Performance of a customised picking system in a fast moving consumer goods distribution centre

by
Wayne Peter Lucas

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Supervisor: Prof Johannes Jacobus Louw (Stellenbosch University, South Africa)
Co-supervisor: Prof Johanna Helena Nel (Stellenbosch University, South Africa)

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Abstract

In the business world the majority of industries need an efficient supply chain to get their products to their customers. An integral link in this supply chain is the distribution centre (DC) that collects and distributes products to various end consumers for the business. Of the various functions, which forms part of the DC's daily operations, possibly the most influential in affecting efficiency, is picking. Ineffective picking can negatively affect the DC's performance and add greatly to the expenses of the business. In an effort to increase efficiencies, many organisations develop and implement customised picking systems in their DCs. Whether or not these customised picking systems actually enhance the performance of the DC is a question that needs to be addressed.

Research in the form of a case study was done at Pick n Pay's Philippi DC in the Western Cape, who gave permission for their name and information to be published within this thesis in a public domain. The aim of the research was to analyse the newly installed picking system, which was designed and customised specifically for this facility, and replaced a more traditional pick path sequence in which pickers start at one end of the facility and are guided through rows of shelving, picking articles on their way and finishing at the opposite end of the facility. The new pick tunnel is substantially different to the old picking facility. In order to maximise space utilisation the pick tunnel consists of four picking levels. Pickers are dedicated to each level and do not pick from multiple levels. The research for this thesis compared the performance of the old picking system with that of the new one.

An operational assessment was conducted on both systems in which employees were followed and their daily activities were documented. With regard to the quantitative research, a framework was developed in which the KPIs of the facility as well as a balanced scorecard were used to measure the change in performance of the DC. Questionnaires were used to investigate the balanced scorecard. This was to determine and justify the reasoning behind the specific metrics, which were used in the scorecard. In addition to this framework, an Independent t-test and Bonferroni multiple comparison tests were conducted to determine whether there were significant differences in the KPIs measuring throughput and efficiency. The findings of the thesis were that the implementation of the new picking method did lead to an improvement in the performance of the fast moving consumer goods (FMCG) DC, specifically the volume processed through the facility.

The strategic KPIs measured by the balanced scorecard also showed that the majority of the strategic goals were met. Further, similar studies should be done in the future to determine whether this is the case.

This research resulted in a framework being developed to measure the impact of picking methods on a DC, and investigated whether implementing a unique picking method resulted in operational advantages for Pick n Pay’s Philippi DC.

Opsomming

Verskeie nywerhede in die sakewêreld, indien nie almal nie, maak staat op ‘n effektiewe voorsieningsketting om hul produkte by hul verbruikers te kry. Een aspek van hierdie voorsieningsketting is distribusiesentrums wat gebruik word vir die samevoeging en herverspreiding van produkte aan besighede se afstroom verbruikers. Verskeie funksies in die distribusiesentrum vorm deel van hul daaglikse bedrywighede. Een van die mees vername funksies is die van uitsoek van produkte vir versending. Indien uitsoek nie effektief gedoen word nie, loop ʼn distribusiesentrum die risiko van verlaagde prestasie en kan onnodige uitgawes vir die onderneming tot gevolg hê. Sommige besighede het reeds unieke uitsoekstelsels ontwikkel en geïmplementeer om hul distribusiesentrums se effektiwiteit te help verhoog. Daar is egter nog ‘n gaping in kennis rakende die vraagstuk of hierdie unieke uitsoekstelsels in werklikheid die prestasie van distribusiesentrums verbeter of nie.

ʼn Gevallestudie navorsingsontwerp is gevolg en is uitgevoer by Pick n Pay se Philippi DC, wie hulle toestemming gegee het om die inligting openbare kennis temaak vir die tesis. Die doel was om die nuwe doelvervaardigde uitsoekstelsel, spesifiek vir die fasiliteit ontwerp en geïnstalleer, te ontleed. Die vorige uitsoekstelsel is gebaseer op 'n tradisionele uitsoek-loop-volgorde waarin die uitsoeker by een punt van die fasiliteit sal begin en gerig word deur rye met rakke, artikels uitsoek op sy pad totdat hy aan die teenoorgestelde kant van die fasiliteit sy opdrag voltooi het. Hierdie metode het veroorsaak dat uitsoekers ʼn groot area dek en ʼn lang tyd neem om te voltooi. Die uitsoektonnel is heelwat anders as die vorige uitsoekfasiliteit. Om die ruimtebenutting te maksimeer is die uitsoektonnel uit vier uitsoekvlakke saamgestel. Uitsoekers word toegewys aan elke vlak en voer nie uitsoekwerk op verskillende vlakke uit nie. Hierdie tesis het die verandering in prestasie van die vorige uitsoekstelsel na die nuwe stelsel ondersoek.

Deelnemende observerende navorsing is gebruik vir die operasionele beoordeling van werknemers se daaglikse aktiwiteit. Met betrekking tot die kwantitatiewe navorsing is ‘n raamwerk ontwikkel met sleutel prestasie-indikators vir die fasiliteit. Dit is in saam met ʼn gebalanseerde telkaart gebruik om die prestasie (en verandering in prestasie) van die distribusiesentrum te evalueer. Vraelyste is ook gebruik om die gebalanseerde telkaart te ondersoek. Die doel was om spesifiek die oorsprong van die maatstawwe vir die telkaart te bepaal. Bykomend tot die raamwerk is die T-toets en Bonferroni se meervodige vergelykings gebruik om te bepaal of daar ʼn beduidende verskil in die persentasie-indikators was wat deurset

en effektiwiteit prestasie meet. Die gevolgtrekking bereik was dat die implementering van die nuwe uitsoekstelsel tot ‘n verbetering in die algemene prestasie van die Philippi distribusiesentrum veroorsaak het, spesifiek die volume wat die distribusiesentrum kan hanteer beduidend verbeter het.

Die strategiese KPIs gemeet deur die gebalanseerde telkaart dui aan dat meeste van die strategiese doelwitte vir die distribusiesentrum wel bereik is. Hierdie stelling moet weer in die toekoms ondersoek word.

Die raamwerk ontwikkel in hierdie navorsing kan help met die akkurate meting van die deurset en effektiwiteit prestasie van ander Pick n Pay distribusiesentrums. Dit kan ook help met die identifisering van areas wat positief en negatief beïnvloed word. Hierdie impakte kan gemeet word asook geleentheid vir verbetering aantoon.

Table of contents

List of figures

List of tables

List of abbreviations

3PL	Third party logistics service provider
AMT	Arm mounted terminals
DC	Distribution centre
FMCG	Fast moving consumer goods
HU	Handling unit
KPI	Key performance indicators
OWR	Overall work rate
P&D	Pick and drop zones
SKU	Stock keeping unit
TMS	Transport management system
BCP	Business contingency plan
QC	Quality check
PPA	Post pick audit
ATP	Available to pick
AOD	Acceptance of delivery
OHASA	Operational health and safety act
TAT	Turn-around time
OWR	Overall work rate

TU	Transport unit
CEO	Chief executive officer
PROTEA	Plan, respond, order, team work, evaluate, advance
OPS	Operations
WMS	Warehouse management system
RF	Radio frequency device
MHE	Material handling equipment
FL	Fork lift
RT	Reach truck
PPT	Personal power transport
WERC	Warehousing Education and Research Council
IT	Information technology
IS	Information systems

Chapter 1: Introduction

In todays world there are various sectors of business from IT to legal, all rendering products and services to the public. Within this vast list is one sector which provides the bread and butter to the public, the household items which are essential to live from day to day, the fast moving consumer goods (FMCG) sector (Majumdar*,* 2004). A business which falls into this sector is Pick n Pay, one of many retailers in South Africa who strive to provide their customers with the widest range of products at the most affordable prices (Lucas, 2014).

Pick n Pay rely on a strong supply chain to ensure their products are on their store shelves at the right time and price to meet customer demands (Govender, 2014). To ensure this happens they have various distribution centres (DC) throughout South Africa which play a key role, one of which is based in Philippi. The DC recieves stock from vendors, stores the stock, picks it and dispatches it to stores for customers. This thesis is based on measuring the changes in performance within the DC when a key element, the picking of products, is changed.

1.1 Background and rationale

A supply chain must use the two-way flow of goods, information and financials across multiple organisations as if it was one, to satisfy the ultimate customer (Langley, Coyle, Gibson, Novack & Bardi, 2009:20).

As one of the supply chain's components, the distribution centre (DC) plays a key role in controlling the flow of goods through the entire supply chain. Furthermore, it is responsible for a large percentage of the costs (Murphy &Wood, 2011). Various suppliers' stock is stored in the DC where it is picked and shipped according to customers' needs. For a DC in a supply chain`, customer performance is measured according to the number of on time and complete orders delivered. Is is also seen as providing a competitivte advantage to the business, while maximizing total value to the customer (Langley *et al.*, 2009:250).

A number of processes ensure the right product reaches the right customer on time. Among others, these processes include receiving, storing, replenishing and picking, which is a key function of the DC. Accuracy and efficiency play a vital role. If the incorrect articles are picked or the process is too slow, customers will not receive what they have ordered on time. According to Murphy and Wood (2011), picking accounts for a large portion of the DC's operational costs. As such, it is one of the key processes in the distribution chain.

There are several standard picking methods in industry. This includes basic order, batch, zone picking and wave picking. Within each of these picking methods there are systems, which assist the staff in picking products, these include: static shelving, carton flow rack, carousals, automatic storage and retrieval systems, automatic picking machine and automatic conveyor systems as indicated by Piasecki (2012). This thesis looks into a variation of the automatic conveyor systems in the form of a custom picking method.

A customised picking method is designed specifically for the DC it is to be used in and may be a blend of various picking methods aimed at meeting unique challenges in that particular facility. These picking methods are used in various DC's, including those used to distribute FMCG.

FMCG are everyday products which make up a large part of consumers' budgets. When looking at this market from a customer's perspective, it is viewed as items that are purchased frequently; customers do not take long to decide which item to purchase, as products are inexpensive, have short shelf life and are needed on a daily basis (Majumdar*,* 2004).

However, the business and marketing units see things from a different perspective. As mentioned, they view it as high-volume, low-profit products that require large, and even complicated, distribution networks with a high stock turnover through the supply chain (Majumdar, 2004).

Since the FMCG environment is linked closely to the service sector, suppliers and consumers, the back and forth link between the components of the supply chain are critical. Within this context, warehousing plays an important role to ensure products end up where required without adding extra costs (Çelen, Erdogan & Taymaz, 2005).

The FMCG business environment consists of seven retail channels. These are classified by the International Standard Industry Classification (Çelen *et el.*, 2005) by using a four- digit number. Below is the list of seven channels:

- Retail sale in non-specialised store (ISIC 5211);
- Retail sales in non-specialised stores (ISIC 5219);
- Retail sale of food, beverage, tobacco in specialized store (ISIC 5220);
- Retail sale of pharmaceutical, medical, cosmetics and toiletries (ISIC 5231);
- Retail sale via mail order houses (ISIC 5251);
- Retail sale via stalls and markets (ISIC 5252);
- Other non-store retail sales (ISIC 5259).

Of the above seven channels, this thesis is based on the FMCG business, which operates within the first four: ISIC 5211, 5219, 5220 and 5231.

The retail sector provides household essentials and consumption goods. Hotels, camp sites and even restaurants consume similar products as households, which are sourced from the same market. These businesses purchase their FMCG products from wholesale or retail trade outlets. All formats of FMCG consumption contribute to the total consumption and demand for FMCG products.

1.1.1 Pick n Pay Retailer

In South Africa, Pick n Pay is one of several large FMCG companies, which include Checkers, Woolworths and Spar, among others. These companies have DCs that constantly aim to ensure better service to stores and, ultimately, their customers. From this point onwards, this thesis will focus specifically on Pick n Pay as an FMCG and their distribution component. Specific focus will be placed on the Philippi DC in Cape Town.

Pick n Pay is a retail company that was started in South Africa in 1967 by Raymond Ackerman as a decentralised business. Since then, the company has grown to become an international retailer. Pick n Pay currently has 847 stores in South Africa, while 94 stores are located outside South Africa. Until 2009, vendors were responsible for delivering goods directly to stores on a daily or weekly basis, depending on the type of product being delivered. For example, fresh goods were delivered daily, whereas groceries, toiletries, clothing and general merchandise were delivered on a weekly basis. While this distribution model worked for Pick n Pay for many years, it was costly for vendors to maintain. This resulted in ever-increasing distribution costs passed onto the company and ultimately the end customer (Lucas, 2014).

In early 2000, the company decided to embark on a project that would see the entire company moving from a decentralised management approach to one centralised management office. This included the centralisation of product distribution. In 2009, the first centralised DC was opened in Longmeadow in Johannesburg on a 273 103 square-metre site. Infrastructure included a 112 490 square-metre DC and a 72 000 square-metre groceries shed.

This facility supplies all the Pick n Pay stores in Gauteng, Free State and areas north of Pretoria. In 2011, the Philippi DC site in Cape Town was developed to service all the Pick n Pay stores in the Western Cape with dry groceries and toiletries and became operational in 2012. A large portion of distribution to stores has now been centralised. Over the next four years, the centralised distribution of almost all goods into stores will be completed (Pick n Pay, 2014).

The company has also entered into third-party logistics distribution agreements with vendors to distribute frozen goods, as well as local and imported general merchandise products throughout South Africa. It is of utmost importance to make the transition into a centralised business model as efficient and effective as possible which will help to ensure that the new distribution model runs optimally (Pick n Pay, 2014).

Initially, Pick n Pay's Philippi DC used a standard pick-to-order system. How this works is simple: the facility has several aisles running from the inbound to the outbound doors, as illustrated in Figure 1.1. Stock is received at the inbound area and moved into the storage aisles. After receiving picking instructions, pickers start at aisle one and work their way through the aisles to the last one. Along this picking path, each picker loads the required items onto his/her handling unit (HU). When the pick is complete, pickers move to the staging/consolidating area where the HU will be checked and shipped to the customer.

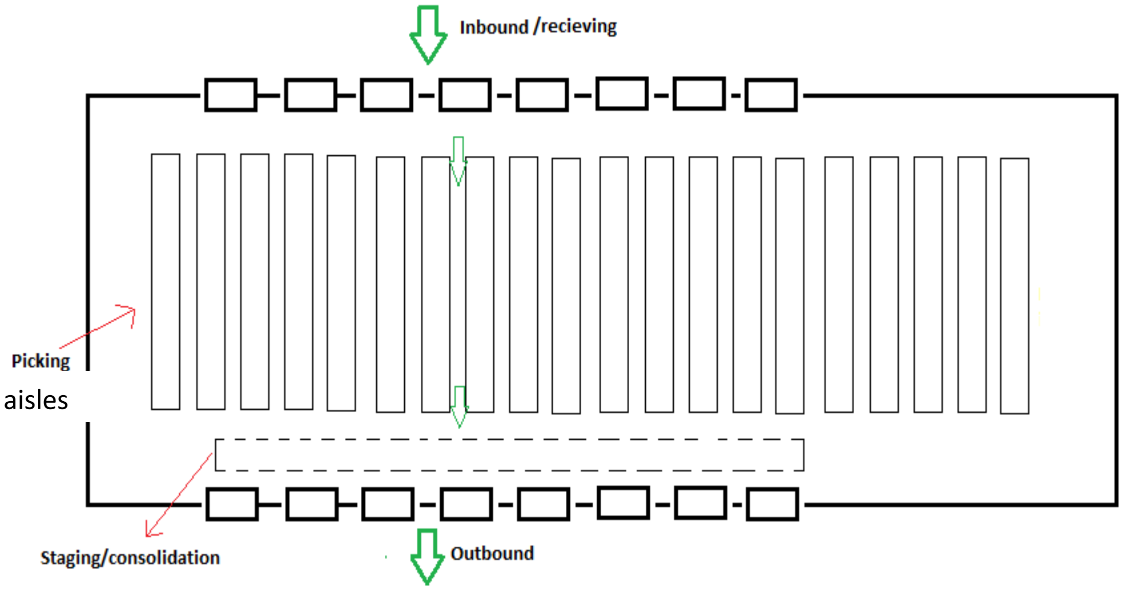

Figure 1.1 DC layout showing original picking method

During 2013, while Pick n Pay was in the process of centralising distribution, it became obvious that their DC in Philippi did not have the capacity to meet the required volume to serve the Western Cape stores. A supply chain consulting company from the United States was contracted to help rectify this problem. The solution that the consultant drew up in conjunction with the Pick n Pay supply chain was to build a customised pick tunnel at the Philippi DC.

The pick tunnel, which is illustrated and described in more detail under Section 5.1, consists of a multiple-level picking area. On each level, conveyer belts carry picked items towards the outbound area. Each level of the pick tunnel has dedicated pickers who do not move between levels and who fill tote bins according to picking instructions. Completed tote bins are placed on the conveyor belts and are taken out of the pick tunnel. The tote bins from all the levels are consolidated in the pick tunnel consolidation area, as shown in Figure 1.2. All the tote bins for an order from the different levels are consolidated here. Hereafter, they are taken to the staging/consolidation area at outbound. This is the first pick tunnel of this type built by Pick n Pay and thus the first study conducted around a system of this nature for Pick n Pay (Lucas, 2014).

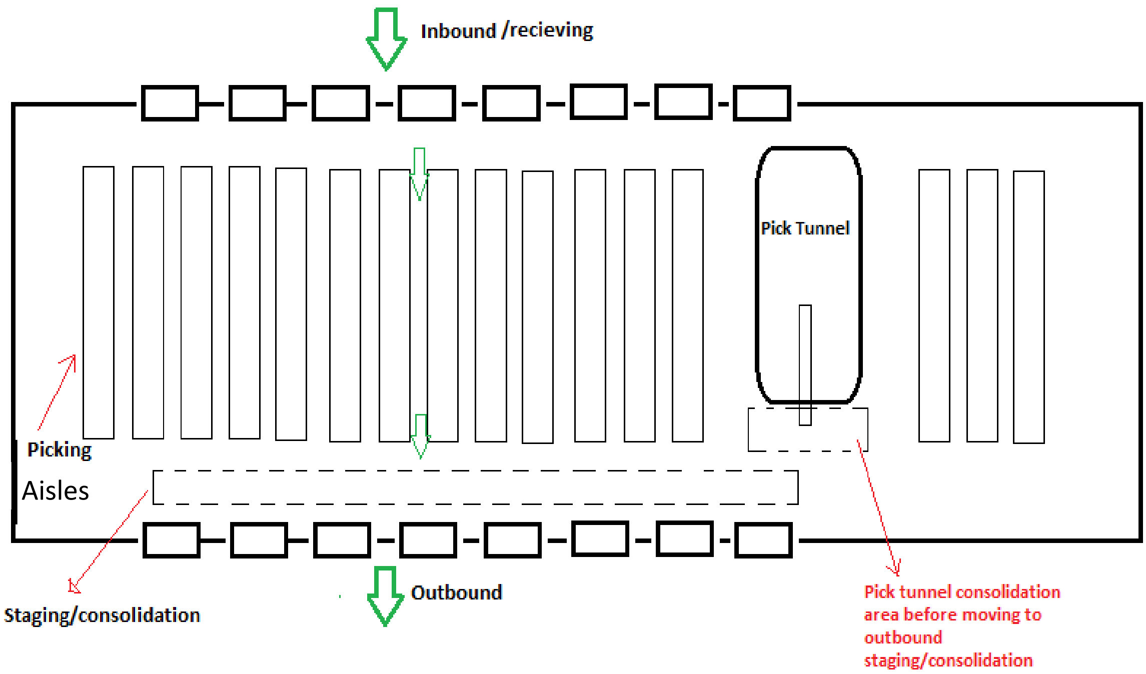

Figure 1.2 DC layout with pick tunnel

The main purpose of the pick tunnel was to allow the DC to pick and ship more volume. To achieve this it will allow picking in different units-of-measure, as well as in different areas of the facility. A picker can either pick single units of a product (referred to as 'picking in shrink') from the pick tunnel, or can pick a case from the general storage area. In this thesis, these different picking methods are referred to as 'pick tunnel picks' and 'break bulk picks', respectively. In addition, the picker can pick in full-pallet picks from the picking aisles, referred to as 'bulk picks' in this thesis. These different units-of-measure are all converted into a case value. For example, five units of a product, which is usually packed in cases of ten, will be seen as half a case. This case value is then used to measure the outbound volume.

Apart from the need for more capacity within the DC, as well as to allow for picking to take place in multiple units-of-measure, Pick n Pay aimed to use the pick tunnel to improve the performance of the DC in all areas. Goals include avoiding unnecessary errors, maintaining high levels of quality within processes and ensuring good customer relations through providing what is needed at the right place at the right time.

According to Marr (2013), performance measurement is vital for any business. As such, implementing the correct measures and acting on the results improve the efficiency of the business and ensure that the end consumer is satisfied.

1.1.2 Key concepts

The following key concepts provide the context for the research and the environment wherein it takes place. These concepts are:

I. Performance management

This tool helps companies to report externally, demonstrate compliance, control and monitor people and processes, as well as to improve current situations. This is achieved by ensuring that information is more understandable on order to contextualise and apply knowledge. This knowledge is then passed through the business to help employees make better decisions and to know which processes need to be monitored, controlled or changed more efficiently. As a business, it is critical to “equip employees with the information they need to make better informed decisions that lead to improvements” (Marr, 2013). Without this information, employees are unable to work to the best of their ability. Furthermore, they cannot work towards goals, as they are unaware of their current performance.

To measure performance, Pick n Pay has implemented a series of key performance indicators (KPIs). Marr (2013) states that KPIs help organisations understand how well they are performing with regard to their predetermined strategic goals and objectives. Tracking KPIs help provide information on the organisation’s performance. ” According to Marr (2013), “KPIs serve to reduce the complex nature of organisational performance to a small number of key indicators in order to make performance more understandable and digestible for us.”

These, along with other KPIs, are used in unison to measure the facility’s performance as a whole.

II. Picking

Picking is the function that takes place once the DC receives an order from its customer. Once received, the order is translated into a pick list, which is printed, displayed digitally or audio streamed to a picker (Pienaar & Vogt, 2009:314). In simple terms, picking is the process of receiving information regarding what the customer requires, retrieving it from the storage area and preparing it to be shipped to the customer. If a DC's picking performance is not on target, the entire DC's performance is affected, as the various functions depend on each other. These functions are explained in detail in Chapter 2. For this reason, it is crucial to develop a picking system that ensures optimal performance, is not complicated and is user friendly for pickers and other staff.

III. Industry

While this paper's findings are not necessarily restricted to a particular industry, it is important to understand the nature of the industry in which the research took place, i.e. the FMCG industry. According to Majumdar (2004:26) and Brierley (2002:14), FMCG are generally sold in high volumes and have low profit margins. These products may be anything from soft drinks to electronics. Despite the low profit margins, this industry thrives on the cumulative profit thanks to the high volumes sold. Within the context of the research, Pick n Pay needs to move high volumes of goods through their DCs in order to meet the demand at store level. As such, there is a need to increase the capacity and performance of the Philippi DC.

1.2 Research problem

It was found that there were minimal research and case studies available on the effect customised picking systems and pick tunnels have on efficiency, as well as the bottom line in the FMCG industry. Instead a large amount of research in the past has focused on the picking method itself and how to automatize it, including layout of stock and picking sequence (Brynzér & Johansson, 1996). As a result, this presented a great opportunity to learn and build a knowledge base around this topic to benefit literature-based information and organisations in general, and Pick n Pay in particular. Due to the high capital and resource investment required in warehousing and DCs (Murphy & Wood, 2011:30), any major change in the picking method needs to be investigated thoroughly.

The aim of this thesis is to analyse the difference between the two picking methods and develop a method to measure the change in performance when implementing a customised picking method. In addition, the question was asked whether the customised picking method would allow the business to cope with increased pressure to meet higher customer demands. Within the aforementioned context, there is a focus on facilitating higher volumes through the facility by being more productive and allowing for picking within multiple units-of-measure.

1.2.1 Primary research question

When comparing the new picking method to the old picking method, does the DC experience better perofrmance with the new picking method or not?

1.2.2 Secondary research questions

I. Research question 1: What alterations (needs brief) needed to be implemented to accommodate the pick tunnel?

A detailed design was drawn up before the pick tunnel was built in the Philippi DC. Within this context, there was a strong focus on how the new pick tunnel would influence other operations within the DC. Questions asked included which alterations needed to be done, as well as whether there were any assumptions and risks that were brought to light.

II. Research question 2: What areas of operations are impacted by the new pick tunnel, and how?

This question will delve deeper into the daily operations of the DC and identify which operations the pick tunnel impacted and how these operations are linked to the pick tunnel.

III. Research question 3: What measurements are used to gauge the performance of the new picking system and how are these measurements applied?

Accurate performance measurement of is essential in order to compare the DC's overall performance prior to, and after, the pick tunnel was built. Measurement-based questions included whether more than one measurement method was necessary to obtain conclusive results, whether the methods used could be applied to all data sets and whether it would be easy to understand and use. In addition, any measurement technique must provide accurate results that are not warped by external and internal factors.

IV. Research question 4: Which system performed better, the old or the new?

This entailed measuring the DC's performance prior to installing the pick tunnel and comparing the results with the post-installation performance.

1.3 Research objectives

This research aims to determine whether the new picking system, designed specifically for Pick n Pay's Philippi DC, performs better than the old picking system from a productivity point of view. In order to do this, certain objectives need to be met. These are summarised as follows:

1.3.1 The first main objective is to understand the operational changes within the DC. This will be achieved through four sub-objectives, namely a needs brief, a case study, operational assessment and questionnaires. This objective and sub-objectives will address questions one and two of the secondary research questions.

1.3.2 The second of the main objectives is to identify the measurement tools that will be used to gauge the DC's change in performance. This objective aims to address question three of the secondary research questions.

1.3.3 These tools will form the cornerstones of the framework, which will be used to achieve the third main objective, namely to measure the performance change in the DC after building the pick tunnel. This will answer to the forth question of the secondary research questions.

Each section of the thesis has a specific objective it needs to meet. The objectives and sub-objectives will be described in detail in the methodology section of this thesis.

1.4 Assumptions

Certain assumptions were made during the research and analysis stages, which need to be explained. Firstly, to ensure that the performance is comparable between the two time frames with different picking systems, the DC needs to service the same number of stores. This will ensure that the demand and volume moving through the DC is similar and comparable.

In conjunction with the above assumption, this study assumes that no additional DCs will be built in the area to service the same stores with the same products. This will ensure that the volume does not get spread out between the facilities and remains at the Philippi DC. This helps isolate possible changes to performance changes within in DC and not as a result of external factors.

The next assumption was that the centralisation process that started in 2013 would be completed. If this did not happen, the pick tunnel would not have served its purpose of increasing capacity and allowing for more vendors' products to be held and distributed. Centralisation is the process in which various vendors, who previously delivered directly to the store, now deliver to the DC. In turn, the DC is responsible for distributing the goods to the store. As such, multiple deliveries from different vendors are consolidated into one delivery from the DC.

With respect to the qualitative research, the assumption was made that the questionnaires were answered truthfully and accurately. This assumption is reasonable, as no one was forced to answer the questionnaires; people were free to decline. Respondents who answered the questionnaires were experts in the field on which the questionnaires were based. These individuals were not only knowledgeable, they were also responsible for, and reported on, their specific sections.

During the case study, it was assumed that the staff being monitored would not increase productivity to seem more efficient in their work. If they did bolster their productivity levels, the operational assessment would not be accurate. Furthermore, possible opportunities for improvement would be overlooked.

It was assumed that the pick tunnel project would meet all expectations and goals with respect to structure and capacity. This would help ensure that performance measurement would be as accurate as possible. If not, the performance data may have been distorted. The planning and construction of the structure, however, was executed carefully and the project was monitored closely. The consultants who designed and built the pick tunnel were held accountable for the project and were required to ensure that it met all the predetermined goals.

The data drawn from the secondary database was not tampered with or altered to influence the results in any way. The only adjustment made was that the data for trainee workers was removed. This was done to ensure that only the actual performance of trained employees was taken into account to provide a true picture of overall performance.

Undeniably, the research relies on accurate data. If the data sets are inaccurate, it will distort and nullify the findings. To prevent this from taking place, more than one individual extrapolated and compared the data to ensure that no discrepancies or variations were present. Due to system restrictions, the data for weekend performance during 2013 was unavailable. Therefore, the weekend data from 2013, 2014 and 2015 was excluded to ensure accuracy and comparability. This does not skew the data and still provides an accurate data set to analyse. This is due to the fact that the two years' data sets are perfectly matched in terms of the number of days/months, as well as which days of the week are measured.

The characteristics of the days and the types of vendors that deliver goods have remained unchanged during the two years. Vendors who delivered goods on weekends during 2013, still delivered on weekends in 2014 and 2015. Importantly, they were not moved into the weekdays (Steenkamp, 2014).

Lastly, to ensure the performance data was comparable, it was assumed that the DC used the same KPIs before and after completing the new pick tunnel. The KPIs were checked to verify that they were the same in order to compare the performance data for 2013, 2014 and 2015.

1.5 Chapter outline

Chapter 1 introduces the research by providing the reader with the background and stating the problem at hand. It explains the research questions which the thesis needs to answer, along with any assumptions for the purpose of the research.

Chapter 2 contains a literature review based on past knowledge around the research topic and the industry in which it was based. From the literature reviews it was possible to identify methods to measure the performance of the DC. Furthermore, the chapter explains why these methods of measurement were seen as relevant to measure the performance data for the thesis.

Chapter 3 focuses on the case study that was undertaken. The case study sheds light on the activities that take place at the facility where the research was conducted and gives the reader insight into the context. It highlightes the influence that different operational areas have on one another is analysed and an operational assessment is conducted to identify any opportunities to improve the facility's operations, together with possible solutions.

Chapter 4 discusses the research method and structure which was used to collect data and information relevant for this thesis. Additionally, the administration of the thesis was also included in this chapter and the inclusions, exclusions and the relevance of the thesis.

Chapter 5 covers the needs brief for the pick tunnel and the business requirements that arose from the brief. This chapter explains how the pick tunnel works, as well as what is needed for the pick tunnel to operate efficiently. This includes any changes to normal operations in the form of process changes, risks, assumptions and other issues. The chapter also looks at the tools used to analyse the performance data for the research, which included KPIs as well as a balanced scorecard in the form of the framework which was developed in this thesis.

Chapter 6 addresses the data analysis section of the research. This section discusses the framework that was be implemented to measure the performance of the DC. The framework consists of performance KPIs, as well as strategic KPIs in the form of a balanced scorecard. Once the performance had been measured, additional statistical measurements were applied to ensure that the findings were as accurate as possible. Findings and conclusions are made with regard to whether the performance of the facility has improved or declined.

Chapter 7 presents the findings and conclusions of the research, along with any further recommendations which may help improve the performance of the DC. Most importantly, this chapter answers the primary research question and identifies whether the gap in knowledge has been filled or not.

Chapter 2: Literature review

This chapter addresses previous literature and studies conducted on the topic of this thesis. The chapter discusses three different groups of knowledge and examines existing knowledge around each of the topics; more recent studies the have been conducted; and any new industry-related ideas that have not yet been researched academically. This structure allows the researcher to cover a broad range of knowledge. The various knowledge groups are not separated under each topic, but are discussed throughout the chapter, as they are interlinked in practice. The chapter also includes a high-level discussion on operations within a DC, as well as a more in-depth discussion, with specific reference to Pick n Pay's DC, is provided in a case study format in Chapter 3.

2.1 Operations within a distribution centre

Retailers' power has increased substantially and has led to the emergence of 'power retailers', which are characterised by large market shares and low prices. Examples of power retailers include Wal-Mart, Home Depot and Best Buy (Murphy& Wood, 2011:26).

According to Murphy and Wood (2011:26), "Many power retailers explicitly recognise superior logistics as an essential component of their corporate strategies, and because of this, their logistics practices are often viewed as a barometer for emerging logistics trends." For this reason, it is important to understand and optimise the operations within a DC.

Pienaar and Vogt (2009:302) list thirteen processes within a DC that need to be controlled and measured to ensure that the facility operates efficiently. These include:

- Pick face replenishment should move stock from reserve racking to the pick face;
- Stock should be counted;
- Multiple picks should be assembled into one load, so that a truck can deliver goods to customers;
- Goods should be delivered to customers;
- Unwanted customer goods should be returned to the DC;
- Stock should be purchased from suppliers for the DC;
- Suppliers' inbound transport should arrive at the DC;
- Stock should be received from the suppliers;
- The DC should provide proof of delivery and billing documents to the supplier;
- Stock picking should take place within the DC for customer orders;

- Customer orders should be processed;
- Stock from inbound area should be transferred to the storage area; and
- Damaged or expired stock should be written off.

All the processes listed above have either a direct or an indirect impact on stock as the primary purpose of warehouses is to facilitate the movement of goods through the supply chain to the end customer (Rushton & Croucher, 2010:256). Of these thirteen processes, this thesis will focus on stock picking, also known as order picking, and the influence it has on other processes and operations within the distribution chain.

Each of the aforementioned processes should be executed, controlled and monitored precisely within a DC. If this is not done, the DC will experience problems, such as inaccurate stock records, stock that is not located in the right place, incorrect picks, stock outs, an extreme drop in efficiency and failure to meet consumer demand (Pienaar & Vogt, 2009:302).

The picking process was described in Section 1.1. To recap, the picking process takes place once an order is received from a customer. Each picker is given a pick list, which is printed, displayed digitally or streamed via audio (Pienaar & Vogt, 2009:314). The picker then moves through the warehouse aisles, picking the items on the list and transferring them into a HU, which could consist of a tote bin, rolltainer or pallet. Once all the items have been picked, the pick list is closed and the HU is placed in the outbound area, where it is prepared for delivery to the customer.

When order picking is examined in detail, another key function in the distribution process becomes evident: inventory management. According to Pienaar and Vogt (2009:182), “Inventory management is so key to the business that the true value of a detailed inventory management strategy is often taken for granted.”

Three areas of emphasis are key to effective and efficient inventory management:

- Customer service;
- Operating costs; and
- Inventory costs.

Two of the above three items are related to costing, showing the importance of inventory with relation to supply chain costs.

If inventory is not managed correctly, it will have negative cost implications for the entire supply chain. Therefore, a specific inventory policy and picking method is required to ensure that these costs are kept to a minimum (Pienaar & Vogt, 2009:182). Marchet, Melacini and Perotti (2011:261) state that inventory management, more specifically picking, influences the overall logistics costs, as well as the service level that the customer receives. Often, more than half of the total warehouse costs are related to order picking. As such, this crucial area requires constant monitoring in order to perform optimally.

To balance supply and demand, effective inventory management must be in place. This helps buffer against uncertainties in supply and demand and prevents the cost of a stock-out. As indicated, inventory plays multiple in the supply chain. As such, it is important to manage inventory in the best way possible to allow for all the functions to operate optimally (Pienaar & Vogt, 2009:213). This leads to a lower-cost supply chain that passes cost savings on to the end-consumer.

From the above two views on the purpose of inventory management, it is evident that there is one major correlation is highlighted, namely cost. When stock picking is linked to inventory cost, it can account for up to two-thirds of a DC's time and costs (Murphy & Wood, 2011:136). This highlights the importance of the stock-picking process that holds the largest opportunity to improve efficiency and effectiveness for the DC and, more importantly, the entire supply chain. There are several factors within picking and inventory management, which play a critical role in ensuring the optimal performance of all operations and one of these is stock location. Salma and Ahmed (2011:508) state that storage is regarded as a task to facilitate the customer's satisfaction under the best condition. Langley *et al.* (2009) stated that three stock location criteria are commonly used to locate stock, namely popularity, unit size and cube.

The popularity criterion locates popular items (most units ordered in a given time period) near the shipping area, while the unpopular items (fewer units ordered) are located further away from the shipping area. This method allows order pickers to travel shorter distances to pick the most popular items being ordered. This requited the time required to pick orders (Langley *et al.*, 2009).

The unit-size criterion indicates that the smaller items are stored close to the outbound area and larger items further away. This allows more items to be stored closer to the outbound and thus less travel time and distance when picking the majority of the items (Langley *et al.*, 2009).

The cube criteria is a variation of unit size, where items with smaller total cubic space requirements (item cube times number of items held) are located close to the shipping area. The logic is similar to that used for unit size (Langley *et al.*, 2009).

Glock and Grosse (2012:4345) enumerate three basic storage policies that differ from Langley *et al.* (2009:427), and yet are equally relevant. The first of these policies is a random storage policy. This policy does not consider the product's characteristics, but has a high degree of space utilisation and is easy to implement. The drawback for this policy is that there is a high average travel time for all pickers.

The second storage policy is the dedicated storage policy, which considers the product's characteristics, such as order picking frequency, weight and measurements. While the storage space is not used optimally, there is lower average travel time for pickers (Brynzér & Johansson, 1996:596).

The third policy is called class-based storage. This policy takes all products and divides them into classes that are stored in specific areas. The storage within each of these areas is random, which allows for improved space utilisation and less travel time.

When considering the above criteria for the DC's layout and stock location, it is evident that one can apply and adopt multiple strategies for various industries or DCs. This depends on the type of product held, picking methods and storage methods. No single method is best suited for a specific industry, but all should be considered when designing the unique stock location for Pick n Pay's DC, and more specifically the pick tunnel.

Russell and Meller (2003:591) state that few studies have been conducted on a pick-and-sort system using a conveyor belt to move items from the picking area to the sorting and dispatch area in the DC, even though this system has been widely adopted in industry. The model designed by Russell and Meller (2003) focuses automated sorting of stock and not specifically for improving pick productivity. As a result, there is a lack of detailed knowledge around a system that is highly utilised in the distribution industry. This is concerning, as research into conveyor belt systems could lead to enhanced knowledge and possible improvements to systems and the bottom line.

From reviewing multiple sources for this study, it is evident in past research that the focus was on the layout of the DC, routing strategies and assigning products to storage locations Brynzér and Johansson (1996), Glock and Grosse (2012:4345), Langley et al. (2009). Little research has been based on how order picking and order-picking systems influence other operations within a DC, such as inbound, outbound and inventory management, among others.

Due to a lack of research on the impact changes in picking and order picking systems have on a DC's operations, more specifically the Philippi DC of Pick n Pay, this thesis will focus on building a body of knowledge around this topic, bringing to light which operations within a DC are impacted, and to what degree. It will focus on determining which of these operations must be altered and how they must be altered to ensure that the pick tunnel can perform optimally in conjunction with the DC's daily activities.

2.2 Using key performance indicators and a balanced scorecard to measure performance

In order to gather and analyse data regarding the DC's performance, two approaches are used: analysing KPIs and a balanced scorecard. Both approaches have their strengths and are important in determining whether the performance has improved, or not. The following section reviews past and present literature around both of these approaches to provide more insight into why they have been selected for this thesis.

2.2.1 Key performance indicators (KPIs)

In business, it is essential to measure performance. The reasons for this may vary between businesses according to their specific goals. However, they are moulded around the same core principles. In the supply chain industry, an example of the aforementioned is to lower logistics-based costs, which lead to a competitive advantage (Liviu, Ana-Maria & Emil, s.a.). Performance measurement is a tool management used to monitor progress and assist in decision-making. By highlighting areas that are not performing optimally, it is possible to implement changes that could lead to better working conditions, more efficient operational systems and an improved bottom line.

One accepted way of measuring performance is by using KPIs, a system that has been well researched. KPIs have been defined as the following examples:

2.2.1.1 A performance indicator or KPI is a tool used to measure the success of a process. Sometimes success is defined in terms of making progress toward strategic goals (Reh, 2013), but often success is simply achieving some level of operational goal on a repeated, periodic basis.

2.2.1.2 Performance measurement has been defined by Neely, Adams and Kennerley (2002) as "the process of quantifying the efficiency and effectiveness of past actions," while Moullin (2002) defines it as "the process of evaluating how well organisations are managed and the value they deliver for customers and other stakeholders."

After examining several sources, the following definition by Marr (2013) will be used, as it is deemed most appropriate. According to Marr (2013), a KPI helps an organisation understand how well it is performing with regard to its predetermined strategic goals and objectives. According to Marr (2013), "KPIs serve to reduce the complex nature of organisational performance to a small number of key indicators in order to make performance more understandable and digestible for us."

After establishing the definition of a KPI, the researcher can illustrate how it is applied to the research being conducted at Pick n Pay's Philippi DC. In 2013, research was done to evaluate the methods of measuring performance of processes in Pick n Pay's Philippi DC. This study will form the basis for measuring and comparing performance of the new and old picking methods in Pick n Pay's Philippi DC in 2014. The research assignment by Lucas (2013) identified three different models for measuring process performance using KPIs, namely supply-chain operations reference (SCOR), Warehousing Education and Research Council (WERC) and Pick n Pay.

After comparing these models, the SCOR model was selected due to specific criteria and strengths. These strengths and criteria ensured that the KPIs' design allowed for all processes to be measured correctly and accurately, while considering quantitative and qualitative measurements. A multiple level structure enabled one to compare and link the performance of various processes within the DC and facilitated clear communication throughout the supply chain.

Lucas's (2013), final recommendation to improve shortcomings in Pick n Pay's KPIs was to investigate implementing the SCOR model. The researcher was of the opinion that this model's structure and measurements were best suited to the design.

Despite the fact that SCOR measurements were found to be more appropriate for measuring performance, Pick n Pay has elected to retain its own KPIs to track the DC's performance. This decision has advantages and disadvantages. Two advantages include that one can now compare previous databases and data measurements to any future measurements. Furthermore, employees who are in charge of the processes have a detailed understanding of the KPIs system. Any process- and measurement-based changes that take place before a large project, such as the building of the pick tunnel, might cause confusion and lead to problems that might hamper the project's progress. This is an advantage as it allows the business to see which changes may have resulted in growth or decline in performance. On the downside, retaining the previously established KPIs means that the several flaws found in the system will continue to remain a challenge, as opposed to choosing a superior performance measurement method (Lucas, 2013). Thus, to optimise the future performance of the Philippi DC's pick tunnel, it is recommended that the KPIs be changed after the pick tunnel has been completed. Notably, this will help accommodate the new picking method and address any other previously identified shortcomings.

The organisational culture was also taken into account when it was decided to retain Pick n Pay's existing KPIs. Beamon (1999:280) states that supply chain performance measures are often an extension of traditional company indicators and strategic goals. For this reason, each organisation has a unique set of performance measures that are in line with its company indicators. Neely *et al* (1995:83) claim that a systematic approach and generic measures, which can be implemented into any organisation, has not been developed yet. In reality, there is a wide range of measurements that can be categorised in various ways. In addition, many measurements have no set definition, as companies develop their own frameworks that may cause problems if implemented into any business. Pick n Pay serves as an example of the aforementioned scenario, by examining the KPIs established by Pick n Pay. It is evident that the data that has been captured to date is in line with Pick n Pay's predetermined KPIs, and not those of SCOR. Pick n Pay's KPIs are included in Appendix A.

It is important to establish KPIs but the key to accurate performance measurement is how one interprets and uses these indicators (Marr, 2013). A balanced scorecard is one way of ensuring accurate performance measurement.

2.2.2 A balanced scorecard

A balanced scorecard is a useful tool to measure performance within a DC. Therefore, it is beneficial to use this measurement method for the purposes of the research. This section discusses the history of the balanced scorecard. Furthermore, a detailed explanation is used on how and why it will be used to measure the DC's performance prior to, and after, building the pick tunnel. This will help to determine whether the performance has improved or declined.

When there is a need to measure the performance of a business, it is essential to gain a holistic perspective –from financial to physical. This can be achieved by using a balanced scorecard, which can be used as a strategic planning and management system in business and many other institutes. A balanced scorecard can be used to align an organisation's business activities to its vision and strategy. Furthermore, it can help improve internal and external communication, while monitoring an organisation's performance against its strategic goals.

The balanced scorecard was designed as a performance measurement framework that added strategic, non-financial performance measurements to traditional financial metrics. Thus, it provides a more balanced view of performance (Balanced scorecards basics, 2013). Before the details of the balanced scorecard are discussed, it is important to establish why it was decided to use this performance measurement tool. This is despite the many contradicting studies that have been conducted over the years on the concept.

Importantly, a balanced scorecard 'assumes' the presence of a cause-and-effect relationship. Thus, better-trained employees will lead to improved business process performance. This creates better customer satisfaction, which, in turn, leads to improved financial performance. Importantly non-financial aspects are linked to financial aspects. Therefore, it is assumed that non-financial measures can be used to predict financial measures (Kaplan & Norton, 1992, 1996).

In light of the link between financial and non-financial metrics, research conducted by Lipe and Salterio (2000:283-298) found that managers simplify their performance reports by focusing on common metrics. Notably, these metrics are not unique to the business and usually refer to financial metrics. Conversely, non-financial metrics are often unique to the business and are harder to quantify and measure. Subsequently, managers' decisions are mainly influenced by financial metrics, while non-financial measurements are ignored.

Porter (1992:65-82) agrees with this over-emphasis of financial measures. He states that prioritising financial measures in corporate business performance have been a primary cause of failing businesses. The statement in the previous paragraph by Lipe and Salterio (2000) and Porter (1992) are supported by Dilla and Steinbart (2005:43-53), as well as Libby, Saletrio and Webb's (2004) findings. If non-financial measures are underutilised, this will prevent the organisation from benefitting fully from the balanced scorecard developed by Kaplan and Norton (1992, 1996). Notably, these non-financial measures reflect key aspects of the businesses strategy.

The balanced scorecard uses numerous measurements with regard to financial and non-financial metrics (Kaplan & Norton, 1992, 1996). However, Neely (2005:1264-1277) regards the aforementioned as inefficient. The author states that the implementation of an 'obese' and 'static' balanced scorecard could hamper performance management. This is substantiated by

Venkatraman and Gering (2000:10-13), who conducted a study on the topic. According to the authors, there are an equal number of cases where the balanced scorecard was successful and unsuccessful; the unsuccessful cases were due to over-measurement. The businesses were measuring too many processes, and, by doing so, they failed to measure the correct and most relevant processes.

In research by Kaplan (1993), Larry D. Brady, Executive Vice-President of FMC Corporation, states that a focus on financial performance had allowed the business to run well for the past 20 years. Due to the company's focus on return on investment, there had been no planning in place to pursue new business avenues. Once again, this focus on financial performance highlights that that, without a balance between financial and non-financial metrics, a business will not be able to grow in the future.

Therefore, it is essential to measure both financial and non-financial aspects of the business. Furthermore, it is imperative to ensure that the correct metrics are used and that the business does not fall into the over-measurement trap. Kaplan and Norton highlight this as a key aspect of a balanced scorecard. The authors explain balance as follows: "By forcing senior managers to consider all the important operational measures together, the balanced scorecard lets them see whether improvement in one area may have been achieved at the expense of another" (Kaplan & Norton, 1992).

According to Kaplan and Norton (1992), there are several examples of companies that have implemented the balanced scorecard successfully. However, there have also been as many unsuccessful implementations. These unsuccessful implementations can be attributed to limitations in the balanced scorecard. Brignall (2002), Neely (2005:1264-1277) and Nørreklit (2000) found that the balanced scorecard had unavoidable limitations as a strategy management tool. NØrreklit (2000) emphasised one of these limitations, which was supported by Veen-Dirks and Wijn (2002). They found that the balanced scorecard does not reflect external changes that have an impact on the business. This is cause for concern, as there is no way to establish whether an increase or decrease in performance has occurred as a result of external factors.

The biggest drawback is that successful implementation depends on accurate, up-to-date data. The high failure rate, along with the mixed research findings, questions the balanced scorecard's effectiveness, as claimed by Kaplan and Norton (1996).

The balanced scorecard consists of four perspectives, namely the learning and growth, business process, customer and financial perspectives, which will be discussed in this section.

According to certain pieces of literature, these four perspectives are linked. In addition, it can form a starting point to investigate an organisation, as well as and to develop metrics and collect and analyse data (Balanced scorecards basics, 2013). Ittner and Larcker (2003:88-95) disagree with this point of view. According to the authors, there is minimal evidence that supports this claim. Moreover, they could not prove that there was any link between the four perspectives.

Despite this, certain scholars argue that, although there is a link, it is an over-simplified version of reality (Brignall, 2002). Both of these alternative points of view hold water. However, Kaplan and Norton (1992, 1996) highlight the fact that non-financial and financial aspects are interlinked and can be used to predict performance outcome. The aforementioned assumption can be seen in any business. If the business provides better customer satisfaction, they will retain and possibly attract new customers. This, in turn, will lead to better financial performance from an increase in sales.

Despite the negative feelings towards the balanced scorecard, some see it as a successful tool to build alliances between corporations, which are regarded key aspect to creating a competitive advantage in today's business environment. Mckinsey and Company found that 50% of alliances fail. According to the authors, the reason for this failure rate is that businesses focus on operational performance metrics, rather than strategic metrics. For example, a pharmaceutical company implemented a balanced scorecard into its alliances and subsequently experienced 40% shorter cycle time for clinical studies. This enabled the company to introduce its product to the market quicker and reduce costs (Archana, Yemeshvary & Palo, 2013). The balanced scorecard also allows for better decision-making as it enables more clarity with regard to the overall vision, strategy and individual roles in any business (Kaplan, Norton & Rugelsjoen, 2010).

Neely (2005:1264-1277) provides empirical evidence that indicates a balanced scorecard does not improved financial performance. However, the aim of this research is not to improve performance, but to measure the change in performance. The purpose of the balanced scorecard is to implement strategy. Using it to measure performance in order to meet strategic goals, therefore, aligns with its original purpose. Furthermore, the balanced scorecard enables management to know how efficient they are at achieving goals. Furthermore, it serves as an early-warning system of any possible issues that may arise (Venkatraman & Gering, 2000). This is important – especially in today's competitive environment where businesses need to be agile and flexible. As such, there is a need for up-to-date, accurate information and the balanced scorecard is a popular tool to provide insight (Banker, Hsihui, Janakiraman & Konstans, 2004:423)

Like any other management tool or system, the balanced scorecard needs to evolve to meet many new challenges within the business environment. As the *Balanced Scorecard basics website* (2013) states:

The balanced scorecard retains traditional financial measures. Financial measures tell the story of past events, an adequate story for industrial age companies for which investments in long-term capabilities and customer relationships were not critical for success. These financial measures are inadequate, however, for guiding and evaluating the journey that information age companies must make to create future value through investment in customers, suppliers, employees, processes, technology and innovation.

What have remained unchanged in the balanced scorecard are the four perspectives from which an organisation is viewed, as well as from which metrics are developed and data is collected and analysed. As mentioned earlier in the chapter, the four perspectives include the learning and growth, business process, customer and financial perspectives. Taken from balanced scorecards basics (2013), each of the four perspectives will now be explained to provide a basic understanding as to what they contain.

I. The learning and growth perspective

Here, corporate and self-improvement are key components, while employee development and corporate cultural attitudes also play vital roles. The continuous training of employees is important to a business, because technology is constantly changing and staff members who use these technologies are the organisation’s main resource. However, staff development entails more than just training. Employees need to be tutored and mentored. Therefore, any metrics established under this perspective must ensure that sufficient resources are dedicated to improving staff knowledge and skills and ensuring that these are up to date with the latest technology.

II. The business process perspective

The business process perspective deals with internal business processes that are used on a daily basis to achieve the required functions and performance of the business. The metrics used in this perspective provide a clear indication of how well the business is operating. The metrics must also measure whether customers find the products and services are satisfactory. Due to the high degree of customisation of processes within a business, someone who has an intimate knowledge of internal processes should develop the metrics

III. The customer perspective

In recent years, there has been an increased focus on customer satisfaction. If a customer is not satisfied, s/he will leave and find a new supplier. For this reason, it is critical to measure customer satisfaction. If poor performance is not corrected, it may lead to a decline in customer satisfaction. When the metrics for this perspective are designed, allowance must be made for different types of customers and the processes needed to cater for these customers.

IV. The financial perspective

In the business world, timely and accurate financial data will always be a priority to any business owner or manager. Often, financial data is over-processed and –analysed. This leads to a delay in presenting data to management and decreases the efficiency of decisions made. This has led to an effort to increase the centralisation and automation of data handling. To ensure that the financial perspective receives adequate focus, it might be wise to include risk assessment and cost benefit data.

These four perspectives from Kaplan's (2010) original balanced scorecard cover the most important aspects of performance measurement. Other organisations have adopted these perspectives to create their own balanced scorecards. One such model is the SCOR model, developed by the Supply Chain Council. This strong, balanced scorecard can be used to measure the overall performance of an organisation. According to the SCOR model (Supply Chain Council, 2012), the definition of a scorecard is a visual display of the most important information needed to achieve one or more objectives, consolidated and arranged in a single view. However, a balanced scorecard provides metrics related to four organisational strategies: financial, customer satisfaction, internal process excellence or efficiency and employee learning and growth.

SCOR has taken the four perspectives (financial, customer, internal processes and learning and growth) and evolved them further, applying them to its own models. The result is a scorecard that provides metrics related to the five SCOR supply chain strategies: reliability, responsiveness, agility, cost and assets. According to SCOR, there are specific requirements for the metrics used to measure each strategy:

- The metrics must be measurable and quantifiable. It must avoid feel-good metrics, such as personal satisfaction from the supplier or end-consumer, unless they are detailed and recorded in a specific, applicable manner. Framework metrics can be used to simplify the process by clearly defining the main objective.

- There must be linkage and responsibility between the various aspects and stakeholders. The metrics should be related directly to performance reviews and be linked to the correct process owner at the correct level.
- All metrics must be well defined to ensure that they are properly understood and user friendly. If a metric is open to different interpretations, this may cause confusion. Subsequently, work could be diverted away from the actual goal or purpose. SCOR metrics are predefined, which limits discussion surrounding the definition.

The Supply Chain Council was not the only organisation to develop a unique scorecard based on the guiding principles of Kaplan (2010:6). The reason for this is that each organisation has a unique operational structure, established goals, operational processes and procedural measurement models. As a result, Pick n Pay also developed its own balanced scorecard based on Kaplan's original design of (Kaplan, 2010).

When the original balanced scorecard of Kaplan is compared to the balanced scorecard used by Pick n Pay it is evident that they are based on the same principles, both scorecards are based on four main perspectives, people, financial, operational and customers. The link between the two versions of the balanced scorecard is explained as follows:

Learning and growth of Kaplan's balanced scorecard is linked to the people's perspective of Pick n Pays balanced score card. Both look at the employees working for the business and how they are trained, grown as individuals and taken care of to ensure productive and efficient work takes place, this includes aspects such as health, leave, coaching, mentoring and being provided the latest technology which allows them to perform their job functions.

Business process perspective of Kaplan's balanced scorecard is linked to the operations perspective of Pick n Pay. These perspectives both focus on the actual business and how it operates, the processes which are followed on a daily basis by all functional areas which ensure the end goal of serving customers is possible. It also focuses on performing these functions as efficiently as possible.

Both Kaplan and Pick n Pay use the customer perspective, this will emphasise the satisfaction of the end consumer of the business. Kaplan and Norton state that if a customer is dissatisfied he/she will find a new supplier. Pick n Pay aim to ensure customer satisfaction by ensuing they supply the correct quantity and product at the desired time to meet customer demand.

The last of the perspectives which are shared by Kaplan's original balanced scorecard and Pick n Pay's balanced scorecard is the financial perspective. This perspective is used to measure the cost of running the business, any risk associated to the business and also to provide information to management to make important decisions as well as ensure the business is operating within its predetermined budget.

2.3 Chapter summary

This chapter referred to numerous studies that have focused on the balanced scorecard. In order to provide a holistic perspective, the literature study included literature that opposed the use of scorecards. The chapter also explained the important role performance orientated KPIs play in measuring business performance, making better decisions and shedding light on the various operations that occur within a DC.

Ultimately, KPIs used to measure the DC's operations and a blanced scorecard ensures that the DC's operations strive to achieve the operational and strategic goals of the business.

Chapter 3: Literature related to facility processes and assessment with case background

This chapter consists of three sections. The first part will focus on the case study, which is a sub-objective of the first main objective. The case study explains the daily activity within the DC, providing background and point of departure for the research. From here, the chapter will investigate the various operations that take place within the DC and how they are interrelated with one another. This plays a critical role, as all operations need to work in unison to ensure the DC performs optimally. The third and final section of this chapter provides an operational assessment of the DC. Here, a list of opportunities within each operation will be highlighted and solutions will be presented to take advantage of these opportunities.

3.1 The case study

Until 2009, vendors were responsible for delivering products directly to all Pick n Pay stores on a daily or weekly basis, depending on the type of product being delivered. For example, fresh goods would be delivered daily, whereas groceries, toiletries, clothing and general merchandise would be delivered on a weekly basis. Although this distribution model worked for Pick n Pay over many years, it became costly for vendors to maintain. This resulted in a higher distribution cost being passed onto Pick n Pay and the end consumer (Lucas, 2014).

In early 2000, the company decided to embark on a project to transform the entire company from a decentralised management stance to one centralised management office. This included the centralisation of product distribution (Lucas, 2014). In 2009, the first centralised DC was opened in Longmeadow, Johannesburg. The 273 103-square-metre site houses a 112 490-square-metre DC and a 72 000-square-metre groceries shed. This facility services all the Pick n Pay stores in Gauteng, Free State and areas north of Pretoria. In 2011, the Philippi DC site in Cape Town was built to service all the Pick n Pay Western Cape stores with dry groceries and toiletries. It became operational in 2012. At that stage, a large portion of distribution to stores had been centralised. Over, the next four years the centralised distribution of almost all goods into stores will be completed (Lucas, 2014).

This research project focuses on the Philippi DC. To provide basic background and a point of departure for the thesis, this case study aims to investigate the various aspects of the DC and its operations. This section follows the flow shown in Figure 3.1.

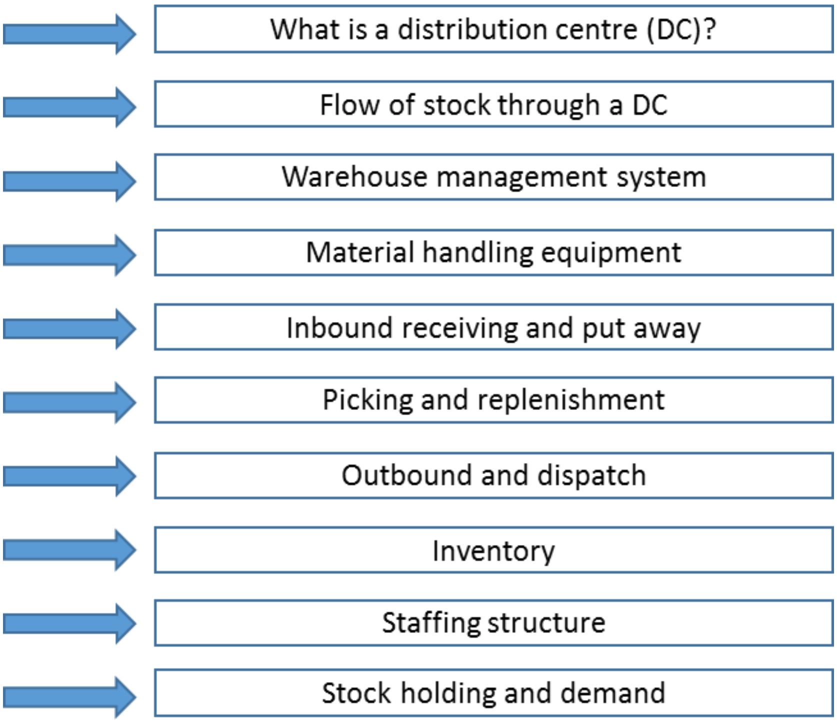

Figure 3.1 Process flow of stock

A DC can also be called a warehouse, a fulfilment centre, a cross dock facility, a break bulk centre and a package handling centre. The name by which a DC is commonly known is based on the purpose of the facility. A facility which distributes to retail stores is known as a retail DC, and for the purpose of this thesis will be referred to as a DC (Cutler, 2013).

A DC is a physical structure that consists of three main sections, known as the functions, inbound, outbound and picking areas. The picking area consists of racking, which is used to store and pick stock. The inbound area is used to receive stock from vendors and put the stock into upper racking for storage. The outbound are is used to prepare stock that has been picked and ship the stock to customers, which in this case are stores. Figure 3.2 shows the flow of stock through the DC.

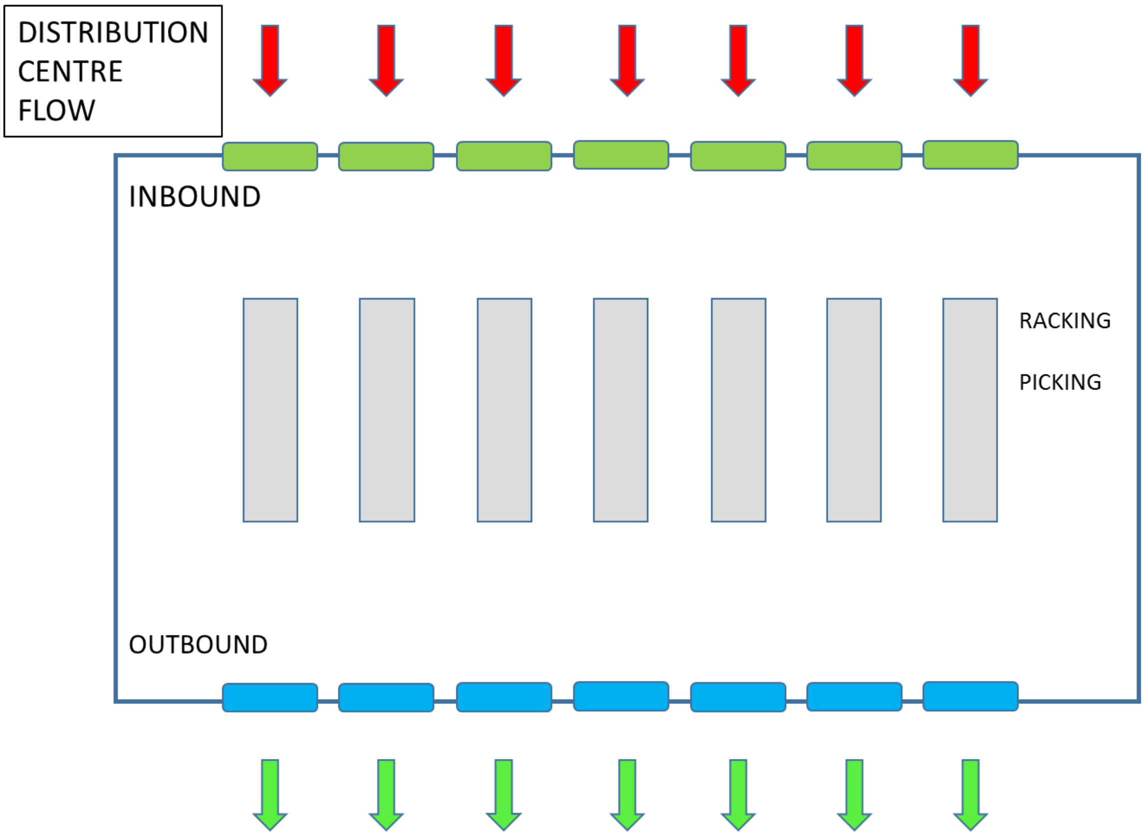

Figure 3.2 Flow of stock through the DC

A DC needs a warehouse management system (WMS) to operate efficiently. A WMS is a software application that supports the day-to-day operations in a warehouse. WMS programs enable centralized management of tasks such as tracking inventory levels and stock locations (Murray, 2009).

Staff members use the WMS via arm-mounted terminals (AMT), also known as a radio frequency (RF) device. Each staff member uses a unique log-on, which is linked to his/her name and job function. This gives staff members access to certain processes they need to complete, such as receiving stock at inbound or picking stock for orders.

Staff members also move around the DC using material-handling equipment (MHE), or motorised machines. This allows them to travel faster, as well as lift and move heavy HU's filled with stock from one location to another. Inbound and put-away teams use forklifts (FL), replenishment teams use reach trucks (RT) and pickers and outbound teams use personal power transport (PPT).

The inbound area is used to receive stock into the DC. Vendors, also known as suppliers, arrive at the DC with trucks carrying pallets of stock. The stock is offloaded at the inbound doors, where the quantity and quality of the stock is checked. Once the receiving team is satisfied that the correct quantity and quality of stock has been delivered, they will receive the stock into the DC and onto the warehouse management system. After the stock has been received, it is then put away into the upper racking area. Here is where it will be stored until it is required to be picked. Figures 3.3 to 3.5 show the flow of stock into the DC via receiving.

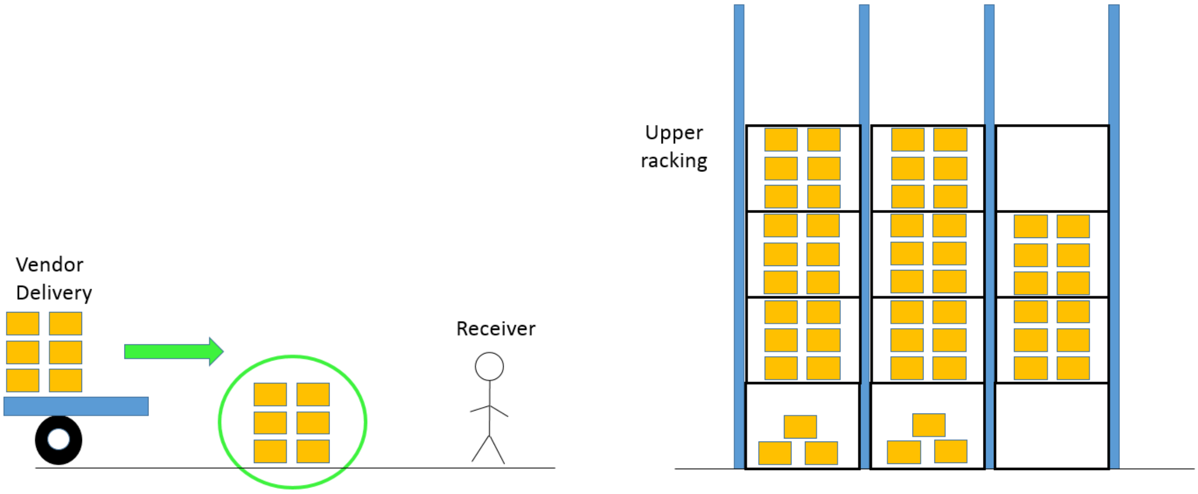

Figure 3.3 Off loading and checking of stock

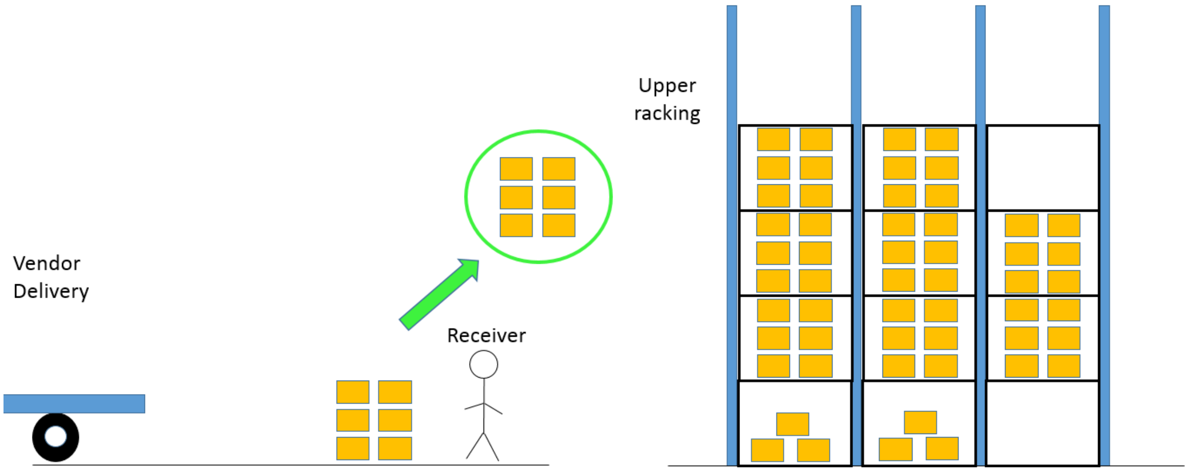

Figure 3.4 Put away

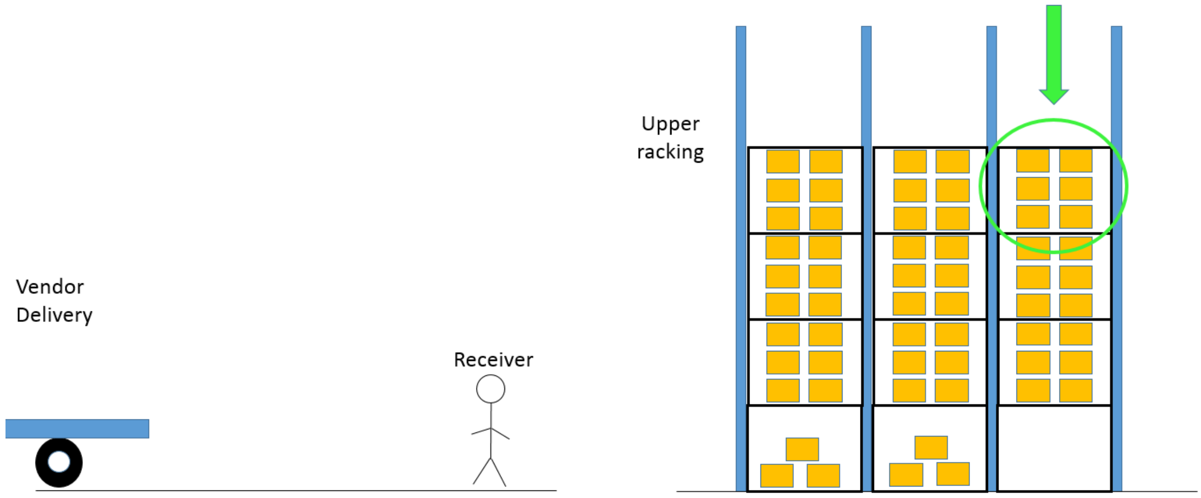

Figure 3.5 Inbound cleared and all stock put away

Once the stock reaches the upper racking, it is available to be replenished down into the pick faces. This replenishment is triggered by the pickers picking a pick face empty. A pick face is an area in racking, typically on the ground level, which is used to pick stock. It holds stock temporarily due to pickers picking all the stock out of it multiple times within a 24-hour-period (Steenkamp, 2014). Some pick faces take longer to empty as they contain slow-selling products that are not in high demand. This is referred to as rate of sale (Steenkamp, 2014). Figure 3.6 is an example of a pick face within racking.

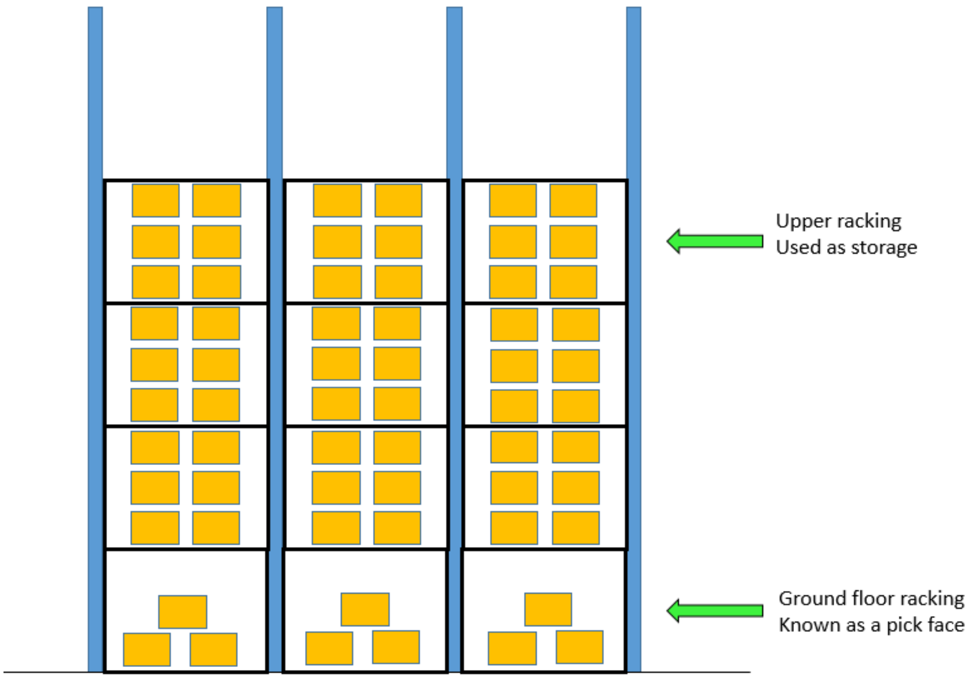

Figure 3.6 A pick face with stocking

When a picker empties out a pick face, the system is alerted that there is no more stock available to be picked, which triggers a replenishment. A replenishment is when stock is taken out of upper racking, known as reserve racking, and brought down to the pick face for pickers to continue picking. Figure 3.7 shows the flow of stock during a replenishment. Once the stock has been replenished into the pick face from the upper racking, the system will allow pickers to pick stock from that location again.

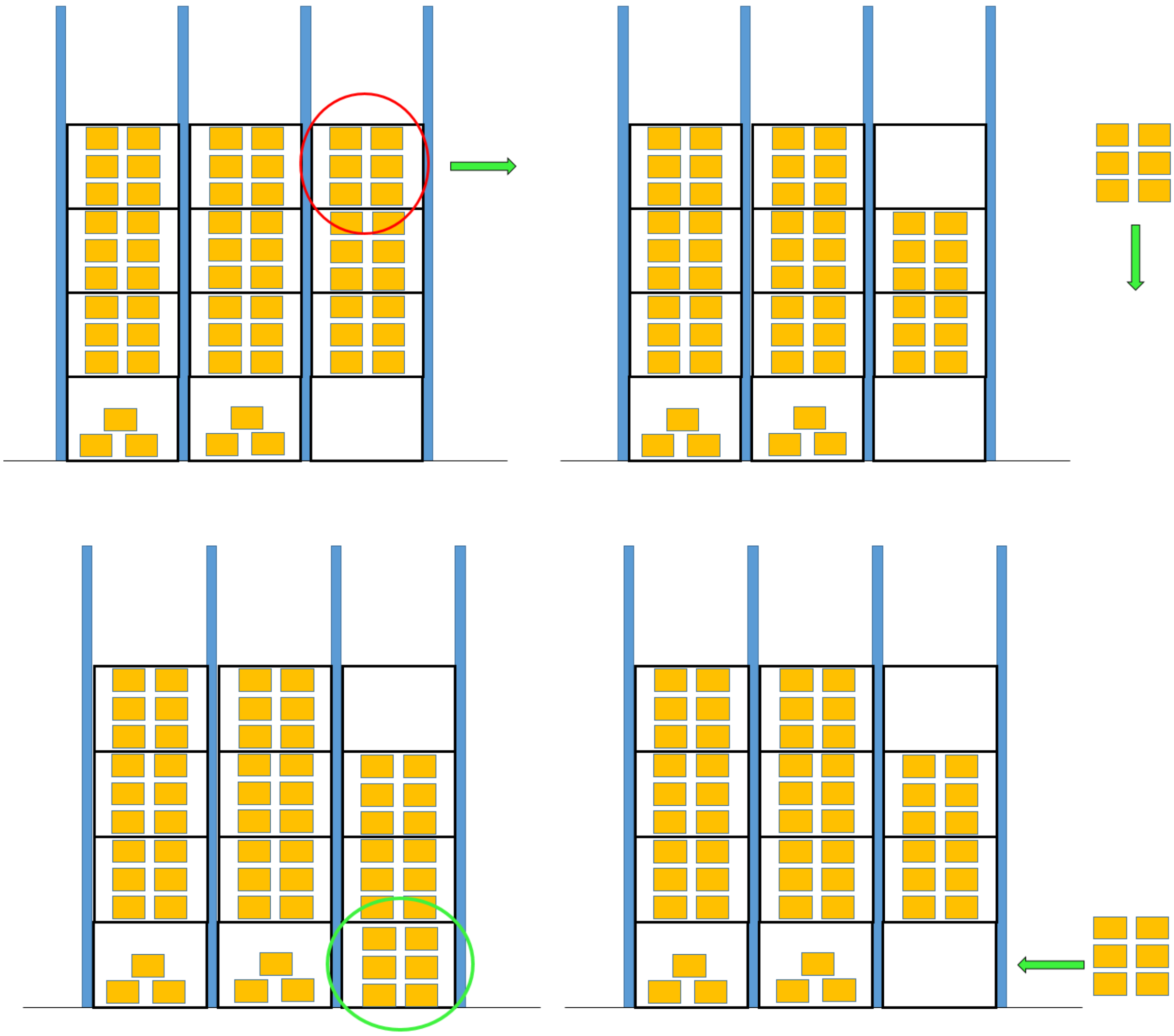

Figure 3.7 Flow of stock during replenishment

Once stock has been picked from the pick faces, it is placed in a HU. This can include a pallet, wooden block, rolltainer or steel cage on wheels. The picker will visit multiple pick faces and pick different products into his/her HU. Once pickers have picked all the stock required for a customer's order, they proceed to the outbound lanes where they will stage they HU that contains the stock.

The outbound team will then take responsibility for the HU's once they have been staged. They need to ensure the HUs are as full as possible, so that space on the trucks is not wasted. This is done by consolidating the content of HUs in the outbound lanes that are designated for the same store, so that the HUs are as full as possible and no space is wasted. This is shown in Figure 3.8 below.

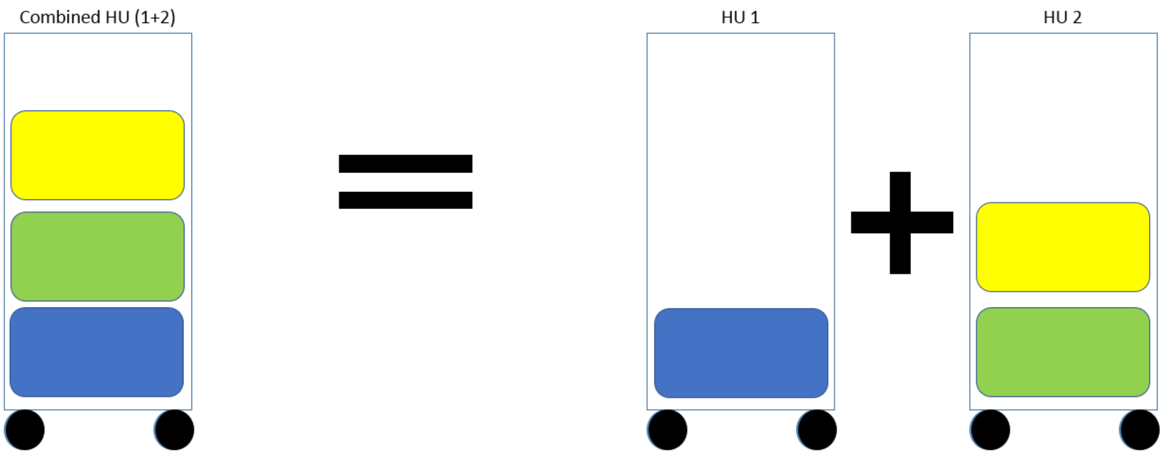

Figure 3.8 Combining multiple sub-optimal HUs

Once all the sub-optimal HUs have been combined, the outbound team will then begin loading the outbound trucks, which that deliver to the customers. They will have a list of HUs per customer order that needs to be loaded onto specific trucks. The team will load all the relevant HUs onto the trucks and send the vehicle to deliver the stock to the customer – a specific store. Figures 3.9 to Figure 9.11 show the outbound process of loading HUs onto the outbound vehicles.

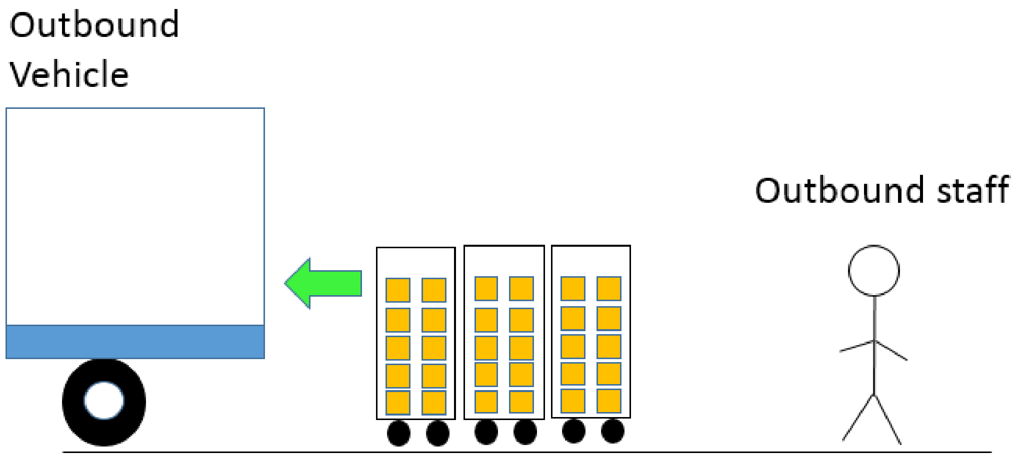

Figure 3.9 Outbound staff ensure all HUs are together for store order

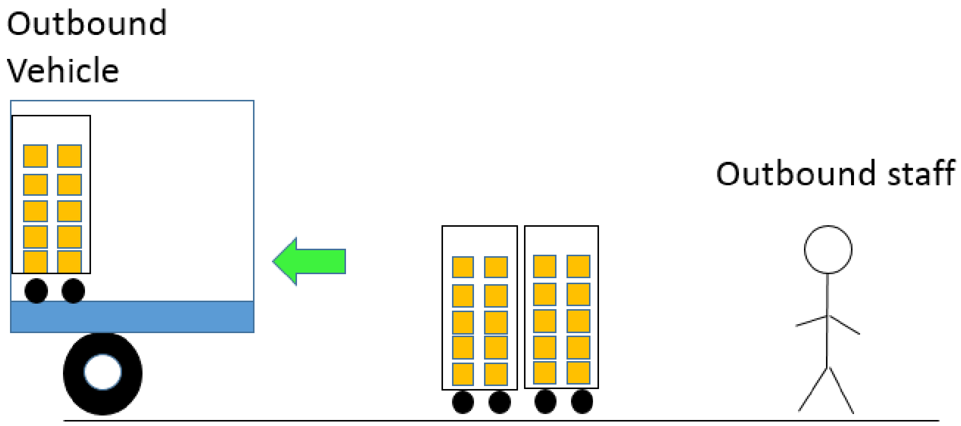

Figure 3.10 Outbound staff start loading the HUs onto the outbound vehicle

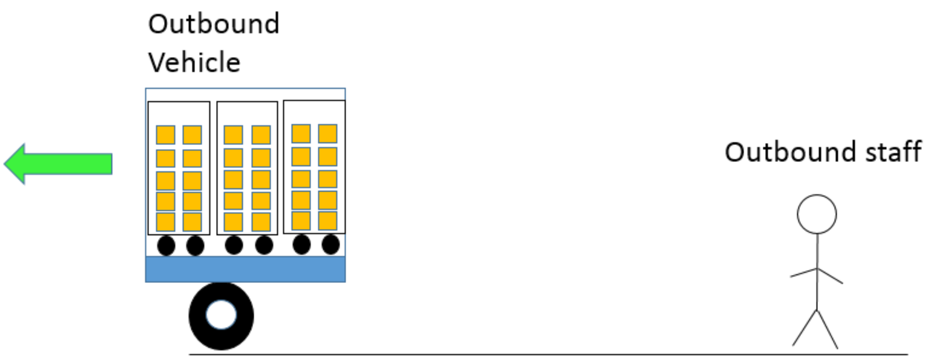

Figure 3.11 All HUs loaded on outbound vehicle, which is sent to deliver stock

The inventory team is responsible for ensuring the stock count in the DC is correct and that stock is in the correct places at all times. This includes stock in the upper racking and \ pick faces. The inventory team will perform periodical counts on pick faces and upper racking bins in the DC, typically counting the entire DC at least once a month.

From a staffing perspective there are teams for each area in the DC. As such inbound, picking, inventory and outbound all have a team of staff. These teams have supervisors to whom they report. The supervisors are responsible for driving the teams' productivity and meeting daily KPI's.

The supervisors in each division have a manager who is responsible for ensuring they perform their daily tasks, such as driving productivity. The managers, who report to the DC manager, are also responsible for ensuring their functional area operates without issues. In turn, the DC manager is responsible for ensuring all functional areas operate efficiently. Furthermore, he/she needs to ensure that the stock enters and exits the facility as planned and reaches the end-consumer when and where required.

All processes within the DC are linked to demand – demand is an economic principle that describes the consumers desire and willingness to pay a price for a specific good or service (Investopedia, 2016). The demand dictates the type and amount of stock that needs to be picked in the DC and sent to the customers. This, in turn, generates orders for the DC to the vendors to ensure that the stock levels in the DC do not fall below 14 days' worth of stock. The company decided to hold anywhere between 14 to 21 days' worth of stock in the DC, which ensures it can always meet customers' needs. The vendors will then deliver the ordered stock to the DC. This stock then enters the DC, waiting to be picked for a customer. When picked, the process starts all over again.

Now that a general understanding of a DC operations has been provided, it is possible to focus on the Philippi DC on which the thesis is based. This next section of work follows the flow shown in Figure 3.12.

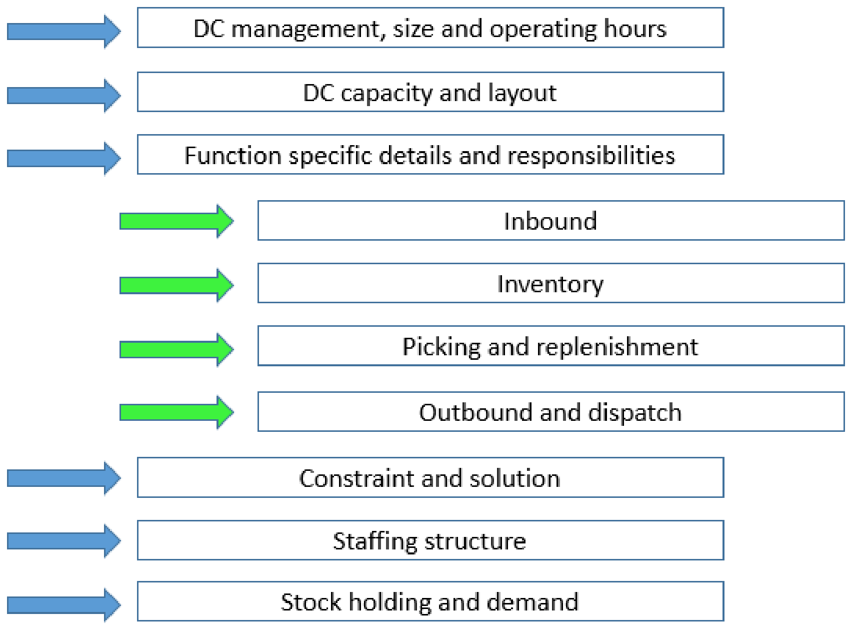

Figure 3.12 Process flow within DC

As Pick n Pay was inexperienced in running DCs, management contracted a third-party logistics service provider to manage the DC on behalf of Pick n Pay. Nonetheless, Pick n Pay still maintains a strong presence in the facility and has deciding power over important factors. Currently, the Philippi DC services 90 stores in the Western Cape region. A daily average volume of 63 057 inbound cases and 64 932 outbound cases move through the DC. According to data drawn from Pick n Pay's database, an average pick rate is 104 cases per hour.

The Philippi DC is built on a 141 653-square-metre plot and the size of the building itself is 41 388-square metres. The inbound staff works two six-hour shifts, from 06:00 to 12:00 and from 12:00 to 18:00. The picking and outbound staff work a full 24 hours per day, which is divided into two 12-hour shifts. At any point during the day, there are an average of 517 staff members working in the DC.

Also known as 'the box', the building itself contains 35 aisles made up of steel racking. The racking holds 10 062 pick faces and an additional 27 109 reserve-racking pallet locations, bringing the total pallet locations in the DC to 37 171. At the inbound section of the DC, there are 12 doors that can be used to receive stock into the facility. The outbound section has 35 doors in order to accommodate the higher volume leaving the DC on any given day.

Apart from the performance measurements of volume and pick rate, there are several other operations in the DC. These performance-measured operations include inbound/receiving, inventory management, picking and outbound – each with its own respective functions. These functions are now discussed in more detail.

Inbound, also known as receiving, is the operation that ensures that the vendors delivering to the DC drop the correct stock on the correct days, in the correct quantities and at the right quality. This is aligned to demand planning to meet customers' needs in stores. Incoming loads are checked and received into the DC. Hereafter, the loads are allocated for put away into their predetermined pick face or reserve-racking location. It is vital to ensure that the stock is received correctly and any discrepancies from the vendors are identified and corrected.

The function of inventory management is to ensure that the stock is stored in the correct location within the DC and accurate records are kept of the stock and its movement. The stock must be recorded correctly into the database using a Cubi-Scanner, a box-like device wherein you place products, to record its dimensions accurately in the form of master data. Using a laser it scans the product and records information such as height, width, length, volume and a scale to weigh products. This information is then stored as master data.

Correct master data ensures that other operations, such as replenishments, can be performed correctly, as it calculates how many of each article will fit into the pick face. The inventory managers are also responsible for ensuring that stock is always available in the pick faces. This is done by monitoring inventory levels and issuing replenishment tasks when the levels drop to set trigger points, an indication that the stock level in the pick face is too low.

Picking is the function of receiving a list of items that a store requires, which is sent to the pickers via the clerks. The pickers will then go into the DC and pick these items. Once the pick is complete, the HU with the required items will be placed in outbound. Pickers are also responsible for reporting any stock-related issues within the DC, such as triggering replenishments by indicating a no stock or zero pick. The pickers will indicate a zero pick when there is no stock in the pick face of the item they are required to pick. They can follow two scenarios. Pickers can either wait for the replenishment to take place, continue their pick and come back for the item. Alternatively, they can cut the pick and leave the item to be picked by another picker, combining the picks in the outbound area. If picking is performed incorrectly, stores receive incorrect stock and the customers' needs are not being met. This results in unnecessary costs and unhappy or lost customers.

The final stage in the DC's operations is outbound. Here, several functions are performed. The first function entails receiving the HUs from the pickers. Once the HUs are in the staging lanes, the outbound team will ensure that the HUs are staged in the correct sequence, according to the stores where they will be delivered. Audits take place within the staging lanes on selected loads, as well as consolidation activity where staff will combine multiple half-full pallets. Once a transport unit (TU) arrives at the door, the HUs are loaded and shipped. The team must ensure the correct load (group of HUs) is loaded onto the correct TU.

In 2013, Pick n Pay realised that the Philippi DC's productivity needed to be bolstered in order to continue business centralisation. This caused a serious challenge, as it was not possible to expand the DC and increase staff at that point. As such, the current space had to be utilised more efficiently. The pick tunnel was identified as the best solution to the current problem. It would allow for a larger volume to be held and moved through the DC, as well as increase its current pick rate and performance. Supply chain consultants from the United States were contracted to design, build and implement a solution for the pick tunnel. In November 2013, the team was flown down to the Philippi DC to commence with the project.

The aforementioned section briefly described several key processes within the Philippi DC, as well as the challenge of space constraints and the need for increased performance. The next section deals with the various operations within the Philippi DC. Each interlinked section plays a key role in ensuring the improved performance of the facility, as is explained below.

3.2 How various operations influence each other

The Philippi DC includes four operations – inbound, inventory, picking and inventory management and outbound – that need to run optimally so that the DC can meet its operational goals. Each operation includes several activities to ensure that they operate at their highest capacity. The activities are listed in Appendix A under their relevant operations.

The following section highlights the interdependence of all operations. In addition, the section indicates why it is important for the unit to work efficiently in their own capacity due to the effect on one another.

3.2.1 Inbound's effect on other operations

The activities in the inbound operation form an important link in the rest of the DC's operations and activities. If inbound is not controlled and performed correctly, it will not be possible to pick and deliver goods to the stores that the DC serves. If a delivery is rejected at the inbound, it could lead to a stock out in the pick faces, as the rejected delivery must be sent back to the supplier.

The vendor is responsible for correcting the order and return it to Pick n Pay's DC. Once this is done, it can be received and put away to make the stock available for picking.

All received stock must be checked. If the stock is not checked correctly, it will result in an error in stock quantity or quality. This will influence the picking and outbound operations, as the inventory levels will not match the actual quantities available. In addition, the DC will not be able to meet the demand it has promised to its stores. As such, inbound and receiving play a key role in ensuring that the DC maintains correct stock levels to meet demand.

Efficient and correct inbound functions play a crucial to ensure that the picking function runs efficiently. For example, should a delivery be received incorrectly, a picker will arrive at a pick face where there will be low stock or no stock. This is despite the fact that the system indicated that the stock was available. This results in a short pick or a delay in completing the pick, as the picker will need to wait for a replenishment to take place. If the quality of goods received is not checked accurately, the stock has be written off at the expense of the DC and is unavailable for picking. Both of these situations lead to incomplete picks, stores do not receive all the stock that was ordered and consumers do not have access to the products they require.

The put-away activity in inbound also plays a critical role in the DC's operations – especially picking and inventory control. Once the inbound team receives the stock and checks whether it is correct, the stock must be put away in the correct location to ensure it is available for picking. If the stock is not placed in the correct location, it will not be available for picking. Furthermore, the stock may get lost in the DC for some time before the error is identified and corrected. Storing the stock in the incorrect place also hampers replenishment and may block a slot that could have been used optimally for other stock. Time and money will be wasted in searching for the stock, replenishing it and correcting the error. These inefficiencies will have a ripple effect throughout the picking and outbound operations of the DC, which is be discussed below.

3.2.2 Picking and inventory's effect on other operations and activities

Picking has a large influence on inventory management and outbound. Notably, picking accuracy and efficiency have a profound influence on inventory management. If the pickers follow their picking route and pick 100% accurately, there should be no issues. However, this rarely is the case.

There are pickers who pick the wrong product or the incorrect amount of the product, which all result in incorrect inventory levels and system data. If the inventory management team is unable to keep an accurate control on the inventory level of pick faces, upper racking, pallet locations above the pick faces that hold reserve stocks, this could lead to complications like unnecessary replenishment tasks, short picks due to unavailable stock and unfulfilled outbound orders (Wessels, 2014).

Inventory and picking have the following effect on outbound: the outbound order fill rate will not hit the set targets due to incorrect or insufficient quantities of stock being picked. When the target fill rates are not met, stores do not receive their ordered stock and customers' needs are not being met. The more energy customers use to make sure you're filling their orders correctly, the more unsatisfied they become. Not being able to ship or deliver on time results in rocky relationships and decreases customer loyalty (Clear spider, 2017). For this reason, incorrect DC operations affect stores, customers and future revenue of the business.

Picking has another effect on operations. Incorrect picks affect inventory management and reaches full circle by affecting picking, as there is no stock available to be picked during the next pick wave. This leads to a build-up of incorrect picks. At the end of the day when all the incorrect picks are calculated, there is a major picking tail or a number of picks that are not completed correctly or not picked at all. This results in overtime picking or picking only taking place the following shift and late deliveries to stores.

Replenishment is a key activity within inventory management, as it ensures that there is stock available in the pick faces that pickers could pick. Replenishment must identify when stock needs to be replenished. Furthermore, this operation ensures that stock is replenished in the correct order, so that there are no delays in the picking process. If replenishment is not timed or controlled correctly, it causes empty pick faces or low stock in the pick faces. Subsequently, pickers are unable to complete their picks. This could result in picking errors that send a ripple effect through the entire DC, which once again affects outbound and end-consumers.

3.2.3 Outbound effect on other operations

Outbound has a significant effect on picking, and this is exacerbated at the Philippi DC due to the space restriction at the outbound doors. A DC will aim to pick a day or two ahead of time. This is to provide enough time for HUs and their contents to be checked to ensure the pick has been completed correctly, as well as to allow for any consolidation or load-sequencing activities to take place.

Initially, Pick n Pay's Philippi DC was designed to pick two days ahead of schedule, as there was enough space available to do so. However, due to the inability to meet demand, picking one day ahead of delivery was instituted. This was as a result of the plans to build the pick tunnel and move the existing racking into the space that was previously used for outbound staging.

Inaccurate picking results in the need for multiple consolidations and congestion in the outbound staging area. Post-pick audits also need to take place, which adds to the congestion in an area where space comes at a premium. As such, it is pivotal to pick accurately, so that the outbound floor is not overwhelmed and can cope with the required activities in the available space.

The outbound floor consists of staging lanes; these lanes hold HUs filled with stock that needs to be delivered to stores. The staging lanes are allocated to a specific TU that delivers to a specific group of stores. As such, the HUs are placed in specific lanes according to their destination. Consolidation activities from poor picking or pickers picking ahead of time could use up the staging lanes' capacity. As more HUs are staged than capacity allows, there will be an overflow in the outbound area and functionality will decrease dramatically. There will be no space for staging and this may lead to incorrect loading of TUs. If the TUs are loaded incorrectly, they will not be able to offload the deliveries efficiently at the stores and it will cause delays in turnaround time of TUs. This slower turnaround time will lead to a delay in loading TUs at the DC. This, in turn, could cause a build-up of HUs in the staging lanes and delay all DC activities and deliveries to stores. To prevent an overflow of HUs and longer turnaround times, the outbound floor's capacity needs to be managed strictly. As such, picking needs to be performed optimally to ensure a minimum amount of consolidation and activity within the staging lanes.

The following section of this analysis focuses on the opportunities for improvement within each operation.

3.3 Opportunities for improvement

This section aims to achieve the sub-objective of understanding the operational aspects of the DC. Within each of the abovementioned operations and activities, numerous improvements were identified and implemented to ensure that each operation, as well as the DC as a whole, performed optimally. These improvements allowed for the pick tunnel to be built and put into operation.

Each operation and activity within the DC was analysed in detail. This was done through an operational assessment and by working with staff members from each activity and observing their daily routine. This resulted in a list of opportunities for each activity within the DC's operations being drawn up. The opportunity list, which includes areas of possible improvement and proposed recommendations, is identified. The opportunity list includes the inbound, inventory, picking and outbound operations. Systems, audit, replenishment, put away and waving were also included. Although they fall under the four main operations, they required additional attention as they provided valuable opportunity for improvement. The reason for this was to ensure that once the pick tunnel was operational, other operations and functions within the DC would not hinder its performance, and vice versa.

3.3.1 Index of opportunity list

The index of opportunity list included key areas in the DC that contribute to the facility's performance. It was equally important to ensure that any possible problems in each respective area were addressed to avoid any future problems. The areas that were examined to identify possible opportunities for improvement are shown in Table 3.1:

Table 3.1 List of areas of improvement

Areas of improvement
• Inbound/receiving
• Inventory
• Put away
• Replenishment
• Picking
• Outbound
• Audit
• Systems
• Waving

3.3.2 Inbound/receiving

When the demand-planning panel was asked whether they had accounted for complex and straight loads in the planning and scheduling for Philippi DC, it transpired that they had not done so. This was despite having allowed for these when developing Pick n Pay's other DC in Longmeadow (Wessels, 2014). As such, they should employ the same principles for Philippi's inbound planning by using load classification planning that may allow for less volume on days with complex loads and make the receiving more efficient. Scheduling complex and straight loads on the same day can cause delays in the receiving process due to the additional time spent on complex loads. Subsequently, not all loads would be processed timeously.

The reserve-storage locations in the DC were severely underutilised due to the high number of single-layer pallets being received and put away into racking. Multiple single-layer pallets were observed in receiving for the same stock-keeping unit (SKU) type that could have been consolidated onto one pallet. The latter would take up only one reserve-racking location instead of several.

Ordering single-layer pallets from vendors results in poor cube utilisation of reserve racking and should be avoided. To eradicate this problem the business should reduce the number of single-layer pallets received from vendors. To facilitate this, the demand planners should change their ordering levels to consolidate single-layer pallets into multi-layer or full pallets. This leads to better capacity utilisation within the facility, which was one of the constraints the business faced.

Due to limited space in the DC, and the fact the DC continued to operate during the construction of the pick tunnel, the inbound volume had to be reduced in order to empty out space in the DC. In line with this, stock being held in the aisles was moved to create space to build the pick tunnel. This was a top priority, as the construction could not begin until the stock had been removed from the aisles. Once the aisles had been emptied, the racking could be moved so that the construction of the pick tunnel could start.

Another possible area of improvement related to goods that were rejected due to the fact that vendors failed to arrive during their allocated time slots. This influences replenishment and picking due to stock not being available. The business should have enforced vendor compliance to keep to scheduled timeslots. Also, instead of rejecting a late load, they should have made the vendor pay a penalty. This would have helped enforce compliance, while simultaneously ensuring that stock was available for picking to fill store orders.

It was found that the make-up of the receiving teams slowed the receiving process. The receiving team consisted of multiple associates across functional areas that processed loads in receiving. This included staff for checking, auditing and putting away from separate tasks that slowed throughput. In addition, numerous checks and audits were required before a load was cleared and received, which caused a delay in receiving. A solution to this issue was to create receiving teams consisting of an off-loader, receiver and auditor that could be assigned to a load based on planned activity. In addition, too many checks and audits were required to receive loads. The warehouse management third party logistics service provider (3PL) that managed the DC on behalf of Pick n Pay implemented these solutions.

It was noticed that checkers who were checking loads constantly walked back and forth between the loads. Furthermore, the printers where checkers printed HU labels to place on the loads once they had been checked slowed down the receiving process. Providing checkers with a roll of blind

HU labels to be applied as pallets were counted would have reduced the need to walk to printing stations.

The DC was performing full-load receiving, which meant that only once an entire load had been checked for quality and quantity and had no defects, could it be received and the driver be sent away. This caused a delay at the inbound yard, longer turnaround times for the trucks and higher costs. The solution for this was to implement pallet-level receiving. With pallet-level receiving, each pallet is checked and received, as it is unloaded from the truck. However, there was a concern, as this system necessitates a returns process to vendors that can be costly and take up valuable space. Full pallet receiving would work if there were a record of high vendor performance and minimal damages or returns.

The multi-loads and skim loads were being processed outside the inbound doors. This took up space and time and increased the number of times the product was handled. A mini-load is when a truck only delivers one pallet, as opposed to a full truckload. A skim-load is when a truck delivers a layer of a pallet, which is less than a full pallet. The inbound doors should have had a dedicated area where this could take place. A dedicated team should be allocated to this function, so that it did not affect the receiving of normal loads.

Processing time of complex loads was up to twice that of normal loads, causing delays in inbound activities. As the business was busy with centralisation of SKUs, there would be an increase in the number of complex receipts in the future. Multiple SKUs per pallet load would also make the receiving process more complex. To alleviate this problem, the orders being received should have been equal to planned stockholding (two-week timeframe) to eliminate multiple shipments per week. Suppliers that qualified for consolidation of loads to create an express-type receipt needed to be identified and planned accordingly.

To meet the increase in volume, dedicated lanes were proposed for different types of trailers, as well as complex or straight loads. This would allow for dedicated teams that could focus on specific load types without having to work between multiple lanes and on multiple loads.

The DC was receiving numerous skim loads, i.e. loads with multiple SKUs on one pallet that need to be separated, so that each SKU can be put away in its appropriate location. These loads were received on one specific day per week, causing a bottleneck effect at the inbound doors. This was due to the fact that receiving teams had to unpack and repack pallets. This bottleneck effect could be minimised by spreading these out throughout the week.

The allocation of HU labels during receiving hampered the productivity of reach trucks – the HU labels were being placed in multiple positions on the pallet. This required reach truck drivers to reverse into the staging lane, scan the label and then to drive out and re-enter the lane to pick up the pallet for put away. A solution to this would be for inbound managers to ensure that there was a standardised process where labels had to be placed on the bottom right-hand corner of the HU.

Due to limited equipment, the put-away and replenishment functions shared reach trucks. Subsequently, stock had to stand at inbound for long periods of time, as the reach trucks were busy performing replenishment tasks. This blocked the inbound lanes and prevented other trucks from off-loading. A solution was to form a dedicated team of reach truck drivers allocated to put-away tasks, who were able to perform replenishment when they were not being used. This would ensure the inbound doors could be cleared as quickly as possible and that there was always stock in the reserve racking to be replenished into the pick faces.

The prescribed layout of categories was not being followed. As a result, stock from the same SKU was being put away in diverse locations, which meant that the stock was not being kept together. This resulted in more travel time and distance for put-away tasks from the same inbound lane, slowing the process down and occupying an inbound door for long periods of time. Therefore, trucks would have to wait before they could unload their deliveries. Re-slotting of the DC, which is when the layout of products is re-arranged, had to take place. Alternatively, staff needed to adhere to more strict put-away locations that are in line with the DC’s category. This would minimise the travel time, distance and time needed to clear the inbound doors.

3.3.3 Inventory

When a new SKU entered the DC, it was scanned using a Cubi-Scanner that recorded the data for the item, such as the weight, height and volume. This was recorded in the master data for use in other operations. After sampling and measuring several SKUs, it was found that the master data was inaccurate and that some of the items were not scanned into the system. Since the master data was incorrect, the DC would not be able to operate at full capacity. Examples of this were that the pigeonholes and pick faces were not being used to full capacity. According to the system and master data, they were fully replenished, but in reality, they were not. This decreased the capacity of the entire DC, as critical space was wasted.

Due to unreliable master data, insufficient stock was being replenished. The replenishment team replenished five cases when ten could fit into the pick face. Thus, there was a need for a second replenishment soon after. This slowed down the picking and also delays valuable resources, such as reach trucks that were used for both put-away and replenishment functions.

The slotting of SKUs within the DC was highly inefficient. It was found that similar SKU-type items were slotted far apart and not in their allocated aisles. The reserves for particular SKUs should have been slotted above, and close to, the allocated pick face to allow for shorter replenishment time. However, the reserves were found up to 10 aisles away from each other and from their allocated pick face. To solve the problem, the slotting of the DC needed to be re-evaluated by making use of a slotting tool. The re-slotting was critical as the B level (second level of racking) pick faces were removed once the pick tunnel was operational, which restricted the number of available pick faces. It was essential to optimise the DC’s layout that no pick faces were wasted.

Another possible opportunity to improve the replenishment process was to monitor stock levels in pick faces. Preventative replenishment could also be implemented by calculating the difference between the stock needed for the following pick wave and the stock remaining in the pick face. If the pick face did not have sufficient stock to fill the next picking-order, replenishment would be triggered before the next pick wave was released. This would ensure the picker did not have to wait for replenishment stock.

Aligned to this was the question of how much stock needed to be held in a pick face. According to Wessels (2014), three days’ worth of stock is optimal. However, this depends on the pick rate for the specific item and needs to be calculated carefully for each SKU.

Regarding order picking, when a line had more than one pick face, the system would send the picker to the pick face with the highest level of inventory in it. This meant that the pick faces were being depleted simultaneously. As such, they all hit the replenishment trigger point at relatively the same time. This could be avoided by allowing the pick faces to be emptied in sequence. For this reason, only one pick face was picked out of at a given time. When that pick face emptied out, the system would direct the picker to the next bin. This allowed for replenishment to take place during picking, which reduced time wasted due to hold-ups.

The physical inventory counters did not have the licences required to operate the reach trucks. Therefore, they had to wait for reach-truck drivers to assist them. On the other hand, the reach truck drivers were busy with put-away and replenishment tasks and had to finish them before they could help the counters. This slowed down the process dramatically. The best solution was to ensure each counter had a licence to operate a reach truck, so that s/he did not have to wait.

3.3.4 Put away

A system error was found while observing the reach-truck drivers performing put-away tasks: the system determined the priority of put-aways. However, when there was only one load that had been checked and cleared for put away, all the reach-truck drivers were directed to perform this task. This resulted in congestion due to multiple reach trucks arriving at the same staging lane to collect pallets for put away. Subsequently, reach trucks had to wait their turn to pick up a pallet. System-driven allocation of tasks needed to consider optimal dispersal of tasks across lanes to reduce congestion and increase productivity. If there is only one load available, the reach trucks should be re-assigned to replenishment tasks.

It was difficult for the reach truck drivers to read the check digit on higher level-beams, beams that hold the pallets of reserve stock, due to the check digit being quite high up. Pick n Pay needed to add the check-digit label onto the level indicator plaque on the ground floor for all levels and change the system from entering check digits manually to scanning barcodes to confirm the put away.

3.3.5 Replenishment

The DC held various stock lines that moved at different speeds, which meant that some lines were picked more often than others were. The differences in article velocities resulted in the need for more replenishment to ensure there was always stock available. Due to the DC’s limited capacity, only a small number of pick faces were allocated to these faster-moving SKUs. A solution was to increase the number of pick faces allocated to minimise the number of replenishment tasks needed, which would bolster efficiency and productivity. A slotting tool could keep tabs of items’ volumes and the speed at which they were picked. Furthermore, the tool would be able to calculate the correct number of pick faces to allocate to each SKU.

Pick n Pay had set up the pick faces according to two types: pallet or pigeonhole. This resulted in sub-optimal slotting and utilisation of cubic meters. The pick faces needed to be reconfigured to match the requirements of the centralisation process. This necessitated different-sized SKUs at various volumes, allowing for some items to be picked in pallets and others in cases or shrinks, the units within a box. A slotting tool was required to determine the optimal pick-face allocation, as a diverse list of SKUs were held in the DC and not all of them were suited for the current pallet or pigeonhole pick faces.

A replenishment trigger point set at a specific number of items was allocation to each pick face. Replenishment was triggered once the stock count reached that level. It was found that the trigger points were set too low for some SKUs. Therefore, by the time the picker arrived at the pick face to pick, stock had not been replenished yet. As such, the picker had to wait or caused a zero pick to occur, i.e. there was no stock to pick. This led to increasing tail picks and consolidation was required in outbound. A pick tail is several products that could not be picked in their original picking path, due to issues such as no stock, which are consolidated and picked again at a later stage to complete the original order.

According to Wessels (2014), trigger points needed to be set at three days' worth of picking activity to prevent a zero pick and allow the pickers to continue picking until a replenishment took place. When calculating the trigger points, it was important to consider any spikes observed. An example of this is month end when picking usually increased. This would affect the rate at which the SKU was picked and the bin was emptied out.

Replenishment into pigeonholes did not make full use of the pick-face cube. Notably, replenishment quantity was manually set and did not take volumetric calculations into account. Subsequently, multiple replenishment tasks were created for each pick face. An improvement would be to use automated max bin calculations (volumetric based) when setting replenishment quantities. To ensure the calculations were accurate, all SKUs that were held in the DC had to be scanned using Pick n Pay's Cubi-Scanner. SKUs that had already been scanned needed to be checked to ensure accuracy. This would have assisted with the slotting of the DC, as the data was needed to perform both tasks.

A picker's maximum reach height is determined at 1.8-metres. Due to this height, restriction on the second (B) picking level, pickers were unable to fill the pick face, as they could not reach the top items. As the stock was replenished partially, it led to the need for more frequent replenishments and this had a negative effect on productivity. The pick tunnel would help address this issue, as all B-level picking was to be removed once the pick tunnel had been built. There would only be pick faces on the A level, allowing for full pallet replenishments to take place.

During replenishments, it was noted that the replenishment teams did not clear the bins of any left-over stock before placing new stock into the pick face. Subsequently, old stock was pushed to the back of the pick face. As a result, this stock could reach its expiry date before being picked. The 'first in first out' rule was not being maintained in the pigeonhole pick faces, which resulted in a 'first in last out' scenario. The business had to enforce correct replenishment procedures to ensure that old stock was not pushed to the back of the pick faces, but was brought forward during the replenishment task.

As there was a delay in replenishment tasks due to a limited number of reach trucks and longer picking waves, the replenishment tasks were not completed before pick tasks were issued. This resulted in multiple zero-pick exceptions. Pick n Pay's Extended Warehouse Management (EWM) system allowed pick tasks to be created, resulting in pickers arriving at a location and encountering zero stock. This led to longer tail picks, lower productivity and increased consolidation requirements.

Although the EWM system was set up to allow for planned replenishment, the tasks were only issued based on trigger points being met. The picking waves needed to have shorter intervals. This meant less picking took place in one wave, less replenishments were needed and the replenishment teams were able to cope better with the workload. Another possible solution was to use the planned replenishment system function by calculating which SKUs needed to be replenished during the pick wave, based on picking volume. This would enable the replenishment team to replenish these SKUs before the pick wave was released or before the trigger point was reached.

3.3.6 Picking

Many of the shortcomings discussed under the Inventory and Replenishment sections above influenced the picking function. For example, when the researcher followed several pickers around the DC on their picking path, it became clear that, on average, the pickers were only completing two out of twelve picks, as there was no stock in the remaining bins. The pickers were reaching a pick rate of 110 cases per hour. This was low, as only a third of the pickers were reaching their targets and thus could improve greatly. The low productivity was linked to the poor replenishments, which needed to be corrected by planning replenishment tasks more efficiently. In addition, better slotting; more accurate trigger points; opportunistic replenishments before a pick wave is released; and smaller picking waves to decrease demand on replenishment teams during the waves would also have assisted in correcting this issue. These and other inefficiencies will be discussed in more detail in this section.

The inadequacies of the DC's slotting and layout, as discussed in Section 3.3.3, had a severe impact on the picking function. Subsequently, pallets had to be rebuilt. The pick faces were not laid out for an optimal pallet build. Subsequently, heavier items were sometimes picked after lighter items. As a result, the picker had to rebuild the pallet. Experienced pickers were able to deal with this more efficiently by cycling through tasks to identify a pick path that would result in a better pallet build (heavy to light). This should never have been allowed, as inexperienced pickers were unable to follow suit, As a result, they were forced to reorganise the picked stock to optimise the pallets. In addition, productivity was reduced when pickers cycled through tasks and this process also resulted in errors being made. An improvement in the slotting would alleviate this problem. However, any change would need to ensure that stock within each category was slotted from heavy to light, thereby enabling a better HU build.

Due to incorrect item master data and/or poor packing of HU's, sometimes pickers had to cut a HU and move the remainder of the pick to a new HU as the weight or height limits had been reached. When this happened, pickers were required to find the supervisor who would cut the HU before picking could continue. As a result, neither pallet would be packed optimally, which increased the consolidation burden in the outbound lanes. Two interventions could correct this. Firstly, pickers should be trained in following the correct packing procedures. Secondly, the master data should be updated and checked continuously to ensure that pallets are configured optimally when a picking order is compiled. Another possible solution would be to allow pickers to cut a HU, which would save time looking for a supervisor. However, concern was raised that this would lead to picks being cut due to negligence, or poor work ethic as pickers may want to complete tasks quicker.

Prior to the installation of the pick tunnel, pickers picked multiple package sizes (cases, shrinks and pallets) within the DC: The pick tunnel was designed to isolate shrink picking. Subsequently, pickers could only pick cases or full pallets outside the pick tunnel.

The pickers picked for one store at a time, onto one pallet. The material-handling equipment used for picking was capable of holding two pallets or rolltainers. Efficiency would increase if the pickers were trained to pick for two different stores onto two different HUs simultaneously. This would require a high level of staff discipline to ensure they did not mix the store's picks. Suitable training for the pickers and implementing strict business processes could help address this problem. If this were executed correctly it would increase productivity and decrease picking time.

Lack of enforcement of rules resulted in inefficiencies. Due to poor discipline, pickers were creating multiple zero-pick exceptions (no stock) before shift end in order to clear their task list. This allowed them to drop the HU in outbound before signing off from their shift. This increased the number of tail picks and added complexity in outbound, as there was a greater need for consolidation.

The supervisors needed to follow up at the end of each shift to ensure pickers had completed their full task lists. In certain instances, pickers needed to pick from a second location for SKUs with multiple pick faces, if there was no stock in the location they had been directed to. If they failed to scan the new location, an incorrect inventory balance reflected on the system. This, in turn, resulted in an increase in future zero-pick exceptions. A possible solution would be to tighten discipline and not allowing pickers to pick stock from a location that did not form part of the pick path. Furthermore, stock levels should be checked and accuracy should be ensured to prevent stock-outs from occurring without the system triggering replenishment.

As rules were not enforced stringently, pickers were seen sticking the HU labels onto their arms or legs, instead of onto the HUs. When picking into multiple HUs such as rolltainers, this resulted in miss picks by placing products into the wrong HU. Labels were also lost during this process, which resulted in rework and unnecessary checking of HUs. This highlighted that labels needed to be applied to the HU itself to minimise potential misplacement of stock.

Further inefficiencies in the picking function resulted from the auditing process. Once the pickers had completed their picking task, a certain percentage of HUs was selected for auditing. During this manual process, the auditor unpacked the HU, checked the contents by scanning each item and then repacked the HU. On average, each HU took one hour to audit. The auditors were also undisciplined and were observed standing around, talking to colleagues and taking their time with the process. The solution to the poor work ethic would be to have a supervisor in the audit area to improve productivity and increase the working pace. Implementing a new automated audit process that circumvented the manual unpacking and repacking of the HU would decrease the auditing time of each HU considerably.

3.3.7 Outbound

The design of the outbound lanes at the DC did not provide consolidation space for HUs. As a result, some operations would spill over into neighbouring lanes. This not only led to congestion, but also raised the possibility of moving stock to the wrong HU during the consolidation phase. Consolidating of partial HUs takes up space that reduces the turnover of the staging area considerably.

As discussed in the above sections, part of the solution to the consolidation issue lies in correct HU builds (picking) and effective slotting of the DC (inventory). However, when consolidation has to take place, available space should be used more efficiently. This could be done by restricting the process to the staging lanes to prevent mixed orders, access aisles only being used to move

HUs. A redesign of the outbound floor would enable this. As such, it was one of the tasks that was included in the pick-tunnel project.

Consolidated HUs were found to be over-stacked, which could cause problems during offloading at stores. Maximum stacking levels were needed which supervisors would actively check to ensure compliance. Addressing this entails a two-fold approach: Firstly, by ensuring the master data is updated, maintained and correct to allow for optimal HU builds. Secondly, by training pickers on how to stack and pack HUs correctly to avoid reworking.

When HUs arrived at the outbound staging lanes, they were not always in sequence according to the store-order deliveries. The HUs could not be sorted easily into loading sequence due to outbound layout's limited capacity. This meant that the HUs were being handled numerous times and needed to be reworked. This caused a drop in efficiency and slowed down the ability to turn the outbound floor as needed, as well as clear and fill the floor with the next group of orders to be shipped out. Again, the redesign of the staging lanes, which formed part of the pick tunnel project, would address this problem. Smaller picking waves could have also been set up with store-drop sequence being taken into consideration. This would help ensure that the loads arrived at the staging lanes in sequence and that there was enough room to move the loads around as the lanes would not be full.

The turnaround times for trucks delivering to stores were long and some deliveries took up to six hours. This reduced the potential to perform second delivery runs with a vehicle. This, in turn, influenced outbound floor turns.

The racking was moved to make space for the pick tunnel and took up space in the staging lanes. With the new pick tunnel and limited outbound staging lanes, the DC needed to turn the floor more often to ensure that there was no overflow or congestion. The turnaround times at stores had to be managed more effectively through better scheduling to ensure trucks could be offloaded the moment they arrived, so that they did not have to wait. Devising standard processing times and enforcing compliance via penalties would help to address this issue.

Planning outbound operations was complicated by the fact that outbound managers did not receive an accurate view of when vehicles would arrive on site. Ensuring that truck arrival times were always visible would assist the managers to better plan the loading process. Improved supply-chain planning would also ensure that loads were ready for the trucks. If a vehicle was available, loads prepared ahead of schedule could be sent out immediately. When shipments were ready to be loaded, there was a high number of trucks and trailers being staged in the yard, but not pulled to the loading door. Truck drivers were onsite but not actively working to ensure trailers were ready for loading. The drivers needed to pull their trailers to the loading doors once the doors had been cleared, so that they were available for loading.

The vehicle-loading operation monopolised the time of a number of people due to the way tasks were structured. Supervisors printed loading sheets that were read out to the loader who confirmed and loaded by sequence. Other staff members were observed who formed part of the process (i.e. checking, HU identification). This was a waste of resources and slowed down the process. To simplify the process, the supervisor could give a print-out of the loading sheet to the loader, who could then load by sequence and check the HUs off the list himself.

When the vehicles were being loaded, the adjustable straps that were used to secure HUs on the trucks sometimes damaged the products. The DC had to pay for the damages, which was an unnecessary negligence-related expense. This could be addressed by ensuring that the straps were used in the correct manner, without over-tightening them.

3.3.8 Audit

HUs were audited after the completed units were moved to the staging lanes at outbound. Only a percentage of the HUs were audited. Once an HU was audited, it was sealed with shrink wrap and security tape. The researcher noticed that the HUs were removed not being sealed correctly. As a result, there were gaps where products could be taken off or additional products added, reducing the value of the auditing process. The HUs had to be sealed completely after the audit to ensure the HU could not be tampered with afterwards.

The audit process dictated that the HU had to be unpacked, checked and repacked by hand. This time-consuming process resulted in extended processing times, while products were handled too many times in order to complete the check. To address this issue, a ‘pick and mark’ (scan an item and mark it with a pen) audit process needs to be implemented for pallet HUs. Once all items are scanned, the system will indicate whether all items are on the pallet or not.

A weight-based audit process would be best suited for rolltainers and tote bins. The rolltainers and totes can be weighed once the pick has been completed. The total weight can then be compared to a pre-calculated, system-determined weight when the picking instruction is compiled. Any variance in weight would indicate whether the pick load is correct or requires further investigation. A weight-based audit process requires accurate, up-to-date master data. Furthermore, vendors need to cooperate by stating any changes in pack specifications or product design.

3.3.9 Systems

An electronic system was used to communicate with the pickers. Pickers carried wireless AMT to communicate picking tasks and any other instructions. It was found that the system was overloaded and did not have sufficient capacity. Subsequently, pickers were standing around waiting for their new pick instructions to be issued. This also affected replenishments, as the replenishment teams worked off the same system. As such, the slow system hampered the entire DC's operations. The system capacity needed to be upgraded to allow for quicker communication between staff, so that they could receive their instructions as soon as they have completed their last task.

The system was set up to restrict pickers to only pick for one store at a time although the low-level order picker (LLOP), the material handling equipment, could accommodate up to three rolltainers. The system was able to accommodate multiple store picks. However, due to the error rate experienced in the past, this functionality had been switched off. The business should allow the top-performing pickers to pick to multiple HUs. This should be rolled out gradually to include more pickers once they have been trained to handle the more complex system and there was no danger of increased pick errors. The pickers needed to be trained for this function to ensure that followed the correct procedures to ensure pick accuracy.

As discussed earlier, pickers were allowed to surf through their pick task and select which items to pick first. This was due to the fact that pick tasks were not optimised and sometimes heavier items would follow lighter items in the pick list. Task surfing increased the travel time. This influenced the time it took to complete an HU and decreased productivity. The DC needed to be re-slotted and the system needed to prevent task surfing. This ensured that the pickers picked in the sequence they were instructed to. Once the DC had been re-slotted, the pick instructions would allow for an optimal HU build so that the HUs did not have to be reworked during the picking task.

With regard to the picking process, it was found that when SKUs have multiple pick faces, the pickers were directed to the pick face with the largest quantity of stock. Subsequently, a higher number of zero picks took place simultaneously and numerous replenishments were triggered at the same time. The system needs to direct pickers to empty out one pick face at a time. Pickers should only be directed to the next pick face after the previous one has been emptied. By following this procedure, the empty pick face can be replenished, while the pickers continue picking from another location, which ensures that there is always stock available to be picked.

Due to limited resources, the reach trucks had been prioritised for either replenishment or put-away tasks. More careful prioritisation of reach truck tasks is required to focus on completing replenishment tasks that are critical to picking. While urgent replenishment should be prioritised, careful scheduling of the work could allow for the reach trucks to do put-away or picking tasks in the same area where they have been replenishing stock to minimise travelling time.

Ideally, separate task types should have reach trucks dedicated to that specific function, such as replenishment. If a replenishment reach truck is not busy, it can be used for put away as a secondary function. The system must be able to prioritise tasks based on importance or need, followed by batch tasks in the same aisle to reduce travel time.

It was found that the system was not updated regularly with accurate inventory levels. This was obvious because the system indicated a different inventory level to the amount of products that were physically counted in the bins. This discrepancy between the system total and physical levels created zero-pick exceptions and slowed down the picking process. This could have been avoided if the stock levels were accurate and trigger points for replenishment were activated at the correct time to allow the bin to be replenished before the next picker arrived. To help alleviate this issue, the pickers should be able to perform cycle counts and verify bin quantities at random when they are asked to do so during picks.

3.3.10 Waving

During the operational assessment, it was found that multiple picking waves were being released. This resulted in a high number of picking and replenishment tasks that occur simultaneously. It was decided that this was due to the waves being too large. A solution would be to redesign the waves, based on the pick rate and number of pickers available to ensure that the picking tasks could be completed within the time allocated for the wave. In addition, smaller waves and fewer pick instructions would help the replenishment teams cope with the demand. The waves were being assigned manually. Subsequently, they were released early and not when the system planned them; this needed to be changed, so that the waves were system directed.

Figure 3.13 explains the qualitative data flow and where the information in this chapter fits into the research framework. The case study and operational assessment provided a clear understanding of how the DC operates and which processes are in place for the various functions. It also provided an understanding of how the processes are linked and how they affect on one another. From this understanding, it is possible to identify the processes that need to be measured in the DC and link these to the performance KPIs in Section 2.2.1. These KPIs form part of a framework that was developed for this thesis to measure performance change.

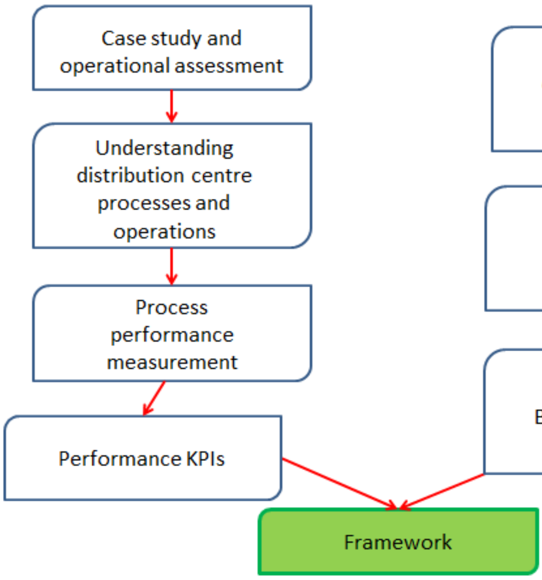

Figure 3.13 Qualitative data flow of thesis

3.4 Chapter Summary

This chapter explaines the daily operations within the DC and how various functions are executed. It also details the effects inbound, picking, inventory and outbound have on one another, emphasising the importance of ensure all operate optimally.

The chapter highlighted several opportunities for improvement under each operation. Two key opportunities that were found repeatedly in all areas included master data inaccuracies and deficiencies and the re-slotting of the DC. Resolving these two issues alone would have a significant impact on productivity. Opportunities were identified and solutions were proposed. If these opportunities were optimised, they would have a positive effect on the overall efficiency of the DC.

Chapter 4: Methodology and structure

Chapter 4 discusses the research methodology and steps taken to ensure that the results and conclusions of the study are accurate and relevant. The qualitative and quantitative data are examined and the data collection and analysis methods are discussed. This chapter starts with an explanation of the study objectives. The aim of placing the objectives here is to clarify the reasoning behind the methodology, to provide insight into why certain actions were taken, as well as to outline the research goals. Lastly the scope of the thesis is dusciussed along with the relevance of the thesis to the business and academic environment.

4.1 Objectives

The research goals were to determine whether the new picking system, designed specifically for Pick n Pay's Philippi DC, performed better than the old picking system. To ensure correct measurement, the researcher formulated certain sub-objectives that were derived from the three main objectives. These objectives aim to answer specific research questions, as briefly explained in Section 1.2.2.

4.1.1 Objective 1: Understanding the operations within the DC

Four important sub-objectives were formulated to help understand the operations within the DC, these sub-objectives were used as the methods to conduct the research required to answer the primary research question.

I. Needs brief

During the design phase of the pick tunnel, a needs brief was drawn up. This took place during November 2013 when representatives from the American consultancy company, Pick n Pay and the system company that runs Pick n Pay's DC systems met daily over a period of two weeks to discuss and establish a needs brief for the pick tunnel that was to be built.

The needs brief is a detailed document that highlights how the pick tunnel would influence various operations within the DC. It was formulated to explain the scope of the pick tunnel project and the purpose of each operation that would be affected, provide a detailed process requirement description, as well as address assumptions around the pick tunnel, system requirements, risks and dependencies. This enabled project role-players to understand the overall impact of the pick tunnel and understand what changes had to be implemented to the current operations to accommodate the new pick tunnel.

II. Case study

A case study of the daily operations within the DC was conducted by following various employees from each operational area and observing their daily activities. Case study participants include employees from each operational area, namely inbound/receiving, inventory, picking and outbound. One to two weeks was dedicated to each operation, as this tied into the operational assessment (another sub-objective for this thesis).

III. Operational assessment

An operational assessment was conducted over a period of three weeks. Within these three weeks, the assessment focused on each operational area: receiving, put away, replenishment, picking, outbound, systems, inventory, audit and waving. As mentioned in the case study, the researcher followed an employee from each operation and observed his/her daily activities. Various random checks and observations within the DC were also conducted. At the end of each day, the researcher documented the notes made during the observations. At the end of the operational assessment, a detailed list of improvement opportunities was presented. The detailed list included areas for improvement within each operation, along with suggested solutions to these shortfalls.

IV. Questionnaires

Questionnaires based on a balanced scorecard were given to each of the management-level staff responsible for finance, operations, sustainability and human resources. Members of management were given a week to complete the questionnaires. The researcher was of the opinion that this would give respondents enough time in their busy schedules to answer the questions accurately. The questionnaires included simple questions aimed at understanding the measures used to track the DC’s performance by making use of a balanced scorecard.

After the questionnaires were answered and processed, the researcher had a clear understanding of the specific methods measured and why they were selected. This would allow for a better understanding of the balanced scorecard selected to measure the performance of the DC.

4.1.2 Objective 2: Establish measurement tools

These sub-objectives are aligned to performance measurement. Each of the sub-objectives described below has a specific purpose in establishing an overall view of whether or not the DC’s performance has improved.

I. Identify key performance indicators

The aim of this objective was to identify the KPIs that were relevant to measuring the performance of the various processes and to determine whether the business had achieved its strategic goals. Ensuring that the KPIs were relevant would facilitate a balanced conclusion regarding whether the pick tunnel had increased or decreased the DC's performance. The strategic goals would be measured using a balanced scorecard. In turn, KPIs would measure the performance of the various processes within the DC. Statistical tests were also used to further break down the performance data and provide clearer conclusions.

II. Framework

Using the above measurement tools, a framework was established that would be easy for the reader of the thesis to understand. It consisted of KPIs, statistical tests and a balanced scorecard that would compare three years' performance data and indicate which year had performed better – prior to or after installing the pick tunnel. The metrics used in the balanced scorecard were not measured in 2013. As such, the data for the balanced scorecard was split between two time periods during 2014. This enabled a comparison of the metrics to establish whether there had been an improvement or a decline in performance. Pick n Pay stopped using their balanced scorecard after 2015. Thus, no data was available to compare with 2014.

4.1.3 Objective 3: Measure performance

The analysis of performance data took place over a period of fifteen weeks. The data was drawn from a secondary database managed by Pick n Pay and the warehouse management company contracted to manage the Philippi DC for Pick n Pay. Performance data collected over a fifteen-week period, from three years, was analysed from a daily, weekly and monthly perspective. In order to compare the three years, data was drawn from the same period for 2013, 2014 and 2015. The 2013 data represented the DC's performance without the pick tunnel, while the 2014 and 2015 data showed performance including the pick tunnel. The data was analysed and displayed using various techniques that included a balanced scorecard.

I. Measure the performance of the distribution centre

The final sub-objective was to use the developed framework to measure the performance of both picking methods, compare the results and determine which picking method performed better. This would answer the research question: Has the new picking system performed better than the old picking system?

4.2 Research methodology, structure and logical flow

Pick n Pay had the need build a pick tunnel in order to increase the performance of the DC and had no way to measure the impact of this change, which represents the gap in knowledge. After building the pick tunnel it was required to measure the change in performance to determine whether the pick tunnel was able to achieve the goals it was built for. In order to do this there was a need to measure different types of metrics and to build a framework using these metrics to determine whether there was a significant change in the facility's performance. This process is show below in Table 4.1, which breaks down the whole research methodology into six steps.

Table 4.1 Steps to determine whether there was a change in performance

	Steps	Description
Step 1:	What?	Identify which functional areas within the DC will be effected by the pick tunnel being built,
	How?	Various workshops were held in which each functional area was discussed to determine impact
Step 2:	What?	Build case study for each functional area.
	How?	Staff were shadowed in each area, following them during day to day activities.
Step 3:	What?	Literature review on productivity measurements.
	How?	Multiple sources were studied, such as text books, journals and other publications to gather adequate information.
Step 4:	What?	Decide which measurements to use.
	How?	Using research to determine which are most appropriate for the type of data and processes available for this thesis.
Step 5:	What?	Build a list of all measurements to be used - this is the development of the framework.
	How?	From the literature review create a list of various metrics that are

		appropriate to measure the holistic change in performance of the DC.
Step 6:	What?	Extract and apply data to framework.
	How?	Use SAP and EWM to extract the relevant data for the DC and apply the relevant metrics to the data drawn.

Step 1: The first step is to identify the areas that will be affected when the pick tunnel was built in the DC. During different workshops, different functional areas were discussed, such as picking, inbound, outbound and IT/IS (Information Technology/ Information Systems). These workshops enabled the researcher to compile a list of current processes that might have to change or new processes that would have to be added to the DC.

Step 2: Once the areas which would be impacted were identified, the next step was to monitor staff within each functional area. To this end, a case study was developed to help identify functional areas that required further improvements. This was done by starting with the inbound section, followed by the put away, replenishment, picking, outbound and inventory management systems. There had been discussions on what changes needed to be implemented for the pick tunnel. As such, it provided a clear indication on the steps that would be implemented within the process as well as which steps were currently missing to help ensure the success of the pick tunnel project.

Walking through the processes also provided a visual on how the current process could be adapted to achieve the end goal. Time was spent with each area's manager to discuss challenges they were experiencing within the DC. The process was followed with staff members using daily processes to determine coherence between the two. It also helped determine any issues, as staff members were the best port of call to highlight challenges. The points were then documented in a case study and solutions were provided for each challenge as well as the change, which would need to be implemented.

Step 3: The literature review was conducted while the pick tunnel was being built. Here, the key focus was on determining the most efficient ways of measuring the DC's performance. The literature review consisted of of several types of sources, as shown in Table 4.2.

Table 4.2 Breakdown of different sources used during literature review

Resource Type	Number of resources
Published paper	2
Text book	9
Journal	22
Article	8
Website	2
Working paper	2
Informal discussion	4
Case study	3
Business financial report	1
Total sources	53

Step 4: After the literature review had been conducted, there was a need to investigate the different performance and strategically orientated measures. With regard to strategic metrics, Pick n Pay's current company metrics were first analysed, as reflected in its balanced scorecard. Due to this, there was a need to research the history and use of a balanced scorecard. The research resulted in finding a definition and purpose for establishing a balanced scorecard for a business. More inportantly, the aforementioned needed to be in line with how Pick n Pay was using its balanced scorecard.

This was followed by a focus on performance metrics, as represented by the various KPI's used by the business and other businesses. To ensure they were aligned, a literature-based definition of a KPI was compared to Pick n Pay's interpretation. After an applicable definition was established, the researcher checked whether Pick n Pay was measuring the correct processes. This was achieved by comparing Pick n Pay's measures to that of industry industry leaders.

Hereafeter, the researcher set out to identify how the various processes are linked within the DC. This information was also presented in a case study. To understand the operation in step 2 of this section, applicable information was also drawn from shadowing staff. This was achieved by identifying where the various processes overlapped or were linked to one another.

Step 5: Once the various metrics were established and how they affected one another it was possible to build a framework to merge the various metrics and make it easy to apply to the data sets. Notably, the key aim was to determine whether there was a change in the DC's performance.

Step 6: After creating a framework, it was possible to draw the performance data linked to the respective metrics and apply the framework to the data. Firstly, data was drawn for 2013, the period before the pick tunnel was buily. Data was also drawn for 2014 and 2015 after the pick tunnel was up and running. The reason for including the two years after the pick tunnel was built was to provide a more accurate view of the short-and long-term changes in the pick tunnel's performance .

The data was extrapolated from the Extended Warehouse Management (EWM)and SAP software systems that the company used. The system tracked and recorded activity data for all movements within the DC which was based on product movements. This is done by scanning location verifications each time a product is moved to a new location.

Each of these steps represents a section in this thesis,where they are discussed in further detail. These individual sections will provide more insight in the information shared thus far, Table 4.3 below indicates which chapters relate to each of the six steps.

Table 4.3 A chapter based discussion research methodology steps

Step	***Chapter***
Step 1:	Chapter 5
Step 2:	Chapter 3
Step 3:	Chapter 2
Step 4:	Chapter 2
Step 5:	Chapter 5
Step 6:	Chapter 6

4.3 Data collection process

Several research methods were used to ensure that the study included the necessary quantitative and qualitative data to make accurate conclusions. The research methods included empirical studies, which is suitable for this thesis as it is a way of gaining knowledge by means of direct and indirect observation or experience. Empirical evidence (the record of one's direct observations or experiences) can be analysed quantitatively or qualitatively (Goodwin, 2005). The qualitative data was in the form of primary data collected in a low control environment by using a case study which advantages are that it is applicable in real-life situations and its public accessibility through written reports (Soy, 1997). Participatory research/action research was also used as it linked the researcher to those he interacted with in the form of co-researcher, they both had a stake in improving the topic of research which in this case are the staff and DC respectively (Carr & Kemmis, 1986). A questionnaire was used as it allows access to large amount of information which can easily be quantified and assessed (Popper, 1959).

The quantitative data were derived from numeric data analysis, also known as secondary data. The data were collected in an empirical study format using existing databases. Each of these data types are summarised in Figure 6.1 and are discussed in more detail.

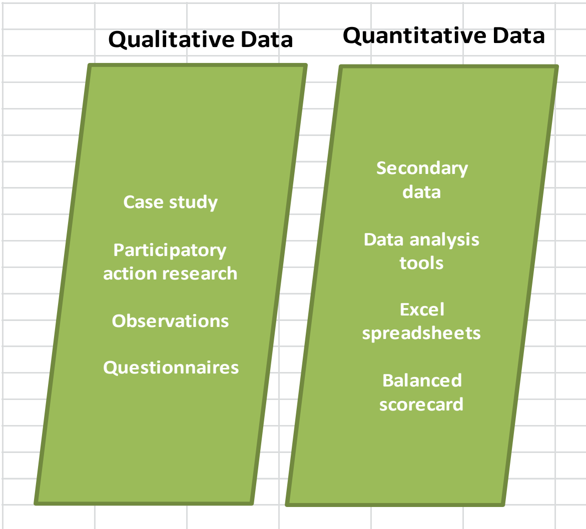

Figure 4.1 Research and analysis techniques used for data

4.3.1 Qualitative data capturing

In order to collect the qualitative data needed for this research, observations were used as a data source. More specifically, this entails participant observation in a natural field setting. In line with this data-capturing method, the researcher took notes of the observations on a daily basis while spending time within the DC.

For the case study and operational assessment, a team of workers were selected randomly – one from each of the operations. The researcher followed these workers around during their daily activities. However, observations were not restricted to these staff members, as other staff members' activities were also observed at random during the period. These observations helped identify and document the daily activities within the DC, as well as any opportunities for improvement.

With regard to the use of the questionnaires, as included in Appendix B, a set of questions were created to gather qualitative data on the use of a balanced scorecard in Pick n Pay to measure performance. This specifically related to how Pick n Pay's defined each measure to provide insight into its balanced scorecard.

The questions were designed to help determine which measurements were used, what was measured and why that specific measurement was deemed important. The prospective questionnaire respondents were chosen according their position in the business and knowledge of the subject matter.

4.3.2 Capturing and analysis of quantitative data

From a quantitative perspective, secondary data were used that were electronically stored in a database. The numeric data were analysed using several variables, such as time, volume, cost and other specific KPIs that were discussed in the balanced scorecard section of the research.

Secondary data analysis forces one to be explicit about the assumptions and theories on which the data is based. No sampling was necessary, as existing data were analysed. The strengths of this data analysis tool include time and cost savings, as existing data were used. Furthermore, it was also possible to re-analyse previous findings. In certain forms of participatory action research (PAR), data analysis is viewed as a collaborative effort between the researcher and participants. This assumption was applicable for this research study, as Pick n Pay collaborated and shared data from its database. The strengths for this research type include that the subjects participate and are involved in the process. This enhances the chances of high construct validity, low refusal rates and ownership of findings.

To analyse the data and make conclusions regarding the DC's performance, the research drew three sets of data. The first was for 2013 before the pick tunnel was built and was based on the DC's performance as a whole, including all operations. The second and third data sets were for 2014 and 2015 after the pick tunnel was built. The analysis was once again based on the DC's performance as a whole, while taking the effect of the pick tunnel into account.

The Philippi DC database served as a source for secondary data. The data was extracted for the period of 1 June to 13 September for 2013, 2014 and 2015. The data was divided into their relevant operations. Furthermore, relationships were drawn between the numeric values to develop trends and information that could be used to analyse the DC's performance.

To measure the DC's performance accurately, several KPIs were used that had been taken from research by Lucas (2013), which aimed to determine the effectiveness of the KPIs used in Pick n Pay's Philippi DC. Along with the KPIs, the research included statistical tests and a balanced scorecard, an existing instrument to measure the strategic goals of the business. Chapter 2 provides an in-depth discussion of the measuring tools that have been proven to be efficient in tracing performance. The Bonferroni and independent t-test were the final techniques used to analyse the performance data. These tests determined any differences in the mean of the data sets and provided a clear indication as to which year had performed better. Table 4.4 summarises the definitions of the Bonferroni and Independent t-test. As seen in Table 4.4 both tests are based on the mean values of the data and therefor make them compatable with one another for the purpose of this thesis.

Table 4.4 Summary of statistical test definitions

Statistical measures	What does it measure?
Bonferroni multiple comparisons	A multiple comparison test used to determine whether there is a statistical significance between means of more than two groups.
Independent t-test	The t-test compares the means of two independent groups to determine whether there is statistical evidence that the associated population means differ significantly

In addition to the Bonferroni and Independent t-test the following performance KPIs were used in the framework to measure any change in the DCs performance as described by Lucas (2013) and Govender (2014):

Inbound and outbound volume: This allowed for volume to be measured accurately, which had moved through the DC over the determined time period. If the pick tunnel was successful in increasing the DC's capacity and overall performance, this measure would have shown a significant increase from 2013 to 2015.

Put-away rate: Put away was not measured for the pick tunnel. This measurement focused on the rest of the facility, known as the general population. If the pick tunnel had a positive influence on the performance of the operations within the facility, the put-away rate would indicate this by showing an increase in pallets put away per hour.

Replenishment rate: Also, this was not measured for the pick tunnel. Therefore, it was only measured and compared for the general population. This allowed for the research to determine how the pick tunnel would affect the process and whether it improved the process, or not.

Picking rate: This formed the majority of the performance metrics. For picking, there were certain factors that needed to be considered. Firstly, the pick tunnel lines were not picked in the same manner as the general population and in a different measuring unit. In the pick tunnel, items were picked in shrinks (individual items). For example, cereal is delivered in boxes (outer cases) which contain 10 individual boxes of cereal. In the pick tunnel, these are picked as individual boxes of cereal, not as a unit of 10 boxes. For the general population, the picks were performed in the form of bulk pick (a full pallet) and break bulk picks (individual outer cases). These three picks were analysed independently and an overall deduction was made regarding the performance as a whole.

Percentage of errors: The research considered the error percentage, which occurred within the facility. This metric should have decreased after the pick tunnel was operational. The assumption was that pickers were less likely to make mistakes during their pick waves.

The quantitative data for these metrics were recorded as follows: the data drawn from the database was recorded using a warehouse management system called SAP (Steenkamp, 2014). Staff, such as pickers and forklift drivers, make use of AMT that are used to capture data regarding the various tasks they perform. These employees receive a task from the warehouse management system on their AMT screens, directing them to a specific location to perform a set task. Throughout the activity, they perform several scans and checks, all of which are downloaded into their AMTs and stored in the DC's database.

The following are some examples of these checks: when a picker arrives at the pick face, s/he scans the pick face location and stock-keeping unit barcodes. Hereafter, the amount of picked items are entered into the system. The system asks for confirmation that the number was correct and directs the picker to proceed to the next pick task. After completing all the picks, the picker scans the HU holding the picked items into a predetermined staging lane at the outbound area. At the end of every shift, the data is gathered and the system releases a report that summarises the performance for the shift and indicates whether the KPIs have been met for that specific shift.

4.3.3 The limitations of each of the research techniques

One of the limitations of a case study format is the generalisability of results, “a case study has a relative absence of methodological guidelines” (Yin, 2009:14-15). Also a case study is influenced by researcher subjectivity, and external validity (Willis, 2014).

One of the limitations of using secondary data is that in some cases the data is collected with a specific goal in mind which may cause vaildity issues. The data may also have been collected seceral years ago which means it may be outdated or inaccurate as the environment has changed with time (Denscombe, 2007).

Saunders, Lewis and Thornhill (2011) also raised concern over the lack of quality of the data. In some instances there may be external or even internal influences which skew the data of which the researcher is unaware of.

The disadvantages of questionnaires are seen to be the lack of aility to understand emotions and behaviour in the perons writing or answers as well as the inability to determine how much though the respondent has put into their answers or how truthful they are (Popper, 1959).

4.4 Administration

Multiple planning sessions and update meetings took place from 12 November 2013 to 26 March 2014 to discuss the progress of the pick tunnel project. The aforementioned was included in the research was to cover all aspects relating to the operational changes brought about by the pick tunnel. Notably, this helped ensure that performance data was analysed efficiently and correctly after the pick tunnel was built. Representatives from all relevant parties, namely Pick n Pay, the company that manages Pick n Pay’s transport planning, the US consultancy company, Pick n Pay’s systems management and the warehouse management business contracted to run the DC attended these planning sessions. During the planning sessions, the following points were discussed and decisions were made.

Pick tunnel demand planning formed an important discussion point, as the pick tunnel construction could not start until this meeting had taken place and decisions had been made. During a meeting on 19 December 2013, key points and decisions included that capacity needed to be reduced, so that racking could be moved out of the area where the pick tunnel was to be built. The target was to make 1 500 reserve-pallet locations available. The key aim was to increase space capacity in the remainder of the DC to accommodate the pallets being moved out of the racking where the pick tunnel was to be built.

Floor walks of the DC and operationally focused discussions with the US supply chain consultancy company took place were conducted on several occasions. The dates are provided below in Table 4.4. Each floor walk focused on a specific operation, covering all operational processes.

Table 4.5 Break down of operational assessment dates

Operation	Start date	End date
Receiving	13/01/2014	17/01/2014
Put away	13/01/2015	17/01/2015
Replenishment	13/01/2016	17/01/2016
Picking	13/01/2017	24/01/2014
Outbound	20/01/2014	24/01/2014

The final version of the pick tunnel needs brief was documented during January 2014. This needs brief was a detailed description of the business requirements and served as an introduction to the business requirement document.

On 27 January 2014, the topic of the current pick path, and how to optimise the design, was analysed in a meeting. The key role-players that needed to be appointed for the pick tunnel were discussed. These included pickers, as well as replenishment, tote preparation and cleaning teams. It was essential to make the best use of resources in these roles. There had to be a security checkpoint in the high-risk cage, as well as security walking between the different levels of the pick tunnel.

Another topic of discussion was waste management. The high-risk area waste chute had to be controlled, as it could be a security risk. The chute needed to have small openings into which folded boxes and plastic could be placed. This allowed for easier handling and better space utilisation, as unfolded boxes took up more space.

A meeting on 4 February 2014 focused on high-level timelines, data analysis conducted by a US consultant regarding using scales in the auditing procedure, as well as presentation on several findings with regard to the operational assessment. The meeting discussed various business processes within the DC and the pick tunnel that was to be built. It established the standard operating procedures that needed to be implemented or changed to accommodate the project, as well as any staff training and change management that needed to take place.

During the same meeting, a discussion was held on warehouse management rules for tote picking within the pick tunnel. It was proposed that one standard-sized tote bin be used throughout the supply chain. While this tote bin size was already in use in the DC, in future a uniform tote weight would become a strict requirement. This move would support the potential implementation of weight-based auditing. At the time, totes were only used for high-risk articles. Therefore, rules had been added into the SAP system to allow for its use in other picking areas of the DC. In future, all articles picked in the pick tunnel (both high-risk and others) would be deposited in totes.

The cutover brainstorming session took place on 5 March 2014. This meeting focused on planning the various steps needed to ensure that all testing was completed at the same time the tunnel construction. This was to ensure that the system would operate with no problems. Several key milestones were outlined:

- Integration testing: 14-25 April;
- Regression test: 28 April to 9 May;
- Technical readiness: 5 to 16 May;
- Pre-go live (small scale test): 5 to 16 May;
- Go live on the 20 May;
- Live pilot: 26 to 30 May;
- Cab request;
- Go or no-go meeting

On 17 March 2014, the unit of measure changes for the pick tunnel and DC were discussed. During this session, it was decided that certain articles' measurement units needed to be changed to ensure that the facility would not be over stocked, as well as to accommodate the transition into the pick tunnel. Certain vendors made the process difficult, as the change in measurement units needed to be implemented across the entire supply chain. It was decided that the instituted procedures for changing the measurement unit would be followed to help implement these changes.

A meeting on 18 March 2014 focused on the infrastructure requirements to support the design and building of the pick tunnel. The following key points discussed and listed in the minutes of the meeting. The supply chain consultants required access to the Pick n Pay network, including usernames and passwords. This was in order to update the system and allow for the conveyor belt to be linked to the network. Additional workstations needed to be built to accommodate normal and label printers, as well as network connections. Pick n Pay needed to order in thirty AMT units for picking and audits. A supply chain consulting company would install one personalised computer located within the pick tunnel at the bottom of the spiral. This was used to control and operate the spiral feed system for the totes.

The list of articles to be held in the pick tunnel was communicated to the team working on the pick tunnel project on 26 March 2014. A Pick n Pay member of staff compiled and communicated the list.

During this entire planning period, weekly reports were sent out to the parties involved to provide an update on the project's progress. Any new decisions made since the last meeting and updated deadlines for the various tasks assigned to individuals were included in these reports. The update also included capacity reports for the DC and inbound and outbound volumes at the facility.

When the planning team was confident that they had made the correct project-related decisions, they submitted it for approval. The executive steer committee had to approve any tasks before they were implemented. This happened on a monthly basis, or when requested.

Selected members of senior management attend executive steer committee meetings. The meetings are used for report backs, discussion of pertinent topics, strategy planning and other related matters. When necessary, board members could also attend steer committee meetings. Steer committee meetings are also scheduled on a regular basis for reporting on the business progress to ensure compliance with budgets and KPIs.

4.5 Inclusions

This thesis includes all processes and functions, which related directly to Pick n Pay's Philippi DC, as well as the pick tunnel project. Due to the case study format, the study was restricted to the FMCG section of the Philippi DC.

The thesis covers meetings or planning sessions regarding the pick tunnel, as well as any projects that may have had a direct influence on the outcome of the research. The KPIs that Pick n Pay has used in the past are incorporated to measure the performance of the pick tunnel and the facility as a whole.

The scope of the thesis includes all activities at the Philippi DC, as well as all meetings and planning sessions that took place with regard to designing and building the pick tunnel. Importantly, the thesis included the financial, operational and strategic aspects of running the Philippi DC. All quantitative data recorded from Philippi DC was included, as well as all qualitative data and documents that were relevant to the research objective.

4.6 Exclusions

This study excluded all non-retail business environments, non-FMCG, as well as any facility or DC other than Pick n Pay's Philippi DC.

For the purposes of this study, several of the metrics were not measured for the pick tunnel. The reason for this is that Pick n Pay is not satisfied that the processes are efficient and up to standard. Thus, any data related to it would not be valid or accurate. These metrics include the pick tunnel replenishment rate, pick tunnel put away rate and cases counted in the pick tunnel.

4.7 Relevance

As mentioned in Section 1.2, most of the academic literature on order picking productivity focuses on optimizing or improving technical or system-related aspects of particular picking methods such as routing (De Koster, Le-Duc & Roodbergen, 2007) (Hwang, Oh & Lee,2004) (Petersen, 2004), storage assignment (Jarvis & McDowell 1991), warehouse layout (Hsieh & Tsai 2006), and zoning (Jane & Laih 2005) (Le-Duc & De Koster 2005). Minimal literature was based on the effect that a change in picking systems had on the productivity of the DC.

The reason this thesis is relevant to the business environment as well as the academic environment is it will bridge an exisiting gap in knowledge and allow anyone to apply the framework designed in this thesis to a business or case where a change has taken place. The framework will then allow anyone to determine whether the change has achieved the pre-determined goals it was implemented to achieve. In business this is fundamental as sometimes these changes are key to increasing productivity, decreasing costs and growing the business in line with its strategic goals. If these goals are not achieved through the change the business needs to revise whether it should leave the change in or not (Lucas, 2013).

In order to bridge this gap in knowledge a literature review was conducted in order to ensure that the research in this thesis has not been conducted previously. The University of Stellenbosch (US) library was used as an initial point of research. The University's online tool was used to search through the vast collection of journals, books and published work. During the literature review, different sources, such as the Emerald research tool, EBSCO Host research database and Scopus were used. Key search words were selected carefully to highlight previous research that scholars and industry leaders had done on topics similar to this thesis, as well as works that were related in some manner. Key words used included: logistics, warehousing, DC, picking, picking sequence, picking optimisation, inventory management, supply chain management, KPIs, balanced scorecard, performance evaluation, performance management, picking methods and picking automisation.

To reach a solid knowledge base, the researcher started off by reading the text books referenced in this research. Using this knowledge base, the researcher found more work by the same authors, as well as authors who were referenced in the initial textbooks. This process of looking up work referenced by the last author in each respective work took place several times

The same method was applied to journals like *The International Journal of Product Research,* which was a large contributor to the research. The following journals also contributed to building the researcher's knowledge base:

- The International Journal of Operations and Production Management;
- International Journal of Production Economies;
- International Journal of Physical Distribution and Logistics Management;
- Journal of Business Logistics;
- European Journal of Marketing; and
- International Journal of Logistics Research and Applications;

In addition to the journals, published works by old and new authors were also examined. Some of the earlier authors referenced multiples times in this document include Kaplan and Norton (1996), whose ground breaking work on balanced scorecards played an important part in this thesis. Brynzér and Johansson (1996) provided valuable information on finding the shortest picking path, as well as improving current picking rates. Beamon (1999), Neely, Gregory and Plattes (1995) all provided information on how to measure performance effectively by using methods such as KPIs. These authors' research provided a solid foundation for the thesis and subsequent information gathering.

More-recent published works include some of the above authors, as well as authors such as Veen-Dirks and Wijn (2002) who focus on the strategic control of a balanced scorecard. Referenced in several journals and publications with regard to costing and picking method performance, Russel and Meller's (2003) work was examined closely. The work of Reh (2013) also addressed progressive measurement of performance with relation to a specific goal. The aforementioned is similar to the purpose of this thesis and helped the researcher in understanding the method or path that needed to be followed to achieve the desired outcome. The aforementioned work formed part of a vast body of work that was studied in order to understand the industry, completed research and the knowledge that was built up over the years.

These information sources ensured that the theoretical knowledge for this thesis was based on previous literature related to the key search words used. In addition, it also helped highlight thought and industry leaders' new work being discussed in industry-related journals. The literature review highlighted the following trend: a handful of researchers were referenced multiple times. This served as a clear indication that they were leaders in their respective fields. These leaders' works were given extra time and effort.

A broad body of knowledge was covered and ensured that the topic of this thesis was approached from various angles to ensure that the literature referenced in the thesis was legitimate. This also confirmed that there was a knowledge gap that was not addressed in other research. As mentioned, a large corpus research conducted by Brynzér and Johansson (1996) has focused on the picking method and how to automise the process. This includes the layout of stock and picking sequence. However, there has been minimal research on the effect different picking methods have on operational performance – specifically the custom picking method that was built for Pick n Pay's DC.

The most common form of research that has been conducted around DCs was a case study format, as seen in the research of Hoffman and Cardarelli (2002), Novotny (1997), as well as Brynzér and Johansson (1995), among others. Case studies appear to provide the most accurate results, as they consider operational influences and are not restricted to a laboratory- or theory-tested environment. The focus of the aforementioned case studies is qualitative in nature. In addition, a large portion of the work relating to picking sequences is quantitative, as it focuses mathematical equations to find optimal routes. Therefore, this thesis will use a combination of quantitative and qualitative research to provide a more rounded conclusion to the research.

4.8 Chapter summary

Chapter 4 presented the objectives of the research in detail, these objectives were divided into two groups, the first of which were used as the method of research and the second was used to assess the change in performance of the DC after the custom-picking method was adopted.

This chapter also discussed the research methodology in detail, explaining each step in the research process, the types of data collected and how they were collected. These steps in the research process included the objectives also discussed.

This chapter included the administration section which documented all formal meeting which took place regarding the custom-picking method. These meetings formed the starting point for the research as they determined a number of events which would take place. Lastely this chapter included the inclusions, exclusions and relevance of the work to the business and academic environment.

Chapter 5: Needs brief, pick tunnel requirements and testing framework

Chapter 5 focuses on the needs that had to be met to ensure that the pick tunnel project was successful. These needs ensured that operations ran optimally and that there were no issues that could have resulted in the collection of inaccurate data. The management of various processes allowed for developing the scope, inclusions and exclusions at the end of this section.

5.1 Needs brief

5.1.1 Introduction

In this section, the needs and specifications of the pick tunnel are brought to light. There is a focus on how the pick tunnel affected the other operations within the DC. Hereafter, there is a focus on alterations that were necessary to accommodate the pick tunnel and to ensure that the entire DC would perform optimally. This chapter addresses the sub-objective of the thesis relating to the needs brief. To understand the needs brief, the old picking system's architecture and the new pick tunnel are explained below.

Pick n Pay's original picking system was based on simple methodology. Each picker would receive picking instructions and would then pick up a pallet and move to the start of the aisles. Pickers carried AMTs to direct them to the items that need to be picked. They worked according to the order of the aisles and picked only from the level one and two pick faces, which were both within reach. Figure 5.1 below shows the start and end of the pick path, weaving between aisles as the picker progresses through the picking list. Once the picking list was completed, pickers placed the pallet in the outbound area and waited for a new picking instruction.

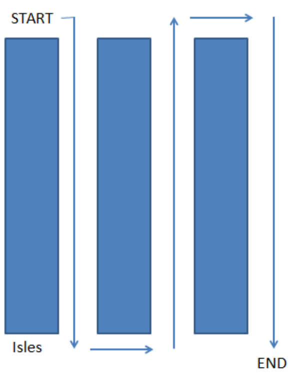

Figure 5.1 Top view of original picking method

The pick tunnel introduces a different picking method. To maximise space utilisation, the pick tunnel consists of four picking levels. Each level has dedicated pickers who do not pick from multiple levels. This saves time, as there is no need to travel between levels. Similar to the old system, pickers receive picking instructions via their AMTs, collect tote bins (totes) wherein they will collect articles and begin their pick. Pickers start at one end of the pick tunnel and weave between the aisles in a pattern similar to the old system.

Due to the smaller pick faces and higher product storage density, pick tunnel staff are able to pick more articles in the same amount of floor space than general-population picking. After the picking has been completed, totes are placed on a spiral, as depicted in Figure 5.2. This spiral is attached to a conveyor belt that transports the totes to a consolidation area, where staff members are waiting to move the stock to the outbound area. This system allows for minimal travel and dead time (stationary time), while optimising efficiency.

Figure 5.2 below depicts the pick tunnel picking method in a plan view. In Figure 5.3, a cross section of the pick tunnel shows the multiple levels, spiral and conveyor belt that transports the full totes from the pick tunnel.

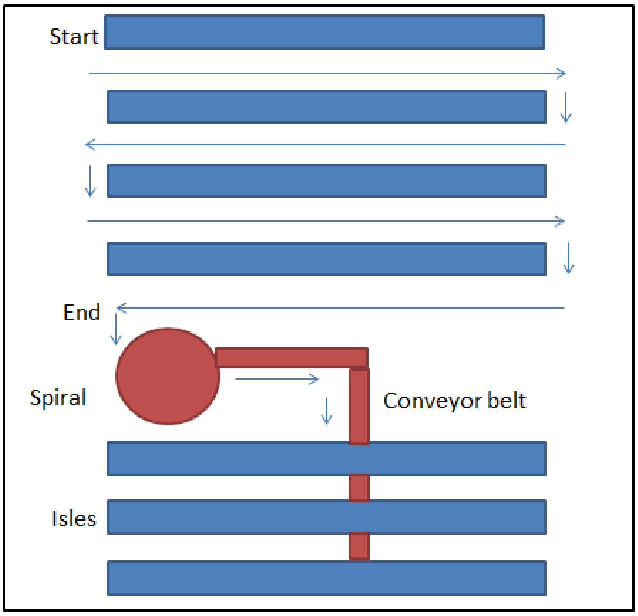

Figure 5.2 Top view of pick tunnel picking method

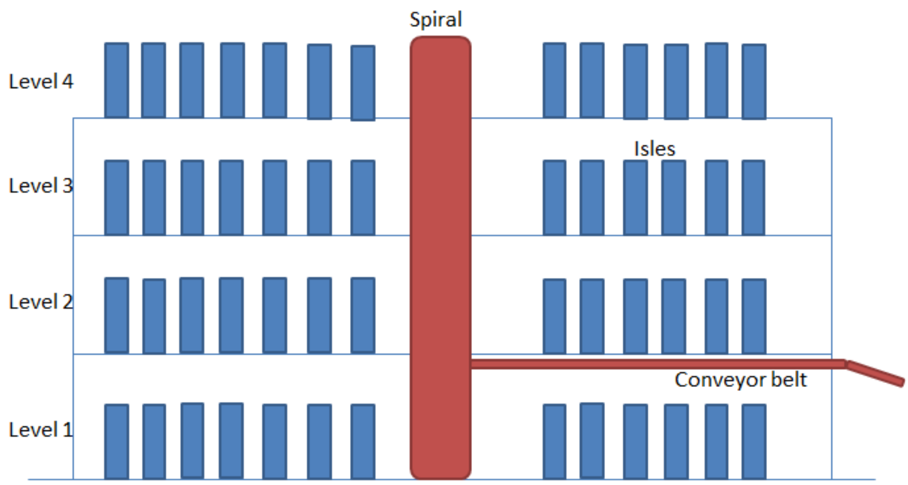

Figure 5.3 Pick tunnel side view

The two picking methods differ vastly; the pick tunnel utilises space optimally and decreases travel time. The pick tunnel has specific requirements in order to work efficiently and optimise other operations within the DC. If the following needs are not met, the pick tunnel will not operate efficiently.

5.1.2 Pick tunnel design requirements

During 2013, Pick n Pay identified the need to improve their operational performance in the Philippi DC. This need was linked to centralising the organisation's distribution network in order to increase profitability. The pick tunnel was chosen as a solution, as it would contribute to the centralisation process, increase capacity without the need to expand the DC, allow for picking in multiple units and potentially increase revenue.

The goals established for the pick tunnel were, as mentioned above, to increase productivity in the picking process, facilitate picking in multiple units of measure and increase the DC's capacity. The increased capacity would bolster the centralisation of products through the DC. This, in turn, would lead to added distribution allowance revenue and improved service to stores. From a corporate viewpoint, the core of the business case and project was the pick tunnel's ability to add additional distribution allowance and to improve the service to stores. For the purposes of this study, the most relevant of these is the need to increase productivity and the facility's capacity.

In addition to building the pick tunnel, there was a need to analyse and evaluate the current DC operations in order to identify, propose and implement changes to improve operational efficiencies. This influenced systems, processes and layout, also known as physical racking configuration.

These changes to the DC's operations and systems were required to support efficient put away, replenishment of, and picking from, a pick tunnel, all of which should contribute to improving the DC's performance. The pick tunnel was constructed at the Philippi DC, but the process and system changes needed to be implementable in any of the DCs within the Pick n Pay supply chain.

The following section provides a detailed description of which operations were affected by the pick tunnel. Furthermore, insight is provided on how those operations needed to be altered or adapted to ensure that the pick tunnel and the DC as a whole operated optimally. This section includes the relevant risks, assumptions and system changes.

Figure 5.4 below provides a summary of the composition of the needs brief. The four elements of this figure, namely inbound deliveries, outbound deliveries, warehouse picking and warehouse master data, are all discussed in this chapter and expanded on by looking at the needs of each, as depicted in Figure 5.4.

Figure 5.4 Pick tunnel needs brief summary

5.2 Business requirement scope

The business requirement scope explains the changes that needed to be implemented to ensure that the pick tunnel operated efficiently. It looked at four key operations, namely inbound, outbound, picking and master data. These four operations played a key role in the success of the pick tunnel. As such, the purpose of each operation's purpose needed to be understood. This included process and system requirements, assumptions, risks and dependencies. Once this had been done, it was possible to determine the inclusions and exclusions of the pick tunnel scope.

5.2.1 Manage inbound deliveries

I. Purpose

The purpose of this operation is to manage the receipt of goods ordered into the DC, as well as to manage the return of goods that were not ordered or that did not meet quality standards. The operation is also responsible for placing goods received into storage locations in the DC, known as the put-away function.

II. Detailed process requirement description

The pick tunnel raised a need for a new put-away process. Stock would be removed from reserve racking and moved to the pick tunnel's pick and drop zones (P&D). Here, stock is taken and slotted into the pick faces by hand in smaller quantities, as pallets are replenished one at a time. Pickers would be instructed to place pallets in a specific gate, the entrance to the pick tunnel. Hereafter, the stock would be removed from the pallet and packed lose into the pick faces. However, if this gate was unavailable, pickers had to place the pallet in the nearest available gate on that level. If there were none available, pickers would escalate the issue to an inbound supervisor.

III. Assumptions

A man-up order picker, a machine that lifts a picker on a platform up to a higher level, will be used at all levels of the pick tunnel. Therefore, the stock that needs to be replenished can be taken directly to the floor where it should be placed. The reserve pallet locations for the pick tunnel will be in the wing-racks, located on the sides of the pick tunnel. As mentioned earlier, from there the stock is placed in the reserve racks and then hand-packed into the pick faces.

IV. Systems requirements

The system needed to allow for the implementation of procedures to receive by line at all DCs that required it. As such, it could receive specially required stock that was not supplied to the DC in the past due to low demand. This would allow DCs to order specific products that were not normally stocked, or in a different quantity to what was normally received. In addition, there needed to be an assignment of put-away tasks to equipment type based on destination of pallets and the goods they hold. The pick tunnel put-away process had to be system-guided and pickers should not be allowed to decide where to place the pallets.

V. Risks

As the business was busy centralising all operations, including all vendors to the Philippi DC, there was a possibility of inbound capacity constraints through increased inbound volumes. The risk was that the DC would be unable to accommodate the increased capacity while new put-away procedures were being implemented and staff members were being trained.

VI. Dependencies

Additional resource types, such as the man-up order picker, needed to be acquired.

5.2.2 Manage warehouse picking

I. Purpose

Warehouse picking entails picking stock from pick faces to meet the demand from stores and other DCs in the supply chain that place orders with the Philippi DC.

II. Detailed process requirement description

Staging lanes at the outbound doors should be assigned to a pick, as the picking wave is released from the system for the pickers to complete. The lanes in the outbound area must be managed in sections. As the lanes were designed to accommodate access to each pallet that is staged in it at any time, the staging lanes will not be staged in load sequence. As such, pickers can pick orders in any sequence and the loading team can simply re-position the completed picks, as required. This will also ensure the trucks are loaded in the correct sequence for multiple store deliveries, as the pallets can be moved and shuffled, and are not restricted to the order in which various pickers complete the picks. If a lane is full, the supervisor will be able to override the lane allocation and assign a new lane for the remainder of the pick. This will require strict floor management and constant feedback to ensure supervisors are up to date with what is happening at all times so that they can make efficient decisions.

More careful wave management will be required to turn the dock (outbound area) as many times as required to meet centralisation targets. Wave management entails determining when to release different groups of pickers with the picking orders they need to complete. Therefore, the outbound staging lanes must be filled with orders that are sent off. The aim is to clear the dock as many times as possible to cope with the demand from stores.

There are multiple shipments or TUs per wave. TUs with similar departure times are grouped into a wave. The time frame for waving was initially set at two hours for each wave and these waves needed to be synchronised. For example, picking from the Choc Box (the fridge area where chocolates are kept), pick tunnel, high-risk and the general pick face in the DC must be synchronised, so that picking for all store deliveries in the same wave is completed in time for loading the scheduled dispatch. The building and release of the picking waves should be system automated, so that all waves are released on time. In the case of staging lanes reaching capacity, these can then be delayed.

Replenishing stock in pick-tunnel locations is trigger-based. When the stock in a pick face reaches a certain predetermined quantity, the replenishment is triggered. No change to the replenishment process will be required for pick tunnel pallet flow rack and reserve locations. The hand-stack pigeonhole locations on all levels would be replenished from single or multiple SKU pallets. These replenishments would be done through P&D zones on each level. A new process would be required for the pickers with regard to replenishing hand-stacked locations from the reserve wing-rack locations. The pickers will perform the replenishment for these locations. This will be triggered when a zero pick (no stock) or partial pick (not enough stock to fill the order) occurs at a hand-stack location.

A new process will be needed to pick the replenishment pallets for pick-tunnel hand-stack locations. The process is similar to the break-bulk picking process, but the destination locations are P&D zones. In addition, P&D zones on levels one to three require a man-up order picker.

The same exception handling, as in the case of break-bulk picking, will be provided for situations when there is insufficient space in the HU being picked into. The system gives the picker the option to create a new HU or split quantity and place the balance of the stock on an alternative HU for the same store. It also caters for insufficient stock in the bin with partial- or zero-stock confirmations. Stock will be replenished from reserve locations in P&D zones first, followed by the pick tunnel (wing-rack) reserve locations.

There were no changes to the old unit-of-measures picking. The pickers would still pick full pallets and cases, also known as break bulk picks. However, a new process was designed and implemented for break-bulk picking processes. The aforementioned pertains to picking store orders from pick tunnel locations on levels one to three. Store orders will be picked into tote bins that are moved around the pick tunnel in carts. Trolleys will be pre-stacked with totes before pickers collect them. Label printers will be located on the same level to enable the pickers to print labels for the various orders and place them on the totes. It is imperative that the labels be placed in a user-friendly manner that facilitates picking, as well as auditing, consolidation and staging.

The totes are to be closed and sealed when the pick is complete or the HU is full. Totes from the non-high-risk area are to be closed and sealed with cable ties, while those from the high-risk area will follow existing security procedures and no changes will be needed. Once the tote is closed, the HU label will be repositioned on the tote, so that it can be read as the tote comes down the spiral. Sealed totes will be moved to, and placed on, the spiral conveyor once the pick is completed or the tote is full and sealed. All empty trolleys must be returned to the trolley preparation area, so that they can be prepared for the next picker.

Articles that required inner and Express store picks would be stored and picked in the high-risk area. These items are identified from a list of articles in the DC at the starting point of the project, as well as additional product lines that were be brought in during the centralisation process.

A new ‘pick and pass’ picking process will be built for Express store order picking. A ‘pick and pass’ is when a picker starts a picking task, but does not complete the pick. Instead, it is passed to another picker to complete. Picks for Express stores will start in the general pick faces and racking or Choc Box areas, where after it is passed to, the pick tunnel (pick and pass) to allow articles from the pick tunnel to be picked onto the same HU.

Once all stock from the different areas has been picked, the HU will be moved to the Express store holding area (in the pick tunnel ground-floor wing-rack locations). Articles that are picked from the ground floor of the pick tunnel will be consolidated onto the store HUs.

III. Exception handling

Incomplete picks were shut down at the end of the wave and the order reduced to only those items that were picked successfully. During the wave, new tasks could be created for the balance of unpicked items. However, this would impact the staging and TU capacity, as the number of HUs would be greater. This created a need for consolidation.

IV. Assumptions

The only assumption made was that man-up order pickers would be used at levels one to three of the pick tunnel.

V. Systems requirements

The system had to allow for automated staging lane management; this included lane allocation and capacity control to prevent overflow. In addition, there had to be automated wave management, which controlled the release of waves according to the planned schedule and workload. A system-guided replenishment and picking function would also be built into the system.

VI. Reporting needed

Lane and section status needed to be reported on at all times to indicate the total capacity of the lane or section and the occupied portion. In addition, pick wave progress needed to be communicated, as well as which resources had been allocated and utilised.

A report on the percentage utilisation of tote capacity was required. This would help identify wasted space to ensure that the totes were packed to full capacity. It was found that the existing reports would provide this information, but future reports needed to ensure the standards were upheld if the information resources were changed in any manner.

VII. Risks

To prevent conflicts, assigning a lane that was already earmarked for other deliveries needed to be managed.

VIII. Benefits

The new processes and systems will allow for better wave planning and management. The improved scheduling of replenishment will improve pallet-packing performance. Furthermore, it will reduce the need for consolidating and combining HUs in the staging lanes due to a drop in picking exceptions. Distributing staging (and loading) across the outbound staging area will reduce congestion and the risk of overflow of lanes into allocated lanes.

IX. Dependencies

The master data must be updated to ensure all current data is correct and that any new items entering the DC are added to the master data.

5.2.3 Manage outbound deliveries

I. Purpose

To manage the quality control, loading and dispatching goods ordered to stores and other DCs in Pick n Pay's supply chain.

II. *Detailed process requirement description*

Transport planning: To plan for loads and shipments each day, it is important that the transport management system (TMS) capture specific delivery time-slots accurately. In addition, the TMS will need to provide a load sequence for the multi-drop deliveries (deliveries to more than one store). To speed up delivery and turnaround time, the TMS will ensure that TUs are loaded according to the sequence in which they are delivered.

HU audit: The HU audit process had to support the required floor turnaround and be able to audit both pickers and stores. The existing HU audit system did not support these requirements. In order to uphold quality standards, the audit selection criteria had to change according to what the business deemed appropriate. The totes from the pick tunnel had to be audited separately in a dedicated area outside the pick tunnel. A new scan-and-tick audit system needed to be implemented to avoid totes from being unpacked for auditing, allowing for errors to occur. High-risk totes would be audited in the high-risk area, which would help ensure that they would only leave the area after being sealed by security.

Consolidation of totes: A new process was needed for consolidating totes from the pick tunnel into store HUs. This process would be similar to that of the flow-through picking process and would be system directed to indicate which totes needed to be consolidated and onto which HUs. HUs that could accommodate the consolidation of totes would be placed at the end of the conveyor belt. This would help ensure that they were consolidated onto the correct HUs and no time was wasted searching for an appropriate HU.

To facilitate consolidation, there would be dedicated HUs for each store within each picking wave. The totes would be removed from the conveyor belt and placed onto the appropriate store’s HU. The consolidation area would be prepared at the start of the shift. As such, each store’s HUs would be labelled and placed in the correct area, so that they were ready and no time would be wasted.

Once the tote was consolidated onto the HU, the HU would be removed from the consolidation area and staged in the outbound area. Here a new label would be printed and placed onto it, if required. There would be no combining of totes in the consolidation process. The totes would only allowed to be placed onto HUs, and not opened and repacked with other totes.

Outbound: No changes were necessary to outbound HU inspection, static HU check, combining HUs and discrepancy management (overs, shortages, damages, etc.). Following a process of “combine on the go rather than combine just prior to loading,” inefficiently packed HUs would need to be combined with other HUs before being placed in the staging lane. This would ensure that there would not be any consolidation-related delays once the TU pulled up to be loaded.

III. Exception handling

Scheduled deliveries could be rescheduled to an earlier wave if the earlier wave had capacity. However, a change could not be accommodated if earlier waves were full. Emergency orders would only be considered if the order was placed within 12 hours of requested delivery.

IV. Systems requirements

In terms of staging-lane control, there was a need to auto-assign single-load sections. However, manual assignment for multi-load sections had to be enforced to ensure the lane capacities were fully utilised. The aforementioned would also give supervisors more control to re-assign new lanes to a wave or load if there was an overflow. The system had to accommodate multiple TUs per lane and multiple stops per TU. These would help ensure that the staging lanes' capacity was fully utilised. Furthermore, it would help eliminate half-filled lanes due to system restrictions when an additional load could be fitted into the remaining lane capacity.

To ensure that all outbound processes operate efficiently, there needed to be system-guided picking and replenishment, as well as automated wave management and route determination system in place.

V. Constraints

The only constraint identified was the limited floor space in the outbound area to allow multi-load staging and consolidation to take place.

5.2.4 Manage warehouse- Management master data

I. Detailed process requirement description

The article data needed to be cleaned up. For example, article dimensions had to suit pick tunnel locations. A unit of measure change had to be implemented. As a result, the supply-chain data team had to become more involved and help control this change, as it would have a significant impact on the slotting. It was likely that to the article maintenance process, particularly article site-status and unit of measure changes, would be required to allow for more accurate stock-keeping and master data. This would help ensure that the information would be readily available, if need be.

After considering abovementioned needs relating to the pick tunnel, it was possible to determine which aspects were within or outside the project's scope.

5.2.5 In-scope

Part of project management entails determining beforehand what will be included in the scope of the work, i.e. what will be influenced or have an influence on the outcome. For the purposes of the pick tunnel project, the scope included the following:

- New and changed processes and systems support for put away, replenishment of and picking from pick tunnel locations and for auditing totes from the pick tunnel;
- Automated wave management;
- Route determination and load sequencing;
- Cartonisation;
- Multiple issuing units from the DC

5.2.6 Out of scope

Project teams need to determine beforehand what will be excluded from the scope of the work, i.e. what will not be influenced or not have an influence on the outcome. For the purpose of the pick tunnel project, the scope excludes the following:

- Deconsolidation and distributive put away, as well as the implementation of receiving teams.
- Developing a new HU label that makes identification of store easier for pickers (enabling multiple stores to be picked at the same time) and for easier placement in the correct staging location (particularly for multi-store loads);
- Eastern Cape cross-dock staging and loading;
- Loading directly to the TU; and
- A weight-triggered auditing process for rolltainers.

5.3 Framework

This section focuses on the framework sub-objective, which is linked to the second main objective, namely establishing measurement tools. The two key elements of the research framework were the KPIs and the balanced scorecard. The literature study in Chapter 2 focused on both these measurement methods. It was established that they were both suitable to track the facility’s performance after the pick tunnel build was completed.

The literature study highlighted that KPIs and a balanced scorecard were both relevant to measure change from an operational and strategic point of view. More importantly, they are interrelated. Marr (2013) states that a KPI is there to help an organisation understand how well it is performing operationally with regard to predetermined strategic goals and objectives.

The balanced scorecard was originally designed as a performance measurement framework that added strategic, non-financial performance measurements to traditional financial metrics. As such, it provided a more balanced view of performance (Balanced Scorecard Basics, 2013). The fact that a balanced scorecard is based on a business's strategic goals makes the two types of measures, KPIs and balanced scorecard, compatible with one another.

Therefore, the framework uses operational measures, KPIs, strategic measures and a balanced scorecard to measure the DC's change in performance against the operational and strategic goals of the business. Figure 5.5 below provides a schematic diagram of the framework.

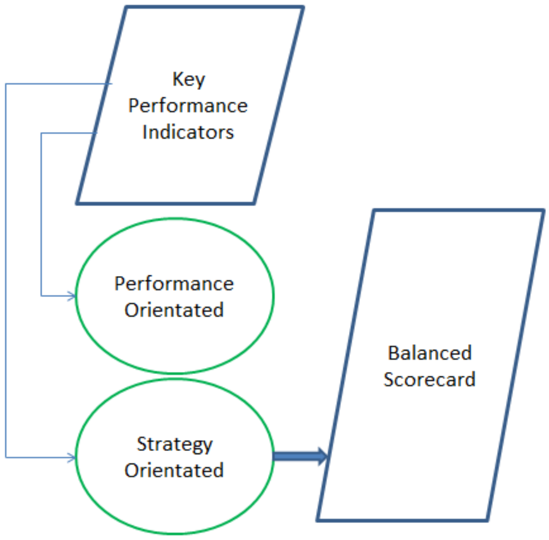

Figure 5.5 Framework design

The organisation used the KPIs to measure performance within a facility. Notably, this performance is related to specific functional areas and processes. Figure 5.6 summarises all the performance KPIs that the framework measure to determine any change in performance. These KPIs were selected by analysing which KPIs the DC currently uses and which are used in the industry to measure the same processes.

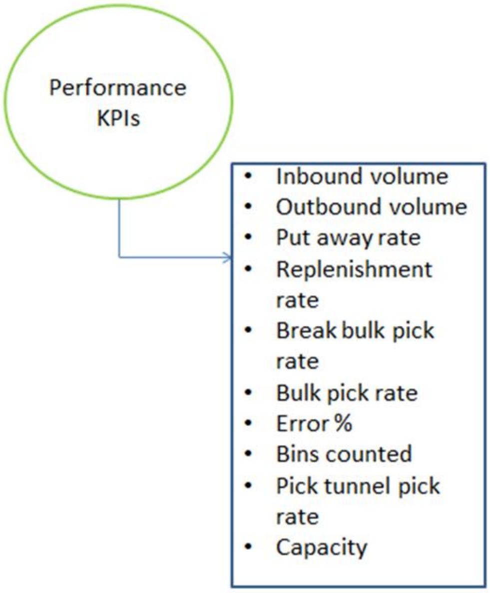

Figure 5.6 Performance orientated KPIs

Figure 5.6 breaks the framework down further and provides a list of performance-orientated KPIs. These KPIs were measured in the DC over three similar time periods for three consecutive years. Once this had been done, statistical tests were used to analyse the results further. The statistical tests used, which were explained in Chapter 4, are summarised in Table 5.1 below with relevant descriptions.

Table 5.1 Summary of statistical test definitions

Statistical measures	What does it measure?
Bonferroni multiple comparisons	A multiple comparison test used to determine whether there is a statistical significance between means of more than two groups.
Independent t-test	The t-test compares the means of two independent groups to determine whether there is statistical evidence that the associated population means differ significantly

The common factor between the statistical tests was whether there was a significant difference between the KPIs for the three years. If there was a significant difference, it meant that the pick tunnel was able to change the performance to such an extent that it had an impact on the business. If no significant difference was observed then any change that took place had no significant impact on the business.

Figure 5.7 highlights the strategy-orientated KPIs. These had been selected according to Kaplan and Norton's (1992) original balanced scorecard, well as Pick n Pay's strategic goals, which were explained in Chapter 2. The strategic KPIs were applied to the data collected, where after the results were assessed and conclusions were drawn to support the operational KPIs. The balanced scorecard does not measure a direct change in the facility's performance. Rather, it looks at the data collectively and determines whether the business is achieving its strategic goals. The balanced scorecard can be used to support any change in operational performance, which is measured by the operational KPIs.

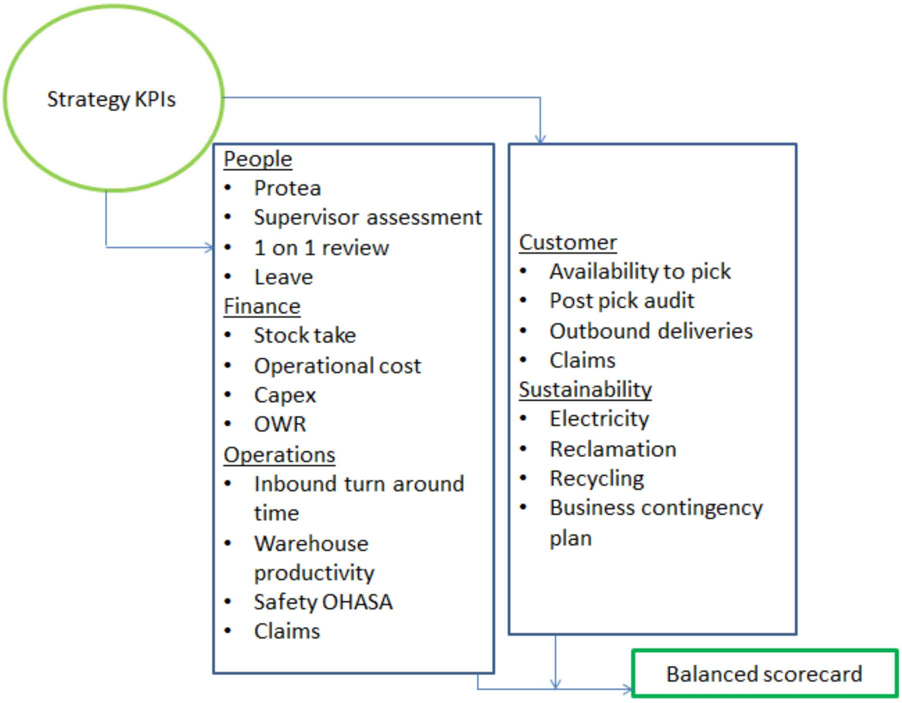

Figure 5.7 Strategy orientated KPIs

Now that the design of the framework has been explained, it is possible to provide the steps of implementation in order to utilise the framework. Figure 5.8 below shows each step in the process that was applied to this thesis in order to use the framework efficiently and meet the requirements of this thesis.

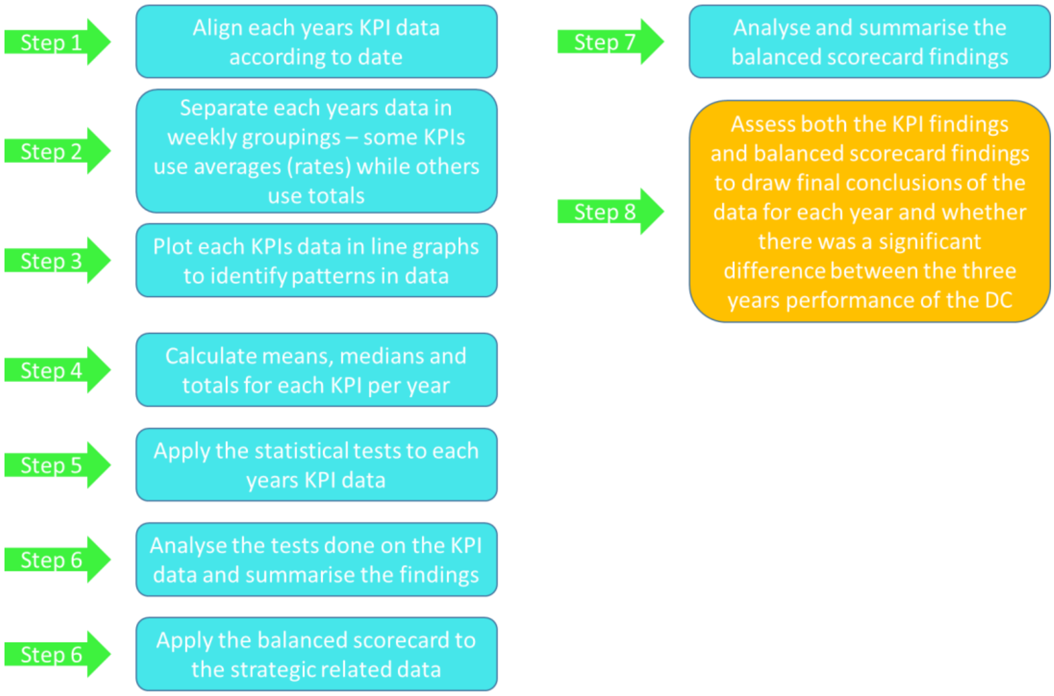

Figure 5.8 Process to implement the framework

5.4 Chapter summary

Chapter 5 presented the needs of Pick n Pay which resulted in the decision to use a custom-picking method. The custom-picking method selected was the pick tunnel, once this was decided the needs of the pick tunnel was documented as well as the impact it would have on the DC as a whole, including what needed to change to ensure its successful implementation.

The chapter then presented the framework which was used to measure the impact of the pick tunnel on the performance of the DC. The framework was explained by breaking it down into its various components and measures as well as a step by step guide as to how it was used.

Chapter 6: Data analysis

One of the objectives of this research was to develop a framework that could be used to test the change in performance of Pick n Pay's Philippi DC after a pick tunnel was installed. The literature review in Chapter 2 supported the decision to use two performance measurement elements in the framework. These two elements are the key performance indicators (KPIs) and a balanced scorecard.

The KPIs were used to measure the change in performance, while the balanced scorecard was used to measure strategic metrics that were supported by the KPIs. Section 2.2.1 explained performance KPIs and the theory behind their use, while the balanced scorecard was discussed in Section 2.2.2.

The below sections discuss the data which was collected and analysis thereof in order to draw conclusions on the impact of the pick tunnel on the Philippi DC.

6.1 Data-analysis process

As explained in Section 5.3, the data analysis followed a specific structure to ensure the data was examined correctly and that the various KPIs were analysed in the same manner. This helped ensure that the results were not only accurate, but also coherent with one another. Figure 5.8 showed this structure in its various steps.

The data findings in this chapter follow a set structure. Firstly, each metric is introduced and explained. Hereafter, a summary of each year's data is presented individually and then collectively for the entire period. Box plots are used to present the data in a manner that is easy to interpret. Hereafter, various statistical tests for each KPI are presented and discussed. Each KPI also has a summary, while the chapter conclusion presents a collective summary of all the KPIs.

As part of the analysis, there is a need to standardise and simplify data. Hence, Table 6.1 shows each KPI with the relevant description, measurement type and other related information.

Table 6.1 Summary of KPIs related to descriptions

Variable (KPI)	Data Field Descriptions (also referring to calculation & definition later)	Base data measure	Data aggregation	Unit of Measure (UoM)	Data format	Type of data/ variable ?
Date	The day the data was collected for the record	Daily	Week, Month, Year	-	Date	Ordinal
Year	The calendar year for the record of the date of the record	Daily	Week, Month, Year	-	Date	Ordinal
Weekno	As defined by PnP; also to have comparative weeks across the years in the sample of data	Daily	Week, Month, Year	-	Text	Ordinal
Inbound volume	The number of cases which were received into the DC on a particular day (# of cases received)	Daily	Week, Month, Year	Cases	Number	Ratio
Outbound volume	The number of cases picked and shipped from the DC on a particular day (# of cases picked and shipped)	Daily	Week, Month, Year	Cases	Number	Ratio
Put away rate	The rate at which stock is cleared from the inbound floor and stored in pre-assigned slots within the DC on a particular day (# of pallets per worker per hour)	Daily	Week, Month, Year	Pallets/ worker/ hour	Number	Ratio
Replenishment rate	The rate at which pallets were replenished per week; pallets brought down from the higher reserve racks to be put into the lower racks or pick faces to be picked by pickers on a particular day (# of pallets per worker per hour)	Daily	Week, Month, Year	Pallets/ worker/ hour	Number	Ratio
Break bulk pick rate	The rate at which pickers pick break bulk (articles at case level) from within the general population of the facility on a particular day (# of SKUs per worker per hour)	Daily	Week, Month, Year	SKU/worker/hour	Number	Ratio
Bulk pick rate	The number of full pallets which are picked per hour per employee on a particular day (# of pallets per worker per hour)	Daily	Week, Month, Year	Pallets/worker /hour	Number	Ratio
Errors as a count	The number of errors which occurred during picking (The sum of errors experienced)	Daily	Week, Month, Year	Number of errors	Number	Ratio
Errors %	The number of errors which occurred during picking as a percentage of total volume picked on a particular day (# of picking errors as % of total volume picked)	Daily	Week, Month, Year	Avg %	Number	Ratio
Pick tunnel pick rate	Stock is picked in shrinks (a case inner) within the pick tunnel which was a different unit of measure from the general population (Shrinks picked per worker per hour)	Daily	Week, Month, Year	Shrinks/ worker/ hour	Number	Ratio

6.2 Performance data analysis

This section focuses on the data that was collected and analysed in relation to the change in performance at the DC. The results are discussed in detail to determine whether there was a positive or negative change in performance at the DC after the new picking system was built. Each figure is based on their respective KPIs and all figures are shown in daily values for ease of comparison. The Bonferroni grouping and independent t-test are used in addition to the figures and tables to show whether there was a significant change from 2013 to 2015.

The Bonferroni grouping will indicate a significant change when the letters for each year differ. In addition, the independent t-test uses a p-value to do this; if the p-value is less than 0.05, the change is seen as significant.

A note must be made of the gaps in the line graphs, these are as a result of days where no data was recorded as it was a weekend. Also the fact that Pick n Pay works on their financial calender day numbers, per week, which when compared to calender dates, differe year to year. For this reason the weekends where no data was recorder could not be matched up on the businesses financial calender.

6.2.1 Inbound Volume

Inbound volume measures the number of cases that are received by the DC for a particular period of time. The overall performance of the DC is affected by volume, the facility must be able to handle large volumes at inbound as well as in other areas in order to be efficient. This inbound volume dictates whether stock will be available within the DC to be picked for customer orders. If stock is not received, the DC cannot meet customer orders.

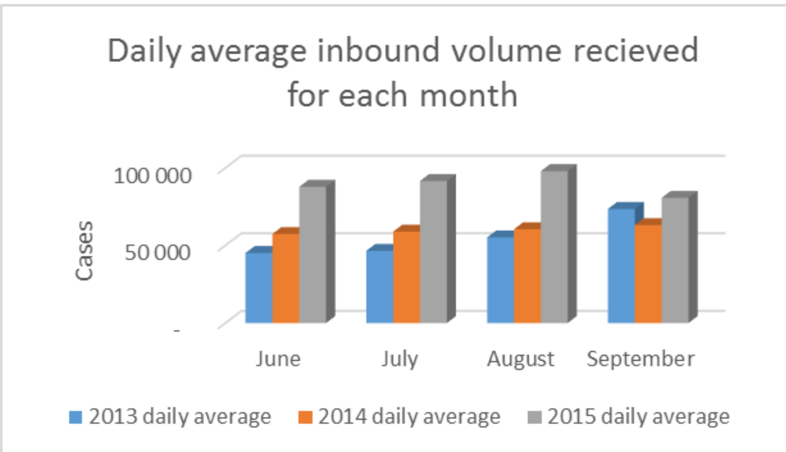

Figure 6.1: Line grap of daily inbound volume recieved

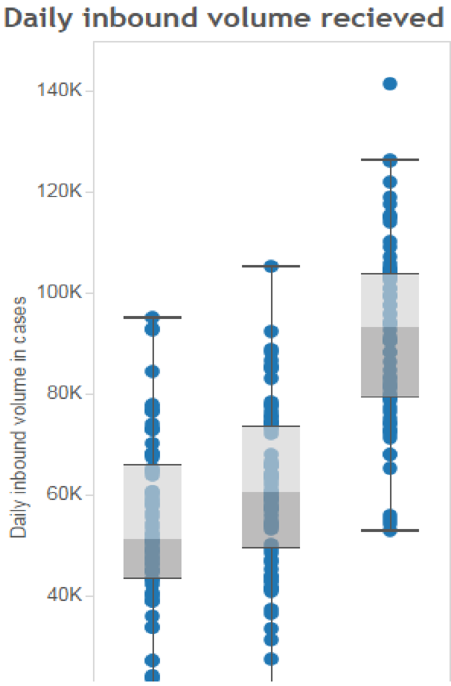

Figure 6.3: Box plats of Daily inbound volume recieved

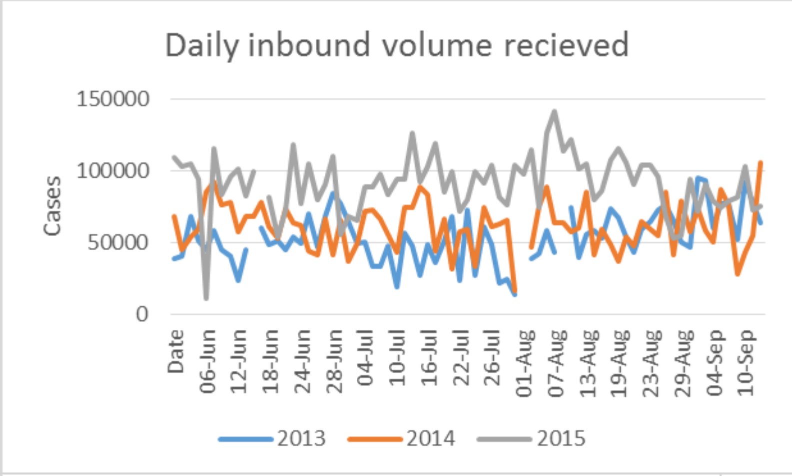

Figure 6.2: Bar graph of daily average inbound volume received for each month

Inbound volume for week 23 to 37				
	2013	**2014**	**2015**	**Unit of measure**
Number of days	104	104	104	days
Number of weeks	15	15	15	weeks
Daily average volume	52 126	59 444	90 981	cases
Daily median volume	51 030	60 015	93 168	cases
Total volume for 15 week period	3 857 290	4 458 278	6 732 612	cases
Bonferroni Grouping	***B***	***B***	***A***	
Significant difference between weekly values for 2013 and 2015				
Independent t-test	<0.0001			

Table 6.2: Summary of inbound volume statistics

Figure 6.1 above shows the daily inbound volumes received for the fifteen-week period for 2013, 2014 and 2015. The figures show that the lines for 2013 and 2014 intercept multiple times and do not have a large difference. However, the line for 2015's inbound volume is clearly above that of 2013 and 2014, which indicates that the DC received significantly more volume this year.

Figure 6.2 shows the same data as Figure 6.3, but breaks it down into the daily average volume received per month for each of the three years. This provides a better reflection of the volumes of 2013 and 2014, which are closely matched; 2014's volume is slightly above 2013 for June, July and August, but in September the volume for 2013 was above that of 2014. The volume in 2015 was clearly above the volume for 2013 and 2014 in Figure 6.2, which matches content of Figure 6.1.

Figure 6.3 shows the daily inbound volume received in a box-plot format. This highlights the median values for each of the year's daily inbound volumes. This figure again confirms the findings of Figure 6.1 and Figure 6.2 that there was a slight increase in volume from 2013 to 2014 and a clear increase to 2015.

Table 6.2 summarises the data from Figure 6.1, Figure 6.2 and Figure 6.3 and also shows the results from the Bonferroni and independent t-test that highlight whether there was a significant increase in the inbound volume received from 2013 to 2015.

Table 6.2 shows the daily median volume received increased consecutively from 2013 to 2015. Notably, 2013 had a daily median inbound volume of 51 030, cases while 2015 had a daily median inbound volume of 93 168 cases, an 82% increase. From 2013 to 2015, the total inbound volume received also showed an increase of 75%, from 3 857 290 cases to 6 732 612 cases. The Bonferroni and independent t-test show a significant difference in daily inbound volume received from 2013 to 2015.

6.2.2 Outbound volume

Outbound volume measures the number of cases that are shipped out of the DC during a specific period. The DC's overall performance depends on the outbound process running efficiently. If the cases are not sent out, the facility's activities will come to a stop due to congestion on the outbound floor and customers will not receive their orders.

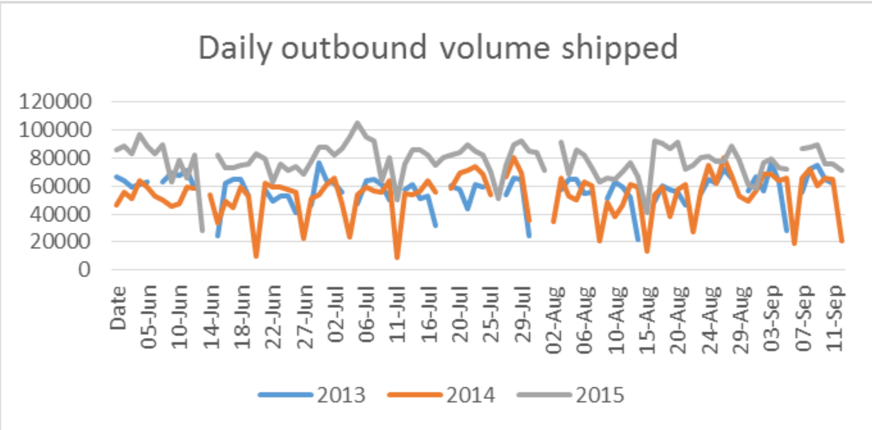

Figure 6.4: Line graph of daily outboound volume shipped

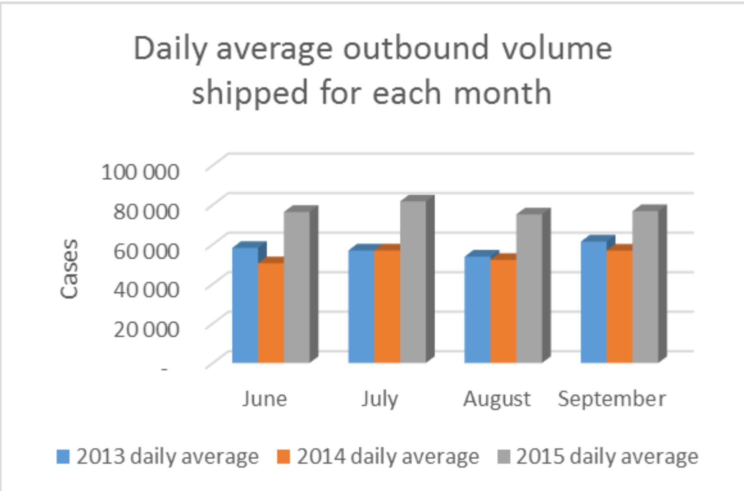

Figure 6.5: Bar graph of daily average outbound volume shipped for each month

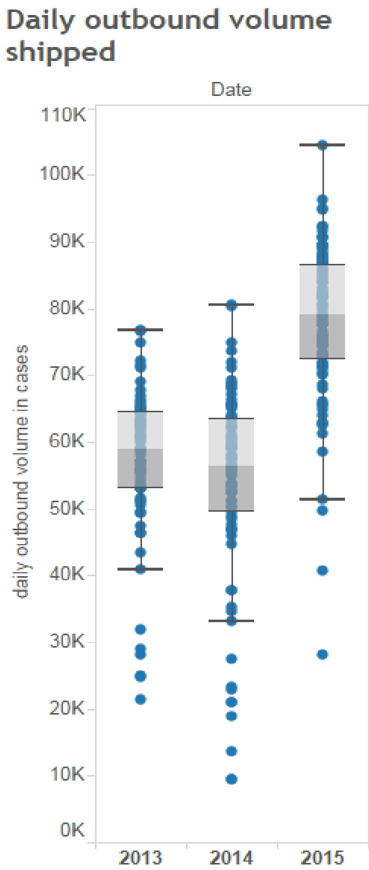

Figure 6.6: Box plot of daily outbound volume shipped

Table 6.3 Summary of outbound volume statistics

Outbound volume for week 23 to 37				
	2013	2014	2015	Unit of measure
Number of days	104	104	104	days
Number of weeks	15	15	15	weeks
Daily average volume	56 990	53 713	77 856	cases
Daily median volume	59 016	56 461	78 988	cases
Total volume for 15 week period	4 331 276	4 780 423	7 084 864	cases
Bonferroni Grouping	B	B	A	
Significant difference between weekly values for 2013 and 2015				
Independent t-test	0.0001			

Figure 6.4 above shows the daily outbound volume shipped from the facility for the three years of 2013, 2014 and 2015. The lines for 2013 and 2014 are matched closely, with each breaking through the other multiple times. However, the line for 2015 is clearly above that of 2013 and 2014. This indicates that the volume shipped was significantly higher in 2015 compared to the other years.

Figure 6.5 shows the outbound volume for each year separated into the average daily volumes per month. When examining the change from 2013 to 2014, it shows that a lower volume was shipped in 2014 than in 2013 –a decrease in outbound volume. When comparing 2015 to 2013, however, it is evident that there was an increase in the daily average volume shipped per month.

Figure 6.6 shows the daily outbound volume shipped in a box plot, highlighting the median values for each year. This figure again shows the decrease from 2013 to 2014 in median daily outbound volume shipped. It also shows the clear increase in median daily volume shipped from 2013 to 2015.

Table 6.3 summarises the data from Figure 6.4, Figure 6.5 and Figure 6.6. It also reflects the results from the Bonferroni and independent t-test, which show whether there was a significant increase in the outbound volume shipped from 2013 to 2015.

Table 6.3 highlights that the daily median volume shipped had an initial decrease from 2013 to 2014. However, there was an increase from 2014 to 2015, passing the initial volume of 2013. Notably, 2013 had a daily median outbound volume of 59 061 cases, while 2015 had a daily median outbound volume of 78 988 cases, a 34% increase. The total outbound volume shipped also highlighted an increase of 63% from 2013 to 2015, from 4 331 276 cases to 7 084 864 cases. The Bonferroni and independent t-test shows that there was a significant difference in daily outbound volume shipped from 2013 to 2015.

6.2.3 Put-away rate

Put-away rate measures the rate at which pallets are removed from inbound and into reserve racking to be stored. It is critical to have an efficiently functioning system, as it ensures that the inbound floor is cleared, so that more stock can be received. Furthermore, it also helps ensure that there is stock available in the racking to be picked and shipped to meet customers' orders.

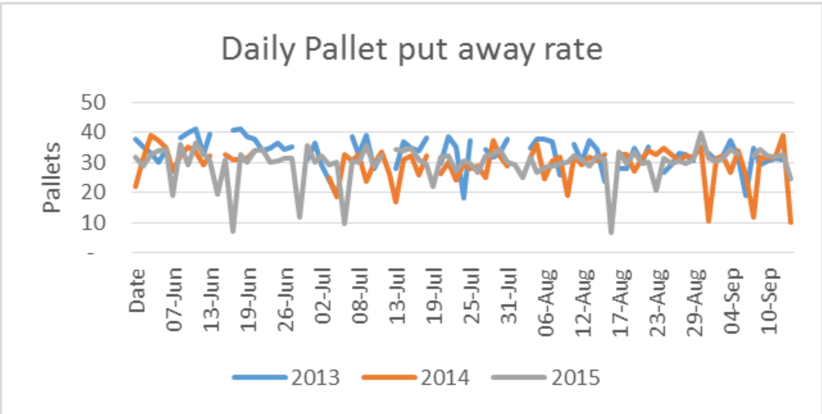

Figure 6.7: Line graph of daily pallet put away rate

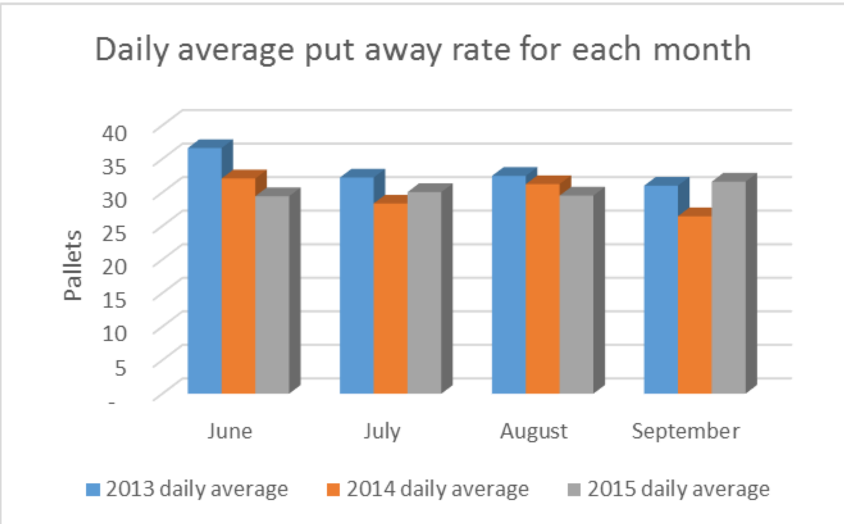

Figure 6.8: Bar graph of daily average put away rate for each month

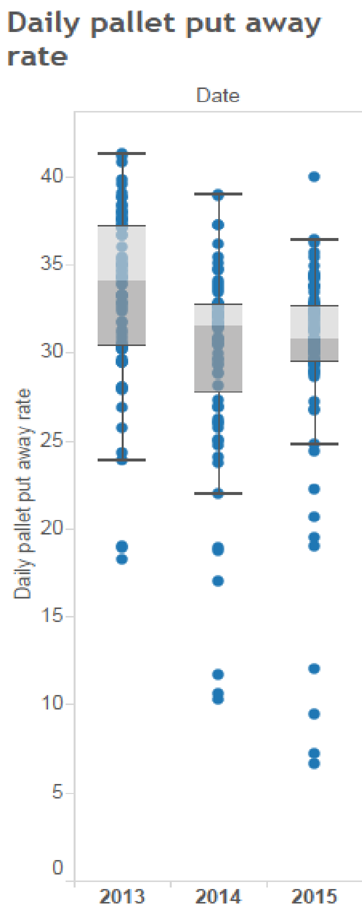

Figure 6.9 Box plot of daily pallet put away rate

Table 6.4 Summary of put-away statistics

Put away rate for week 23 to 37				
	2013	2014	2015	Unit of measure
Number of days	104	104	104	days
Number of weeks	15	15	15	weeks
Daily average rate	33	30	30	pallets
Daily median rate	34	32	31	pallets
Bonferroni Grouping	A	B	B	
Significant difference between weekly values for 2013 and 2015				
Independent t-test	0.0019			

Figure 6.7 shows the daily put away rate per year on a linear graph. All three years are matched closely, which makes it difficult to determine a difference between the three years' data. Figure 6.8 shows the daily average put-away rate for June, July, August and September for each year respectively. Notably, Figure 6.8 highlights that each year performed differently in each month. As such, there is no clear indication of a change in the daily put-away rate in the DC from 2013 to 2015.

By using a box plot shown in Figure 6.9, it is possible to see the change in daily put-away rate from 2013 to 2015 using daily median put-away rates. Importantly, there was a clear decrease in the DC's daily median put away rate from 2013 to 2015 meaning it took longer for staff to put pallet away from inbound to racking the area.

Table 6.4 shows similar findings to Figure 6.9. Likewise, the daily median put-away rate in Table 6.4 shows a decrease from 2013 to 2015. Furthermore, there is a significant difference in the Bonferroni and independent t-tests, which indicates that the decrease in performance was of significant value.

6.2.4 Replenishment rate

Replenishment rate measures the rate at which pallets are taken from reserve racking and put into pick faces to be picked. It is critical to have this function running efficiently, as it ensures there is always stock in the pick faces when the pickers need to pick for store orders. If this does not happen, the entire operation slows down dramatically.

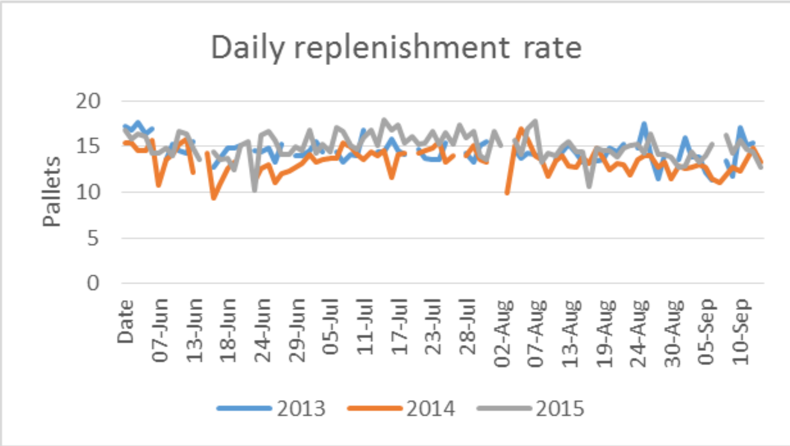

Figure 6.10: Line graph of daily replenishment rate

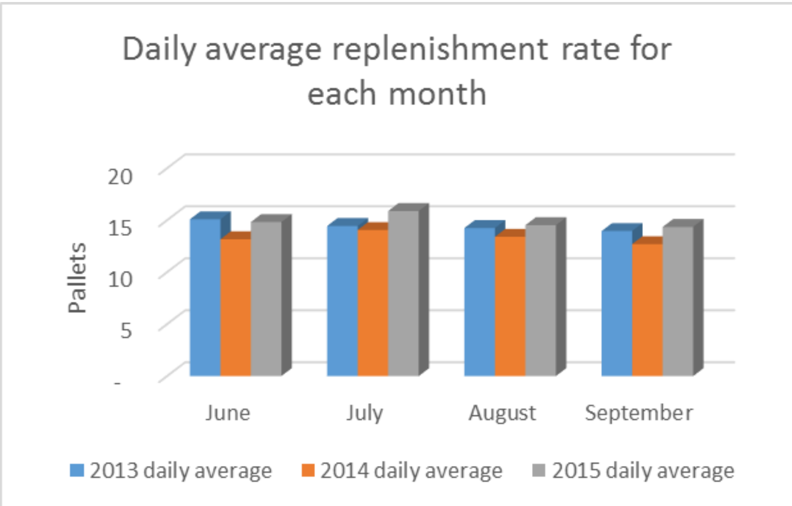

Figure 6.11: Bar graph of daily average replenishment rate for each month

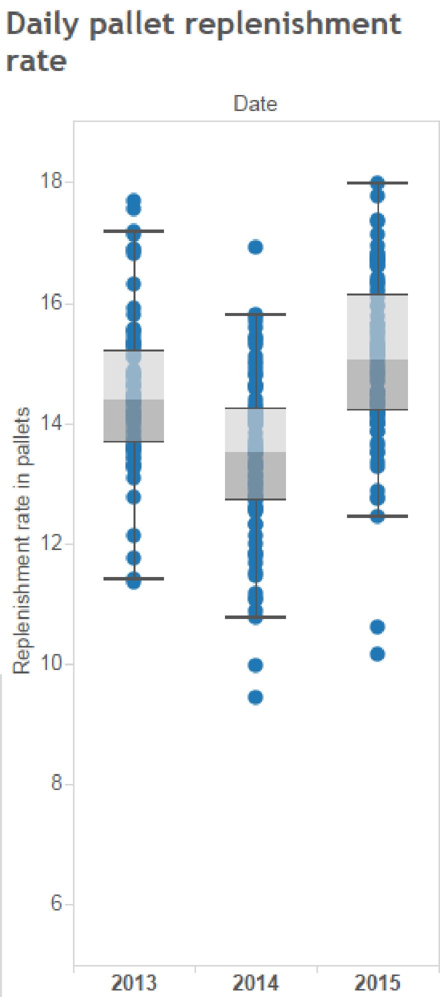

Figure 6.12: Box plot of daily pallet replenishment rate

Table 6.5*: Summary of replenishment statistics*

Replenishment rate for week 23 to 37				
	2013	**2014**	**2015**	**Unit of measure**
Number of days	104	104	104	days
Number of weeks	15	15	15	weeks
Daily average rate	14	13	15	pallets
Daily median rate	14	13.5	15	pallets
Bonferroni Grouping	***A***	***A***	***A***	
Significant difference between weekly values for 2013 and 2015				
Independent t-test	0.2668			

Figure 6.10 above depicts the DC's daily replenishment rate in a line graph. In this figure, the data are matched too closely to determine whether there was a clear change in the performance of the daily replenishment rate. Figure 6.11 shows the average daily replenishment rate for each month of the period in each year. Once again, there was no clear indication of change in this figure; 2013 and 2015 were matched closely for three of the four months, with 2015 breaking above 2013 in July.

Figure 6.12 shows the daily replenishment rate for each year in a box plot format. Based on the median values shown in the box plot, there was a decrease in daily replenishment rates from 2013 to 2014. However, there was an increase from 2014 to 2015, which slightly surpassed the daily replenishment rate of 2013.

Table 6.5 supports Figure 6.12, showing the daily median replenishment rate increasing from 14 in 2013 to 15 in 2015, a 7% increase. However, the Bonferroni and independent t-test indicated no significant change in daily replenishment rate.

6.2.5 Bulk pick rate

Bulk pick rate measures the rate at which pallets are picked by pickers from the reserve slots in the racking throughout the DC. This function ensures the correct stock is picked on the correct days, so that the DC can dispatch the stock to stores in time to meet customers' needs.

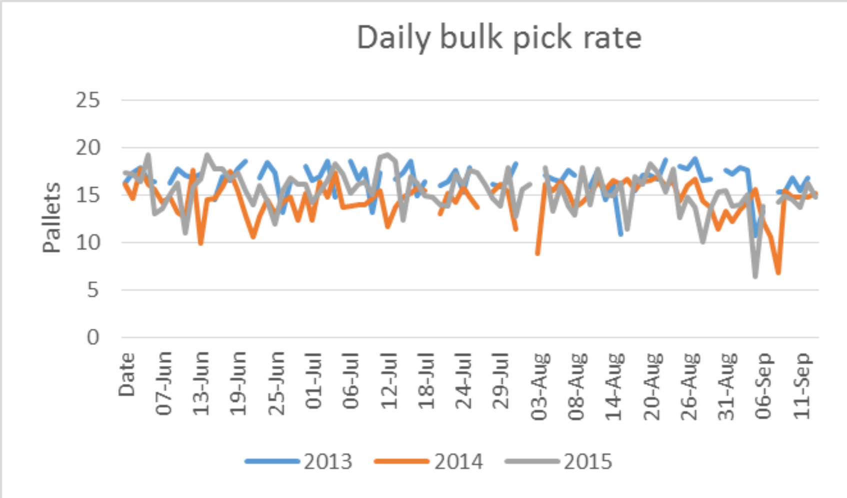

Figure 6.13: Line graph of daily bulk pick rate

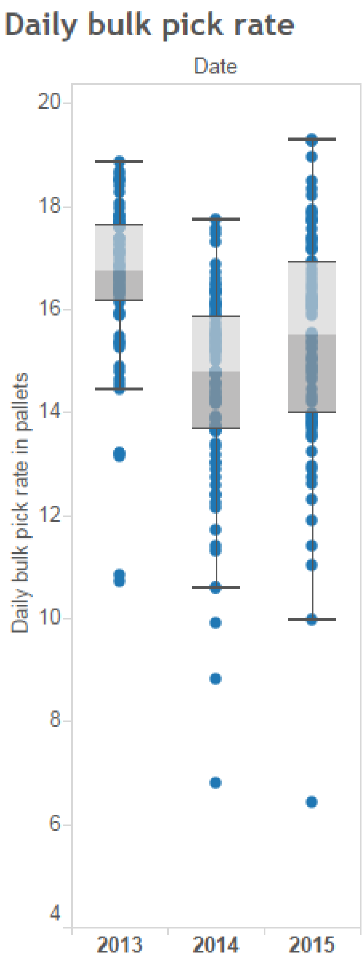

Figure 6.15: Box plot of daily bulk pick rate

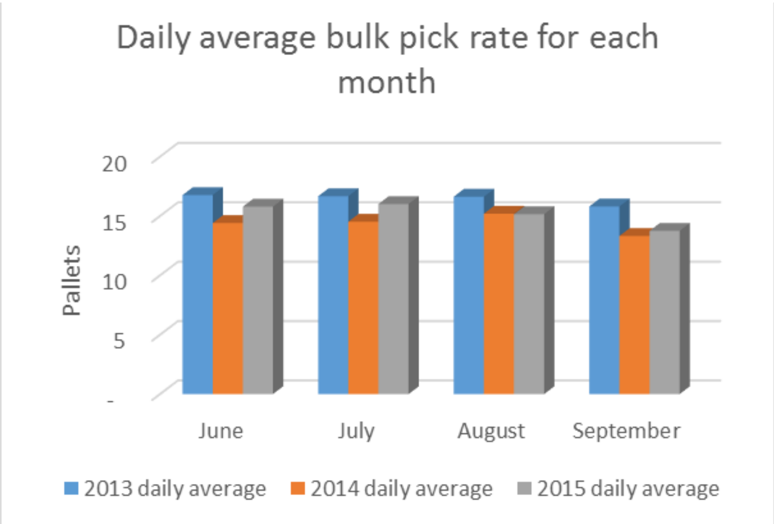

Figure 6.14: Bar graph of daily average bulk pick rate for each month

Table 6.6: Summary of bulk pick rate statistics

Bulk pick rate for week 23 to 37				
	2013	**2014**	**2015**	**Unit of measure**
Number of days	104	104	104	days
Number of weeks	15	15	15	weeks
Daily average rate	16.6	14.5	15.4	pallets
Daily median rate	16.8	14.8	15.5	pallets
Bonferroni Grouping	***A***	***A***	***A***	
Significant difference between weekly values for 2013 and 2015				
Independent t-test	0.7231			

Figure 6.13 shows the daily bulk pick rate in a line graph format for each year. The three lines intersect one another multiple times in the figure, making it extremely difficult to draw any viable conclusions. Figure 6.14 shows the average daily bulk pick rate for the three years separated into each month of the time period. The figure clearly indicates that, when compared to 2014 and 2015, 2013 had a higher daily average bulk pick rate for all four months in question. Notably, this indicate a decrease in the daily bulk pick rate from 2013 to 2015.

Figure 6.15 shows the daily bulk pick rate in a box plot. This highlights the median daily bulk pick rate for the entire period. It clearly shows a decrease in the bulk pick rate from 2013 to 2014, followed by an increase from 2014 to 2015. However, the aforementioned rated does not surpass 2013 again. Overall, the median daily bulk pick rate decreased from 2013 to 2015.

The findings in Figure 6.15 is supported by Table 6.6, which shows a decrease in the median daily bulk pick rate from 2013 to 2015. The rate decreased from 16.8 cases to 15.5 cases, an 8% decrease. Table 6.6 also shows no significant change in the bulk pick rate in the Bonferroni and independent t-test.

6.2.6 Break bulk pick rate

Break bulk pick rate measures the rate that pickers pick cases from the pick faces throughout the DC. This function ensures that the correct stock is picked on the correct days, so that the DC can dispatch the stock to stores in time to meet customers' needs.

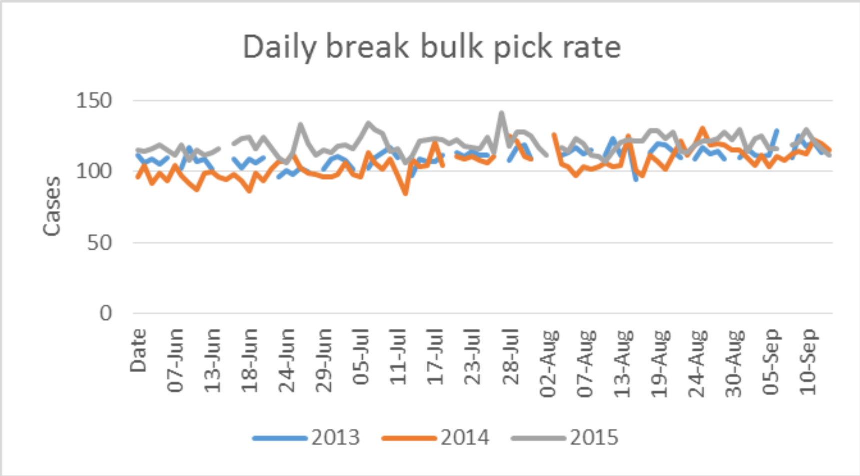

Figure 6.16: Line graph of daily break bulk pick rate

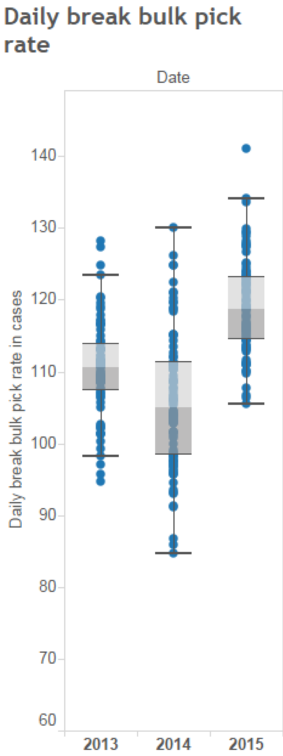

Figure 6.18: Box plot of daily break bulk pick rate

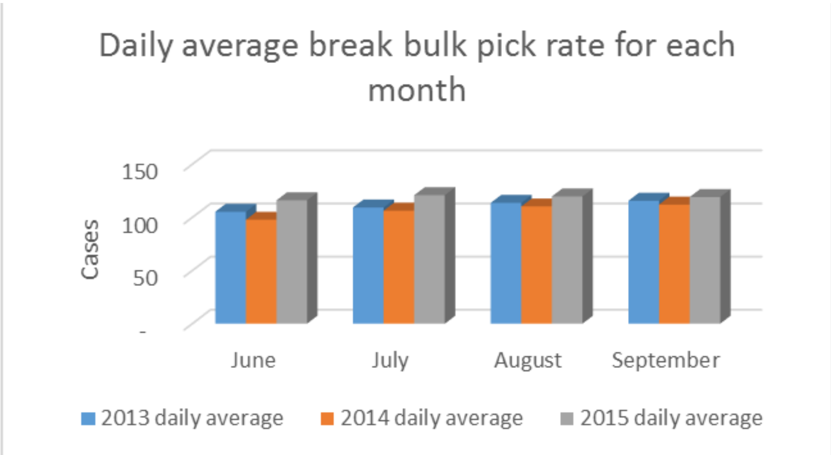

Figure 6.17: Bar graph of daily average break bulk pick rate or each month

Table 6.7 Summary of break bulk pick rate statistics

Break bulk pick rate for week 23 to 37				
	2013	2014	2015	Unit of measure
Number of days	104	104	104	days
Number of weeks	15	15	15	weeks
Daily average rate	110	106	119	cases
Daily median rate	111	105	119	cases
Bonferroni Grouping	B	B	A	
Significant difference between weekly values for 2013 and 2015				
Independent t-test	0.1426			

Figure 6.16 above shows the daily break bulk pick rate in a line graph. The lines for 2013 and 2014 are matched closely. However, the line for 2015 appears slightly above the other two years for the majority of the fifteen weeks. Figure 6.17 illustrates the aforementioned more clearly. The figure shows data in the average daily break bulk pick rate for each month, per year. Furthermore, Figure 6.17 shows that the bar for 2015 is above those of 2013 and 2014 for each of the four months.

Figure 6.18 shows the daily break bulk pick rate in a box plot format. The box plot highlights the median daily break bulk pick rate for each year. The median daily break bulk pick rate decreases from 2013 to 2014 and then increase again from 2014 to 2015, surpassing the median daily break bulk pick rate of 2013.

Table 6.7 supports the findings of Figure 6.18 and illustrates that the median daily break bulk pick rate increased from 111 in 2013 to 119 in 2015, a 7% increase in the median daily break bulk pick rate. The Bonferroni highlights a significant difference between 2013 and 2015, but the independent t-test does not show a significant difference.

6.2.7 Pick tunnel pick rate

Pick tunnel pick rate measures the rate at which pickers pick shrinks, also known as inners, from the pick faces within the pick-tunnel structure. This function ensures the correct stock is picked on the correct days, so that the DC can dispatch the stock to stores in time to meet customers' needs.

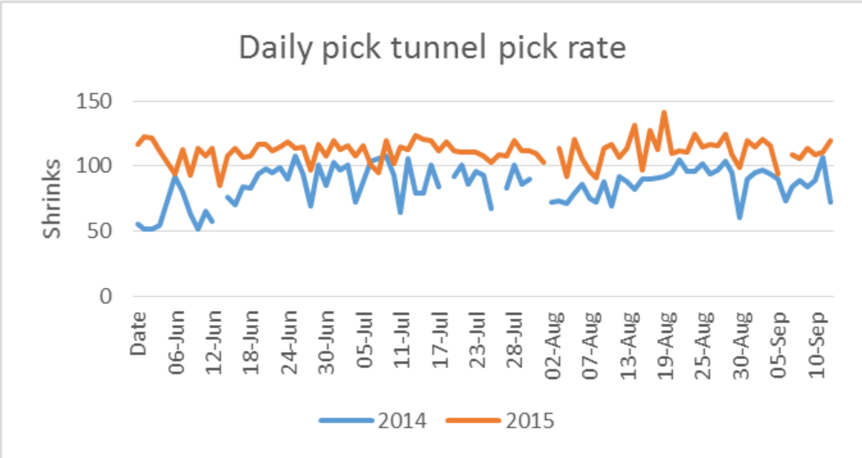

Figure 6.19: Line graph of daily pick tunnel pick rate

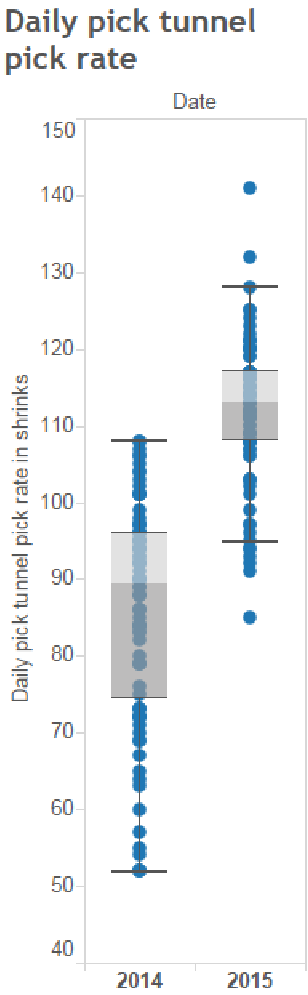

Figure 6.21:Box plot of daily pick tunnel pick rate

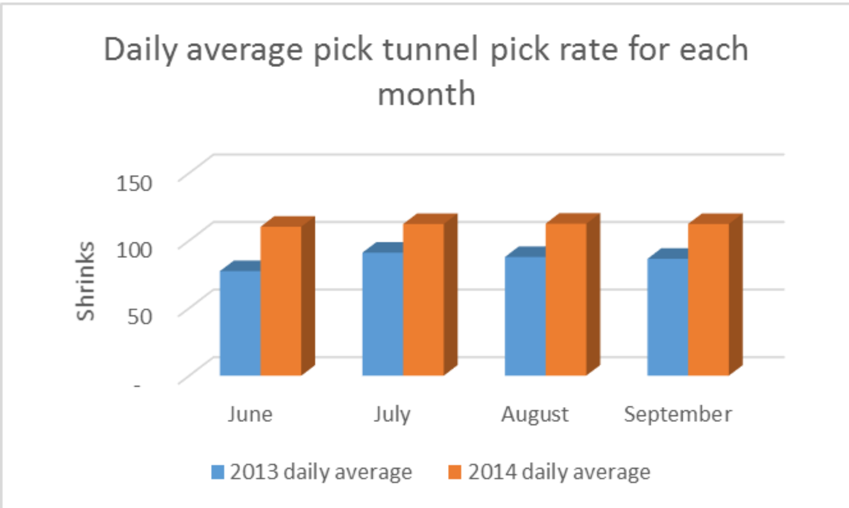

Figure 6.20: Bar grapg of daily average pick tunnel pick rate for each month

Table 6.8 Summary of pick tunnel pick rate statistics

Pick tunnel pick rate for week 23 to 37			
	2014	2015	Unit of measure
Number of days	104	104	days
Number of weeks	15	15	weeks
Daily average rate	85.7	111.3	shrinks
Daily median rate	89.5	113.0	shrinks
Bonferroni Grouping	B	A	
Significant difference between weekly values for 2013 and 2015			
Independent t-test	0.004		

Figure 6.19 above shows the daily pick tunnel pick rate in a line graph, this figure clearly shows a difference between the two years lines with the line of 2015 above 2014, indicating an increase in the daily pick tunnel pick rate. Figure 6.20 shows the same findings as Figure 6.19, the average daily pick tunnel pick rate is shown for each month. 2015 appears above 2014 for all four months.

Figure 6.21 shows the daily pick tunnel pick rate in a box plot. The median values for the two years support the deductions of Figure 6.19 and Figure 6.20, that 2015 saw an increase in the median daily pick tunnel pick rate from 2014. Table 6.8 further supports these findings, showing again the increase in daily median pick tunnel pick rate from 89.5 in 2014 to 113 in 2015, a 26% increase. The Bonferroni and independent t-test both showed a significant difference between the two years data sets.

6.2.8 Errors as a percentage of cases total picked

Errors as a percentage of cases picked measures the number of picking errors such as the incorrect quantity, incorrect stock and damaged goods picked in number of cases, which is totalled and calculated as a percentage of total cases picked for the same time period. This allows the DC to track whether the pickers are picking large numbers of cases that contain numerous errors or if they are picking quality cases with no errors. Ideally, this KPI would need to decrease in order to show an improvement.

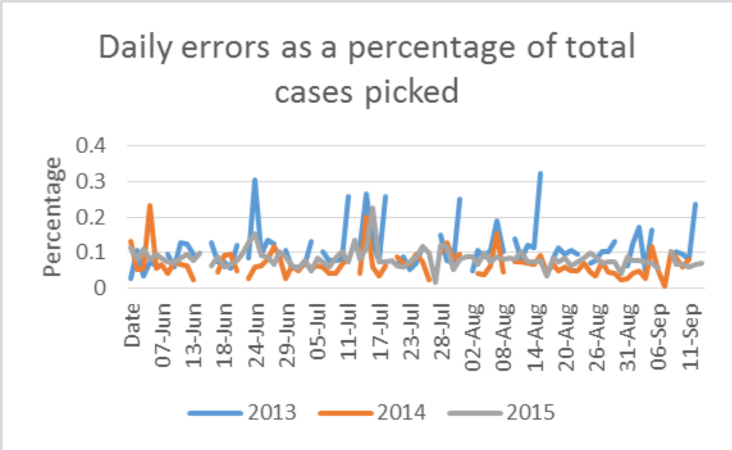

Figure 6.22: Line graph of daily errors as a percentage of total cases picked

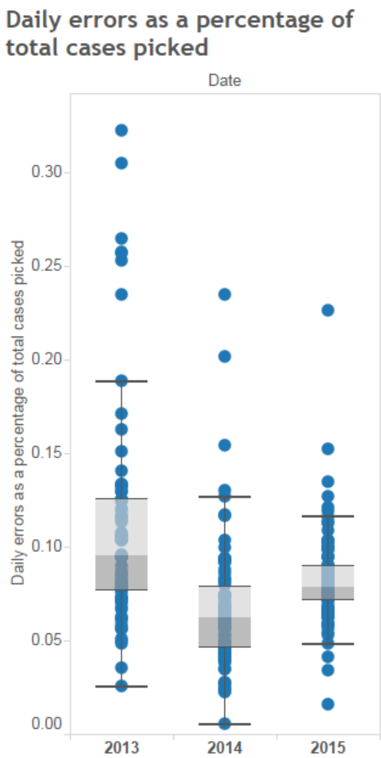

Figure 6.24: Box plot of daily error as a percentage of total cases picked

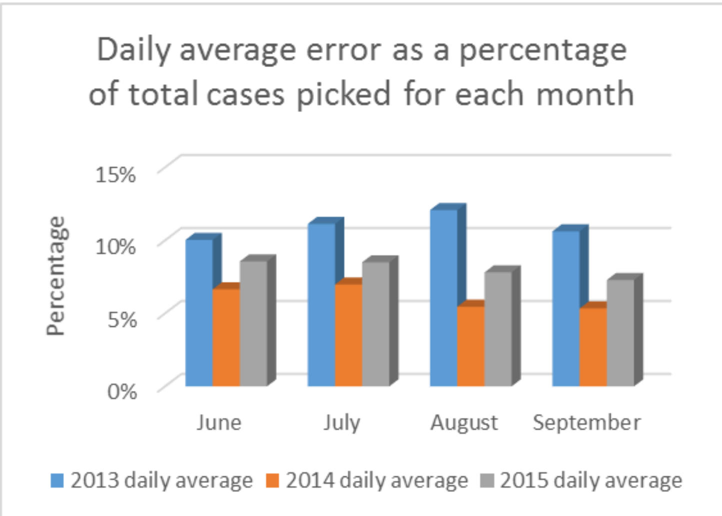

Figure 6.23: Bar graph of daily average error as a percentage of total cases picked each month

Table 6.9 Summary of errors as a percentage of cases picked statistics

Errors as a percentage of cases picked for week 23 to 37				
	2013	**2014**	**2015**	**Unit of measure**
Number of days	104	104	104	days
Number of weeks	15	15	15	weeks
Daily average error percentage	11.0%	6.2%	8.2%	percentage
Daily median error percentage	9.5%	5.8%	7.9%	percentage
Bonferroni Grouping	***A***	***B***	***A***	
Significant difference between weekly values for 2013 and 2015				
Independent t-test	0.1921			

Figure 6.22 above shows the daily errors as a percentage of the total cases picked in a line-graph format. The three years' lines are close to one another with several spikes along each line. Importantly, there is no clear difference between the years data in this figure.

Figure 6.23 shows the daily average of the errors as a percentage of total cases picked for each month of the three years. This figure clearly shows that the errors percentage decreased from 2013 to 2014 but saw a slight increase in 2015. Notably, the error percentage of 2013 is not surpassed.

Figure 6.24 indicates the same findings in the form of a box plot. Here, the daily median errors is emphasised as a percetage of total cases picked. The median error percentage decreases from 2013 to 2014, and saw a slight increase in 2015. Importantly, the error percentage of 2013 is not surpassed.

Table 6.9 supports all three figures for the error percentage of the total cases picked. The table shows that the daily median error percentage decreased from 9.5% in 2013 to 7.9% in 2015. A 16% decrease in errors as a percentage of total cases picked. However, the Bonferroni and independent t-test did not indicate a significant difference between the years.

6.2.9 Discussion of results

Table 6.10: Summary of significant changes in KPIs

Significant change		***No significant change***
Inbound volume		Replenishment rate
Outbound volume		Bulk pick rate
Put away rate		Break bulk pick rate
Pick tunnel pick rate		Error as a percentage of cases picked

Table 6.11 Summary of the change in daily median values for each KPI

	Daily median value				
Performance KPI	2013	2015	% change	Positive/Negative	Significant
Inbound volume received	51 030	93 168	82%	Positive	yes
Outbound volume shipped	59 061	78 988	34%	Positive	yes
Put away rate	34	31	-9%	Negative	no
Replenishment rate	14	15	7%	Positive	no
Bulk pick rate	16.8	15.5	-8%	Negative	no
Break bulk pick rate	111	119	7%	Positive	no
Pick tunnel pick rate (2014/2015)	89.5	113	26%	Positive	yes
Error percentage of total cases picked	9.5	7.9	-17%	Positive	no
*Please note the pick tunel pick rate was recorded for 2014 and 2015.					

After examining all of the KPIs which are used the measure the performance of the DC on a daily basis along with the independent t-test and Bonferroni multiple comparisons it was possible to determine which of the KPIs saw a significant change in performance from 2013 to 2015 after the implementation of the pick tunnel. To summarise these findings from Section 6.3 Table 6.10 and Table 6.11 were put together.

Table 6.10 shows that from the eight KPIs assessed there were only three that saw a significant increase in performance with five that did not see a significant increase in performance. Table 6.11 indicated the change in the median values for each KPI, despite only three KPIs showing a significant increase in their performance, six of the eight KPIs saw an increase in their median values from 2013 to 2015. This indicated that with time these KPIs might increase further.

Inbound volume received and outbound volume shipped had seen a significant increase from 2013 to 2015. This indicated that the DC was able to move more volume through it in the same time frame. By looking at the various picking rates; break bulk, bulk and pick tunnel it was evident that the break bulk pick rate and pick tunnel pick rate both saw an increase, pick tunnel seeing the highest increase. Bulk pick rate however saw a decrease in performance.

The put away rate also experienced a decrease in performance. The reasons being that a portion of the stock was being put away into the pick tunnel and not into the general population. This had a negative impact as it was further travel distance to put away for most products as they were more evenly spread through the DC in the past and now consolidated into one side.

The next section of the framework, the balanced scorecard, now comes into play which will examine the strategic KPIs of the business in order to determine whether the change in the performance KPIs was aligned with the businesses strategic goals.

6.3 Balanced scorecard analysis

During September 2013, Pick n Pay decided to develop a balanced scorecard to measure the Philippi DC's performance from that point onwards. Pick n Pay designed the balanced scorecard around the most important strategic goals for the business related to the DC. A balanced scorecard is an effective tool to establish whether a business is achieving its strategic goals or not (refer to Section 2.2.2). Pick n Pay's balanced scorecard consists of five categories, namely people, finance, operations, customer and sustainability.

In light of the first main research objective, namely to understand operations within the DC, and to gain more insight into the strategic measures linked to the second main objective, namely to establish performance measurement tools, a questionnaire was developed and handed to two members of Pick n Pay's management. Each of the selected members of management is responsible for a specific category that the balanced scorecard measures.

These specific individuals were asked to answer the questionnaires, as they were solely responsible for compiling, analysing and reporting on the balanced scorecard to the company's chief executive officer (CEO). The aim of the questionnaire was to gain insight into Pick n Pay's definition of each balanced scorecard measure, so that the reader is up to date with the status quo.

The two respondents were also selected due their high levels of responsibility within the DC. Furthermore, their knowledge of Pick n Pay's balanced scorecard is unmatched. To add credence to the researcher's choice, the two respondents are responsible for financial and operational aspect to ensure the goals of the scorecard are implemented and performance of the DC continues to show improvement. Appendix B includes the full questionnaires and the respondents' answers. The following section includes a short profile and description of the categories they were questioned about and why these were selected.

6.3.1 Personal profile 1

Job Title: Operational supply chain manager

Responsibilities: The national operational supply chain manager is responsible for all Pick n Pay DCs nationally. His responsibility starts with taking deliveries from vendors into the various DCs and ends at the last 100m at store receiving. All processes within this are his responsibility. Nine DC managers from the various facilities across the country report to him on a daily basis

He was questioned about the following categories, as they all fall under his portfolio as national operational supply chain manager:

People;

Operations;

Customer; and

Sustainability.

6.3.2 Personal profile 2

Job Title: Coastal Region Finance Manager – Supply Chain

Responsibilities:

- Preparing financial statements and budgets according to company polices and good accounting practices;
- Managing financial and system risk in the DCs and stores;
- Expense control; and
- Stock-in-transit control.

Although the financial category still reports to the first respondent, it was deemed appropriate to question this manager about the DC's finances and financial metrics, as he is the expert in this field.

6.4 The five categories of the balanced scorecard

The scorecard's five categories contain specific measurements that have been selected, as they meet the required criteria. Furthermore, they are seen as best suited to represent a balanced view of the business's performance. The categories include the following respective measurements:

6.4.1 People

- Protea (an acronym for Plan, Respond, Order, Team Work, Evaluate and Advance);
- Supervisors' assessment;
- One-on-one review; and
- Leave.

The Protea measurement allows the supply chain to keep track of any cultural change within the DC. Furthermore, changes can be adjusted accordingly to ensure that members work in a happy, comfortable environment to promote efficiency and effectiveness.

The supervisors' assessment measures supervisors' capability in the various operational departments. It implemented to determine whether the supervisors could take responsibility for their departments' KPIs and if not, to try and determine a reason for this. It was of key importance that supervisors took responsibility for their KPIs so that the business could track the overall performance according to predetermined goals.

The purpose of the one-on-one review metric was to measure people's development, growth and contact sessions to build their networking and people relations. This was important, as a business without proper communication will not be able to perform optimally. People need to be able to communicate comfortably with each other. They should have the confidence to share ideas and information that will allow them and others to perform better in the work environment by making more informed and accurate decisions.

As people work in operations and other areas, they accumulate days off according to the number of days they have worked. This has to be measured and recorded to ensure that staff members take their needed leave and do not overwork themselves. It is important to ensure members are well rested and rewarded for the time they put into the business. The health of Pick n Pay's staff members is important to the business.

6.4.2 Finance

- Stock-take results (any shortages experienced during the DC's stock take);

- OP's cost (operational cost of the DC);
- Capex (capital invested in the DC); and
- Overall Work Rate (OWR)

Stock take results is a KPI used to measure the accuracy of inventory records. Importantly, the physical verification of inventory is not only company financial policy, but also forms an important part of the company's internal asset control. Stock take results provide a snapshot of the health of the business and highlights areas of concern, such as shrinkage. The metric indicated the level of shortages. Thus, the lower the metric, the better it performs, as there are fewer shortages.

OP's measures the cost per case. In other words, this is the cost to company per case, from receiving at the DC (inbound) to the store delivery. Lower cost per case and productivity are directly related. The lower the cost per case the more efficient operations become. Labour and transport are the key components in cost per case calculations.

Capex measures the amount of capital allocated to the DC that is used during the year. If the facility is able to perform without using all capital allocated, it saves the business money and helps lower the cost of running the facility.

OWR measures the utilisation, performance and quality of the workforce and its impact on productivity within the DC. It is calculated by using the cost per case linked to the labour component in the facility. If labour is more efficient, the OWR will decrease. This measurement is important, as it identifies overstaffing in departments and measures productivity against the specific predetermined KPIs. This measure includes permanent staff and management in the calculation, which provides a comprehensive outlook on productivity.

6.4.3 Operations

- Inbound TAT (turnaround time);
- Warehouse productivity;
- Safety OHASA (Marsh Africa score / National Risk / Audit – every six months to a year); and
- Short- and over-claims (over-claims logged for oversupplied articles; short-claims logged for short delivered stock).

The inbound turnaround time is the time measurement for a vehicle from the time it enters the gate at the DC until the acceptance of the delivery (AOD). This enables members to see the time stamp break down. This forms part of a process occurs at various stages in time, which enables one to identify any sub-standard areas that can be improved to speed up the vehicle's overall turnaround time. The shorter the turnaround time the better, as this speeds up the rate at which loads are received. Importantly, the more loads a DC receives, the more efficiently it operates.

Warehouse productivity is a simple yet important measurement. It allows the facility to measure the number of cases each picker picks per hour (pick rate).The higher the pick rate the more efficiently the DC is being run. Importantly, the aforementioned is linked to several other metrics, such as claims, outbound volume shipped and OWR.

The Operational Health and Safety Act (OHASA) measures the organisational health and safety of the DC's operations. This ensures that all safety requirements are met, safety regulations are complied with and that staff members work in a safe environment.

Claims include the total claims against the DC from the stores serviced. These claims may result from quality issues, expired stock, incorrect stock sent, shorts and any other expenses incurred due to the DC's negligence. Importantly, this cost could be avoided if processes such as picking are controlled and performed optimally.

6.4.4 Customers

- Availability to pick (ATP) – strike rate of the actual picked quantity versus the original available to pick quantity;
- Post-pick audit (PPA) – actual quantity checked versus picked total by pick date. The target is 4% of all cases picked;
- Outbound deliveries the strike rate of orders delivered against orders placed; and
- Claims relating to quality control (QC) – poor quality, short-dated and expired from the stores against the DC.

The ATP measurement aims to record the availability to pick accurately. This is a visual of how much stock is available to pick in comparison to the stores' orders that the DC received. One of the main purposes for a warehouse or DC is to hold stock and ensures that it readily available to meet demand of the stores it services. Thus, the ATP should be as high as possible. If this is not achieved, the DC fails to perform a key function.

The PPA represents the error percentage that the picking team causes in the DC. The PPA includes error picks, zero picks, short picks and over picks. The aim is to keep this percentage as low as possible. A high error percentage increases costs and also decreases performance levels. Subsequently, stores do not receive the correct stock and are unable to meet customers' demands.

Outbound deliveries measure the number of store orders received in a region and the quantities dropped at each store per vehicle. While this is a simple metric, it is important, as it is used to determine the service level given to the stores that the DC services. This metric should be as close to 100% as possible at all times.

Claims show the number and cost of claims relating to expired stock and quality issues from various stores against the DC that distributes to them. This particular metric excludes claims relating to incorrect quantity, as the store bills the DC for sending these products. Once again, claims need to be kept to a minimum to decrease distribution costs and this is achieved by accurate picking and distribution.

6.4.5 Sustainability

- Electricity consumption –The previous six months' electricity versus the current six months' consumption taking operational changes and energy efficient projects into consideration;
- Reclamation – The value recovered from damages;
- Recycling – The value recovered from recycling efforts, such as cardboard, plastic and all other recyclable materials that the DC generates; and
- Business contingency plan (BCP) – A full dry run is conducted every six months; the dry run is audited and governed by a set checklist of requirements.

To keep track of costs and electricity usage, the DC measures its electricity usage from South Africa's power utility, Eskom. This needed to be measured accurately to ensure the DC does not overuse electricity. This helps with cost saving, power saving and future preservation of electricity, as well as to minimise pollution caused by generating power unnecessarily.

Reclamation is the metric used to record the number of damaged delivery units that can be salvaged, so that stock and money is not wasted. In conjunction with reclamation, the DC also measured its recycling. This important metric allows the DC to measure the function of gathering paper and plastics to sell for extra income. In terms of sustainability, paper and plastics are separated for environmental reasons.

The BCP is a safety measurement that is implementing to ensure that there is a primary and secondary plan in place should a strike occur. This ensures that the DC would be able to continue to operate and distribute stock to the various stores that depend on it. Every six months, the DC performs a dry run in which the plan is fully executed. This is then audited and governed by a set checklist of requirements. The above explanation aims to provide a clear understanding of the balanced scorecard's various metrics, who is responsible for these metrics and what is being measured.

The next section discusses the results of measuring each category and provides an indication of whether the performance improved or not according to this measurement tool.

Pick n Pay's customised balanced scorecard was based on Kaplan's work and measured the four categories the researcher identified as important (Kaplan, 2010:6). This was used to measure the Philippi DC's performance in 2013. It made sense to use this balanced scorecard to measure the Philippi DC's performance during 2014, after the pick tunnel had become operational.

As discussed in Chapter 2, although Pick n Pay had not chosen to adopt the SCOR balanced scorecard, their customisation and adaptation of the balanced scorecard concept resulted in a useful evaluation tool. All three scorecards (Kaplan's, SCOR and Pick n Pay's) used the same foundations, namely employees, business processes or operations, the customer and finances. In Pick n Pay's case, an additional category –sustainability – was included. This spoke to the organisation's focus, not only on past operations, but also on future performance, and how they can be improved. The findings of the balanced scorecard evaluation are discussed below.

6.5 Balance scorecard findings

Importantly, both the balanced scorecard and results solely aim to support the operational KPIs' findings. Therefore, the balanced scorecard cannot be used on its own to determine whether the DC is performing better than before. However, it indicates whether the performance change in the operational KPIs supports the strategic goals of the business. The scorecard results will indicate whether building the pick tunnel was in line with the strategic goals of the business (Govender, 2014).

As mentioned in Chapter 2, the balanced scorecard is an efficient tool that is used to measure the performance of a business in relation to its strategic goals (Kaplan & Norton: 2010, 1992, 1996).

For this reason, the balanced scorecard forms part of the framework used to measure the performance change at the Philippi DC. This section analyses the data captured by the balanced scorecard, which provides a clear indication of whether the facility increased or decreased its performance.

Table 6.12 displays the balanced scorecard and all relevant data. The balanced scorecard contains five categories and each has an unique and specific set of metrics. There are three sections within each of these metrics. The first section is demarcated by ‘P’, which stands for past performance. The aforementioned relates to the three-month period prior to the latest measurement. The second section is demarcated by ‘T’, which represents the DC’s target. The final section, ‘A’, denotes the actual performance of the facility over the last three months. For this particular balanced scorecard, quarter ‘P’ was from April until June 2014. During this period, the pick tunnel was not yet completed and operational.

Therefore, the measurements would indicate how the facility performed before the performance of the pick tunnel took effect. The three-month period ‘A’ was from July to September 2014, when the pick tunnel was fully operational. As such, there would be a visible effect on the facility’s performance. Unfortunately, this was the only data available, as the company stopped measuring the balanced scorecard after September 2014.

Table 6.12 Pick n Pay's balanced scorecard 2014

	PEOPLE				FINANCE				OPERATIONS				CUSTOMER				SUSTAINIBILITY			
1	Status Comments	P	T	A	Status Comments	P	T	A	Status Comments	P	T	A	Status Comments	P	T	A	Status Comments	P	T	A
	Protea	0%	100%	100%	Stock Take	0.10%	0.10%	0.05%	Inbound TAT	3h00	3h00	2h35	ATP	98.50 %	98.50 %	99.18 %	Electricity	287 234	250 000	231 259
2	Supervisor Assessment	0%	100%	50%	Operational Cost	7.90%	7.90%	7.00%	Warehouse Productivity	127	127	103	PPA	0.30%	0.25%	0.30%	Reclamation	9 tons.	5 tons.	8 tons.
3	Review 1 on 1	75%	100%	100%	Capex	R2.4m	R2.1m	R0 m	Safety OHASA		96%	96%	Outbound Deliveries	100%	100%	100%	Recycling	0.01%	0.01%	0.01%
4	Leave	20 days	20 days	12 days	OWR	R 1.21	R 1.07	R 1.50	Claims - Short / Over		0.03%	0.25%	Claims – QC	0.05%	0.03%	0.03%	BCP	100%	100%	98%

In the following sections, the balanced scorecard is divided into each of the five categories. Each category is discussed, where after a summary covers key findings

6.5.1 People

The following metrics were found in this category:

PROTEA: This measurement allows the supply chain to keep track of any cultural change within the DC and adjust this accordingly to ensure staff members work in a comfortable, happy environment. The metric showed that there was a 0% performance in the past. The reason for this could be that the metric was not implemented fully at this point.

The target for PROTEA was set at 100% and this target was reached within the actual time period. This highlighted that the facility showed an increase in cultural activity and showed diversity, with no resistance to the multiple cultures within. The staff had indicated that they were happy with their work environment.

Supervisor assessment: As there was no past measurement, the researcher could not measure an improvement. The past measurement was 0%, as it was not measured, while the actual was 50%. However, the target was set at 100% and this had not been achieved. A reason for this could have been that building the pick tunnel introduced several new roles for the supervisors, which they had not adjusted to or taken responsibility for yet. Although the measure showed a 50% rating, they had not reached the target plausible that they were not yet able to perform optimally with regard to their KPIs.

One-on-one review: This metric also showed a positive performance growth when compared with past actual measurements. In the past, the performance scored 75% in relation to the 100% target. After the pick tunnel was built, the performance saw an increase to 100%. This matched the target and thus indicated that the pick tunnel had no negative effect on the metric's performance.

The staff working in the facility have shown an increase in networking skills and have developed stronger people relations. These stronger people relations enable staff to perform their jobs better through clearer communication and more informed decision-making.

Leave: The aim of this metric was to ensure that staff took their off days (leave) earned and were not overworked. The past performance was measured at 20%, which matched the target of 20%.

The actual performance showed an 8% decline from 20% to 12% between the past and the actual. This meant that staff members were not working ergonomically by taking the leave due to them. They ran the risk of being overworked in the future if this trend were to continue.

One reason for this may have been that staff members needed to be trained in the new pick tunnel procedures. This training was necessary to ensure that they were capable of performing their daily activities and specifically the new activities that were aligned to the pick tunnel.

6.5.2 Finance

The second category to be analysed is the finance category; this consists of the following metrics:

Stock take: The stock take metrics show the level of shortages within the facility. This is an indication of stock that was recorded on the system, but does not physically appear in the DC due to theft, pilferage and damage. The past measurement showed 0.10% shortages in the inventory, which matched the target. From past to present, shortages decreased from 0.10% to 0.05%. This highlights an increase in stock accuracy and control. The new pick tunnel enabled higher stock levels; the fact that there were fewer shortages shows an improvement in performance.

Operational costs: This can be seen as the total cost per case. The cost to receive, sort, store, pick and ship a case from the facility was taken into account. The lower the cost per case, the more efficient the facility is. The target was set at 7.9% cost per case, with a past performance of 7.9% and an actual performance of 7%. Since the implementation of the pick tunnel, the DC has seen an increase in efficiency, as reflected in a decrease in operational cost (cost per case).

Capex: Capex measured the amount of capital allocated to the DC that was used during the year. The aim was to keep the amount below the set target. The past capex spend was R2.4-million, which was double the target set for the current period. A probable reason for this was the incurred additional costs the pick tunnel. The actual target was R0, which showed that no more capex was spent in the facility after the pick tunnel was built. This decrease in capital expenditure indicates that the pick tunnel will be able to pay for itself over the next few years and increase the facility's efficiency

OWR: This section measures the utilisation, performance and quality of the workforce and its impact on the DC's productivity. As explained earlier in this chapter, it relates to the cost per case linked to the labour used in the facility. The target was set at R1.07. While both the past and actual periods were higher than the target, there was an increase in cost from past to actual. The increase from R1.21 in the past to R1.50 is a cause for concern, as it highlights that the cost had increased since the pick tunnel was built.

6.5.3 Operations

The following metrics were measured in the operations category.

Inbound turnaround time (TAT): This relates to the time it takes for delivery vehicles to deliver their orders. The total time is measured from the moment the truck enters the DC's gate until the store accepts the delivery. Thus, the shorter the turnaround time the more efficient the receiving process is. In the past, the facility reached a TAT of three hours, which was on par with the target set for the facility.

With the most recent measurement of TAT, the metric showed a value of two hours and thirty-five minutes. Since the implementation of the pick tunnel, the TAT had decreased by 25-minutes. This was better than the target and indicated that the facility's receiving was operating more efficiently than before the pick tunnel was built. This could ascribed to certain stock being placed directly into the pick tunnel. Subsequently, the floor (inbound area) is cleared quicker and allows for more trucks to be off loaded in the same time frame.

The reason for the stock being put away quicker was that the distance for put away to the pick tunnel was shorter than to the majority of the general population.

Warehouse productivity: Warehouse productivity allowed the facility to measure the number of cases a picker picks per hourr (pick rate). This is an indication of how efficient the picking process is, as well as the facility's overall efficiency, as picking is linked to other activities. The past metric matched the target, which was set at 127 cases per hour per picker. However, that productivity decreased to 103 cases per picker per hour after the pick tunnel was built. As discussed in the data analysis section, the decrease in picking could be linked to the a large amount of goods that were being picked in the pick tunnel. Due to a change in the unit of measure, these were not included in the general population pick rate or warehouse productivity analysis.

Safety OHASA: This measures the DC's organisational health and safety. The Safety OHASA ensures that safety regulations are in place and met on a consistent basis, so that staff members work in a safe environment. The past measure was 0%, as this metric was not fully implemented and measured. For this reason, the comparison was based on the actual and target measurements. Both the set and actual targets were 96%. As such, set targets were met and staff was operating in a safe working environment.

Claims (short/over): The claims metric includes the total claims against the DC from the stores that are serviced. This includes quality issues, expired stock, wrong stock sent, shorts and other expenses incurred due to the DC's negligence.

Claims should always be kept to a minimum, as they are costly for the DC. The past claims were not measured, which showed poor control over the process. This possibly resulted in money being spent unnecessarily. The target was set at 0.03% of all outbound loads, with an actual measurement of 0.25%. As such, the claims were higher than the set target and that the facility was spending more money on claims than they had budgeted.

6.5.4 Customer

The customer category was analysed with a view to determine whether the customers' needs have been met.

Availability to pick (ATP): This measures the amount of stock available to pick from the DC with the amount of stock that the stores ordered. The higher the facility's ATP, the more efficient the performance. The target was set at 98.5%, which was met by the past measurement and out-performed by the actual measurement, reaching 99.18%. This showed that the pick tunnel had increased the DC's ability to match all store orders with regards to stock availability to pick.

Post-pick audit (PPA: This measures the error percentage of all picks performed within the DC. The lower the PPA, the more efficient the facility is with regard to picking. The target was set at 0.25% PPA. However, this was not met in the past or actual measurement. Both the past and actual were measured at 0.30% PPA, meaning that the facility was picking incorrectly that influenced efficiency negatively.

The pick tunnel did not have a noticeable influence on the PPA. However, if this error percentage could be brought down to the target of 0.25%, the facility would perform better and save money spent on labour to correct the picking errors.

Outbound deliveries: The outbound deliveries measure the number of stores serviced and the loads delivered to each. It indicates the percentage of loads correctly delivered to stores. All three measurements, namely past, target and actual, were at 100%. This indicates that all loads were delivered to the correct stores and that the pick tunnel had not influenced this metric negatively. There was no clear indication whether the pick tunnel had a positive influence, as it was not possible to be more than 100% efficient.

Claims: The claims metric shows the number and cost of claims relating to expired stock, as well as quality issues from various stores against the DC. This metric was drawn from claims in the financial category. The target was set at 0.03%. The past had a higher value of 0.05%, but the actual matched the target at 0.03%. This was an indication that the quality control over claims had improved since the pick tunnel was built.

6.5.5 Sustainability

The sustainability category measures how environmentally friendly the DC. Furthermore, it measures whether the DC can follow the same status quo, or whether the evaluation raised a red flag to preserve the business and environment for future generations.

Electricity: An accurate measurement helps ensure the DC does not overuse electricity. This not only relates to cost savings, but also to preserve electricity and to minimise pollution caused by generating power. Past electricity usage was 37 234 kW above the set target of 250 000 kW. However, this has changed, as the actual was measured 19 741kW below the target. This was a great improvement, as the pick tunnel was operated electrically and should have increased consumption. The overall decrease could also be ascribed to the fact that the remainder of the facility was electricity efficient

Reclamation: This was the measure in tonnage of the stock items that were damaged and unsalvageable. The DC has certain programmes in place to ensure that waste is kept to a minimum. For example, one of these programmes addresses waste due to pilferage: if one shrink from a box has been stolen, the remainder can still be sold to specific stores.

The five-tonne-target was surpassed by the past and actual measurement. With regard to the past metric, nine tonnes of stock was salvaged, while the actual metric saw a slight decline to eight tonnes of salvaged stock. This was positive in that large amounts of damaged stock were being salvaged, which led to cost savings. Even with the slight decline, this metric’s performance was still well above the set target, even after the pick tunnel became operational.

Recycling: This metric measures percentage of paper and plastic passing through the DC that is recycled. This provides an additional income for the facility. More importantly, it helps contribute to a more sustainable future and healthier environment. All three metrics, past, target and actual had identical readings of 0.01%. This indicated that the pick tunnel had no influence on the recycling as a percentage of paper and plastic moving through the facility.

Perhaps a more accurate measurement would be to state the recycled tonnage. The reason for this is that if the amount of paper moving through the facility increases, but the percentage remains the same, there would actually be an increase in recycled tonnage. This would not have been reflected as a growth in recycling as a percentage of totals.

Business contingency plan (BCP): This safety measurement is in place to ensure that the business has a primary and secondary plan should a strike occur. The metrics show that the past and target both had values of 100%. This indicates that if there were a need to implement the contingency plan, it would be rolled out with no issues.

However, the actual value saw a decrease to 98%. This indicates that a rollout of the contingency plan would not be successful and would cause challenges. This needed to be investigated, as it might have been linked to a decrease after the pick tunnel came into operation.

6.6 Chapter Summary

Chapter 6 focused on analysis of the data collected for this thesis. This was done by assessing the data through the framework developed in this thesis. The chapter first assessed the performance KPIs and then the strategic KPIs in the form of a balanced scorecard.

The findings of the performance KPIs were that only three of the eight KPIs experienced a significant improvement in performance. The balanced scorecard had a 62.5% increase in its metrics which indicated that the business saw an improvement in its strategic metrics. These findings are discussed further in Chapter 7,which follows, bringing the research to a close and answering the primary and secondary research questions.

Chapter 7: Conclusions

This summative chapter provides a discussion of key findings and draws conclusions around these. It makes suggestions on possible future improvements on the topic of this thesis and answers the research questions established at the start of this thesis.

7.1 Findings and conclusions

Through this research, it was possible to fill the knowledge gap that was presented at the beginning of this thesis. This claim is supported by the following findings and conclusions in the thesis.

7.1.1 The secondary research questions and objectives of the thesis

By following the predetermined research structure, it was possible to address each of the secondary research questions and objectives, as they were interlinked. This led to answering the primary research question of whether the new picking method resulted in better performance within the DC, when compared to the old picking method.

7.1.1.1 Research question 1 and 2 and objective 1

The first main objective was to understand the operations in the DC. There were four sub-objectives that made up this main objective. These included the needs brief, case study, operational assessment and questionnaires. This objective included the secondary research question numbers one and two, namely the needs brief and what operations within the DC were affected by the custom picking method and therefore needed to be altered.

The needs brief was able to identify which process would be affected by the pick tunnel. These included inbound deliveries; and warehouse picking that included staging lane management, wave management, replenishment, execute picking and picking for Express stores. Outbound deliveries were also affected along with the transport planning and HU audits. Although transport planning and HU audits are not covered in the research, but are mentioned as they are relevant to the overall pick-tunnel project.

The warehouse master data, which is critical in ensuring all functions operate efficiently, was the final process or department that was affected. In addition to the processes that the pick tunnel affected, the needs brief was also able to describe how these processes needed to be altered. In addition, the research included which assumptions, risks, benefits and dependencies were present for each. The needs brief highlighted several alterations that needed to take place in order to accommodate the pick tunnel and ensure it reached its pre-determined goals successfully.

An initial case study was performed to provide information on the Philippi DC's background. This was in order to shed light on the daily operations in the facility and to set a departure point for the research being conducted. In addition, it was possible to identify how various processes affected one another. This, together with the needs brief, provided knowledge on how the pick tunnel would influence the various different processes.

An operational assessment was conducted during which the various operations were studied for a set time period. In this time frame, several opportunities for improvement were identified and solutions were proposed to capitalise on these opportunities. The proposed solutions would ensure that the specific operation would perform optimally and help bolster the DC's overall performance. In addition to improved performance, the solutions would allow for the pick tunnel to be built and operated effectively. This is due to the fact that many of the opportunities were linked to functions that affected the pick tunnel, such as inbound, replenishments, put away and picking.

Through using questionnaires to comprehend the metrics used in the balanced scorecard, it was possible to achieve an accurate understanding of why the metrics were important to the business from a strategic perspective.

7.1.1.2 Research question 3 and objective 2

The second main objective was to establish a measurement tool to measure the effect of the pick tunnel on the DC's performance. The second objective was divided into performance and strategic KPIs, which led to developing a framework. This objective was aligned to answer the secondary research question.

The framework was designed to include the most relevant KPIs. Hereafter, the KPIs were analysed using quantitative tools, such as line graphs, bar graphs, box plots, Bonferroni multiple comparison test and an independent t-test, as well as a balanced scorecard. The KPIs used were taken from a study by Lucas (2013) and was based on developing the most appropriate KPIs to measure the performance of processes in a DC. These KPIs were the original ones used by Pick n Pay. This ensured the comparability of the three time periods (2013, 2014 and 2015).

In order to develop the balanced scorecard, a literature study was conducted on the history of the balanced scorecard and on the work of Kaplan (2010), who developed the first balanced scorecard. Although some may disagree with its use, individuals like Brignall (2002), Neely *et al*

(1995), Norreklit (2000), Ittner and Larker (2003), Silk (1998), Lipe and Salterio (2000), Dilla and Steinbart (2005) and Libby, Saletrio and Webb (2004) supported its use. These researchers view it as an efficient tool to track strategic goals and performance related to them. It was found that Pick n Pay's customised balanced scorecard was based on the same principles and categories as Kaplan's (2010). This ensured it took into account all relevant information and gave accurate results.

Questionnaires were developed around the balanced scorecard's metrics to provide a clear understanding of what was being measured and why it was relevant. Once the framework was established, it was tested on the Philippi DC within a case study environment. This resulted in all performance being measured accurately. Furthermore, it allowed for deductions on whether the pick tunnel increased or decreased the DC's performance.

7.1.1.3 Research question 4 and objective 3

To present the performance data's findings, it follows the structure of the framework. First, the performance data (KPIs) were discussed along with the Bonferonni grouping and independent t-tests. This was followed by a discussion of the results of the balanced scorecard. In addressing this objective, answers were found for the secondary research question number four, which can be summarised as performance and strategic metrics.

A. Key performance indicators (Performance metrics):

The performance measures used for the purposes of this thesis followed a simple logic. First, the metrics were applied to the data collected and the results analysed. Thereafter, more statistical tests were used to gain a more accurate research perspective. When applying the metrics, it was found that many, if not all of the metrics, had outliers that skewed the results. This meant that using the mean values for each year was not feasible. However, the outliers did not skew the median values of the data sets and therefore these were found to be more reliable.

Of the eight performance KPIs that were examined, it was found that only three of them saw a significant improvement over the measured period. Conversely, the other half did not see a significant increase. KPIs that experienced a significant increase included inbound volume received, outbound volume shipped and pick tunnel pick rate.

Of all the KPIs, the inbound volume received and outbound volume shipped showed the biggest improvements. The total inbound volume received increased from 3 857 290 cases in 2013 to 6 732 612 cases in 2015, a 75% increase in volume received. The daily median inbound volume received increased from 51 030 cases in 2013 to 93 168 cases in 2015, an 82% increase.

The total outbound volume shipped increased from 4 331 276 cases in 2013 to 7 084 864 cases in 2015, a 63% increase. The daily median outbound volume shipped increased from 59 061 cases in 2013 to 78 988 cases in 2015, a 34% increase.

These two KPIs clearly indicate that after the pick tunnel was built, the DC was able to receive and ship more volume than ever before. However, this was not the only reason the pick tunnel was able to improve the DC's performance significantly.

Of those performance KPIs which did not see a significant increase, three of the five did show an increase in their median values; replenishment rate, break bulk pick rate and error percentage of the total amount of cases picked. This was an indication that, although there was no significant change, the KPIs were moving in a positive direction.

Despite only three of the performance KPIs showing significant changes, the others showed signs of future growth, as mentioned in this section. When considering the time frame of the research, it is evident that the new picking method is still in its infant stages. The DC was not yet operating optimally and staff members were not yet confident or efficient enough with the newly implemented processes. With time, the staff members will become more comfortable with the new picking method. In terms of performance, the DC could possibly show better growth. For this reason, the framework developed in this research should be re-applied in future and compared to these findings. Other than the time factor, there were other possible explanations as to why some processes saw a decrease in performance.

To summarise the findings of the performance metrics, only three of the eight KPIs saw a significant performance improvement. Three of the five KPIs that did not show significant improvement, did show signs of future improvement once the DC and new pick tunnel was fully operational. The purpose of the pick tunnel was to allow for more stock to be picked and shipped from the facility, in light of the above information it was possible to state that this was achieved.

B. The balanced scorecard (strategic metrics):

The balanced scorecard showed that there was an overall 62.5% increase in the performance of the metrics measured from 2013 to 2014. As such, 62.5% of the strategic goals were met and indicated an improvement. Conversely, 37.5% of the strategic metrics did not improve during this period. The areas of concern were staff leave, overall work rate (OWR), claims from stores, a business contingency plan and warehouse productivity that were linked to the break bulk pick rate and bulk pick rate.

This meant that the balanced scorecard was able to measure the pick tunnel's effect on the organisation's performance from a strategic perspective. Furthermore, it indicated that the implementation of the pick tunnel had a positive influence on the strategic metrics. This, in turn, ensured the DC performance was aligned to the strategic goals of the business.

It also proved that Kaplan and Norton (1996) were correct in stating that non-financial metrics, such as inbound volume received and other performance metrics, could predict the behaviour of financial metrics. For example, the improvement in performance metrics could also be seen in the decrease in operational costs and stock-take shortages.

7.2 Recommendations

Based on the results of the study, the following recommendations are made. The framework designed to measure the DC's performance change was implemented successfully. However, the fact that it was tested in a case study situation must be taken into account. Therefore, if Pick n Pay or any other party wishes to use this framework to measure their facility's performance, it will need to adapt it. This can be done by using similar measurement tools, such as KPIs, independents t-tests, Bonferroni multiple comparison test, as well as the balanced scorecard. Furthermore, the KPIs used for the framework must be selected from the facility's existing indicators. Importantly, the KPIs must be used to measure two timeframes. Once the aforementioned is completed, various quantitative tests such as the independent t-test and Bonferroni multiple comparison test, should be conducted.

Pick n Pay stopped using their balanced scorecard after 2014. For this reason, there was no comparative data for 2015. It is recommended that Pick n Pay re-implement the use of the balanced scorecard, as it plays a key role in tracking the strategic goals of any business (Kaplan & Norton, 1992, 1996).

Additionally, it is recommended that the balanced scorecard include the same categories, as these have been based on Kaplan's (2010) initial balanced scorecard. The metrics within the categories must be aligned to the business strategy, but should still fall into the categories used in this framework. The reason for this is that the metrics are established according to the strategic goals of the business and each business has unique strategic goals. It would be more effective if similar measurement tools were applied to the balanced scorecard, as with the performance KPIs. This would allow for a more detailed explanation on why certain strategic goals were not met, while identifying opportunities for improvement.

After careful consideration, the research found that certain of the balanced scorecard metrics are not relevant to measuring the DC's performance and should be replaced with metrics that are more suitable. One of these is capital expenditure (capex). This is not an accurate performance measure, as it only shows how much of the budget was spent on projects. Management could stop this spending at any stage for reasons that are not related to productivity. The capex metric should be replaced with claims and post-pick audits. This thought process was verified by Govender (2014), who was in control of all financial metrics at the Philippi DC. Claims and post-pick audits will help ensure that picking and loading is measured accurately. This will help improve the DC's credibility, while promoting green-light receiving at store level. Green-light receiving is when the store trusts that the quantity and quality of stock they receive is correct and up to standard. With this new metric in place, the balanced scorecard will provide an accurate reflection of the DC's performance.

With regard to the performance of Pick n Pay's Philippi DC, the main recommendation was that time be given for the picking method (pick tunnel) to operate at full capacity and allow staff to be trained in the newly implemented processes. Even though two years had passed since the implementation of the pick tunnel, a change of this magnitude takes several years to tweak and allow to settle. As mentioned in Section 6.3.9 even though only three KPIs saw a significant increase, the majority of the KPIs saw an increase in their medians, which was an indication of growth and improvement.

Pick n Pay should re-apply the framework developed in this research to the DC once a year. The findings should be compared the results of this research to ascertain how the new pick tunnel has changed performance over time.

In conclusion, this framework was designed and tested in a case-study environment at Pick n Pay's Philippi DC. It has been successful in measuring the facility's change in performance as a result of the pick tunnel project. Furthermore, the research helped determine whether the pick tunnel was able to achieve its predetermined goals. In terms of practicality, the framework can be adapted and used to measure performance change in any other facility when a new picking system or major operational project is being implemented.

7.3 Answering the primary research question

After making the above conclusions and recommendations for each of the sections, the primary research question can be answered. According to the performance data and strategic metrics that were measured and assessed using the custom-designed framework, it can be said that Pick n Pay's Philippi DC did see an improvement in performance as it was able to move more volume through the DC in the form of inbound volume received and outbound volume shipped. However, there was a statistically significant increase in only three of the eight performance KPIs.

As discussed in Section 6.3.9 this was an indication that the facility was able to increase the volume it could process through the DC in the same time frame. A main contribution to this was the improvement in the pick tunnel pick rate from 2014 to 2015 as well as the break bulk pick rate, which directly resulted in more volume being shipped from the DC.

Now that the framework has been tested and proven to be efficient in measuring the change in performance, it can be implemented in Pick n Pay's other DCs to assess the impact on performance of similar projects. The performance and strategic metrics of the framework are based on industry best practice, as well as past guidelines to measure a DC's performance accurately. It allowed for conclusive coverage of all aspects of the custom-picking system's effect on a DC. Furthermore, it highlighted the change in performance and any shortcomings to allow the opportunity to improve on those.

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Appendix A

Pick n Pay's Distribution Centre KPIs

Inbound:
1. Receive non packed inbound delivery
• Per-alignment must be done 100% to prevent re-counts
• Number of records per receiver
2. Receive packed inbound delivery
• Number of records per receiver
• Total time of receipt
4. Confirm delivery into warehouse
• Turnaround time for bulk delivery is 1 hour
• Turnaround time for flow through is 30mins
6. Perform inbound HU check
• 10 minute window allowed for quality checks
7. Perform inbound DU check
• 10 minutes allowed for DU quality checks
8. Perform audit on AOD and PTR issued
• There should be 0% discrepancy on audit result
3. Receive import inbound delivery
• Third party service provider receive the Ti - Hi specs before the container arrives from the depot
• All articles must have a pack instruction before receiving DC takes stock in
5. Put away bulk delivery
• All inbound bulk HUs must be accounted for
• Bulk HUs must be placed in the correct location from start
9. Perform audit on put away task
• 100% correct placement of HUs that was put away
• Number of put away tasks completed per individual per hour
10. Perform volume count
• Record the volume of inbound deliveries received per shift

Inventory and Picking:
1. Develop floor plan
• 100% of deliveries requiring picking must be assigned lanes
• Outbound strike rate
2. Perform wave administration
• On time departure as a percentage of departures
• Pick strike rate
• Pick denials as a percentage of pick task quality
3. Review/ schedule pick waves
• On time departure as a percentage of departures
• Pick strike rate
4. Perform replenishment
• Replenishment rate
• Completion of replenishment tasks within agreed time limit
5. Release picking waves
• Outbound strike rates
• On time dispatch
6. Perform break bulk picking
• Pick rate (DU's per man hour= DU's picked / labour hours) target specified by each DC
• Pick error rate (inaccurate picked DU's as a percentage of total DU's picked per shift)
7. Close HU
• DUs/ closed HU/ picker
• Volume (CD3)/ closed HU / picker
8. Perform flow through product driven picking
• Pick rate (DUs per man hour = DUs picked/ labour hours)- target specified by each DC
9. Perform merchandise distribution Cross-dock Picking
• Pick rate (DU's per man hour = DUs picked/ labour hours)- target specified by each DC
10. Perform full pallet picking
• Pick rate (DUs per man hour = DUs picked/ labour hours)- target specified by each DC
• Pick volume (HUs moved)
11. Bins counted (capacity)
• Number of bins allocated to stock

Outbound:
1. Perform outbound HU inspection
• An HU to be audited is not allowed to be in the B Staging lane for more than 24 hours
2. Perform HU audit
• HUs to be audited are not allowed to be in the HU work centre for more than 1 shift
• 98% successful HU audit 2% discrepancies allowed
3. Resolve HU audit discrepancy
• Exception Storage area cleared 100% at end of shift
4. Prepare for HU loading
• 0% tolerance is allowed on HU discrepancies
5. Resolve pre-loading HU issue
• DUs clamed for as a % of DUs issued
• DUs goods issued as a % of DUs available
6. Rebuild HU
• % store claims will be indication of the effectiveness of this process
7. Combine HUs
• When a TU is fully loaded, all HUs on the TU must be packed to maximum capacity
8. Nest high risk HU
• % store claims on HUI due to secure HUs not nested
9. Load HU (combined to calculate total outbound volume)
• X number of HUs loaded per hour per operator
10. Handle HU loading discrepancy
• No outstanding discrepancies at end of shift
11. Resolved orphaned HU
• Number of orphaned HUs per shift = 0%
12. Dispatch outbound
• On time dispatching of outbound deliveries as per outbound schedule
13. Perform static HU check
* % of HUs audit for selected stores

Appendix B

Questionnaires

Questionnaire for balanced scorecard measures:

This questionnaire seeks to understand the reasons for selecting each of the measures used for Pick n Pay's balanced scorecard and provide an explanation for each of the measurements indicating what they are measuring.

Customers:

- ATP

What does this measure? Available to Pick

Why is it seen as important? It showed the quantity available to pick against store orders.

- PPA

What does this measure? Post Pick Audit

Why is it seen as important? Error % in DC with pickers-

- Outbound deliveries

What does this measure?
How many Store orders there are in region and quantities drop per vehicle- the percentage of stock picked vs goods issued.

Why is it seen as important?
To determine service levels to stores.

- Claims

What does this measure?
It showed the claims from store against DC for poor quality and expired stock

Why is it seen as important?

If the DC billed for sending the wrong quantity to store.

Questionnaire for balanced scorecard measures:

This questionnaire seeks to understand the reasons for selecting each of the measures used for Pick n Pay's balanced scorecard and provide an explanation for each of the measurements indicating what they are measuring.

Finance:

1. Stock take results

What does this measure?

Accuracy of inventory records.

Why is it seen as important?

Physical verification of inventory is not only company financial policy but also an important part of the company's internal controls over assets. Stocktake results provide a snap-shot of the health of business, highlighting areas of concern i.e. shrinkage.

2. OP's Costs

What does this measure?

Cost per case – cost involved from receiving (Inbound) to delivery to store.

Why is it seen as important?

Lower cost per case and efficiencies are directly related. The lower the cost per case the more efficient operations become. Labour and Transport are the key components in cost per case calculations.

3. Capex-what is available at begin of year, what has been spent of the budget.
4. Claims & Post Pick Audits

What does this measure?

Accuracy of picking and loading

Why is it seen as important?

Highlights concerns in the operations.

Positive side - improves creditability of the DC while promoting green light receiving at store level.

5. OWR

What does this measure?

The utilization, performance, and quality of the workforce and its impact on productivity.

Why is it seen as important?

Identifying overstaffing in department and measuring productivity against KPI. Includes permanent and Management in the calculation therefore giving a comprehensive outlook on productivity. Cost per case according to labour. Cost of labour divided by volume.

Questionnaire for Balanced scorecard measures:

This questionnaire seeks to understand the reasons for selecting each of the measures used for Pick n Pay's balanced scorecard and provide an explanation for each of the measurements indicating what they are measuring.

Operations:

- Inbound TAT

What does this measure? Total time from Gate to AOD.

Why is it seen as important? To see the 7 times stamp break down

- Warehouse productivity

What does this measure? Cases picked per hour

Why is it seen as important? The measure the performance of the pickers. Warehouse productivity Expressed as the units per man hour calculation

- Safety OHASA

What does this measure? Organizational health and safety

Why is it seen as important? Organizational health and safety of DC regulations-legal requirement

- Claims

What does this measure? Total claims

Why is it seen as important?

Questionnaire for Balanced scorecard measures:

This questionnaire seeks to understand the reasons for selecting each of the measures used for Pick n Pay's balanced scorecard and provide an explanation for each of the measurements indicating what they are measuring.

People:

- Protea

What does this measure? Acronym?
Plan
Respond
Order
Teamwork
Evaluate
Advance

Why is it seen as important? Culture change in DC

- Supervisors assessment

What does this measure? Assesses the capability of supervisors on Operation's department

Why is it seen as important? See if Supervisors can take the responsibility of KPIs

- Review 1 on 1's

What does this measure? Development; growth; contact sessions of people to build people relations

Why is it seen as important? Communications between people

- Leave

What does this measure? People gather days off for time worked in Operations

Why is it seen as important? People need to rest to alleviate stress and burnout.

Questionnaire for balanced scorecard measures:

This questionnaire seeks to understand the reasons for selecting each of the measures used for Pick n Pay's balanced scorecard and provide an explanation for each of the measurements indicating what they are measuring.

Sustainability:

- Electricity

What does this measure? Power from Eskom the DC uses

Why is it seen as important? To measure that the DC does not over spend on Electricity-track efficiencies

- Reclamation

What does this measure? Salvage damage DUs and saves articles

Why is it seen as important? To see the rand value recovered on articles

- Recycling

What does this measure? Gather paper and plastics to sell them for extra income.

Why is it seen as important? To separate paper from plastics to for environmental reasons

- BCP

What does this measure? Business Contingency plan

Why is it seen as important? To have plan A & B in place if a strike would occur.

The following Information was also received with the questionnaires to aid in answering any questions from the questionnaire in case his answers were not clearly understood.

KPI Definitions

People	
❑ Protea	
❑ Supervisors assessment	
❑ Review 1 on 1's	
❑ Leave	
Finance	
❑ Stock take results	
❑ OP's cost	
❑ Capex	
❑ OWR	
Operations	
❑ Inbound TAT	
❑ Warehouse Productivity	
❑ Safety OHASA	Marsh Africa score / National Risk / Audit – every 6 months to a year
❑ Claims – short/over	Over – Claims logged for oversupplied articles Short – Claims logged for short delivered stock
Customer	
❑ ATP	Strike rate of the actual picked quantity vs the original available to pick quantity.
❑ PPA	Actual quantity checked vs picked total by pick date. Target is 4% of all cases picked (LMDC – All other DC's have their targets Error rate as a percentage of the total cases checked – (Over Under/Wrong stock picked) – Target 0.1%)
❑ Outbound Deliveries	
❑ Claims – QC	Poor quality, short dated and expired
Sustainability	
❑ Electricity	Previous 6 vs current 6 consumption taking operational changes and energy efficient projects in considerations
❑ Reclamation	Value recovered from damages
❑ Recycling	Value recovered from recycling efforts – cardboard and plastic and all other recyclable materials generated by the DC
❑ BCP	Full dry run every 6 – Dry run audited and governed by set checklist of requirements

Appendix C

Permission from Pick n Pay to publish information

15 January 2017

To whom it may concern,

This letter serves as approval for Wayne Peter Lucas to use information gathered from Philippi Distribution Centre between 2013 and 2015 to complete his Masters degree in Logistics Management at Stellenbosch University. Permission is also granted for Stellenbosch University to publish the information in their public library.

Kind Regards,

Name: H. J. KRUGER

Signature: