networks, and seek to reduce costs. Smart route planning is one of the outbound loading strategies that is considered to be successful. Spichkova, Simic and Schmidt (2015) highlights that it is important to have a formal model as smart routing covering real-time and space aspects. Adoption of smart route planning can reduce waiting and travel time for deliveries.

2.5.3 Methods of handling stock in logistics

The stock handling procedure includes the following steps; receiving goods, checking them, marking the goods with information, and delivering them. Jeganathan and Naveenkumar (2018) mentioned that material handling is defined as the movement, storage, control and protection of material, goods, and products throughout the distribution process. Furthermore, material handling is composed of methods using

material equipment handling such as; pallet truck, forklifts, load conveyor, stillages, order pickers and manually, operated by human resource rather than automatically (Jeganathan and Naveenkumar 2018). It is essential for equipment to be adequate to handle stock cautiously and efficiently during the process.

Vacuum grippers are equipment's that use suction to lift and manipulate objects. It is commonly used in logistics industries to handle cardboard materials for stacking and arranging products on pallets for transportation or storage. Chiaravalli *et al.* (2020) stated that vacuum grippers are mostly used for depalletizing cardboard packages, however cardboard packages cannot always support the weight of the stock they contain, consequently this is not the best handling method. The integration of human resources and equipment handling is optimal and safe, therefore implementing package care handling as part of training is imperative for optimisation of logistics and distribution of parcels.

Successful methods of handling stock in logistics include stacking and palletizing. Palletizing is related to the final stage of production. Packaged goods or bulk packing should be stacked on the palette in increasing layers until the desired height or weight is reached. The requirement to utilize the biggest surface area of the pallet led to the intentional alignment of each layer in the schematic (Szymonik 2016).

2.6 Gap from the literature review

Not many studies have examined the optimisation of logistics and distribution of parcels relating to package damages in courier services. Proto *et al.* (2020) studied the importance of adapting to advanced sensor and information technologies in courier services to prevent package damage to goods. It was indicated by Pereira *et al.* (2020) that in the recent years several studies were conducted regarding improvements made in the cardboard industry. Research on the material used to manufacture a corrugated cardboard package is essential since this would entail a detailed specification of the material used by a manufacturer, types of corrugated flute produced in relation to the weight a package can carry to optimise the distribution of goods. This research gap limits our understanding of how cardboard packages are manufactured and which material can be used to optimise the distribution of parcels while reducing potential risk of package

damage. Therefore, this study aims to explore how courier services can optimise controllable factors such as methods of handling packaging with care, conveyor system operations and stacking corrugated packaging in a vertical flute direction to offer best stacking strength.

2.7 Conclusion

This chapter discussed an overview of the literature on services provided by courier companies with the inefficiencies in the distribution of parcels and looked at how tools, techniques and practices have been implemented in other industries to continuously improve the distribution of parcels in logistics. In addition, the chapter revealed the benefits of implementing PDCA methods for optimising logistics services to reduce packaging claims associated with packaging damages in terms of improving package handling. The literature review supported the research study by reviewing previous literature related to optimisation of logistics and distribution of parcels. Information sources that were reviewed include journals articles, books, conference proceeds, report, and thesis. The following chapter will discuss the research methods which were used to conduct this study.

CHAPTER 3 : RESEARCH METHODS

3.1 Introduction

The previous chapter revealed a detailed literature review on courier services and tools that can be used to optimise distribution of parcels with an aim of reducing packaging claims associated with breakages. This chapter focuses on the research methods that were adopted for the study. It commences with a research framework that is used as a guide for the focus of the study, ethical considerations, and the research limitations of the project. The structure of the study and how the data is systematically collected and analysed is described by the research methodology (Polit and Beck 2004). The chapter then focuses on methods that were adopted to attain the four research objectives.

3.2 Research Framework

The steps taken throughout the research are implemented by the research framework. It is used as a guide by researchers to focus on the scope of the study (Harrison et al. 2017). It is the basic structure of ideas underlying the phenomena under study, providing a structure for conceptualizing, and designing research studies, understanding data, and enabling researchers to transcend common sense (Beck *et al.* 2022).

The problems of optimal scheduling of deliveries and optimising the structure of the parcel distribution system are characteristic for courier companies and still require better solutions (PIERZCHALA, GUTOWSKI and CZUBA 2020). With distribution of parcel as the central concern regarding packaging breakages, Grönman et al. (2013) developed a research, framework for packaging design. Using an iterative research approach, after planning, analyzing, and evaluating the current state of the literature, a new research framework that embraces three dimensions, which are logistics supply, process parameters and distribution demand, was proposed.

A conceptual framework is the product of the conceptual design that would comprise of the research objective (what is to be achieved by the research), theory or theories that are a focus of the research study, the research questions (knowledge produced) and the operationalisation of concepts and constructs that will be measured during execution (Tobi and Kampen 2018).

The research proposes a PDCA (Plan-Do-Check-Act) research approach for the provision of a structured and rigorous problem-solving process for optimisation of logistics and distribution of parcels. Taniguchi (2014) conducted a study in urban freight transport (city logistics) by adopting the PDCA research approach and found that the optimisation of logistics activities incorporates the social issues of the environment, congestion, and energy savings as well as economic issues relating to urban freight transport within the framework of a market economy.

Novická, Papcun and Zolotová (2016) conducted a review of logistics pillars to reduce inventory and improve customer satisfaction while minimizing delivery time, using appropriate methods and tools such as PDCA for optimisation of logistics and distribution of parcels and found that logistics pillars are vital for the efficiency of distribution. PDCA would enable the identification of improvement opportunities on parcel handling and pursue the investigation of cause and effects for parameters resulting in breakages during distribution of parcels. PDCA Cycle refers to the continuous improvement to achieve higher competitiveness (Wang and Liu 2010). This tool can help logistics industries evaluate process parameters continuously, monitor and analyse implemented operational procedures.

Guided by the PDCA research approach, as shown in Figure 3.1, the research framework encompasses the underlying factors that determine logistics operations and optimisation of distributing parcels by identifying and measuring process parameters with an aim of handling parcels efficiently to eliminate customer packaging claims, customer complaints and increase business revenue in a local courier service. The research framework embraces the distribution process for a cross docking system, identification of the process parameters resulting in breakages, and optimising controllable factors by developing training solutions to empower internal staff about parcel handling methods.

The methodological framework chosen for the subsequent empirical analysis is presented in Figure 3.1. After conducting a comprehensive literature review, prior to the detailed study, a detailed parcel assessment measurement was conducted to obtain detail packaging information from all suppliers.

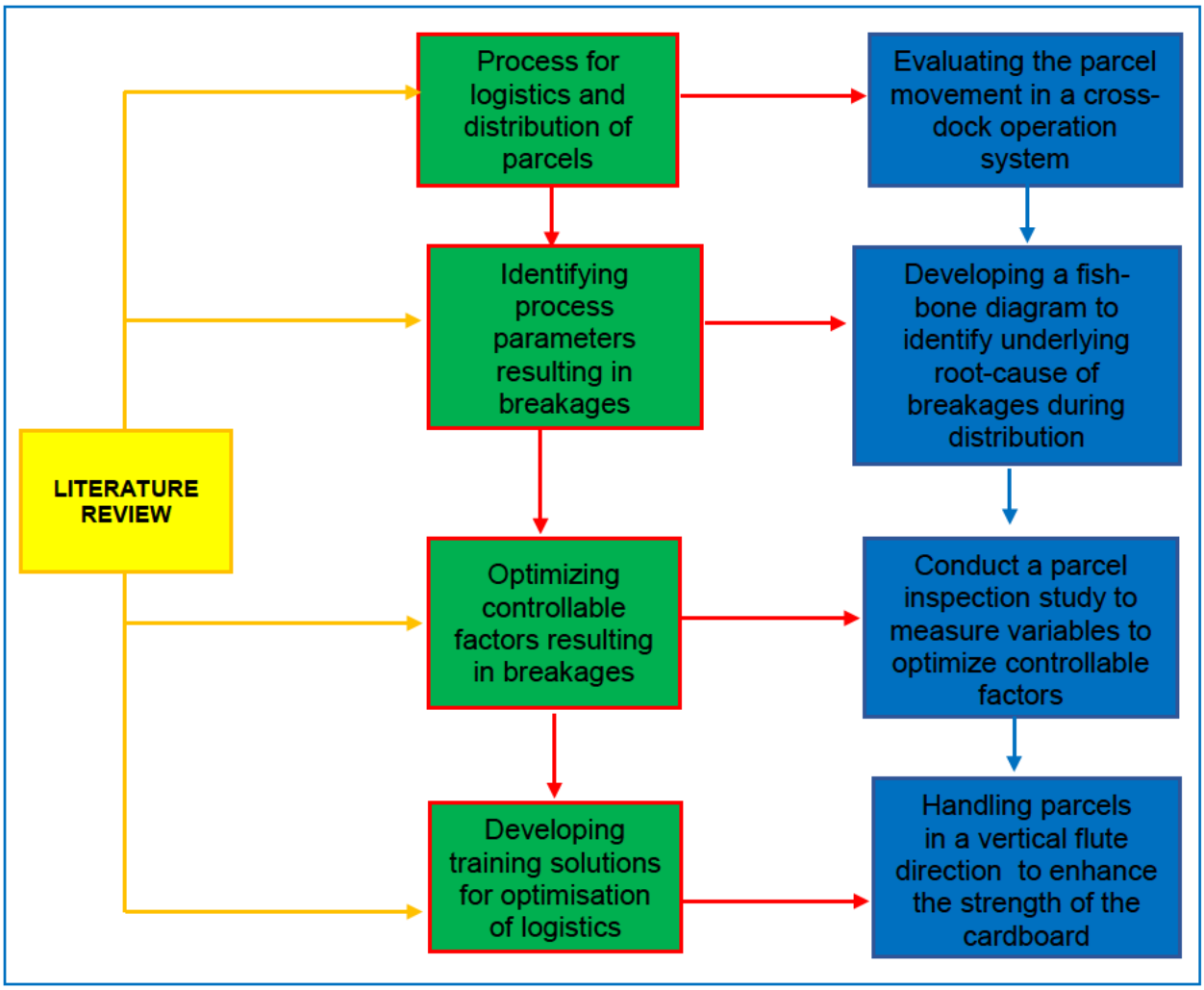


Figure 3.1: Schematic for a research framework

The Plan (P - in the PDCA) for the cited organisation, NLC, embraced the design and assessment stages, which included identifying critical problems, underlying cause of problems, define goals, describing movements of freight vehicle, and combining measures and approaches.

The crux of the research work was the development of parcel inspection document to collect information and data of the variables influencing claims for each damaged package in terms of parcel specifications, which represents the plan phase, according to the PDCA approach. In the Do (D) phase, the correlation analysis was performed on measured variables and the results of the study were used to design required operational processes by identifying process parameters which are resulting to cardboard packaging

damages. This stage also included capturing and measuring the package variables of all damaged packaging.

To accurately describe the problem, a fishbone diagram was developed to identify the root-cause to improve controllable factors that influence reduction of packaging claims, while Check (C) was accomplished to create a database for capturing structured information related to damages received within the distribution network with an aim of understanding a detailed description of the damaged package. In the Action phase, the results were validated through statistical analysis and used to develop regression model for optimisation of packaging size and implement training solutions to empower employees for sustained optimisation of logistics and distribution of parcels. Lastly, cardboard packaging damages were tracked to verify if there were improvements in reduction of packaging claims after the implementation of the PDCA cycle and training solutions.

3.3 Methods for analysis of process for distribution of parcels

The first objective of the study was to analyse the process for distribution of parcels in a logistics company that practices cross docking operation, to identify potential opportunities for the reduction of excessive claims associated with parcel breakages in the process. The research strategy that was used commenced with an assessment of an organization in terms of its awareness of customer requirements regarding effective movement of packages in the supply chain along with packaging types, considering package requirements that should fulfill it functions. The following questions were used to elicit information from management at the distribution centre:

- What are the current methods used to handle packages in the distribution network from the point of receiving in-bound, sorting/storage through to dispatch out-bound, with an aim to achieve reduction of package breakages?
- When is the organisation responsible for package breakage, and when can a claim be made against the courier?
- What is the root-cause of package breakages?
- Does the type of package used by customers meet the required specifications to sustain the weight of the units inside the package?

- Is the condition of the equipment used for transportation and sorting suitable for handling packages?
- Have roles, responsibilities and authority been identified for all persons influencing package handling and is this documented?
- Is there parcel care handling training conducted at least once a year and is the progress evaluated by root cause information of package claims?

The research approach also entailed identifying accurate operating percentage rate which is compiled by measuring the overall equipment effectiveness of the machine within the cross-docking process. The cross-docking performance was measured to elicit the current throughput of the NLC and examine activities associated with operational performance. In relation to measuring the cross-docking performance, VSM was used to reveal inefficient processes which add no value to the process and time spent on each operation. By identifying non-value-adding activity in every process and focusing on value-adding activities, VSM makes it easier to achieve goals more efficiently.

3.4 Methods for identifying process parameters leading to breakages

The second objective of the study was to identify process parameters which are resulting in breakages in the logistics and distribution process. The research approach which was adopted to identify process parameters resulting in breakages was the 6M's fishbone diagram (Man, Method, Machine, Material, Measurement & Mother Nature), which entails identifying all parameters contributing to breakages.

The first step in the research approach was listing and defining factors resulting in breakages. The source of variations is the reason of imperfection, therefore the 6M's fishbone diiagram is used for product design and quality prevention to identify potential factors causing an overall effect (Thakkar, Maheshwari and Rajhans 2018).

3.5 Methods for optimising controllable factors for reducing packaging claims

The third objective of the study was to optimise controllable factors for reduction of packaging claims. The research approach embraced determining and measuring the correlation between variables and elevating awareness of packaging pictorial markings (PPM). The correlation analysis was crucial for providing the relevant information on

packaging specifications that determine a detailed information regarding the packaging material of a cardboard, to understand its durability performance and develop solutions to eliminate packaging breakages. Identifying the relationship between variables is crucial to accurately measure the strength between two variables and examine the significance for improvements.

Concerning PPM, the precautionary information provided by the packaging markings was used as the baseline to inform operators regarding handling packaging with care, keeping the package dry and in upward while considering fragility. The Pearson correlation coefficient formula was used to determine the significance between two packaging variables such as, packaging weight and flute corrugated size used on a cardboard package. The relationship between these variables is directly proportional, when one variable is affected or changes, the other variable will change in the same direction.

Since the package used is determined by the supplier, the NLC developed a regression model which computes the optimal package size for packages that are exhausted, oversized or damaged. Information on damaged packages was collected by measuring and recording each variable of a damaged package such as, dimensions, weight of package and flute size. The model was parametrized using the data collected.

A good model was derived from variables that were measured to have impact on one another. The process involved changing the cardboard package provided by the supplier to an optimal corrugated cardboard size depending on the item shape and weight. Furthermore, a mathematical model was developed to optimise the dimensions of the cardboard package using the Solver Add-in on Excel. The variables used to derive the model were length, width, height and weight. To achieve the optimal dimensions, the model had to address the following objectives:

1. Minimize volume size of the package: to reduce transportation costs and make effective use of available space in transport vehicles.
   Objective function: Minimize $V = L * W * H$
2. Validate that the package conforms to size restrictions: must conform to the maximum dimensions that the courier service established.
   Constraints: $L \leq L_{max}$, $W \leq W_{max}$, $H \leq H_{max}$

3. Minimize the dimensional weight of the package: considering the amount of space an item takes up in relation to its actual weight, which may affect pricing.
   Objective function: Minimize D = L * W * H / V_dimensional, where V_dimensional is a constant dimensional factor.
4. Maximize the weight-bearing capacity of the package: to ensure the package is durable and shock-resistance during the transportation process to ensure package arrives without damages.
   Constraint: M ≤ M_max

Using Excel as an option for optimizing packaging size is beneficial since: (a) Excel is generally available at no additional cost on all Windows platforms. (b) Excel is user friendly. (c) Excel offers a great deal of versatility when it comes to data sharing.

The second step in the optimisation of controllable factors for reduction of packaging claims was discovering if there was a need to develop training solutions for handling packaging with care and efficiently throughout the distribution process. Operational changes in organisations require a precise approach that will resolve both entity and operator challenges. Although there were no changes to the operation, the packaging handling methods needed to be defined including the precautions of the PPM.

3.6 Methods for objective 4

The fourth objective of the study was to identify factors that could be used to develop training solutions to empower employees with skills for sustained optimisation of logistics and distribution of parcels, therefore the results of the first, second, and third objectives were used as a baseline to develop training solutions. The approach for developing training solutions included loading and offloading strategies, methods of staging and sorting cardboard in a vertical flute direction which is also support by the PPM, and the type of equipment to be considered to reduce breakages.

The first step in developing training solutions included representing the precautionary information as a video illustrating methods and strategies to be applied. The second step aimed to troubleshoot the potential root causes and identify the inspection procedures to be followed, and the observations to be carried out.

Concerning poor handling of cardboards, the development of training solutions such as handling parcels in a vertical flute direction (VFD) will enhance the strength of the cardboard, developing a parcel inspection document (PID) and using it to collect information and data of the variables influencing claims and also empower employees for sustained framework while optimising distribution services. The team leader and supervisor use a parcel handling evaluation sheet (PHES) to observe employees as they are executing their duties doing a job. The PHES is a customised job description for each of the jobs that are executed within the cross-dock facility.

3.7 Methods of Data Collection

The source of data used to conduct this study was gathered internally within the NLC organisation, which was used to conduct primary research using internal reports and records. By nature, this research is a quantitative study which aims at measuring the current state of package damage incurred by the NLC organisation in relation to customer claims.

3.8 Data Analysis

This study adopted a quantitative research approach, where data collected was consolidated to reveal how the damaged goods associated with customer claim cost impact the NLC organisation. The data collected was analysed and revealed the process parameters resulting in package breakages during logistics operations, while aiming to identify the root-cause and improve controllable factors for reduction of packaging claims. A software program used to gather the information was the internal Logistics Management System (LMS) and Microsoft Excel was used to analyze the data set of the damaged packages captured on LMS.

The data was summarized by identifying the highest contributing factor of breakages while differentiating controllable factors from non-controllable factors that results to breakages. The validation was determined by understanding the nature of logistics operations and customer expectations of a courier service.

3.9 Ethical Considerations in Scientific Research

The level of attention on ethical conduct (personal and professional actions during research activities) has both increased and spread with regards to the society's expectation of greater accountability (Fleming and Zegwaard 2018). Scientific misconduct can be defined as scientific behavior that consciously or unconsciously disregards high ethical and scientific standards. According to the Committee on Publication Ethics (COPE), the code of conduct editors have the right to take action under suspected misconduct (Bordewijk *et al.* 2021). The issues concerning research misconduct include fabricated or modified data, about 2% of scientists were found to admit having falsified, fabricated, or modified results at least once and on average over 14% of scientists observed these behaviours among their colleagues. Research misconduct may result in a waste of human and financial resources and it can pose an imminent risk to human health (Fanelli 2009).

The research was conducted under the support and guidance of Durban University of Technology (DUT). The DUT's research ethics policy and guidelines were used to ensure that the researcher identified and acceptably addressed ethical issues. According to the DUT policy, the study was considered as Category 1, straightforward research without ethical problems and minimal risk to humans, animals, or environment, therefore was exempted from ethics and biosafety research committee review. The reason behind the decision was that the research did not have any potential of harm to the wider community, the participants, the researcher, and the institution. It was also crucial to ensure that the identity of the participating organisation was protected, and the name remained anonymous. The participating organisation was identified as NLC to ensure the protection of the company identity. Appendix 2 reveals the Introduction to Research Ethics certificate obtained from conforming to the DUT's research ethics policy.

Plagiarism detection used to be a challenge in the past, however, the web-based software makes identifying plagiarism easier. The Turnitin Similarity Report highlights any parts of your paper that correspond with outside sources and quantifies the degree to which your work is similar to other written works. The researcher adopted appropriate research methods and sample sizes to avoid misleading results and demonstrating honesty and

sincerity was important to ensure the integrity of the study. The researcher avoided falsification of results and fabrication of data or modifying relevant data. Study results were fully reported, underlying assumptions were clarified, and study bias is also avoided.

3.10 Conclusion

The research proposed a PDCA research approach for a methodical and disciplined approach to problem-solving for optimising logistics and distribution of parcels in a courier service. The research framework embraced the underlying factors that determine logistics operations and optimisation of distributing parcels by identifying and measuring process parameters with an aim of handling parcels efficiently to eliminate customer packaging claims, customer complaints and increase business revenue; and developing optimal training solutions to empower employees for sustained optimisation of logistics and distribution of parcels. The issues concerning ethical approval of the study, plagiarism, research misconduct, and data analysis were cited as ethical considerations in scientific research.

CHAPTER 4 : PROCESS FOR NATIONAL LOGISTICS COMPANY

4.1 Introduction

Distribution Centre (DC) operations are becoming more complex than ever before. For example, current DC operations entail receiving finished goods in cardboard packaging via "inbound" then, depending on the type of operations in each DC, a variety of other processes may occur. For instance, the packaging could be sent directly to temporary storage areas on pallets using forklifts or automated conveyors. DC's handle temporary storage differently depending on the needs of their end customers. Outbound operations, or shipping, include manual picking, case picking, pallet picking, item sorting, or cross-docking to final shipping areas, where packages and pallets are loaded into trailers and shipped to retailers and customers. Similar with the process for the NLC, these processes, like any manufacturing operation, necessitate planning and control to improve distribution services.

4.2 Distribution process flow

Optimising the NLC distribution process required a detailed process flow of a parcel movement in the cross-dock facility. By examining the current process, the average time spent by parcels in each operation was identified. In relation to the value stream map (VSM) conducted, bottlenecks were clearly identified, the amount of work in progress (WIP) and queuing time in the process flow. With all the amount of waste existing in the process, the opportunity to improve throughput in the cross-docking operations is available.

Optimisation is an action of making the best out of the situation or a resource, and in logistics, the aim of optimisation is focused on a more effective utilization of transport means, technologies, and human resources. A typical parcel movement line for inducted stock in the NLC distribution network as shown in Figure 4.1 is characterized by the movement of load vehicles from the warehouse, conveyor belt system, cross belt sorter, palletization and loading vehicle for dispatch. The conveyor belt system improves movement and speed of processing packages from in-bound to out-bound. Cross belt sorter accurately separates packages and routes them to their correct location, whereas

the pallet enables the operator to move multiple items in fewer trips. Since this is a cross dock operation, stock is not stored for a long period in the warehouse.

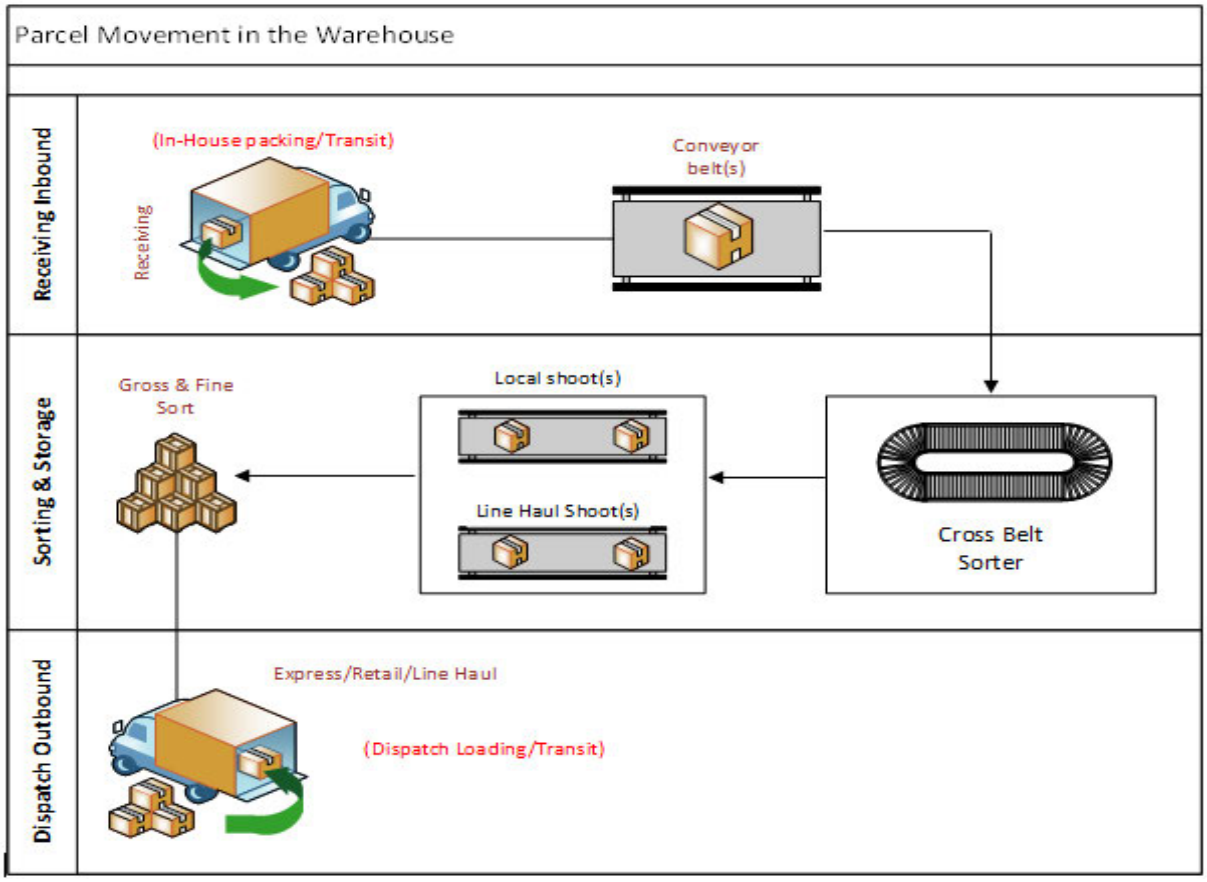


Figure 4.1: Flow diagram for NLC distribution operations

To analyse the process and design of the NLC required an in-depth review on value stream mapping to help visualize the process and target to reduce waste such as excessive claims associated with parcel breakages in the process, which will result to efficient distribution. The research method adopted for evaluating the process was the lean six-sigma tool SIPOC (Supplier-Input-Product-Output-Customer) diagram, which was used to identify the structure of the process. The activities are represented as follows:

- **Supplier** – the consignment is made by the supplier that owns the package stock. This is when the courier will receive information from the supplier and thereafter take full ownership of the product until it reaches the end customer.

- **Input** – resources required for the consignment to be done successful include; man-power, vehicle containers, machinery (conveyor) and trucks.
- **Process** – illustrates a high-level flowchart of the core activities that comprise the logistics and distribution of package stock.
- **Output** – the delivery of goods to the end customer is the output of the service. Delivering the right product to the right consumer in the right quantity, in the right condition, at the right time and place, and for the right price.
- **Customer** – consignee receives all goods and acknowledges stock as successfully delivered by signing POD's (Proof of Deliveries) paperwork.

Figure 4.2 shows a summary of inputs and outputs and more business processes in a diagram format, to present and give a high-level overview of the process for logistics and distribution of parcels from start to end.

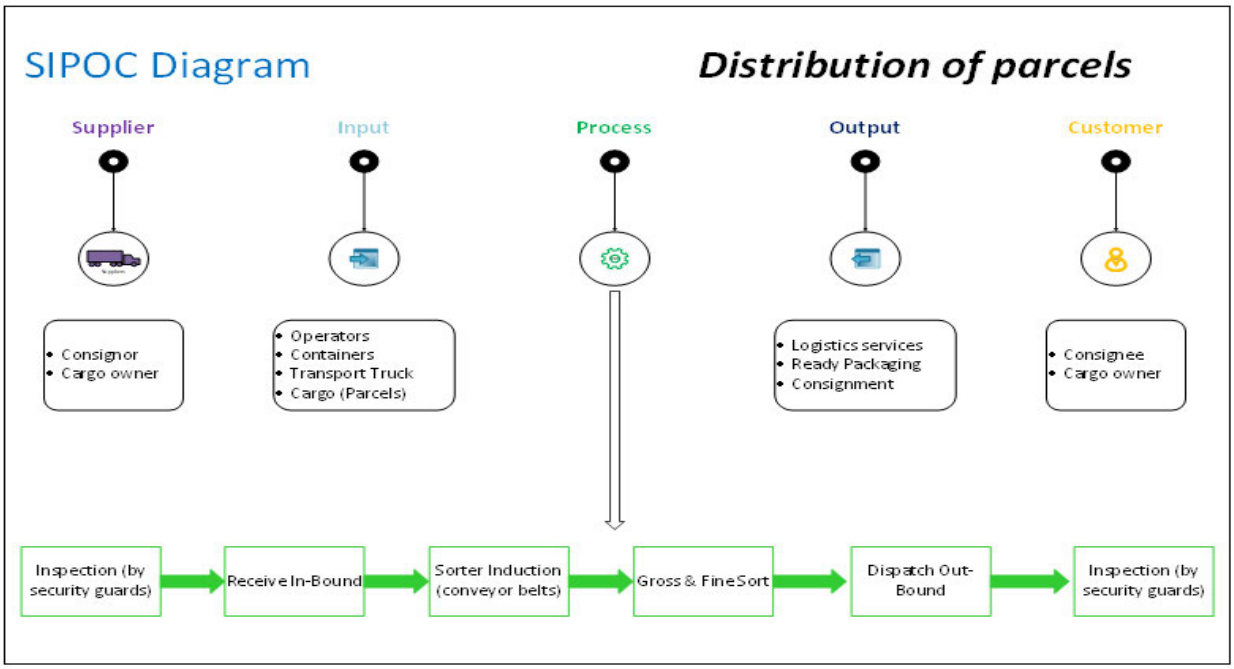


Figure 4.2: SIPOC diagram representing the process of distribution of parcels

The research method also achieved defining a new optimal process after a clear overview of the current process. The VSM was then used to reveal critical steps of both material and information to remove waste in value streams, thereby optimising the distribution process. Value stream mapping is a business improvement tool used to assist in

visualizing the entire production process, revealing both material and information flow (Singh, Garg and Sharma 2011).

4.3 Value Stream Mapping

The VSM originated from the Toyota Production System (TPS) as a lean manufacturing technique that is used to analyse the flow of information and material processed to provide a service to a consumer (Li 2014). Predominantly, lean manufacturing technique is a manufacturing practice that recognises the expenditure of resources for any purpose apart from the creation of value for the end customer as wasteful, and thus a target for elimination (Čiarnienė and Vienažindienė 2012).

Process maps with pictorial representations are a form of communicating with different departments within the organisation which provide visuals as to how work is carried out throughout the entire system.

The scheduling technique adopted was the FIFO (First-In, First-Out) method in relation to delivery lead time. Li *et al.* (2017) indicated that to increase resource utilization of the system and decrease the execution time of tasks, FIFO scheduling algorithm can be proposed. The FIFO approach recognizes that the first products to enter the warehouse are also the first items to exit. This technique is useful for preventing product obsolescence while improving delivery lead times, which then prevents storage of aging stock on floor. The initiative taken towards adopting this technique was the development of colour-coded labels that represent each working day of the week as shown in Table 4.1.

Table 4.1: Colour-code package labelling

DAYS	COLOUR	CODE
Monday	Green	
Tuesday	Blue	
Wednesday	Yellow	
Thursday	Red	
Friday	Purple	

Colour-coded labels help to immediately identify when the package was received in-bound at the distribution centre, therefore in relation to customer lead time and FIFO approach we are able to act on the package accordingly. Colour-coding is also a method of keeping the workplace organized, which reduces confusion of work-flow as it helps identify old versus the new goods.

As complicated as the process might be, all value adding steps are shown in the NLC map along with non-value adding steps. The time taken for each critical operation to be completed is represented as the value-added time (VAT), whereas the time the package spends waiting in inventory between cross docking steps is recorded as the production lead time (PLT). This can be any inventory storage location since inventory is one of the 7 types of Muda (waste) which needs to be eliminated or reduced to optimise the NLC distribution process. Domingo (2015) confirms that inventory waste may also result from an accumulation of work-in-process (WIP) due to lack of planning and failure to match customer demand.

Figure 4.3 illustrates a VSM that was created to examine cross-docking operations to identify activities associated with operational performance.

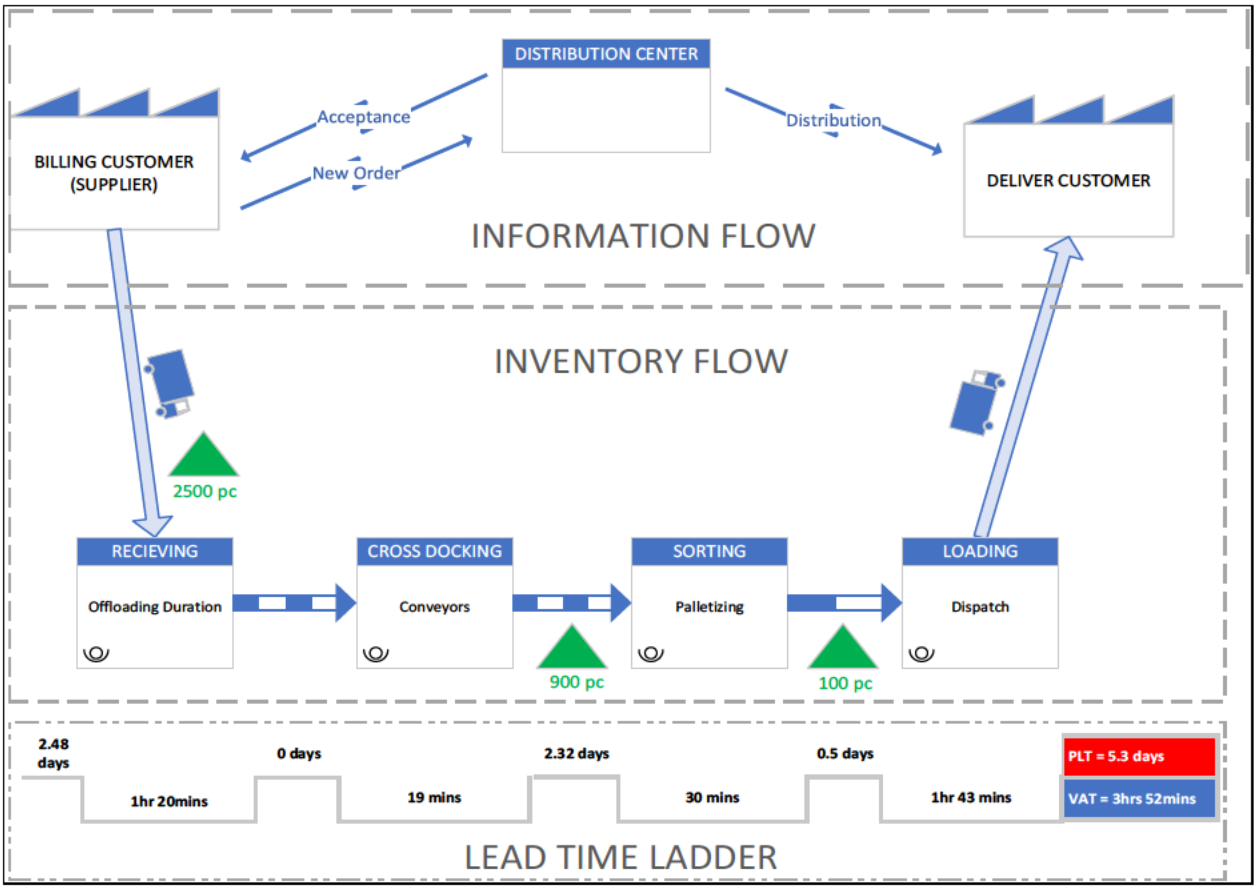


Figure 4.3: Cross-dock value stream map

Parcels were tagged and tracked from receiving to dispatch, this was done to identify lead time components. The value stream map is composed of information flow, which represents electronic communication flow between the billing customer, DC and delivery customer. Material flow, illustrating the movement of parcels, steps and operations performed to deliver to the end customer. Lead time ladder, this is the last element that shows the lead time of each operation and serves as a gauge to measure direct and indirect activities that affect the cross-docking operational performance.

The VSM revealed that the logistics process parcel distribution flow is streamlined and well structed, however, non-value adding activities were identified and recorded to be excessive walking during sorting for storage, incorrect routing of parcels to the desired location and machine (conveyor) set-up time. The value adding activities such as, electronic information acceptance, offloading parcels, processing through conveyors, palletizing and loading outbound for dispatch to the end customers were measured to be

a duration of 3 hours 52 minutes on average. The PLT between cross docking steps reveals the amount of time packages spend waiting in inventory, bottlenecks were identified, the amount of work in progress (WIP) and queuing time in the process flow. This period worked out to be 5 days 7 hours on average.

4.4 Cross-docking performance

The operation steps were observed, and data were collected from the cross-docking DC operations over a five-month period. Data collection revealed a lower than anticipated throughput capacity, throughput results varied from day-to-day operations. According to data gathered over a five-month period, the average throughput was 16 346 parcels/shift, with maximum of 27 240 parcels/shift and a minimum of 2 707 parcels/shift. The throughput measure is a combination of packages processed directly to the end customer and to the following network point within the NLC organization.

Table 4.2 provides descriptive statistics for the data collected. Figure 4.4 below represents the cross-docking performance in terms of throughput for a period of five months, throughput of parcels per shift. The high variability is exposed, with a high standard deviation of 6 839 parcels per shift.

Furthermore, after examining the distribution process in terms of the developed value stream map in Figure 4.3, parcels spent an average of four hours on conveyors between inbound and outbound operations. In addition, the value stream map in Figure 4.3 depicts the amount of work in progress (inventory), which is represented by triangles, as well as the length of time each inventory waited, or queued, in the operations flow.

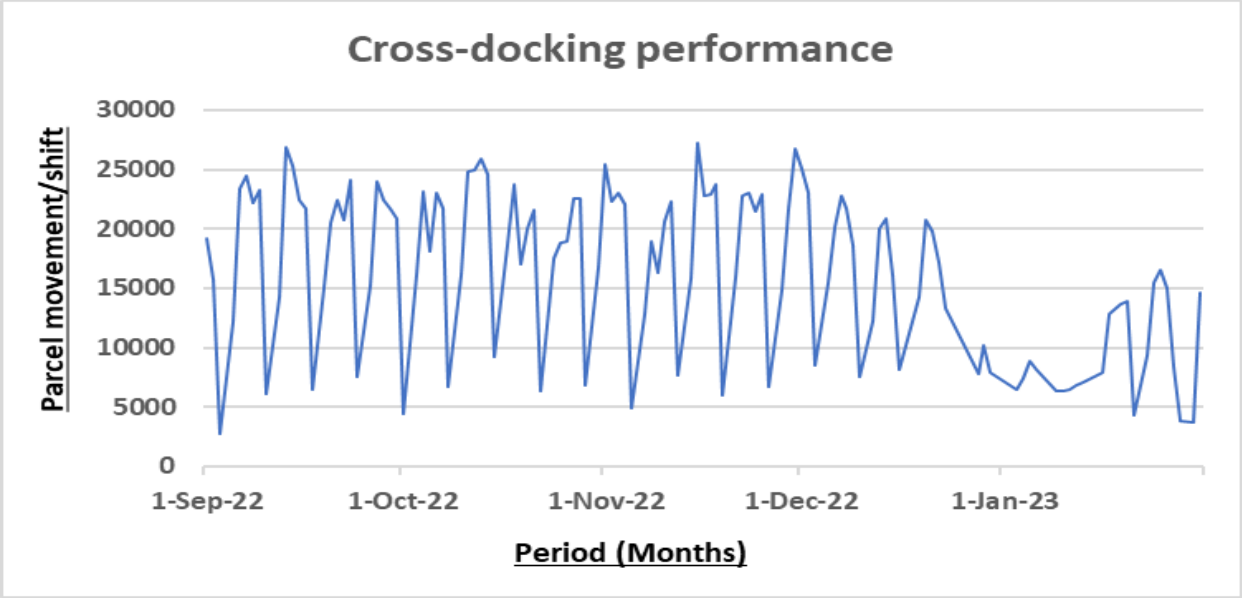


Figure 4.4: Cross-docking performance for five months period

The performance clearly shows a high variability of throughput on a day-to-day shift for a five-month period from September 2022 to January 2023.

Table 4.2: NLC performance per shift

Total Throughput	
Mean	16 346
Standard Deviation	6 839
Minimum	2 707
Maximum	27 240

The NLC performance has been revealed to be less reliable, where the data is widely spread and far from the mean. With regards to the organisation baseline, customer satisfaction and consistent supply of goods are compromised as a result of large variations. High variability means the organisation is not consistent with their distribution of parcels, on occasion the throughput is high and sometimes it is low.

4.5 Conclusion

Cross-docking operations are becoming more complicated, operations planning, and control need to be given more attention. Automation is adopted in some cross-docking DC operations to process cardboard packages. Therefore, automation can result in

massive waste and a decrease in service levels if not measured and analyzed thoroughly. To identify existing operational waste and opportunities for improvement, a value stream map was created.

The lead-time concept was used to analyze the data that was gathered through multiple observations and to identify several wasteful areas in the cross-docking process. Waste was identified through long queues in the conveyor, poor planning, re-circulation of parcels in the conveyor, long storage times and lack of floor supervision during operations. All these types of waste resulted in a longer lead time, where an average parcel could have taken nine minutes to be processed from inbound to outbound but took four hours on average.

This study adds to the body of knowledge about cross-docking operations. Furthermore, the research contributes to a practical understanding of cross-docking workflow and lead time issues, as well as the importance of value stream mapping in identifying waste to maximize throughput.

CHAPTER 5 : RESULTS AND DISCUSSION

5.1 Introduction

The previous chapter revealed a detailed process flow of packages in the NLC with an aim of optimising the cross-docking facilities. This chapter presents and discusses the findings obtained from the study. Continuous improvement tools such as PDCA was used to collect, analyse data, improve, and control operational processes continuously intending to identify potential opportunities for the reduction of excessive claims associated with parcel breakages in the process by implementing training solutions.

5.2 Process parameters for breakages

The second objective of the study was to identify process parameters which are resulting in breakages in the logistics and distribution process. Using the PDCA cycle, Plan (P) was the stage of design and assessment, which included identifying substantial problems and the root causes of issues by defining goals using a visual structured approach of the cause-and-effect diagram, to identify factors contributing to breakages and the underlying cause of the problem. A visual structure included a detailed breakdown of the 6M's which exposes the root causes of the problem. The cause-and-effect diagram is one of the tools used by organisations to provide information about the problems to assist in deriving solutions (Liliana 2016).

5.2.1 Results on package breakages and claims

Historical data of a 6-month period on breakages that incurred within the distribution network was obtained from packaging damage records. The data were drawn from an ERP system used at the NLC, together with measurements that were conducted on site. Figure 5.1 graphical shows a summary of cardboard packaging breakages resulting in excessive claims in the NLC. The count of package breakages is represented based on breakage reasons, which is used as a benchmark to explicate the breakage root-cause. Packaging claims are raised in relation to package breakages. If one of ten units in a package is broken or damaged, the entire package will be considered a claim. Considering at least one-unit breakage, customers file a claim against NLC to compensate for poor service delivery.

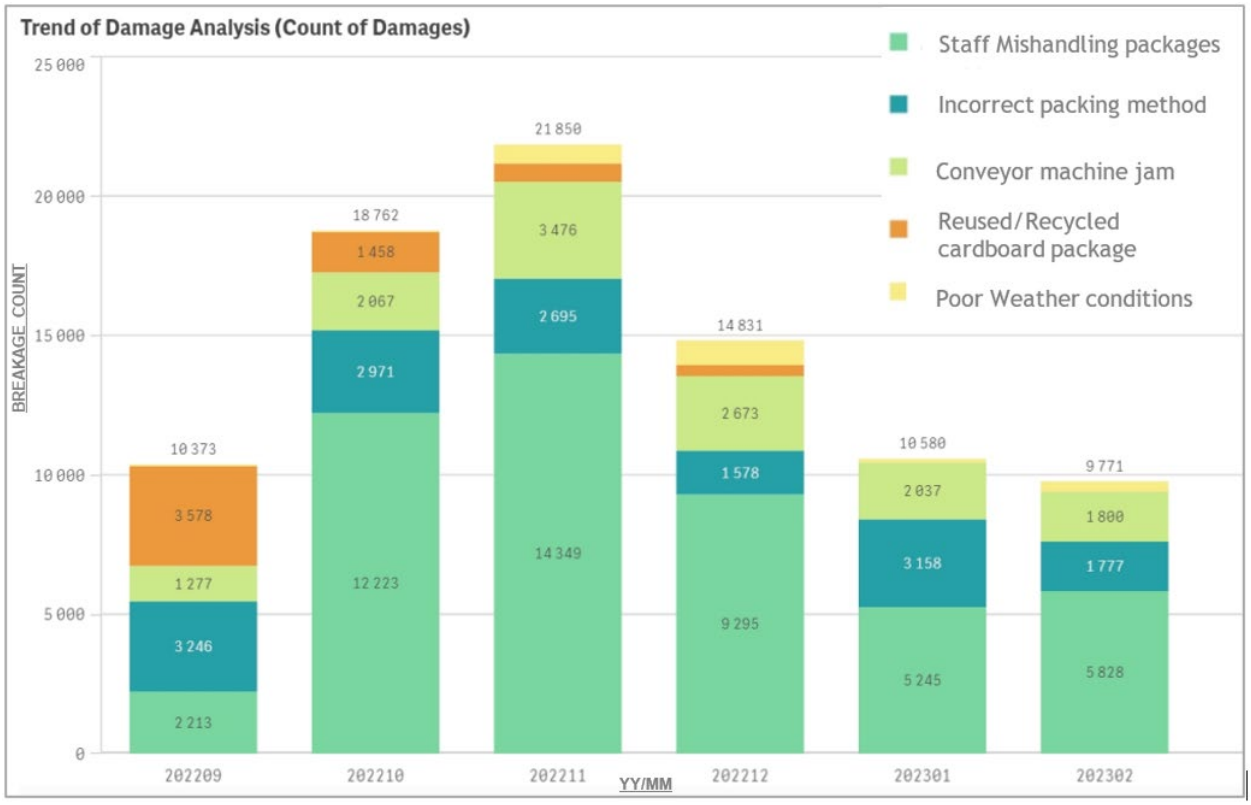


Figure 5.1: Count of package breakages over a period of 6 months

The numerical results represent a count of damages by breakage reason. The total breakage count is represented at the top of each stacked bar, each breakage reason is represented by a numerical value that reveals the contribution per breakage reason in a six-month period.

NLC handles different types of stock that also differ in rand value, depending on customer service. Some customers trade tools and appliances, whereas some customers trade retail clothing which cost less than appliances in rand value. An estimated package claim cost is R350 on average across all NLC customers.

Figure 5.2 shows a summary analysis of packaging claims for six customers in the NLC distribution network who were paid over R500 000 in claims over a six-month period. Entire unit loads could be rejected at the distribution center thereby costing well over a thousand rands each and creating significant delays for the client. Hence, it was imperative to examine how damages occurred before instituting a plan to reduce package damage during distribution and transportation through the supply chain. Freight damage

claims would include visible damage, shortage, and concealed damages that are discovered after the carrier has already dropped off the shipment. The later damage is not initially visible and discovered after the shipment is unloaded, un-palletized and the containers or boxes are opened.

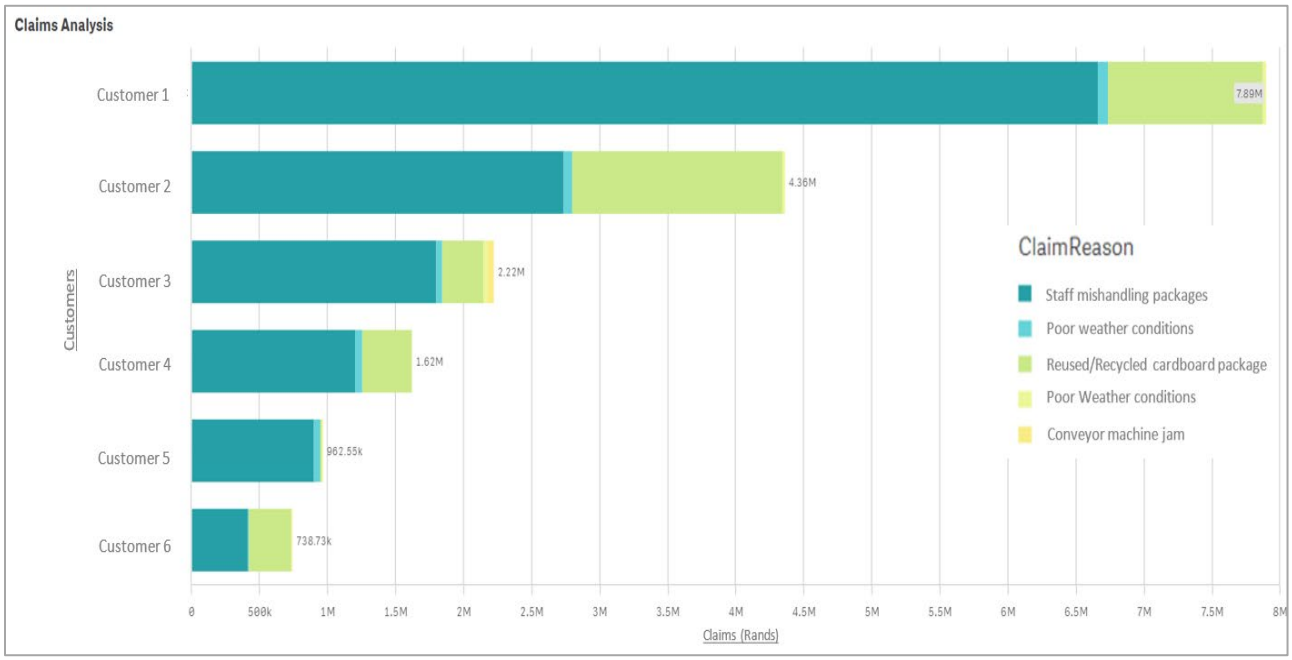


Figure 5.2: Packaging claims analysis

The most common breakage reason amongst the top six customers that has raised claims over R500 000 over a six-month period is revealed to be “staff mishandling packages” followed by “Reused/Recycled cardboard packages”. These reasons reveal opportunity for improvement for both the courier and the supplier.

5.2.2 Root cause analysis for process breakages

Figure 5.3 represents parameters that contribute to the variations and breakages within the process. This represents the deepest underlying cause of positive or negative symptoms within the logistics process that would result in elimination, or substantial reduction, of the symptom (Preuss 2003). Some of the casual factors that contribute to packaging damages were revealed to be specifications such as packaging size, weight of parcel, internal content packaging utilization, flute corrugated size used for the package and manpower struggling with heavy parcels hence resulting in more breakages.

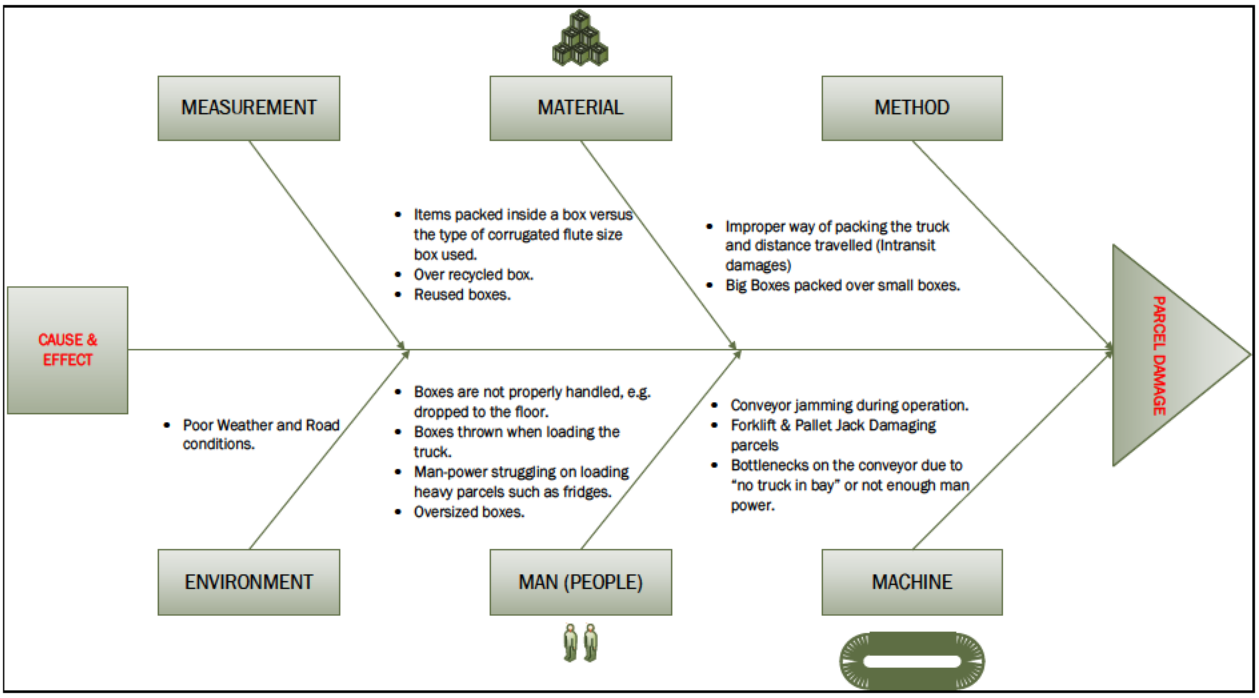


Figure 5.3: Parameters contributing to breakages

The following 6M's were used to provide details of factors that have potential influence variations or breakages.

- **Man** – the functionality of the operator includes motions such as grasping, lifting, and holding the package. Manpower mishandling was revealed to be one of the major issues, which refers to stacking, misalignment of corrugated cardboard due to lack of awareness. Negligence was also witnessed during the study, which also resulted in damages.
- **Method** – the process of offloading, sorting, and loading in logistics requires appropriate strategies to reduce breakages of parcels. Huge packaging cardboard was placed on top of small size packaging cardboard which resulted to squashing and item breakages.
- **Machine** – the systems (conveyor, sorter), tools and equipment (stillage, pallet jack) used are essential to the distribution process. Maintenance issues such as faulty or broken equipment, compromised the packaging. Furthermore, the conveyor pulleys were jamming causing the entire conveyor system to jam which resulted in packaging colliding with each other.

- **Material** – the material used by suppliers for packaging is out of the courier's control to dictate, however contributes to packaging breakages. Reused and Over-recycled packages were vulnerable and collapsed during the movement of parcels, which resulted to item breakages.
- **Mother Nature (Environment)** – the anticipation of weather conditions can be limited. Unexpected poor weather conditions such as heavy rain resulted in packaging being wet during loading/offloading due to leaking containers. Poor road infrastructure and potholes also lead to disturbance and breakage of packaging during transition.
- **Measurement** – Not a considerable factor. It is not considered a factor that influences damages.

5.2.2.1 Man

As part of the 6M's, the highest contributing factor to breakages was identified to be man. The data disclose staff mishandling packages as highest contributing factor towards breakages that occur in the distribution network with a total count of 49 153 package breakages over a period of 6 months as a result of man-power. The lack of awareness of how to handle parcels with care to optimise the distribution of parcels was identified during observations. The operators were reckless and uncertain on how to stack parcels inside the vehicle during loading and stacking for storage.

Figure 5.4 is an illustration of poor packing of parcel at loading point. In order to ensure safe transportation, there are numerous considerations and recommendations to keep in mind when handling and packing parcels inside a distribution vehicle.

Figure 5.4: Illustration of poor load securement inside the distribution vehicle

5.2.2.2 Method

The second highest contributing factor was revealed to be incorrect packing method which refers to the strategies used during receiving package stock in-bound, sorting, storage, and also when loading out-bound for deliveries. To achieve maximum stability there should be no cardboard packages over hanging when packed on top of each other, the weight should be equally distributed, and all cardboard packages should always be packed in a vertical flute direction. Due to lack of training and awareness, the incorrect method used for packing is the second highest contributing factor resulting to a total count of 13 330 package breakages enquired over a period of 6 months.

Figure 5.5 is an illustration of incorrect methods used to handle parcels. The vertical flute direction must always apply. When loading or packing cardboard packages, the sides of the package must always be vertical.

Figure 5.5: Illustration of poor methods of packing cardboard packages at storage

5.2.2.3 Machine

NLC operates in two 12-hour shifts from Monday to Friday, and on weekends when customer demand is high. Machine failure led to untold ramifications throughout the entire operation which resulted not only to package collision in the conveyor line due to conveyor jamming but also loss in productivity. A machine jam is generally caused by a conveyor belt coming off during operation as a result of high speed or dry bearings. The conveyor machine handles approximately 135 cardboard packages per minute through to the out-bound conveyor. The downtime caused by conveyor jam contributed 5% towards the availability time of the machine. The data in Table 5.1 depicts a machine's overall performance.

Table 5.1: Machine performance

OEE Factor	Actual OEE	Target OEE
Availability (A):	80%	85%
Performance (P):	49%	90%
Quality (Q):	97%	95%
OEE:	38%	73%

According to the data in Table 5.1, the overall equipment effectiveness of the machine used as the test bed is 38%. From Table 5.1, the machines availability is at 80% followed by quality of packages handled is at 97% and the lowest is on the machine performance at 49 %. Based on the data gathered, it is clear that none of the factors met the expected performance rate. This implies that the NLC conveyor machine is not operating optimally. As a result, company profits and productivity are lost due to the package damage that led to customer claims. The results demonstrated poor machine performance. It is vital that necessary measures be taken by the responsible departments such as maintenance and production departments to combat conveyor stoppages and improve availability.

5.2.2.4 Material

Poor material use was identified to be the fourth contributing factor to breakages. Most NLC clients used over-recycled and re-used corrugated cardboard packages for delivering goods to end customers, which makes the actual unit protected by the package vulnerable to breakage. The corrugated material condition was identified by measuring the actual thickness of the cardboard. Corrugated material comes in a variety of wall thicknesses known as flute sizes. A flute is a wave shaped structure that provides strength to reinforce corrugated cardboard. Furthermore, a corrugated cardboard is made from liner and the medium paper elements known as the flute (Jones 2004).

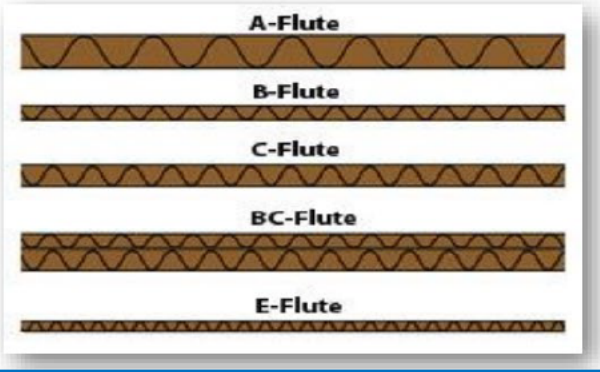
The thickness of cardboard package was measured in millimeters (mm), with single wall and double wall flute being used the most by clients. To measure the flute size precisely, a digital caliper tool was used to measure the corrugated cardboard thickness. Table 5.2

illustrates the measurements and the type of corrugated cardboard that is derived based on standards.

Table 5.2: Corrugated flute profiles derived from cardboard thickness size

No.	Caliper Start (mm):	Caliper End (mm):	Flute Profile:	Type of Board:
1	1.20	2.00	E Flute	Single wall
2	2.40	3.00	B Flute	Single wall
3	3.50	4.00	C Flute	Single wall
4	4.50	5.00	A Flute	Single wall
5	6.00	7.60	DWB BC Flute	Double wall

The flute profile type is derived from the caliper measurement. There is no single standard measurement for a flute profile, therefore measurements are provided in a range format for each flute profile. A value can be a precise measurement, or it can be between the start to the end of the caliper measurement as shown above. Double wall boxes are stronger and typically used to package heavier items. Figure 5.6 shows the corrugated cardboard flute types.



Thickness of cardboard variate from single wall **(A, B, C, E Flute)** to double wall **(BC Flute)**

Figure 5.6: Corrugated cardboard flute types

5.2.2.5 Environment

Poor environmental weather conditions had the least impact towards package breakages. Only 1% of breakages were a result of poor weather conditions. A total of 3121 package breakages were paid as claims over a period of 6 months.

5.3 Optimisation of controllable factors for reduction of packaging claims

The third objective of the study was to optimise controllable factors for reduction of packaging claims. Controllable factors in the study were identified to be Material (calculating optimal package size), Man, Method and Machine. This required developing a model to calculate the optimal package size to reduce the vulnerability of the packages, developing training solutions on optimal methods of handling packaging with care and efficiently throughout the distribution process. Improving machine performance involved adopting the standard machine capacity as per the manual provided by the manufacturer to reduce unexpected machine stoppages/failures which resulted in package collision in the conveyor line due to conveyor jamming.

Table 5.3: Machine performance rates

Current rates	Previous rates
Sorting Rate 100 carton per minute	Sorting Rate 150 carton per minute
6000 Carton per hour	9000 Carton per hour
60000 Cartons per 10-hour shift	90000 Cartons per 10-hour shift

Increasing the machine performance rate resulted in improving efficiency, reduction in material handling and package damages through jamming, thereby enabling full control and higher throughput. The Pearson correlation coefficient formula was used to determine the significance of two packaging variables, such as packaging weight and flute corrugated size on a cardboard package. It expresses the strength of association between variables. A sample of ten cardboard packages was used to measure correlation, packages were obtained from ten different customers within the distribution network. X value represents the package weight, and the Y value represents the flute size.

The Pearson correlation coefficient formula is calculated as follows:

$$r = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2}\sqrt{\sum(y-\bar{y})^2}} \quad (5.1)$$

Table 5.4: Packaging weight and flute corrugated size parameters for breakages

Damaged package	Package Weight (kg)	Flute Size (mm)	Flute profile	(x-ẍ)	(y-ẏ)	(x-ẍ)(y-ẏ)	(x-ẍ)²	(y-ẏ)²
1	7.2	4.3	C Flute	-4.0	0.2	-1	16.4	0.0
2	4.5	3.9	C Flute	-6.8	-0.3	2	46.0	0.1
3	24.3	4.3	C Flute	13.1	0.2	3	170.7	0.0
4	15.2	5.2	A Flute	3.9	1.1	4	15.1	1.2
5	9.0	1.9	E Flute	-2.3	-2.3	5	5.1	5.1
6	7.0	2.0	E Flute	-4.3	-2.2	9	18.1	4.7
7	9.0	1.0	E Flute	-2.3	-3.1	7	5.1	9.7
8	17.0	6.6	DWB BC Flute	5.7	2.4	14	33.0	6.0
9	6.0	6.2	DWB BC Flute	-5.3	2.0	-11	27.7	4.1
10	13.4	6.0	DWB BC Flute	2.2	1.9	4	4.7	3.5
					Σ	**37**	**341.9**	**34.4**

The results of the correlation analysis are as follows:

$$r = \frac{37}{\sqrt{341.9}\sqrt{34.4}} = 0.34 \quad (5.2)$$

The value of 0.34 is between the range of moderate correlation (0.3 to 0.7), therefore considering this range, this correlation is moderate. When one variable changes, the other variable changes in the same direction. These two variables are considered non-controllable. Since the package used is determined by the client's supplier, the NLC can only develop a model that will calculate the optimal packaging size for items to keep intact and reduce the potential of package damaged.

5.3.1 Capturing damaged packages

In the Do (D) stage, all damaged packages went through a quality check (QC), where package details were measured and captured. This was implemented to measure all package damage received in the distribution network and to understand package specifications that resulted in package damage.

Figure 5.7 represents a process flow developed that illustrates a workflow on capturing details of a damaged package. The data captured brought insight to the organization in terms of damage package detail description.

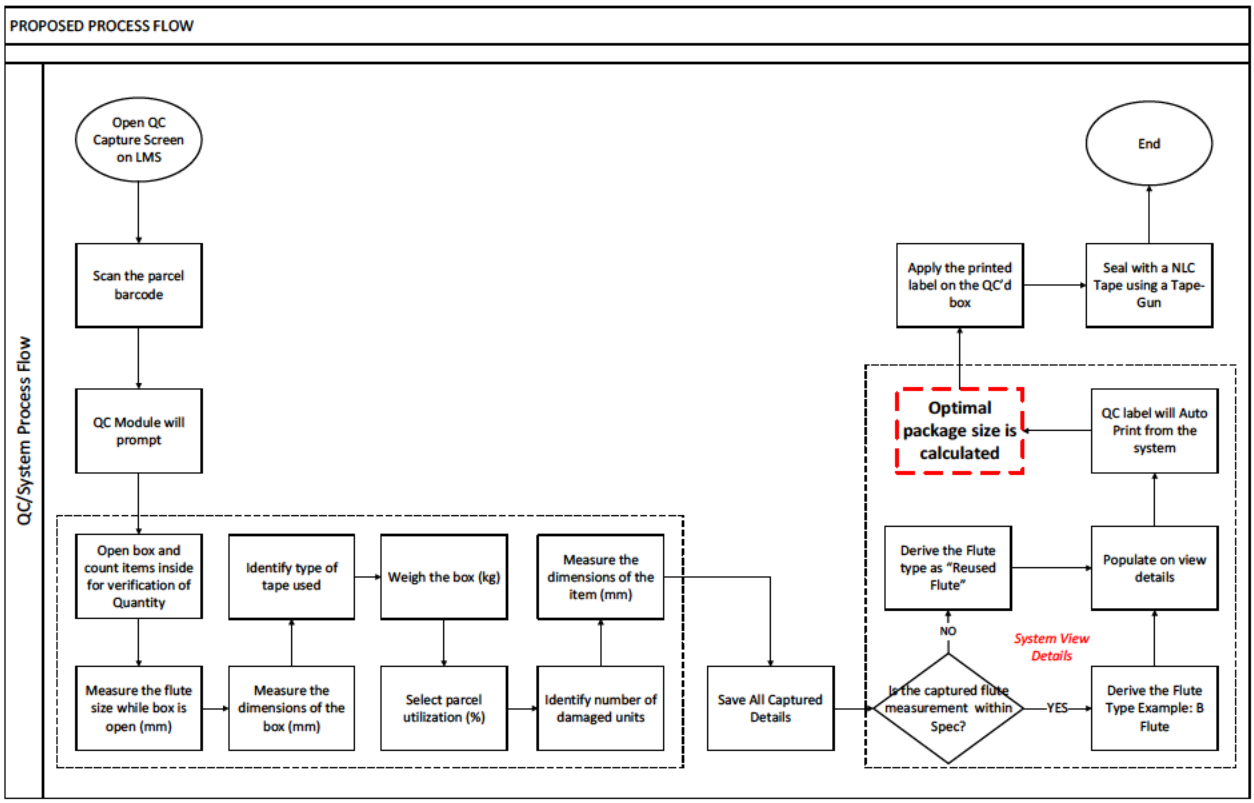


Figure 5.7: QC capture process flow

The aim of this module is to provide a platform for QC to capture a detailed description of every damaged parcel received at each distribution center and requires repairing. It includes a QC capture screen and the damaged parcel dashboard. Figure 5.8 below shows the damaged parcel dashboard.

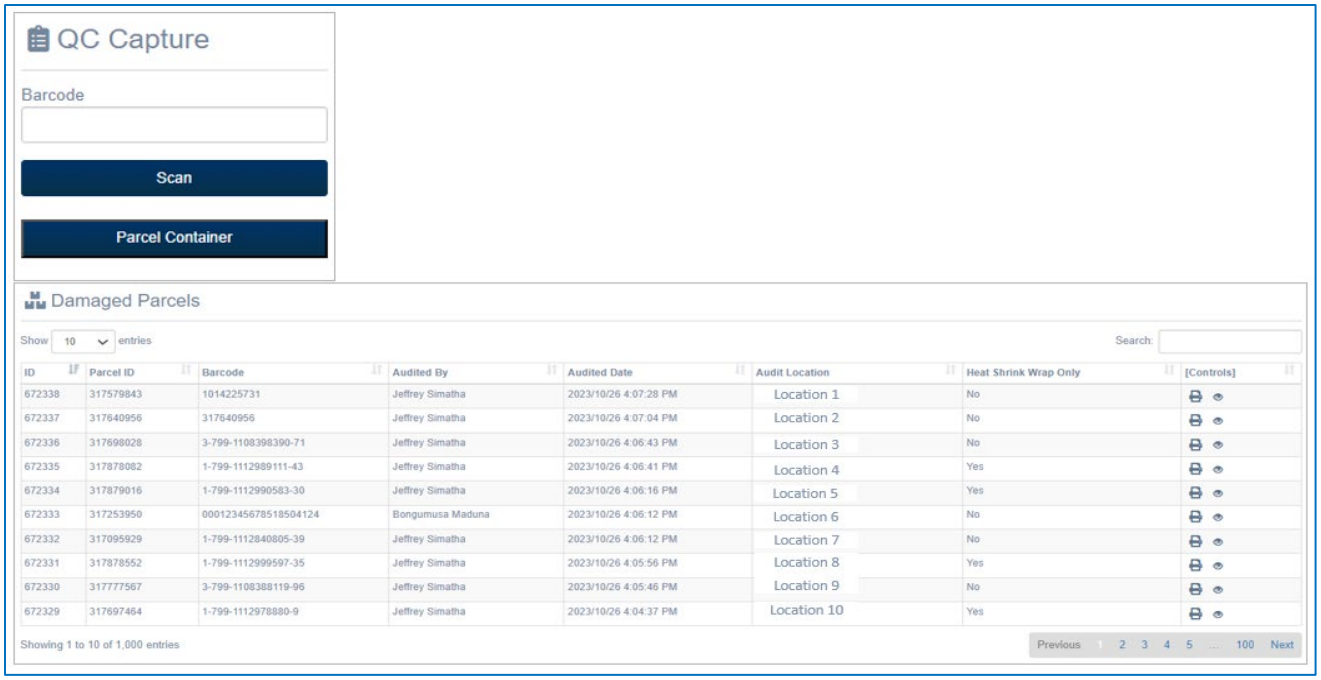


Figure 5.8: Damaged parcel dashboard

5.3.2 Measuring damaged packages

In order to understand all aspects of the damaged package, the Check (C) was executed with the aim to construct a database for capturing structured information relating to damages received inside the distribution network. Figure 5.9 illustrates how to measure the dimensions of the box using a tape measure, that is measuring the length, width and height of the box precisely.

Figure 5.9: Package dimensions

Figure 5.10 illustrates how to open the box and count items inside to indicate quantity of items received and damaged.

Figure 5.10: Performing item count

Figure 5.11 illustrates the step of measuring the weight of the package using a scale.

Figure 5.11: Weigh the cardboard package

Once measurement is completed, the barcode of the package is scanned to access the measurement capture screen. All measured details are captured and the save button is clicked once completed capturing. Figure 5.12 refers to the capture screen used to record detailed variables of damaged packages.

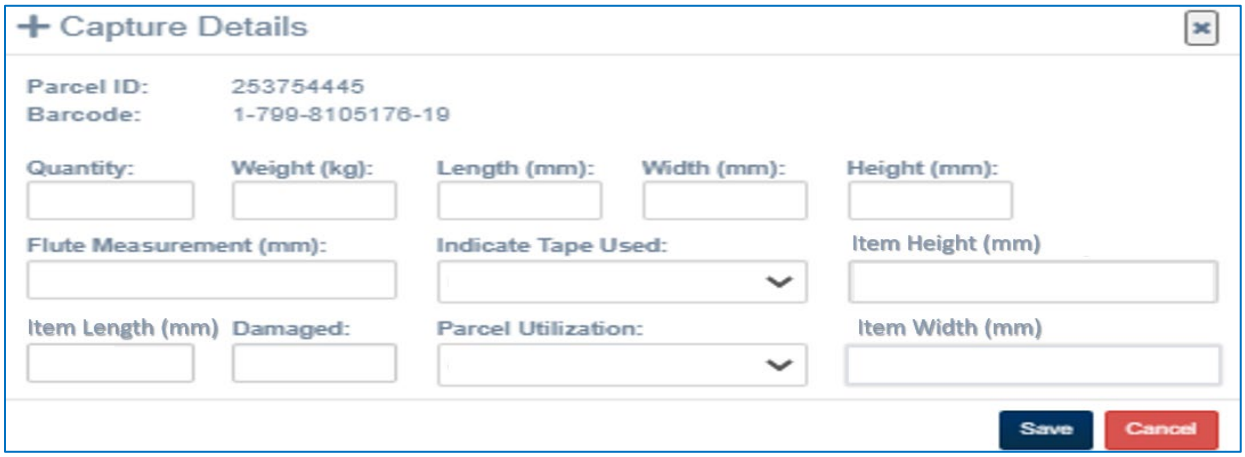


Figure 5.12: Capture details screen

Once capturing is completed, a calculated optimal size will be generated as a proposed package size based on item measurement. The variables used to develop the model were box weight, flute thickness size, box length, box width, box height, item length, item width and item height. Figure 5.13 demonstrates an optimal package size of an item derived from captured variables of a package.

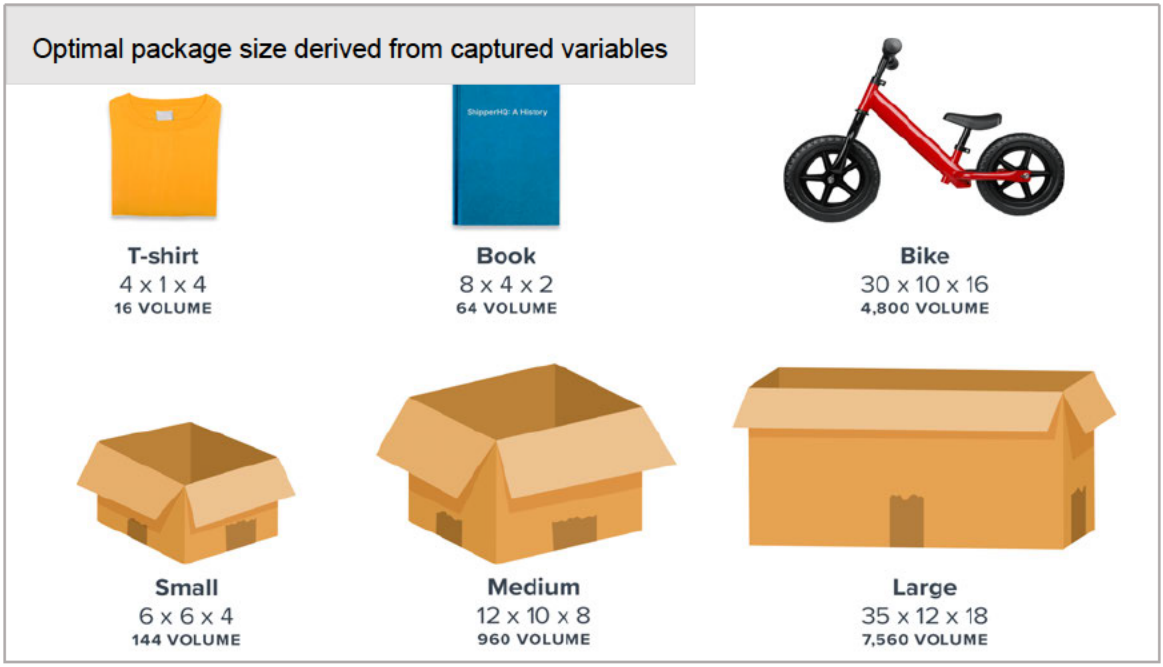


Figure 5.13: Optimal package size

5.3.3 Regression model to calculate optimal package size

This process involves replacing the provided supplier cardboard package with an optimal corrugated cardboard size depending on captured variables, item shape, weight, flute and existing cardboard size. During the Action (A) phase, statistical analysis was conducted to validate the results, which were then utilized to construct a regression model for optimizing package size. To derive a good model for optimisation of a package, it was required to develop a model for each variable (dimensions) of a cardboard package.

5.3.3.1 Optimization of box length

The first model developed for optimisation of a package was for the length of the box. To determine a good model, four variables namely box weight, flute thickness size, box length and item length were used to develop the model and did not provide good results. However, the best model was derived from three variables, box weight, flute size and item length. Table 5.5 below illustrates the results that produced a good model to determine the optimal length of a package.

The results show that at least one variable (x variable 2) has a p-value is less than 0.05, therefore there's a better chance of getting a good model that computes an optimal length

of a package. Furthermore, the Multiple R of 0.995 represents that there is a positive correlation between the three variables since the value is close to +1.

The mathematical method used to determine the optimal length of a package was a linear equation ($Y = mx + c$). The dependent variable which is the proposed box length was considered to be a function of box weight, flute size and item length. As seen in equation 5.3, this equation will be used to determine the optimal length of the package which will be derived from the box weight, flute size and item length.

$$Proposed\ Box\ Length = (Box\ Weight \times -0.332) + (Flute\ Size \times 1.556) + (Item\ Length \times 0.933) + 2.388 \quad (5.3)$$

Table 5.5: Regression results for determining optimal length of a package

Multiple R	*0.995*							
R Square	*0.991*							
Adjusted R Square	0.989							
Standard Error	1.615							
Observations	20							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	3	4773.982	1591.33	609.583	1.06E-16			
Residual	16	41.768	2.610					
Total	19	4815.75						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2.388	1.215	1.965	0.066	-0.187	4.963	-0.187	4.963
X Variable 1	-0.332	0.180	-1.843	0.083	-0.713	0.049	-0.713	0.049
X Variable 2	1.556	0.660	2.357	0.031	0.156	2.956	0.156	2.956
X Variable 3	0.933	0.024	37.568	4.92E-17	0.881	0.986	0.881	0.986

5.3.3.2 Optimization of box width

The second model developed for optimisation of a package was for the width of the box. The best model was derived from four variables, box weight, flute size, box width and item width. Table 5.6 below illustrates the results that produced a good model to determine the optimal width of a package.

The results show that (x variable 3) and (x variable 4) both have a p-value that is less than 0.05, moreover a positive correlation of variables with a value of 0.994. The mathematical method used to determine the optimal width of a package was a linear equation ($Y = mx + c$). The dependent variable which is the proposed box width was considered to be a function of box weight, flute size, item width and box width. As seen in equation 5.4, this equation will be used to determine the optimal width of the package which will be derived from the box weight, flute size, item width and box width.

$$Proposed\ Box\ width = (Box\ Weight \times -0.170) + (Flute\ Size \times 0.787) + (Item\ width \times 0.527) + (Box\ width \times 0.433) + (-0.360) \quad (5.4)$$

Table 5.6: Regression results for determining optimal width of a package

Multiple R	0.994							
R Square	0.988							
Adjusted R Square	0.985							
Standard Error	1.374							
Observations	20							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	4	2445.643	611.410	323.419	2.34127E-14			
Residual	15	28.356	1.890					
Total	19	2474						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-0.360	1.614	-0.223	0.826	-3.800	3.080	-3.800	3.080
X Variable 1	-0.170	0.149	-1.138	0.272	-0.488	0.148	-0.488	0.148
X Variable 2	0.787	0.522	1.505	0.152	-0.327	1.902	-0.327	1.902
X Variable 3	0.527	0.116	4.537	0.000	0.279	0.775	0.279	0.775
X Variable 4	0.433	0.115	3.764	0.001	0.188	0.679	0.188	0.679

5.3.3.3 Optimization of box height

The third model developed for optimisation of a package was for the height of the box. The best model was derived from two variables, box weight, item height and box height. Table 5.7 below illustrates the results that produced a good model to determine the optimal height of a package.

The results show that (x variable 2) has a p-value less than 0.05, in addition the Multiple R results tell us that there is a good correlation between the two variables since the value is 0.997 and close to +1. The mathematical method used to determine the optimal height of a package was a linear equation ($Y = mx + c$). The dependent variable which is the proposed box height was considered to be a function of item height and box height. As seen in equation 5.5, this equation will be used to determine the optimal height of the package which will be derived from item height and box height.

$$Proposed\ Box\ heigth\ = (Item\ height\ \times\ 0.74) + (Box\ height\ \times\ 0.265) + 0.203) \quad \textit{(5.5)}$$

The optimal volume (v) of a package will be derived by:

$$V = Proposed\ Box\ Length\ \times\ Proposed\ Box\ Width \times Proposed\ Box\ Height \qquad (5.6)$$

Table 5.7: Regression results for determining optimal height of a package

Multiple R	0.997								
R Square	0.994								
Adjusted R Square	0.993								
Standard Error	0.899								
Observations	20								
	ANOVA								
	df	*SS*	*MS*	*F*		*Significance F*			
Regression	2	2422.795	1211.397	1497.253		7.7473E-20			
Residual	17	13.754	0.809						
Total	19	2436.55							
	Coefficients	*Standard Error*	*t Stat*	*P-value*		*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	0.203	0.614	0.331	0.744		-1.092	1.499	-1.092	1.499
X Variable 1	0.744	0.103	7.208	1.4632E-06		0.526	0.962	0.526	0.962
X Variable 2	0.265	0.098	2.701	0.015		0.058	0.472	0.058	0.472

5.3.4 Mathematical model for optimizing dimensions

Further to the regression model, a mathematical model for optimizing dimensions of packages in courier services was developed using the Simplex LP method of the Solver Add-in on Excel. Considering the tableau variables and linear programming model, the Simplex method was the most relevant method to derive an optimal solution. A sample results of the mathematical model will be presented considering the following variables and objectives:

Table 5.8: Package variables

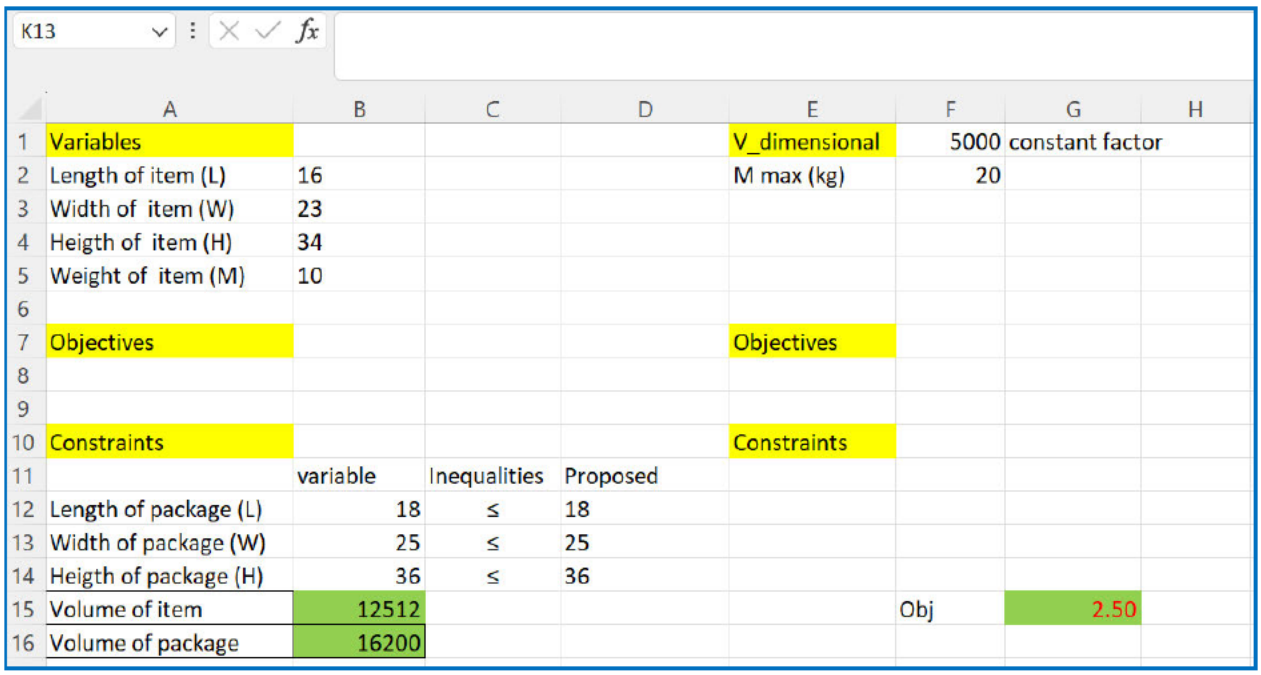
Variables:
1. Length of the package (L)
2. Width of the package (W)
3. Height of the package (H)
4. Weight of the package (M)

Figure 5.14 below illustrates the solver parameter window with input values. To minimize the package dimensions and achieve optimal package size, the Solver Add-in was used to generate results. The objective was to distinguish between item dimensions and package dimensions by adding 2cm to the item dimensions to derive package dimensions in terms of length, width and height. Table 5.9 below shows the variables and objectives used to achieve optimal package size using this mathematical technique.

Table 5.9: Variables and Objectives

A	B	C	D	E	F	G
Objective Function:	Minimize $V = L \times W \times H$	Decision variables:	L	W	H	Objective value:
		Parameters:	16	23	34	2.5
Constraints:	L ≤ L_max					
	W ≤ W_max					
	H ≤ H_max					
Objective Function:	Minimize $D = L \times W \times H / V\_dimensional$	V_dimensional (Constant factor):	5000			
Constraints:	M ≤ M_max	M max (kg):	20			

Figure 5.14 below illustrates the variables, objectives and the results generated by Simplex LP method, excel references are clearly shown in the spreadsheet.



	A	B	C	D	E	F	G	H
1	Variables				V_dimensional	5000	constant factor	
2	Length of item (L)	16			M max (kg)	20		
3	Width of item (W)	23						
4	Heigth of item (H)	34						
5	Weight of item (M)	10						
6								
7	Objectives				Objectives			
8								
9								
10	Constraints				Constraints			
11		variable	Inequalities	Proposed				
12	Length of package (L)	18	≤	18				
13	Width of package (W)	25	≤	25				
14	Heigth of package (H)	36	≤	36				
15	Volume of item	12512				Obj	2.50	
16	Volume of package	16200						

Figure 5.14: Excel spreadsheet illustrating Solver Add-in results

Step 1: We use less than or equal to symbols (< =) because we aim to minimize the total volume of a package, which reduces the dimensional weight.

Step 2: The decision variables, L, W and H are blank because these are required.

Step 3: The Objective value was found using this formula: =(B2*B3*B4)/F1

Step 4: Selected Data menu and clicked Solver. The Solver Parameter window populated. Input values:

Set Objective: G15

To: Tick Min

By Changing Variable Cells: D12: D14

Subject to the Constraints: Click Add and Under Cell Reference, selected B12 and under Constraint, selected D12 respectively. This is represented under Figure 5.16 solver parameter window. The values of the variables in cell B12, B13, B14 are constraints by the proposed dimensions in cell D12, D13, D14.

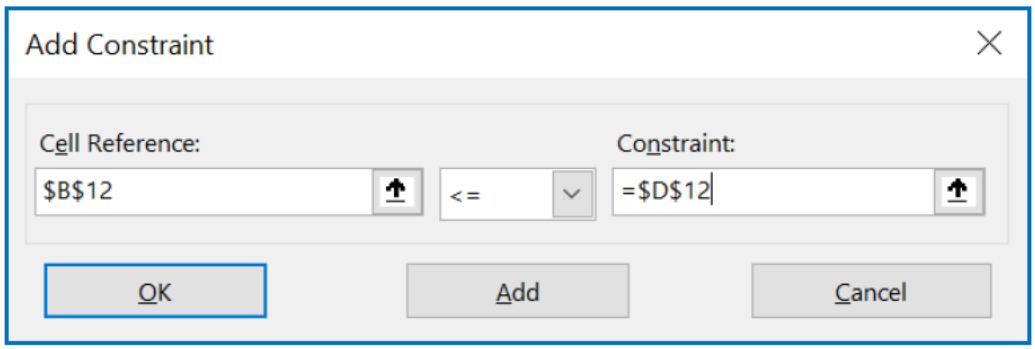


Figure 5.15: Adding a constraint

Note: The Solving method was selected to be Simplex LP. ***Solve*** was then selected after choosing this method.

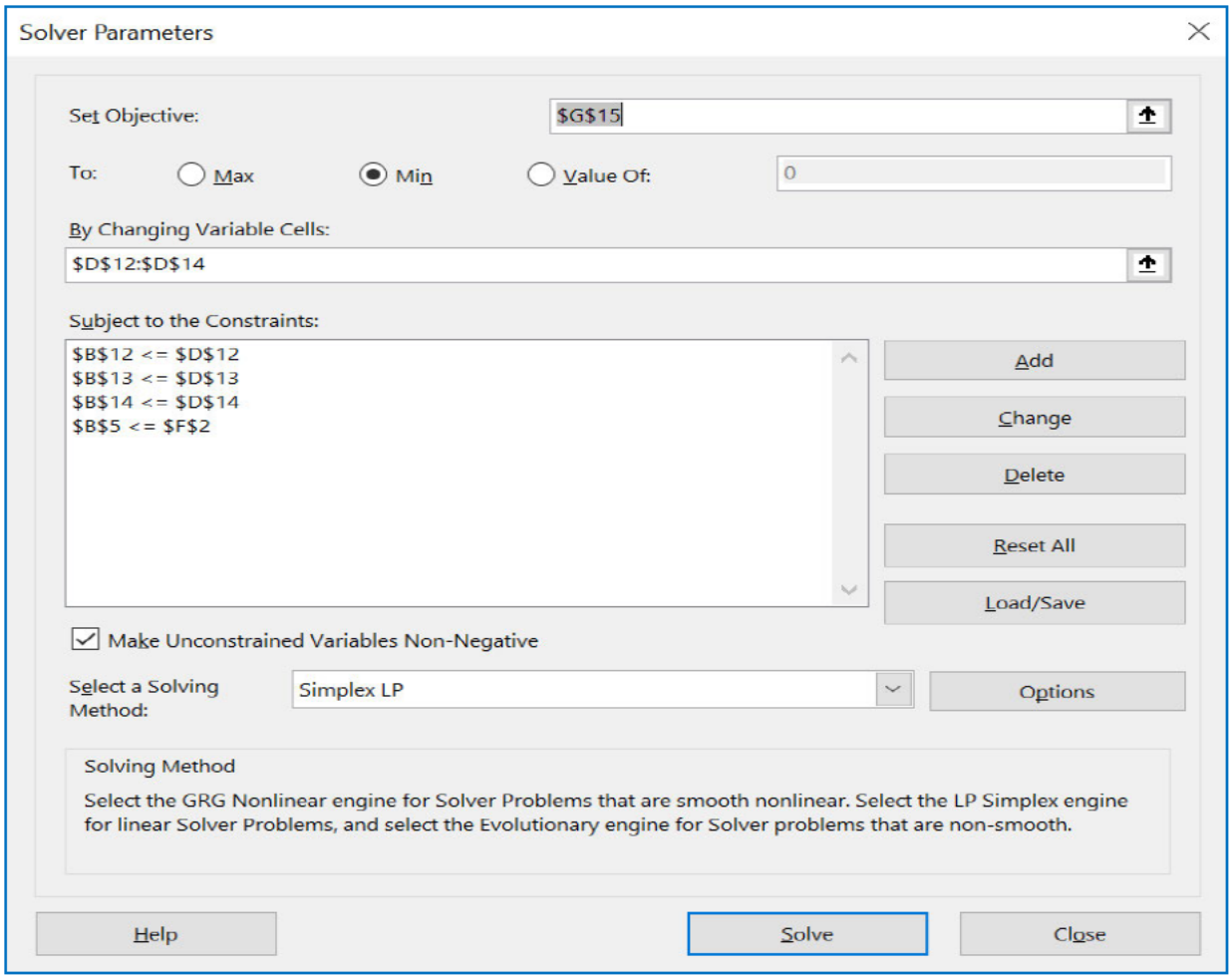


Figure 5.16: Solver parameter window

Figure 5.17 below shows a message which indicates, “Solver found a solution”. After clicking “OK” the values of decision variables clearly populated on the Excel spreadsheet.

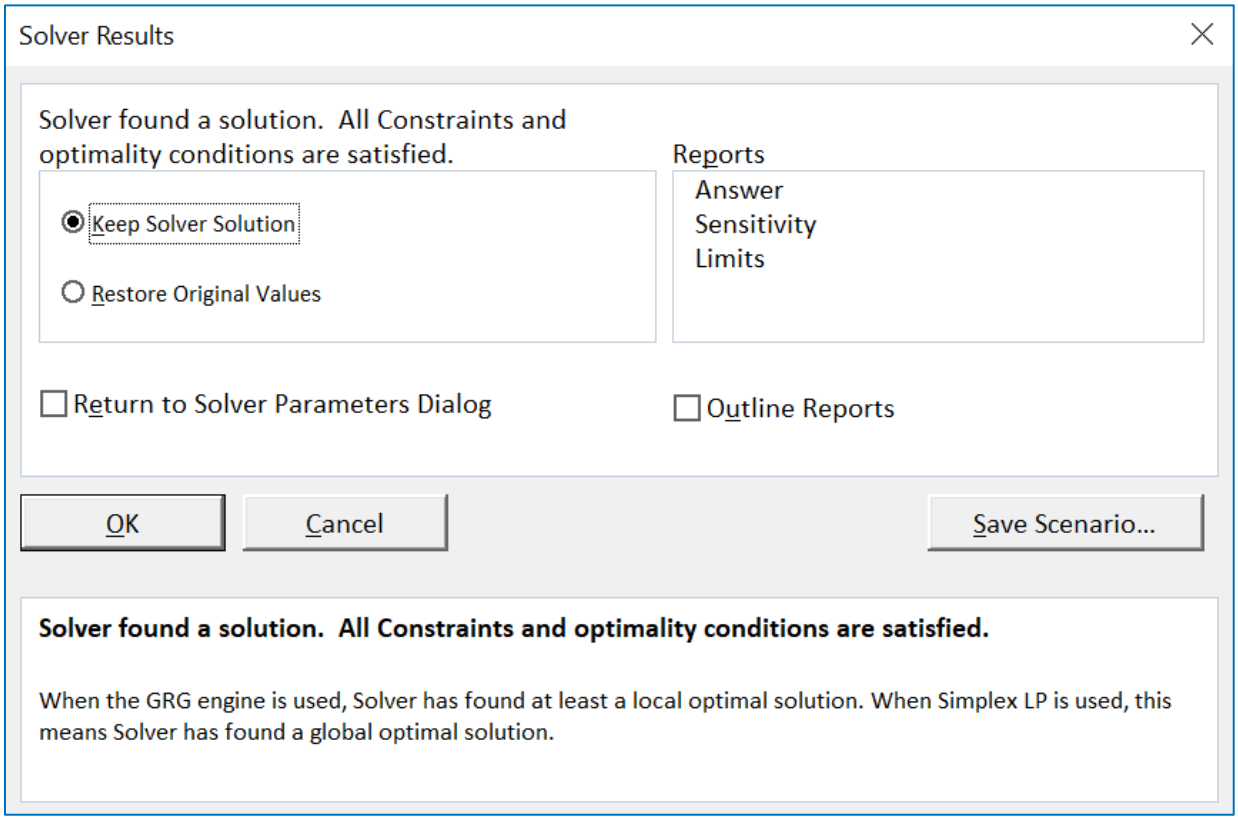


Figure 5.17: Solutions found by solver

Solver then displayed the results of decision variables as shown below on Table 5.10. This is supported by Figure 5.14 above, since the results derived by the model using the provided variables and constrains are illustrated. The model reveals that for an item to have an optimal package size, an addition of 2cm must be added to the original size of an item.

Table 5.10: Results of decision variables

A	B	C	D	E	F	G
			L	W	H	
Objective Function:	Minimize $V = L \times W \times H$	Decision variables:	**18**	**25**	**36**	Objective value:
		Parameters:	16	23	34	2.5
Constraints:	L ≤ L_max					
	W ≤ W_max					
	H ≤ H_max					
Objective Function:	Minimize $D = L \times W \times H / V\_dimensional$	V_dimensional (Constant factor):	5000			
Constraints:	M ≤ M_max	M max (kg):	20			

5.4 Development of training solutions for sustainment of distribution of parcels

The fourth objective of the study was to identify factors that could be used to develop training solutions to empower employees with skills for sustained optimisation of logistics and distribution of parcels. The Do (D) phase also included implementing training solutions aimed at empowering employees to sustainably optimize logistics and parcel distribution. Man-power was discovered to be the highest contributing factors towards package breakages due to lack of awareness on handling packages to reduce breakages. Cardboard packages and fragile goods are easily prone to breakages, which require awareness and commitment of line operators to achieve customer satisfaction by reducing breakages.

As part of developing training solutions, a video framework was developed to represent precautionary handling strategies and methods that need to be adopted. The framework was developed to create awareness on how parcels should be handled within the NLC network to improve efficiencies and reduce breakages. The framework represented the following solutions:

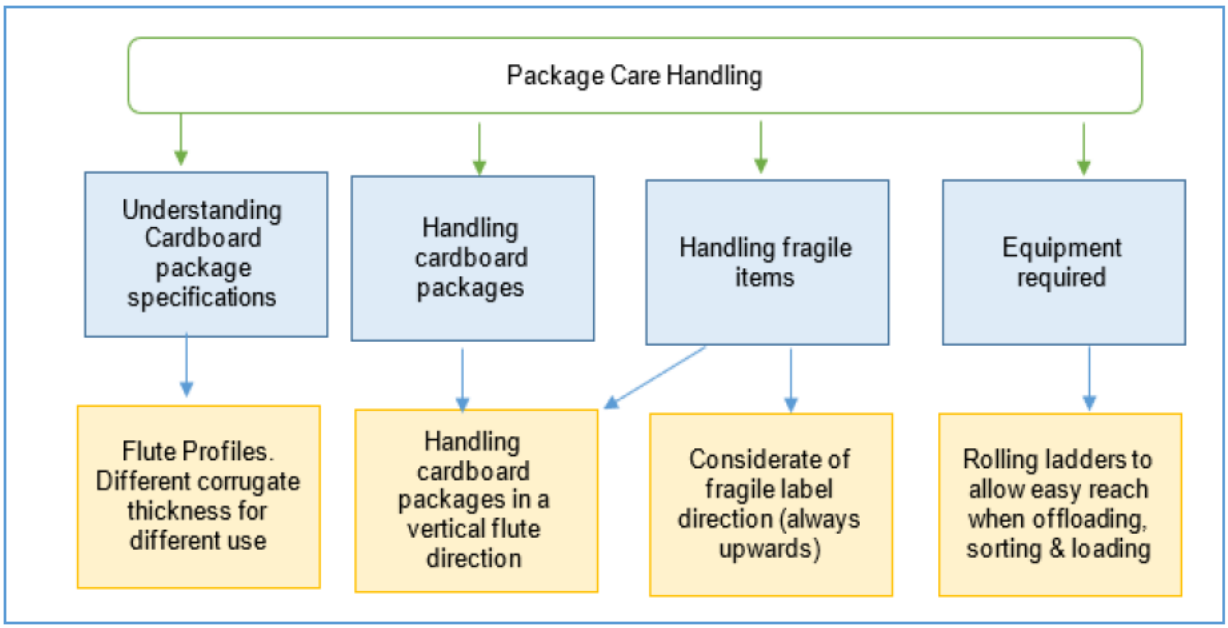


Figure 5.18: Training framework

The second step aimed to troubleshoot the potential root causes as shown in Table 5.11 below, identify the inspection procedures to be followed, and the observations to be carried out.

Table 5.11: Troubleshooting potential causes for packaging breakages

Potential root cause	Inspection	Observation
Incorrect method of handling	Perform PHES to check VFD on handled cardboard packaging	Lack of awareness on handling packaging correctly
Incorrect cardboard size used for packaging item	Perform PID to check cardboard size used against packaged item	Some packaging found to be underutilized
Conveyor jamming during operations	Check if there is enough chain lube on the inbound and discharge conveyor	No issues were observed
Incorrect adhesive tape	Perform PID to check adhesive tape used on cardboard packaging	No issues were observed
Incorrect stacking strength	Perform PHES to check VFD on cardboard packaging ensuring stacking strength	Some cardboard stacked incorrectly
Reused cardboards for packaging	Check for worn cardboard packaging	Some cardboards were worn

5.4.1 Understanding corrugated cardboard package specifications

Since the cardboard packages vary in size and strength, it is important for human resources to understand the cardboard packaging handled in the NLC network. Following the implementation of the model that derives the optimal package size, it was discovered that double wall boxes are stronger and generally used to package heavier items.

Figure 5.19 below describes the cardboard packaging specifications. Flute profiles are composed of glue, two paper liners and wave shaped paper fluting. Larger flute profiles provide more vertical compression strength and cushioning, whereas smaller flute profiles improve the structural capabilities of packaging.

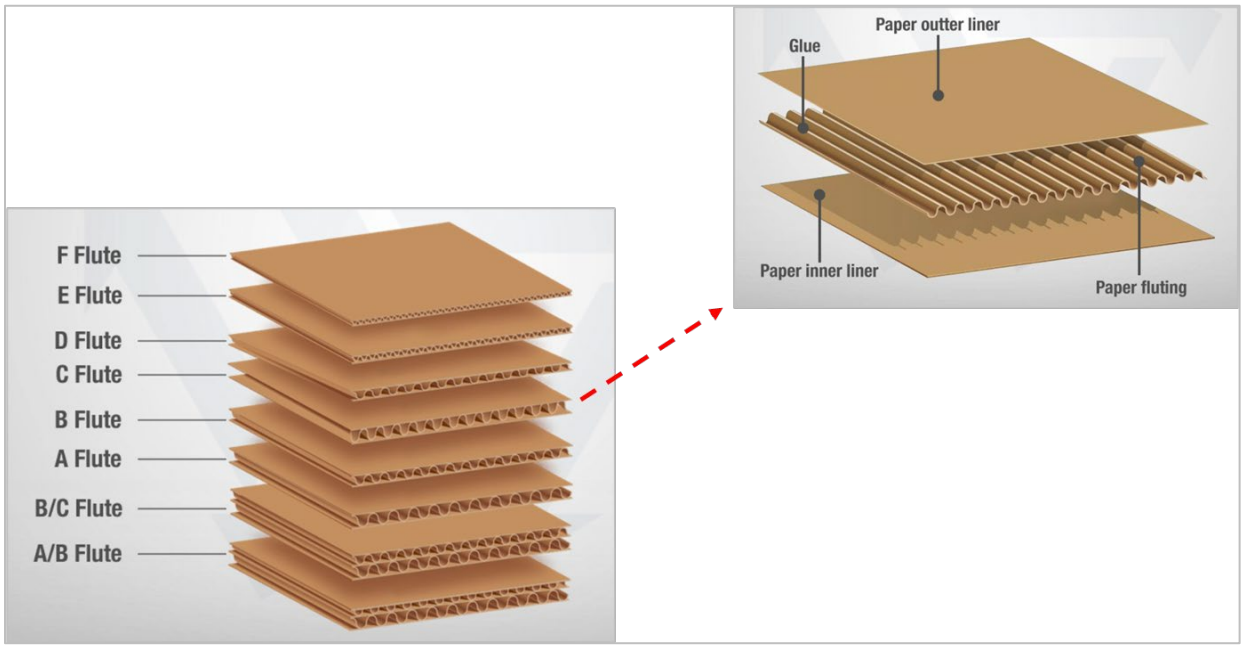


Figure 5.19: Corrugated cardboard package specifications

According to Bivainis and Jankauskas (2015) who conducted a study on corrugated cardboard, one of the most commonly used materials in the creation of packaging on various kinds of products is corrugated paperboard. This is a material with a multi-layered structure called corrugated paperboard (CPB), and it typically consists of three or five different layers of glued paper. During distribution or storage, packaging with goods may sustain punctures from exposure to the weight of other commodities, drops from heights, and shock loads during transit. The thickness, grammage, number of layers, component

paper layers, and type of fluting of corrugated paperboard use in its production vary depending on the function and size of the package.

5.4.2 Handling cardboard packages

To strengthen the cardboard package and avoid breakages, packages must always be stacked and packed in a vertical flute direction. When looking at a package, the flute direction must always be vertical on all sides of the cardboard package. Alternatively, when handling the cardboard packages, the flaps should always be on top to decrease the chances of the product bulging out of the package.

Vertical flute orientation will offer best stacking strength when loading, offloading, sorting and staging stock, whereas the horizontal flute orientation will offer poor stacking strength. Figure 5.20 shows a brief example of a vertical flute direction versus the horizontal flute direction.

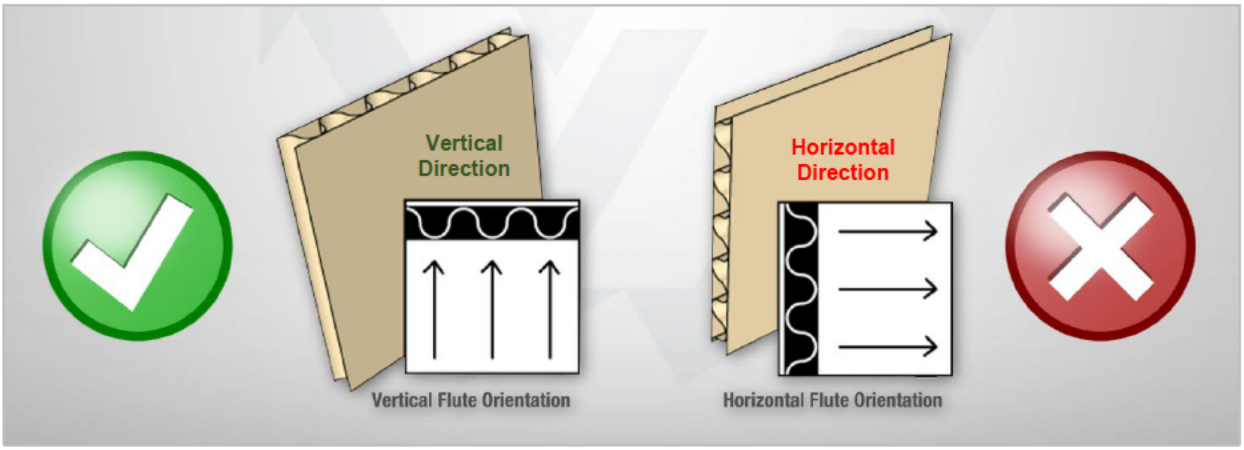


Figure 5.20: Vertical flute direction vs horizontal flute direction

This awareness training empowered operators with the skill needed to handle packaging in the best way to achieve this commitment as part of distribution operations. Kaasinen *et al.* (2020) conducted a research on empowering and engaging industrial workers with Operator 4.0 solutions and revealed that the foundation of worker empowerment is adjusting the work area to the worker's ability, needs, and skills while assisting the worker in realizing and expanding his or her own competence. Developing training solutions included representing the precautionary information as a video illustrating methods and strategies to be applied. The video represented the following solutions:

- **Handling Cardboard packages -** To strengthen the cardboard packaging and avoid breakages, packaging must be stacked and packed in a vertical flute direction. When looking at a box, the flute direction must always be vertical on all sides of the box. A flute is a wave shaped structure that provides strength to reinforce corrugated cardboard. A package stacked in a horizontal flute direction is compromised and can easily be damaged.
- **Handling fragile items -** The PPMs were found to be in line with the manufactured cardboard package. The cardboard flute is in a vertical orientation, correlating the "upward" marking on a cardboard package. As shown in Figure 5.21 below, the markings are aligned with how the cardboard package is manufactured.

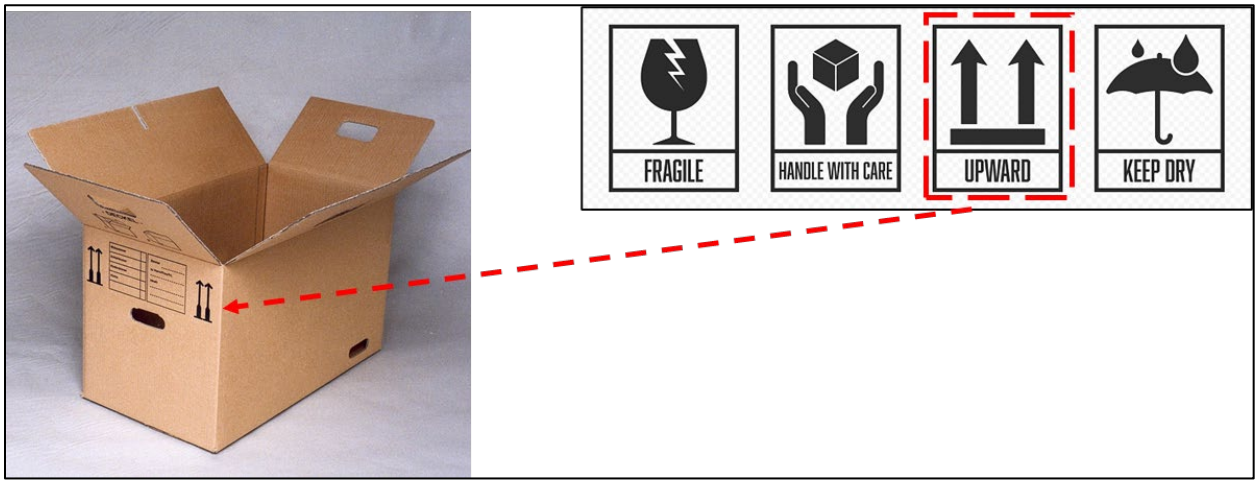


Figure 5.21: PPMs are aligned with manufactured cardboard package

- **Equipment to be considered to reduce parcel damages -** Adequate mobile safety ladders must be used when offloading shipping container trailer, using ladders to offload a container will allow for stock to be easily reached which prevents the collapsing of parcels. Furthermore, using ladders when loading shipping containers will allow for ease of reach, ensuring packaging is packed tightly without any space gapping for distribution of parcels.

5.4.3 Consideration of fragile label direction

Packages with fragile items must be handled, staged and packed with care ensuring the fragile label direction is considered and always facing upwards, which is aligned with the vertical flute direction. Singh and Singh (2005) presented a study which illustrated

warning labels and pictorial markings that can be used on packages. The examples of pictorial markings included ‘Fragile Handle with Care’, which indicate that the content of the package is fragile and has to be handled with care. Fragile stickers are guides which show that the item inside a package is easily breakable and should be handled with care.

Figure 5.22 illustrates a cardboard package that displays a fragile sticker and an arrow facing upwards which indicates the direction a package should be handled.

Figure 5.22: Fragile cardboard package

5.4.4 Equipment considered for reduction of breakages

Rolling ladders allow accessibility of packages when offloading and loading at high storage locations. Using ladders to offload allows easy reach of packages, which prevents the collapsing of parcels. Furthermore, using ladders to load allows for ease of reach ensuring packages are packed tightly. Excessive breakages can be easily reduced by understanding the culture of handling packages with care.

PARCEL HANDLING EVALUATION SHEET						
Date:	**Depot:**		**Area of Responsibility:**		**Responsible person:**	
Important Notice: Please indicate the score for each Method based on the level described					Points target: 12	
METHOD CONCERN	**CHECK FOR** (method of Inspection)	LEVEL (1)	LEVEL (2)	LEVEL (3)	LEVEL (4)	Level indicator
FLUTE DIRECTION	Vertical flute direction applied with parcel flaps on the top to offer best stacking strength	Staff are not aware of handling stock in a vertical flute direction	No vertical flute direction applied	Some boxes are packed in a vertical flute direction	All boxes in a vertical direction and evenly distributed	0
FRAGILE PICTORIAL BOX MARKINGS	Correct stacking pattern, considerate of Fragile sign	Pictorial markings not considered & not adhered to	Some pictorial markings are considered & adhered to	Pictorial markings are considered but do not correspond with flute direction	All pictorial markings considered & parcels are staged/handled correctly	0
EQUIPMENT HANDLING	Suitable equipement used to handle, sort & transport parcels	Incorrect & Broken Equipment used to handling	Incorrect Equipment used for handling	Correct Equipment used but broken equipment used for handling	Correct and suitable equipment used for movement and handling of parcels	0

Figure 5.23: Parcel handling evaluation sheet

Source: Developed by author

Figure 5.23 shows a parcel handling checklist for the optimisation of logistics and distribution of parcels. The following methods were used to elicit information from management, supervisors and operators for measuring and monitoring the progress of the implemented assessment of how to handle parcels to improve efficiencies and reduce breakages with the logistics network.

As part of sustainability, a parcel handling evaluation sheet was developed. Appendix 3 shows a parcel handling evaluation sheet which aims to measure and monitor progress. Method of concerns pursue to answer the following questions:

- Flute direction must be vertical on all sides of the box when stacking as this will ensure the box offers the best stacking strength. This can be easily identified by ensuring the cardboard flaps are visible on top. For the below departments, what percentage of stock comply with the vertical flute direction?
- Fragile stickers provide guidelines on how to handle stock based on the content of the box. Arrows provide directions on how boxes must be stacked. For the below departments, what % of stock comply with the stacking direction as indicated on the fragile sticker?

- Please identify the condition of the equipment used for transporting and sorting parcels at each operational department listed below.

5.5 Discussion

The development of training solutions resulted in an improvement in parcel handling as a result of packaging breakage reduction. The improvements include stacking corrugated cardboard in a vertical flute direction at all times to increase stacking strength and performing packaging feasibility studies on a regular basis.

Figure 5.24 depicts a comparison of before and after packaging breakages scenarios. There has been a decrease in packaging claims after the optimisation of controllable factors and implementation of training solutions, which has broadened the significance of package care handling. A successful consignment of 150 000 parcels delivered in one month to a consignee is equivalent to generating a R1 million-rand sale. In the before scenario, the highest number of package breakages in one month was 21 850 which is 15% of the delivered parcels. The findings show that there is a significant improvement following interventions on issues highlighted by the root-cause diagram for cardboard packaging damages and reduced the number of breakages drastically to 5 570 which is 4% of the delivered parcels in the month of Apr-23.

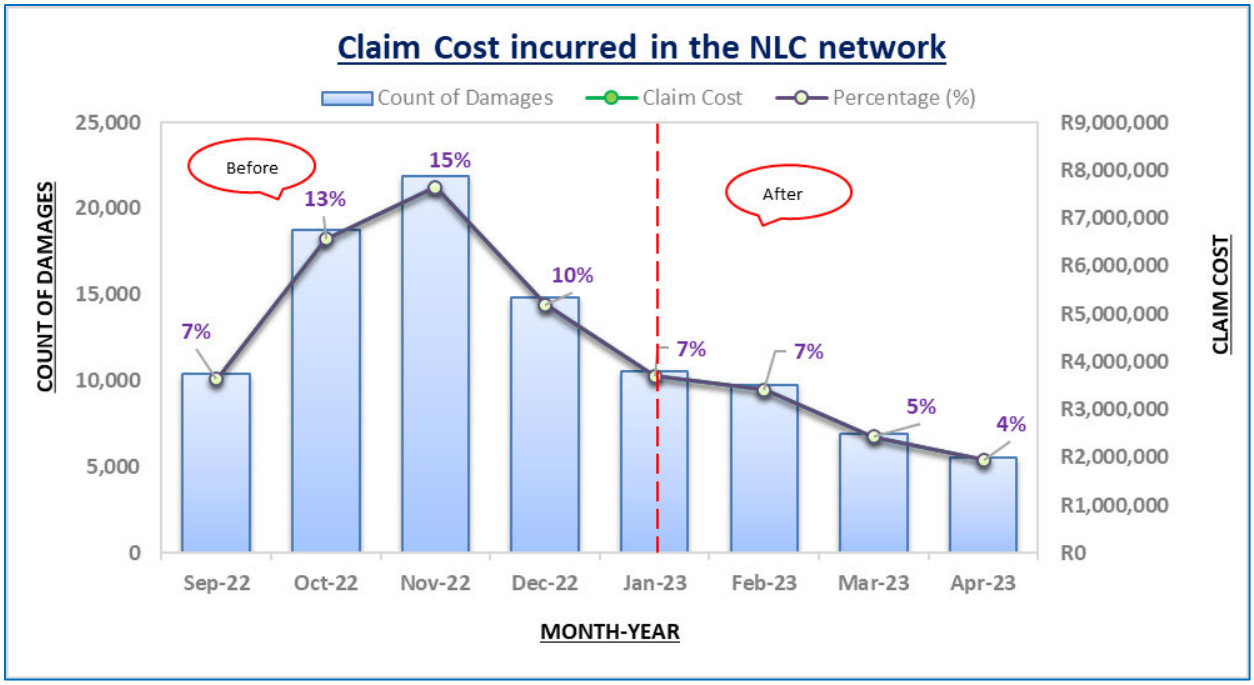


Figure 5.24: Comparison of before and after training solutions implementation

5.6 Conclusion

The aim of this chapter was to present and interpret the empirical findings related to the influence of process parameters resulting breakages in the NLC business. The optimisation of controllable factors and development of training solutions empowered operators to handle packages with care, which has resulted in substantial cost savings and better sustainability of operations. The optimization of packaging size was viable since the regression model was developed using Excel which is widely accessible on windows platform at no extra cost. The model was used to develop an optimal package size that was used for distribution of parcels in the local courier service with and aim of minimizing the dimensional weight of the package, to account for the space a package occupies relative to its actual weight, which may affect pricing.

Training solutions that were developed enhanced the relationship between the consumers and the suppliers since the right package was delivered in the right quantity, in the right condition, at the right place, at the right time, to the right customer, at the right price. To obtain a diverse range of ideas and opinions, the quantitative study was conducted at a local courier service in South Africa.

The outcome of the research revealed a significant improvement in the overall logistics process and the financial performance of the organisation. The logistics process transformation of the NLC proved to have a positive impact on the financial performance of the business by increasing its ability to attract more customers.

The next chapter discusses the conclusions and recommendations based on the findings of the study. The conclusions are related to the research objectives and research problems.

CHAPTER 6 : CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The previous chapter discussed and presented the findings of the study with an aim to either answer or reject the research questions stated. It is crucial that results are discussed in detail to offer precise recommendations based on findings from the study and draw conclusions. This chapter will focus on conclusions and recommendations of the research study.

The logistics and distribution industry must adapt its operations to the shifting market dynamics due to the constantly shifting economic conditions. Currently, the business process operations design is the most important and significant role in the distribution of goods in courier services. The aim of the study was to optimise logistics operations and distribution of parcels by eliminating customer packaging claims, customer complaints and increase business revenue in a local courier service based in South Africa. It was observed that the business's financial performance benefited positively from the decrease in package damage.

6.2 Research Conclusions

The study involved defining and measuring variables that influenced the package, which resulted in packaging expenses. A tool that was used to determine and show potential causes for packing breakages was a cause-and-effect diagram supported by the VSM which was used to expose inefficiencies in the cross-docking process. It was concluded that the process parameters which were resulting in breakages can be improved if it is a controllable factor. Therefore, it was concluded that controllable factors can be optimized to reduce packaging claims. Furthermore, it was concluded that implementation of training solutions can be implemented to empower employees for sustained optimisation of logistics and distribution of parcels.

The challenge of this study was to find a solution for all controllable factors that have a negative influence on logistics and distribution packages. The controllable factors included human resources, machine performance and packaging material used by courier service suppliers. This study demonstrated how complicated calculating the optimal size

of package can be as it is dependent on various variables. The variables were added to the system to form a comprehensive package analysis model which produced optimal package size requirements. Mathematical models were developed to identify the optimal package size of a parcel by minimizing dimensional weight to reduce transportation cost while increasing the rate of items arriving safely and intact. Furthermore, training solutions were developed to improve package handling in the cross-docking process and distribution.

The outcome of this research was complete and ready for use at the NLC. The system was able to process data, do calculations, and effectively support the business to make constructive decisions. Implementing training solutions on parcel handling created awareness and empowered employees to work toward a common goal.

6.3 Recommendations

This study explored a distribution solution based on optimising processes which involve handling, sorting, and storage of packages in local a courier service with an aim of reducing packaging claims. However, it is recommended that damaged cardboard packages which are received from suppliers must be optimised by calculating and deriving the optimal package size for the item to be carried throughout the supply chain. It is recommended that NLC consider this system as a start for a comprehensive study to determine a packaging solution. Further to this, it is recommended that training on package handling is provided more frequently in a form of refresher training to achieve process conformance and increase employee confidence.

Following the model has determined the ideal packaging size, it is recommended that the NLC disseminate information captured and stored in the database with their suppliers since this will increase awareness of optimal package size that can be used by suppliers, and potentially identify standard package size that can be used.

6.4 Limitations of the study

The study was limited to local courier service in South Africa, comparable surveys should be carried out throughout all provinces of South Africa to provide a wide scope and ensure a reliable representation of courier services in the study. It will also be interesting to

conduct a study on other types of packaging such as plastic packaging and its influence on the financial performance of the logistics industry.

6.5 Area for future studies

Logistics activities of manufacturing cardboard packaging were not thoroughly examined in this study. For instance, customers might be resistant to changing the current packaging while suppliers are looking for the best packaging alternative and future research can focus on this role. Furthermore, future studies can focus on the development of standard optimal packages which can be derived from supplier product design.

6.6 Conclusion

The research approach for the first objective of the study, which was to analyse the process for distribution of parcels in a logistics company that practices cross docking operation, to identify potential opportunities for the reduction of excessive claims associated with parcel breakages in the process, was presented in this chapter. The research approach adopted for this objective was the lean six-sigma tool SIPOC diagram, which was used to identify all relevant process parameters before the study commence. The research approach also adopted a value stream mapping which was used to reveal critical steps of both material and information to remove waste in value streams.

The research approach for the second objective of the study, which was to identify process parameters which are resulting in breakages in the logistics and distribution process, was presented in this chapter. The research approach which was adopted to identify process parameters resulting in breakages was the 6M's fishbone diagram. The research approach for the third objective was to optimise controllable factors for reduction of packaging claims. The correlation analysis was crucial for providing the relevant information on packaging specifications that determine a detailed information regarding the packaging material of a cardboard, to understand its durability performance and develop solutions to eliminate packaging breakages. The system was built by system developers in the NLC organisation thereafter a workshop was conducted to the system users to ensure that they understand the system and will be able to use it effectively.

Excessive package damage can be easily reduced by understanding the culture of handling stock with care. The fourth objective of the study was to identify parameters that could be used to develop training solutions to empower employees with skills for sustained optimisation of logistics and distribution of parcels. The awareness training has broadened the understanding of the importance of parcel handling and empowered operators to handle parcels as expected within our operation. The NLC's training programs and the development of mathematical models resulted in the achievement of distribution and logistics optimization within the NLC organisation.

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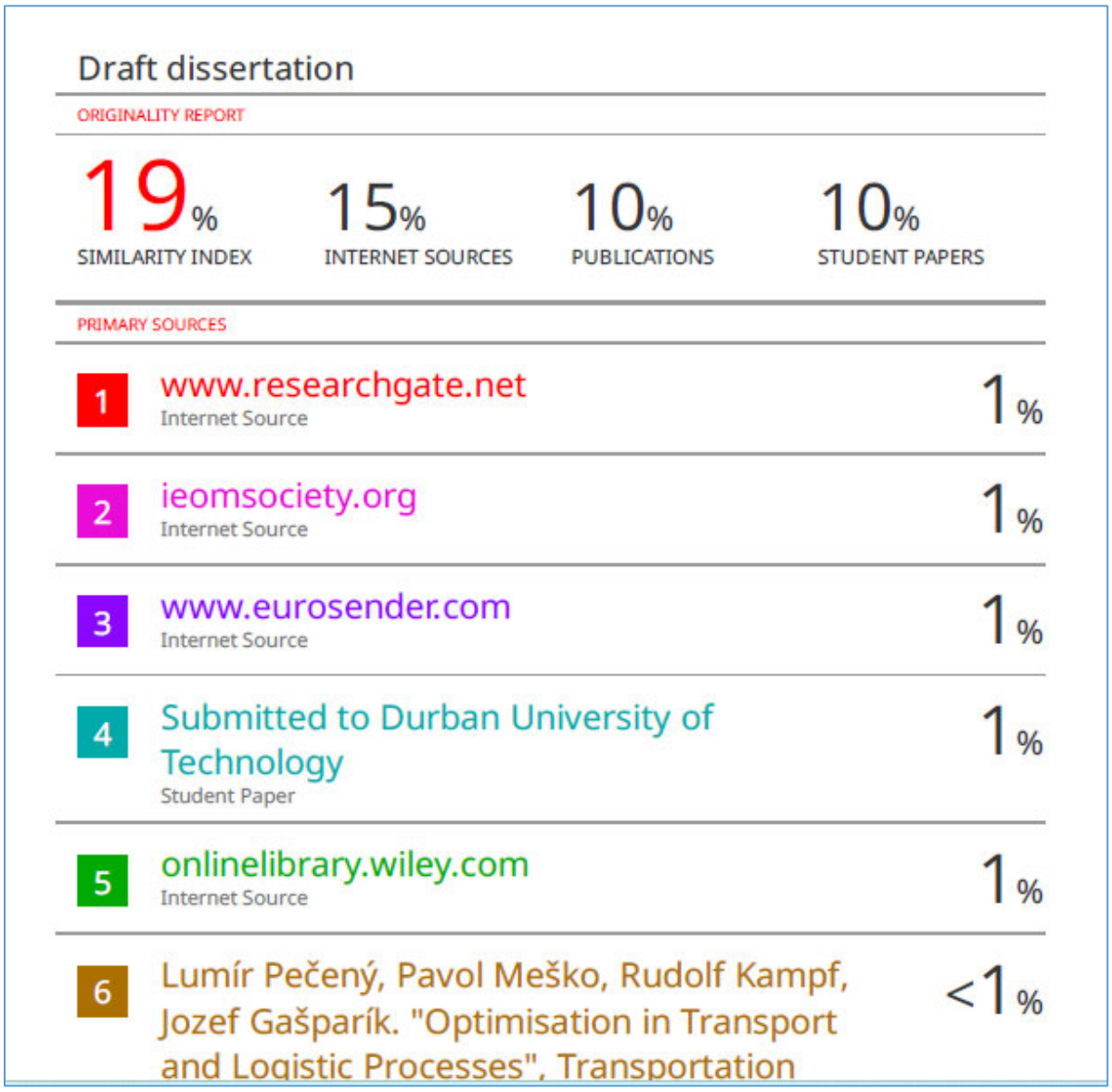
Appendices

Appendix 1: Turnitin report for plagiarism



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Appendix 2: Introduction to Research Ethics Certificate

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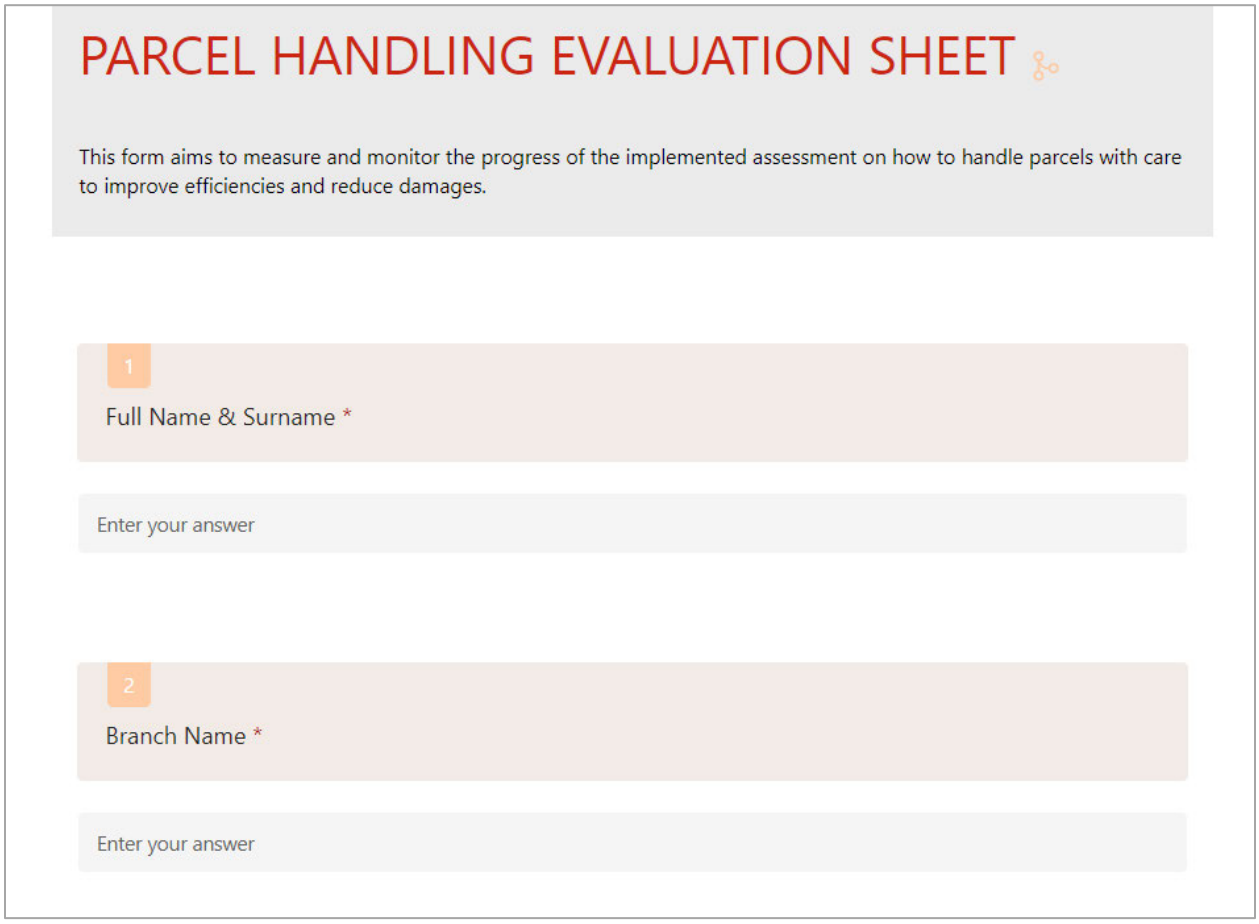
Appendix 3: Parcel handling evaluation sheet



PARCEL HANDLING EVALUATION SHEET

This form aims to measure and monitor the progress of the implemented assessment on how to handle parcels with care to improve efficiencies and reduce damages.

1

Full Name & Surname *

Enter your answer

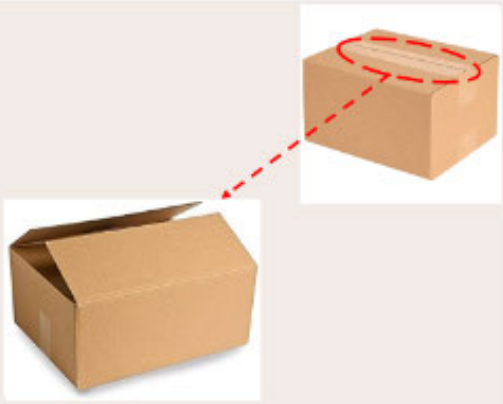
2

Branch Name *

Enter your answer

3

Flute direction must be vertical on all side of the box when stacking as this will ensure the box offers the best stacking strength. This can be easily identified by ensuring the cardboard flaps are visible on top.
For the below departments, what % of stock comply with the vertical flute direction?



Flute *— A flute is the wave shaped structure that provides strength to reinforce corrugated cardboard*

Vertical direction *— the flute goes from top to bottom along the sides of the box "and the flaps are on top" **

	0 - 19%	20 - 39%	40 - 59%	60 - 79%	80 - 100%	N/A
Handling parcels at receiving	○	○	○	○	○	○
Staging sorted stock on pallets and stillages	○	○	○	○	○	○
Loading distribution vehicles	○	○	○	○	○	○
Linehaul loading	○	○	○	○	○	○

4

Fragile stickers provide guidelines on how to handle stock based on the content of the box. Arrows provide direction on how boxes must be stacked.
For the below departments, what % of stock comply with the stacking direction as indicated on the fragile sticker? *

	0 - 19%	20 - 39%	40 - 59%	60 - 79%	80 - 100%	N/A
Handling parcels at receiving	○	○	○	○	○	○
Staging sorted stock on pallets and stillages	○	○	○	○	○	○
Loading distribution vehicles	○	○	○	○	○	○
Linehaul loading	○	○	○	○	○	○

5

Please identify the condition of the equipment used for transporting and sorting parcels at each operational department listed below? *

	Incorrect Equipment used	Correct Equipment, in good condition	Correct Equipment, requires repairs
Handling parcels at receiving	○	○	○
Staging sorted stock on pallets and stillages	○	○	○
Loading distribution vehicles	○	○	○
Linehaul loading	○	○	○