THIRD-PARTY WAREHOUSE LAYOUT AND OPERATION OPTIMIZATION: A CASE STUDY OF BOLLORE AFRICA LOGISTICS LTD NAIROBI.

By

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A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR AWARD OF DEGREE OF MASTER OF ADMINISTRATION, SCHOOL OF BUSINESS, UNIVERSITY OF NAIROBI.

OCTOBER, 2014

DECLARATION

This research project is my original work and to the best of my knowledge it has not been submitted for award of degree in any other university.

Signature………………………… Date…………………………..………

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D61/60872/2013

This research project has been submitted for examination with my approval as the project supervisor.

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ACKNOWLEDGEMENTS

First I thank the almighty God for the gift of life and for giving me the skills, knowledge and energy to complete this project.

My sincere gratitude to my supervisor Mr T.O Kongere and Dr P. Magutu for their patience, guidance and support throughout my research project.

I would also like to make recognition to Bollore Africa Logistics Ltd who facilitated the data collection.

DEDICATION

The research is dedicated to my family members who gave me the needed encouragement and support.

ABSTRACT

The third party warehouse practice in Kenya is increasingly growing as firms in Kenya adopt new management philosophies such as Just In Time (JIT), lean, agile, cross docking, e-commerce and globalization. Third party warehouses are therefore looking for ways to optimize operations so that to add value to the customers as well as maintain competitive advantage. The objectives of the study were: To establish the storage optimization strategies currently employed by third party warehouses in Nairobi; to investigate the relationship between warehouse storage strategies and the level of optimization and to investigate the challenges therein. A case study was carried out in Bollore Africa logistics limited Nairobi where a response rate of 75% was achieved. The analysis was carried out using descriptive statistics, ratios and correlation analysis. The research found that majority of the warehouses used random storage, mechanical devices and casual labour to optimize their operations. The research also found a strong positive relationship between level of optimization and storage system adopted. Research further found that the warehouse adopting random storage system had higher space utilization than those using dedicated or class based storage system. Similarly, labour productivity was found to be low in warehouses using random storage compared to those with dedicated or class based storage system. The research concluded that the random storage guarantee high level of storage space utilization as opposed to the use of class based and dedicated storage design while the dedicated and class based system guarantee high level of labour productivity compared to random storage. The research therefore recommended that third party warehouse should decide on the two trade-offs; Time and space, depending on their constraints and adopt the storage strategy that offers the highest optimization. The study was however conducted on a short span of time and data collected on one organization. The study recommended that further study should be done on a time series approach as well as in other organisations and findings compared to validate the findings.

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ABBREVIATIONS

ITSDF	Industrial Truck Standard Development Foundation
JIT	Just In Time
KPA	Kenya Ports Authority
L.E	Large Extent
M/Hrs	Man Hours
MT	Metric Ton
N.E	No Extent
OEE	Overall Equipment Effectiveness
S.E	Small Extent
SPSS	Statistical Packages for Social Sciences

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CHAPTER 1: INTRODUCTION

1.1 Background of the study

Warehousing has over the years evolved to become a core- competent and strategic weapon that many companies are using to enhance their competitive advantage (Tompkins & smith, 1998). The introduction of modern inventory management philosophies such as lean, just in time, warehouse management system, automation and control systems which are aimed at enhancing return on investment by optimizing the inventory levels and helping reduce the overall warehousing costs has revolutionized the warehouse practice as well as the strategic role of the warehouse (Kare, Veeramachaneni & Rajuldevi, 2009).

In addition to the traditional inventory holding and buffering roles, warehouses have been evolving to act as cross-docking points, value added service centres, production postponement points, returned good centres and many other miscellaneous activities, such as service and repair centers (Maltz & DeHoratius, 2004). Warehousing is one of the most important and critical linkage of modern supply chains, although, it is an activity of high financial cost for companies, standing for approximately 2-5% of total logistical costs (Frazelle 2002). Therefore planning, managing and optimizing of today's warehouse require a more integrated, scientific and professional approach than ever before (Kare et al., 2009).

The ultimate objective of optimizing and managing Warehouse layout and operations is to economically promote and preserve product quality as the products move across the supply chain by ensuring order accuracy through effective use of space, equipment, labor, tools, accessibility of all items and protection of all items (Tompkins & Smith, 1998). Warehouse layout and operational optimization involve examining two different but related element of space utilization: Storage capacity or layout of the buildings and operational efficiency. Layout is direct function of the physical aspects of the layout, the width of the aisles, the storage methods and the types of storage aids. Operational efficiency on the other hand can be termed as how well the storage capacity is being utilized, which is directly a result of how warehouse resources are managed (Benson, 2010).

The third party warehouse practice worldwide is increasingly growing as firms in Kenya adopt new management philosophies such as Just In Time, lean, agile, cross-docking, E-commerce and globalization. Lack of adequate storage space, stringent working rules, increased cost of installing and implementing a warehouse management system and lack of expertise are also cited as other reasons why organizations outsource their warehouse management to third party logistics providers (Tozay, 2012). Tompkins and Smith (1998) defines a third party warehouse as an independent organization specializing in integrated warehousing operation that are scaled and customized to customer needs based on the market conditions and the demand and delivery requirements for their products and materials.

Bollore Africa Logistics Ltd is one of the pioneer companies in Kenya and Africa offering third party warehousing and is the leading third party logistics network provider on the East African market handling over 25% of all East African logistical needs. The organization believes in optimizing logistics as an avenue in reducing poverty in Africa and has demonstrated its zeal in streamlining logistics in Africa by partnering with African Governments in creating trade infrastructures and thereby exploiting the massive unrealized potential for trade between African countries. Bollore Africa Logistics Ltd is the first logistical company to link the economies of the Francophone and English-speaking parts of Africa. (www.economics.com retrieved on 20th July 2014). It is currently preparing a bid for the concession to run the second container terminal at the Port of Mombasa that is currently being constructed by the Kenya Ports Authority once it is complete (www.standardmedia.co.ke retrieved on 20th July 2014). The company's dedication to optimize their operations so as to help the African organizations and government to trade easily amongst themselves and with other continents is the reason this research wishes to explore their warehouse operations.

1.1.1 Third Party Warehousing

There is increased demand for third party warehouse services as firms gravitate towards concentrating on core competences and realigning or right-sizing their operations. Third party warehouses are known to offer flexibility, relieve frustration in areas that your firm has limited (or no) competency, save money and reduce inventory (Tompkins & Smith, 1998). Third party warehouses are divided in to two major groups; public (general) and contract warehouses. The difference between the two is that while both operates for the convenience of other firms, public warehouse focus on short term commodity type storage while contract warehouses have formalized long term agreement with shared risk arrangement and exclusivity of service (www.cilogistics.com retrieved on 4th Sept 2014).

Third party warehousing differ from primary form of warehousing (private warehousing) in that the level of operational certainty is lower in third party warehouses compared to private warehouses. The operators of third party warehouses find it hard to anticipate order arrival or material stay in the warehouse as they do not own or influence their movement compared to private owners who can anticipate stock arrival and duration by checking the operational and sales plans. The high level of uncertainty coupled with the higher need to utilize space pose a greater challenge on the operator of third party warehouses to optimize their warehouse compared to operators of private warehouses (Barthildi and Hackman, 2008).

1.1.2 Warehouse Layout Optimization

Warehouse layout optimization is a process that determines the best layout for an order picking area and the optimal number of aisles and blocks. It is therefore a process of examining the layout design of the warehouse, the choice and dimensioning warehouse equipment and other attributes related to technical structure with a view to minimize time and distance of picking, storage and movement (Karasek, 2013).

Warehouse layout optimization involves four major decisions: determining the overall warehouse structure; sizing and dimensioning the warehouse and its departments; determining the detailed layout within each department and selecting warehouse equipment (Gu, Goetschelckx & McGinnis, 2010). The overall structure (or conceptual design) determines the material flow pattern within the warehouse, the specification of functional departments, and the flow relationships between departments. The sizing and dimensioning decisions determine the size and dimension of the warehouse as well as the space allocation among various warehouse departments. Department layout is the detailed configuration within a warehouse department, for example, aisle configuration in the retrieval area, pallet block-stacking pattern in the reserve storage area and configuration of an Automated Storage/Retrieval System (Gu et al., 2010). The equipment selection decisions determine an appropriate automation level for the warehouse, and identify types of equipment appropriate for storage, transportation, order picking, and sorting.

1.1.3 Warehouse Operations Optimization

Operational optimization seeks to improve efficiency and effectiveness of a warehouse process. Despite the implementation of new philosophies in e-commerce, supply chain integration, quick response, just-in-time delivery and efficient consumer response that aims at shortening the supply chain by connecting the manufacturer with the end customers and hence geared towards eliminating the existence of a warehouse, many organization are yet to be able to implement successfully these philosophies (Tompkins & Smith, 1998). Warehouses are still a common and central feature in most supply chain due to the partial implementation of lean and agile philosophies and organizations need to find ways to effectively manage and perform the operations inside a warehouse with much efficiency and in turn reduce the storage time and costs involved in the storage. These targets cannot be achieved by blindly adapting and deploying the new trends and technologies. There is a need to optimize the technology, operation and the manpower in order to get good results and high efficiency (Kare et al., 2009).

Gill (2006) observes that warehouse management and inventory control are the areas within supply chain with the greatest savings potential when it comes to optimization of supply chain. Therefore by properly managing an organization’s inventory and warehouse operations through best practices, management will provide the largest impact on a company’s bottom line than virtually any other functional area. Recent investigations also reveal that about 33 per cent of logistical costs can be attributed to the costs arising in inventory management and therefore, a proper investigation of savings that might be achieved within this part of supply chain is necessary and is in many cases profitable (Raidl&Pferschy,2010).

Warehouse operation optimization generally focuses on how well the warehouse utilizes the existing storage capacity, measuring the impact of our choices of material handling equipment, labour, methods, procedures, and support systems (Benson, 2010). Operation strategies refer to those decisions about operations that have global effects on design decisions, and include the choice between randomized storage or dedicated storage, whether or not to do zone picking, and the choice between sort-while-pick or sort after-pick (Gu et al., 2010).

1.1.4 Bollore Africa Logistics Ltd

Bolloré Africa Logistics Ltd is a leading third party logistics network on the African continent and the leading operator of public-private partnerships specializing in international freight forwarding, transportation, warehousing and logistics with unrivaled territorial coverage, and effective presence in 55 countries, including 45 in Africa and a total workforce of 25,000 (Bollore, 2012). Bollore Africa Logistics Ltd operates a diverse portfolio of business that include; Haulage, Over-gauge parcels, Shipping, Air, Rail, Barging, Supply chain and warehouse management, Customs formalities, Shipping agency, Port handling, Industrial project logistics, Shipyards and travel agency (www.reelforge.com retrieved on 23rd July 2014).

Bollore Africa has had presence in Kenya since 1950s, then existing in East Africa as Notco & AMI. They later merged with Transintra in 1968 to form Transami SDV africa and in 2008 re-branded to Bolloré Africa Logistics Ltd, uniting all its activities on the African continent and in the countries that have commercial relations with Africa. Bollore Kenya has offices and warehouses in all major cities and towns in Kenya, namely Nairobi, Mombasa, Kisumu and at the main border stations (Malaba, Busia and

Namanga) (www.globalvillagedirectory.info retrieved on 23rd July 2014).

Bollore Africa Logistics Ltd Nairobi warehouse has forty warehouses principally in three locations; North airport road, Jomo Kenyatta International Airport and Mugoya, all in Embakasi region of Nairobi. Bollore Africa Nairobi operates a combined space of around 1,500,000 square feet of general and custom bonded warehousing and specialized facilities for storage and handling of sensitive goods and agricultural commodities for export. They have invested in specialized handling equipment and IT infrastructure enabling them to provide customers with optimized, well co-ordinated inventory management systems. Their Value added services include re-packing, co-packing, labeling, kitting with tailor made stock control and distribution capabilities (www.reelforge.com retrieved on 23rd July 2014).

1.2 Statement of the Problem

The adoption of contemporary inventory management practices such as lean, Just In Time, E-commerce and quick response have made many organizations to outsource their warehousing activities to third party warehouse providers (Tompkins & Smith, 1998). However warehouse optimization still remains a goal not reality (Aberdeen, 2000). This is because many warehouses, especially third party warehouses in Nairobi Kenya still grapple with the issue of how to optimize their warehouses given so many constraints that affect their operations. Bollore Africa is one of the companies that are still grappling with the issue of optimization of its warehouses (KPA, 2012).

Warehousing optimization problem is however not only limited to Kenya but it is universal problem and many scholars have developed both qualitative (Krabbe, 2006; Dharmapriya & Kulatunga, 2011; Freese, 2000; Noble, 2011; Bartholdi & Hackman, 2008; Karasek, 2013) as well as quantitative models (Vrysagotis & Kontis, 2011; Raidl & Pferschy, 2010; Kljajic et al., 2000) to address and solve warehouse optimization problems. Most literature focuses on private warehouses without analyzing the practicability of these models on a third party warehouses.

Gue and Meller (2009) in their study on the application of new aisle designs for unit load warehouses developed and discussed aisle designs and their effect on the performance of the warehouse. They found that contemporary aisle designs significantly improved the performance of the warehouse. The study however did not address the assumptions and the limitations of the models and applicability of the design given various constraints such as nature of inventory, different types of stock keeping units (SKU) and type of equipment.

Kare, et al, (2009) in their thesis on warehouse theory and practice expounded on the concept of warehousing and compared the current warehousing practices in Sweden to the theoretical framework. They found that warehouses were deploying mixture of traditional and contemporary methods and strategies in warehousing. Hausman et.al., (1976) compared random, dedicated and class based storage systems using analytical and simulation models and found that dedicated storage system was ideal for warehouses with many classes of inventory due to significant reduction in travel time. The class based storage system was superior in warehouses with few classes of inventory. The research however did not examine other optimization aspects such as layout location, dimension and equipment and how they relate to the level of optimization.

Tozay (2012) in the study of warehousing location and design among large scale manufacturing firms in Nairobi Kenya investigated the challenges affecting warehousing design decision in Nairobi Kenya. The study found that financial resources, lack of expertise, available space and government regulation to be the main challenges. The study however did not expound on how third party warehouses try to cope and minimize the challenges so as to remain competitive and productive.

Magutu, Chirchir and Mulama (2013) in their study on the effects of logistic outsourcing practices on the performance of large scale manufacturing firms in Nairobi Kenya observed that warehousing and material handling were among the logistic functions most outsourced by large scale firms in Nairobi. The study found that the outsourcing had an effect on the performance of the organization. The study however focused on the outsourcing organization without addressing the methodology and policies the third party warehouses should implement to ensure that the outsourcing organizations attain high performance and remain competitive in the market.

The aim of the research will be to assess the level of space optimization in a third party warehouse and the challenges that they face in their quest to optimize their layout and operations. What optimization strategies are currently employed by a typical third party warehouse in Nairobi? Does the adopted storage design have an impact on the level of optimization?

1.3 Research Objective

The study therefore seeks to;

i. Establish the storage optimization strategies currently employed by third-party warehouses in Nairobi.

ii. Investigate the relationship between warehouse storage design and the level of optimization.

iii. Investigate the challenges third-party warehouses in Nairobi face in their quest to optimize their warehouse.

1.4. Value of the Study

The findings of this research will assist the managers of Bollore Africa Logistics Kenya Ltd to understand how to further optimize their operations and layout configuration so as to improve their service delivery to customers. By understanding warehouse layout and operation optimization, Bollore Africa will identify opportunities for cost savings, increased efficiency and customer satisfaction which will increase the company's competitive advantage.

Other third party warehouses will be able to use the research findings to develop and implement warehouse optimization programs that will ensure attainment of organization's objectives. The findings of the research will be critical in formulation and implementation of warehouse operational manuals and standards and improve the general performance of warehouses across the globe.

Further, this research will provide an important insight on the role of designing, operating and optimizing warehouse service delivery in Kenya and across the world. Finally, The research will contribute to the body of knowledge and academic discourse which will provide a valuable resource to academicians and researchers in improving their warehouse management skills and knowledge.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter focuses on the theoretical as well as empirical background on the concepts of warehouse layout optimization as well as operational optimization. It also include a review of the various empirical studies that have been conducted by other researchers on warehouse layout and operation optimization as well as the conceptual framework adopted for this research.

2.2 Third Party Warehousing

Third party warehouse is an independent organization specializing in integrated warehousing operation that are scaled and customized to customer needs based on the market conditions and the demand and delivery requirements for their products and materials (Tompkins & Smith, 1998). The true value of warehousing lies in having the right products in the right place at the right time thereby providing time and place utility. (Ciilogistics.com retrieved on 2nd September 2014).

The growth of logistical skills and capabilities has resulted in customers demanding higher service expectations and high level of precision. A decade ago 1 or 2 weeks order cycle and 75% order fill was very common and considered good. Today, the expected order cycle is 24 or 72 hours and 100% order fill rate (Tompkins & Smith, 1998). While service expectations increased, costs is expected to remain the same or decline and therefore firms finds it prudent to outsource these logistical services to third party operators who can provide resource network, expertise, scalability & flexibility, time and resource savings and continuous optimization of supply chain and utilize the economy of scale associated with size (www.derbyllc.com retrieved on 2nd September 2014).

The level of third party warehouse optimization is gauged by measuring the facility layout optimization as well as the level of operational efficiency. Layout optimization is a factor of space utilization, equipment utilization while operational efficiency is gauged by the level of customer service, control systems efficiency, inventory accuracy and labour productivity (Tompkins & Smith, 1998).

2.3 Warehouse Layout Optimization

Warehouse layout optimization is a process that determines the best layout for an order picking area and the optimal number of aisles and blocks. It is a process of examining the layout design of the warehouse, the choice and dimensioning of conveyors and warehouse equipment, the design of the physical interfaces to neighboring systems and other attributes related to technical structure with a view to minimize time and distance of picking, storage and movement (Karasek, 2013).

Warehouse layout optimization is a factor of warehouse conceptual design and aisle design (Gue, Meller & Skufca, 2006). The conceptual design determines the sizing and dimensioning of the warehouse and its departments, the specification of functional departments, the flow relationships between departments as well as space allocation among various warehouse departments. Aisle design on the other hand determines material and employees flow pattern and flow relationship within departments and the choice of warehouse equipment (Gu, et al., 2010).

The fluid model of product flow advanced by Barthildi and Hackman (2008) explains that the design and operation of an optimal warehouse should follow three main guidelines: one, the product flow should be with minimal handling as too much handling would result in additional space requirements and extra labor meaning increased inventory handling cost. Second guideline is to implement a warehouse layout that does not impede smooth flow and thirdly, identify and resolve bottlenecks to flow.

Further, Briggs (1978) proposes five decision criteria in designing warehouse layout. They include; determining the overall space requirements for all warehouse processes, specifying (U-shape, straight-through or modular) overall flow design, locating functions with high adjacency requirements close to one another, assigning processes with high storage requirements to high-bay space and labor intensive processes in low-bay space and documenting expansion and contraction strategies for each warehouse process.

Warehouse aisle design is one of the most important design decisions in warehouse layout optimization. This is because aisle design determines the order picking method which according to Frazelle (1996) account for 55% of the warehouse operation cost. Order picking method can be further broken down to traveling 55%, searching 15%, extraction 10%, paper work and other activities 20%. It is quite notable that picking path is the greatest cost consuming part of aisle design (Bartholdi & Hackman, 2008). Tompkins et al (2003) defines order picking problem (OPP) as the process of finding the shortest route that minimizes order picking time and cost.

For a long time many organizations kept a typical warehouse aisle layout hence referred to as traditional layout where items were located on parallel pick aisles, lying perpendicular to the front and back cross aisles, and possibly middle aisles, which made traveling between the pick aisles easier (Gue & Meller, 2009). In the existence of middle aisles, the warehouse is divided into blocks, and the pick aisles were further divided into sub-aisles (Celik & Sural, 2012).

Gue and Meller (2009) analyzed the underlying assumptions in warehouse layout design, and observed that the traditional aisle design had two unspoken rules or assumptions. One, pick aisles were always straight and perpendicular to the cross aisles, and two any middle aisles, if they existed, were straight. However by relaxing the assumptions, new warehouse designs, called the Fying-V and fishbone are created. According to Karasek (2013) these contemporary designs offers a 10% – 20% reduction of traveling distance as opposed to the traditional layouts. Gue and Meller (2009) pointed a serious drawback of fishbone layout which has a limited access to the storage space due to the single pickup-and-deposit (P&D) point and proposed a chevron design which addresses the limitations of fishbone design.

Benson (2012) also expounds that warehouse layout optimization can be gauged by measuring storage capacity verses the overall warehouse capacity. To calculate the storage capacity of a warehouse, the ratio of the cubic storage capacity of the storage aids or storage space (where materials are stored on the floor) is divided by the total cubic volume of the portion of the building occupied by the storage, (or the inverse).

The estimation of space requirement can also be measured using the Little's Law (Little, 1961) where warehouse is viewed as a queuing system. The theory holds that for a queuing system in steady state, the average length of a queue equals the average arrival time times the average waiting time. The average space required can also be calculated by multiplying the average arrival rate of products multiplied by the average time inventory is stored (Bartholdi & Hackman, 2008).

2.4 Warehouse Operation Optimization

Optimization of warehouse operations combines different aspects of business management; inventory management, organization management & transportation management (Karasek, 2013). Warehouse operation optimization is fundamentally a process of utilizing the warehouse existing storage capacity, measuring the impact of the choices of material handling equipment, labour, methods, procedures, and support systems (Benson, 2012). Operation optimization strategies refer to those decisions about operations that have organization wide effects on inventory receiving, storage and retrieval operations. Examples of such operation strategies include the choice between randomized storage or dedicated storage, whether or not to do zone picking, and the choice between sort-while-pick or sort after- pick (Gu et al., 2010).

The basic processes in warehouse are receiving, storing, put-away, picking/retrieving and shipping goods. Receiving starts by notification of the arrival of goods, then unloading, counting, identifying, quality control, and acceptance in relation to type and quantity by unloading staff according to the company rules (Karasek, 2013)**.** Once product is accepted, it is marked e.g. by a bar code and registered in the information system, and staged for put away. The receiving process takes about 10% of operating costs (Bartholdi & Hackman, 2008). It is therefore important for warehouses to optimize the receiving process by ensuring optimal scheduling of inbound tracks, automation of pick and put away processes to avoid too much paper work is not only labor-intensive but also opens the organization up to a multitude of user errors and time wasting (Gill, 2006).

It is also necessary to profile the warehouse receipt and returns profiles so as to determine how to optimize the operations. The receipt profile should include the average number of lines on a receipt/return, the quantities and cube of an average receipt/return, the number of trucks you receive per day, and the units of measure in which you are receiving. Receiving process is also affected by the size and layout of the receiving area. It is therefore important to ensure that the receiving area is roomy enough to accommodate the flow (Krabbe & Klingberg, 2005).

Storing operations consist of the distribution of goods to storage areas, identification and assignment of the storage bin and put-away which is a simple determination of a storage bin concerning the physical dimensions and the weight of goods. This process according to Bartholdi and Hackman, (2008) consumes about 15% of the total operating costs, because it covers a lot of transfers from the gate to the storage place and warehouse operators need to get it right to avoid accumulating costs and damage. Fluid model of product flow as advanced by Barthildi and Hackman (2008) helps in optimizing the storage operations.

Haskett (1963) identifies two basic storage strategies: random and dedicated. While random strategy allows storing a pallet on an arbitrary empty location with the same probability or on the closest empty location, the dedicated strategy allows storing a pallet only on specified locations. The storage locations are also organized based on class or family. Class grouping organize storage according to the frequency of orders. This policy assigns the most frequently requested goods to the closest locations from input/output gates while in family grouping goods are clustered according to relations or similarities between products or orders (Petersen, 1997).

Picking (also called Retrieval) process is the most costly warehousing operation as it consumes about 55% of the overall warehouse operating costs (Bartholdi & Hackman, 2008). Picking can be of two types, homogeneous and heterogeneous. Homogeneous picking is where the picker operates simply with a whole pallet while in heterogeneous picking the picker is told where and what to pick, in what quantity and units. Due to customer needs, the heterogeneous picking is logically more frequent. The disadvantage of heterogeneous picking is that a smaller unit means higher costs (Karasek, 2013).

Warehouse operation optimization metric focuses on how well the existing storage capacity is utilized. This is done by identifying the cubic volume of each area of the warehouse, then estimating the percentage of fill and multiplying the percentage of fill with the theoretical capacity of each area and summing up the result for total cubic feet of inventory. There after divide the storage cube by storage capacity to obtain the capacity utilization percentage (Benson, 2012).

2.5 Empirical Studies

In Gu et al., (2010) warehouse dimensioning problem was first modeled by Francis (1967) who used a continuous approximation of the storage area without considering aisle structure. Bassan et al. (1980) extended Francis (1967) by considering aisle configurations. Rosenblatt and Roll (1984) then integrated the optimization model in Bassan et al. (1980) with a simulation model which evaluated the storage shortage cost, as a function of storage capacity and number of zones. Over the years, many academic researchers have been conducted touching on storage systems and warehouse operations optimization but only a few focuses on systematic approach to be used in warehouse designing (Oxley, 1994). However with the rapid growth in computing hardware and computing softwares for optimization, simulation and general mathematical problems, more robust design- centric literatures are coming up (Gu et al, 2010). Lack of a well-defined and accepted methodology on how to design a warehouse have left designers to rely on their intuition, experience and judgment (Oxley, 1994).

Recent scholars have proposed different warehouse layouts that guarantee cost savings through minimizing picking time, material flow and equipment usage. In Barthildi and Hackman (2008), there are three main architectural design of a warehouse; U-shaped, straight through and L- shaped. Baker and Canessa (2009) advise that U-shaped warehouse design is superior than the rest as it offers excellent dock utilization, facilitates cross-docking, excellent equipment utilization, enables three direction expansion, excellent security and is the benchmark for flow analysis. Straight-through model is proposed for very large warehouses, and L- shaped layout is greatly discouraged unless dictated by the site of the warehouse due to its space limitation (Barthildi & Hackman, 2008).

Hausman et al., (1976) compares random storage, dedicated storage, and class-based storage systems using both analytical models and simulations. For warehouses with many classes of inventory, dedicated storage system shows a significant reduction in travel time compared to random storage and class based storage. However with few classes of inventory, class based storage has been found to be superior compared to dedicated.

Clarke and Wright (1964) also compares the different order picking systems; batching, grouping and zoning and reports that batching had a significant impact on the performance of order-picking especially for small orders. However, zoning, in comparison with batching, does not have significant impact on the performance of the order-picking system (Ruijter, 2007). The advantage of zoning only lay in reducing the congestion in the aisles and when the goods are really in one small area, the traveling is also reduced. The main disadvantage of using zoning is time consumption in consolidating the order when it is completed by more pickers from different zones (Karasek, 2013). Also Gue, Meller and Skufca (2006) in his investigation of ideal aisle design and space optimization by examining the analytical and simulation models of order-picking systems to analyze the system behavior with different activity levels shows that the congestion among workers can be a significant issue if the space is highly utilized.

Moeller (2011) further argues that appropriate sequencing of picking is one of the crucial factors to achieve a high efficiency of picking. The travel time is an increasing function of the travel distance and is considered one of the primary optimization conditions. Hong, Johnson and Peters (2010) also determined a relationship between pick density and throughput, which demonstrated the significance of blocking and proposed strategies to control picker blocking with 5% – 15% reduction in the total retrieval time (Karasek, 2013).

The level of warehouse technology application also determines the level of optimization. Ylitalo (2009) argues that automation of warehousing operation increases the efficiency and effectiveness of a warehouse. This is because technology leverages stock location and inventory control management. Tompkins and Smith (1998) explains that inventory control is the process of managing the quantity of inventory to have to ensure demand is met while stock location management is based on the requirement that when demanded, products must be efficiently and accurately obtained.

However according to Bartholdi and Hackman (2008) low capital investment warehouses tend to outperform those with high capital investment. Presumably this can be attributed to high cost and inflexibility of automation. Despite the cost limitation, automation of warehouse has many advantages that include optimizing storage capacity, effective asset management, inventory control and significant increase in customer satisfaction level. However cost remains a significant limitation to automation. The return on capital employed sometimes takes time before it is quantitatively tangible (Ylitalo, 2009).

2.6 Summary of Literature, Knowledge gap and Methodology.

Many quantitative as well as qualitative models have been advanced by scholars in an attempt to develop an optimal warehouse that maximizes storage while minimizing travel time and storage space. U shaped warehouses have been advanced as the best warehouse layout as it offers excellent dock utilization, facilitates cross-docking, excellent equipment utilization, enables three direction expansions, excellent security and is the benchmark for flow analysis (Barthildi & Hackman, 2008). Class Based storage, batching and sequencing of orders have also been proposed by scholars as superior strategies for warehouse operation optimization compared to other strategies. The level of technology application has been argued as a factor in determining the level of warehouse optimization since technology leverage stock location and inventory control management.

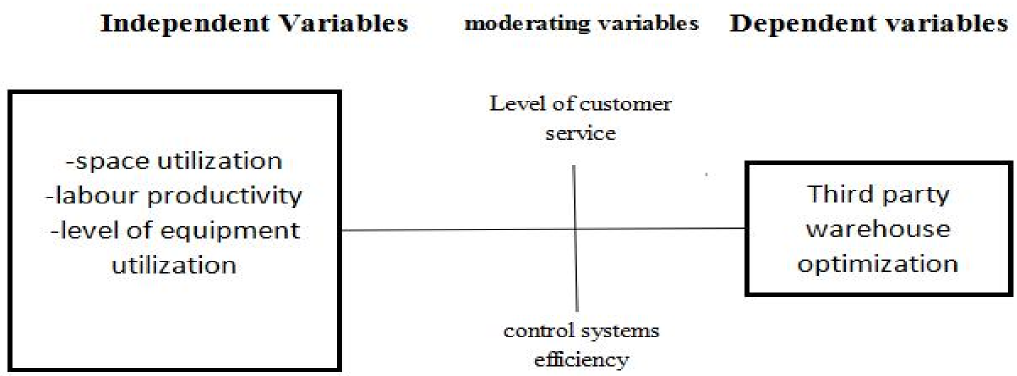
The research will go further and examine the layout configuration in a typical third party warehouse to affirm or modify the arguments advanced by scholars. The emphasis will be public third party warehouses which have been largely ignored by the previous scholars who have examined private warehouses in a production setting.

Traditionally, performance measurement of a warehouse has been through employing a set of single-factor productivity measures that compare one output to one resource or input (Tompkins et al, 2003). The use of ratios and models in assessing the level of optimization in warehouses has been the most recurrent methodology among most scholars and the research will also adopt the same methodology for this study. The study will apply ratios based on a number of Key performance indicators as proposed by Aronovich et al (2010).

2.7 Conceptual Framework

Conceptual framework is a schematic presentation of the theoretical concepts which shows the relationship between the independent variable and the dependent variable. Figure 2.1 shows the relationship between the warehouse layout, aisle configuration and operation with the level of warehouse optimization.

Figure 2.1: Conceptual framework



Source: Researcher

According to figure 2.1, space utilization, labour productivity, level of equipment utilization has a direct effect on the level of warehouse optimization. The extent to which the third party warehouses are optimized is also moderated by the level of customer service as well as the efficiency of the control systems used. Optimization of the warehouses results in third party providers acquiring competitive advantage, improving their profitability, ensuring customer satisfaction and growth.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Introduction

The chapter discussed the research design, target population and sample design as well as data collection instruments and procedures and data analysis.

3.2 Research Design

The research adopted a case study of the layout and operations optimization in Bollore Africa Logistics Ltd Nairobi. The study adopted a descriptive approach as a descriptive research design is used when data are collected to describe persons, organizations, settings or phenomena (Creswell, 2003). Descriptive design was ideal for this research due to the fact that the study involved identifying the level of layout and operation optimization used by Bollore Africa Logistics Ltd.

3.3 Population and Sampling procedures

The target population was forty (40) Bollore Africa Logistics warehouses in Nairobi. The study conducted a census of the entire population due to the small number of the population. The study targeted the warehouse supervisors of the warehouses and therefore the total respondent were 40 supervisors of the Bollore Africa Ltd warehouses in Nairobi.

3.4 Data Collection

The research collected both primary and secondary data. Primary data was collected through the use of questionnaires. This method was appropriate as large amount of data can be collected from many respondents in a short period of time and at relatively low cost. The questionnaires had three sections. The first part contained questions on the bio data as well as general questions on the subject matter; the second and third sections contained questions on the specific objectives of the study.

3.5 Data Analysis

The study collected both quantitative and qualitative data. Two methods of data analysis therefore were adopted to enable the researcher conduct a comprehensive analysis. The quantitative data was analyzed using descriptive statistics, ratios and correlation analysis while the qualitative data was analysed using factor analysis. The findings were presented in ratios, pie charts and tables.

Efficiency and productivity ratios were used to establish the level of optimization currently employed in Bollore Africa Logistics Ltd Nairobi (See Appendix 11). Correlation analysis was used to gauge the relationship between warehouse layout design and level of optimization in Bollore Africa Ltd while factor analysis was used to analyze the challenges that Bollore Africa Ltd is facing as they optimize their warehouses.

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

This chapter discusses the data collected and analyzed using both qualitative and quantitative analysis and presented in tables and pie charts. Forty questionnaires were distributed to all warehouse supervisors in Bollore Africa Logistics Ltd and 30 responses were received thus giving a response rate of 75% in the study. The 75% was considered successful for this study. All of the 10 responses were non-responsive with some respondents communicating that they will complete the questionnaires during the following week, but eventually did not do so despite the many follow-up by the researcher.

This section addresses the responses, findings, analysis and results from the questionnaires received and returned to the researcher. The responses and findings from the respondents were analyzed through the use of factor analysis, means and standard deviation, correlation analysis and factor analysis with the aid of statistical packages for social sciences (SPSS) to derive the results of the study.

4.2 Demographic Characteristics of the Respondents

The research aimed at establishing the optimization strategies employed by third party warehouses in Nairobi. To find out, the research conducted a case study of Bollore Africa logistics Ltd Nairobi and collected a sample of thirty warehouses out of the total forty warehouses in Bollore Nairobi. The demographic characteristics of the respondents considered in this research included the duration they had worked in the company, type of the warehouse they work in, storage system adopted and the equipment used in the warehouse. The purpose of this analysis was to establish unique characteristics of the subject under study. The findings have been presented and explained below.

4.2.1 Respondent's Work Experience in Bollore Africa Nairobi.

The researcher was interested in finding out the duration the warehouse supervisors had worked in their respective warehouses as shown in table 4.2.

Table 4.2.1 ***Work Experience of the Respondents***

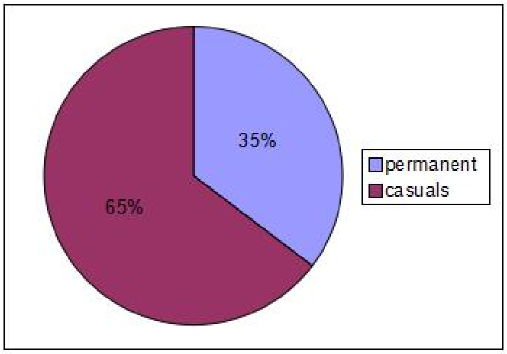
	Frequency	Percentage (%)
less than 1yr	2	7%
1 to 2 yrs	14	47%
3 to 5 yrs	11	37%
More than 5	3	9%
Total	**30**	**1.00**

Source: Research Data (2014)

The findings showed that 47% of the respondents have been actively engaged in warehouse duties and decision for 1 to 2 years and 37% of the respondents had worked with Bollore for 3- 5 years with 9% of the respondent having worked in Bollore for over 5 years. Only 7% of the respondents had less than one year experience with Bollore.

The findings showed that the supervisors had gathered enough experience and were a good source of information on the study. The research further inquired on the composition of the staff in Bollore Africa Nairobi and established that from a total of 249 employees in Bollore Africa Nairobi, 65% were regular casuals and 35% permanent and pensionable employees as shown in figure 4.2.2

Figure 4.2.1.1 Bollore Africa Nairobi Employee Composition



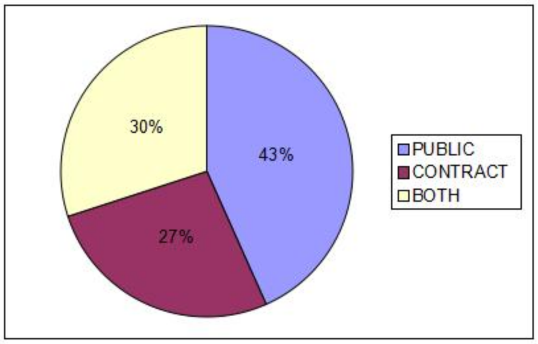
Source: Research Data (2014)

The strategy to use few permanent employees and many casuals in its labour force is an indicator of the zeal to optimize its operations by cutting on labour costs as well as allowing for flexibility in altering labour in line with variability in level of warehouse activity. The use of casuals or contract labour makes it easier to reduce and increase labour as the level of activity in the warehouse change. However over reliance on casuals results in inefficiency as a result of low level of work force experience in terms of machine usage which can result in low labour productivity and low level of machine utilization.

4.2.2 Types of Warehouses in Bollore Africa Nairobi

The research also sought to know the type of warehouses in Bollore Africa Logistics Ltd in order to understand the uniqueness of each warehouse and how it contributes to the level of optimization in Bollore. The study found that 43% of the studied warehouses are public and 27% under contract. 30% of Bollore warehouses though have a combination of public and contract customers as shown in diagram 4.2.

Figure 4.2.2 Types of Warehouses in Bollore Africa Logistics Ltd



Source: Research Data (2014)

The study showed that Bollore Nairobi operates different types of warehouses with different levels of optimization and challenges.

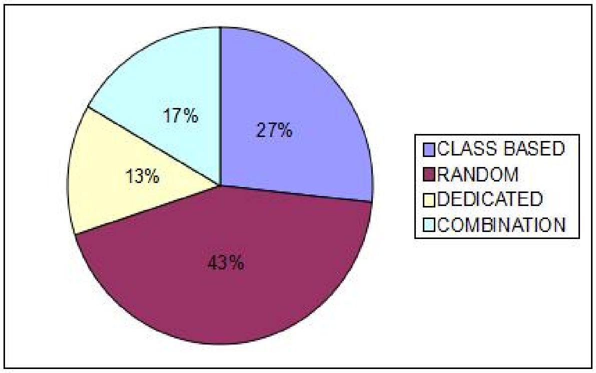
4.2.3 Warehouse Ownership

The study also sought to establish the type of building ownership and the study found that all the warehouses are in a rented space and therefore 100% rental which is an operating cost to Bollore. The purpose of the study was to establish whether Bollore had a luxury of space to its disposal or it had limitation of space which would affect the level of optimization possible. The research therefore established that Bollore Nairobi had no luxury of space and were trying as much as possible to optimize the limited space they have as well as ensure that they reduce fixed costs by maximize on space available.

4.2.4 Storage Systems used in Bollore Africa Nairobi

Additionally, the study sought to know the type of storage used in Bollore Africa ltd Nairobi. The study found that 43% of the warehouses used random storage system, 27% adopted class based system while 17% had a combination of any two storage system and 13% of the warehouses were dedicated to specific goods as shown in Diagram 4.2.4.

Figure 4.2.4 ***Storage systems in Bollore Africa Nairobi***



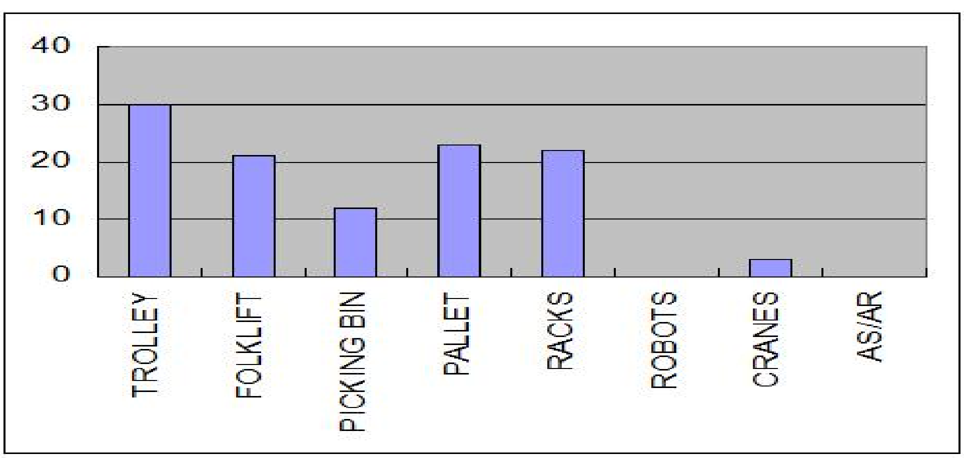
Source: Research Data (2014)

The use of random storage system is consistent with warehouses that do not have luxury of space as it allows the use of available space to store goods as they arrive.

4.2.5 Types of Equipment used in Bollore Nairobi Warehouses

The research inquired on the type of equipment used in the warehouses as a basis of understanding the layout design adopted. The research showed that Trolley is the most used equipment in Bollore with over 27% followed by pallets, racks, forklift, picking bins and cranes with 21%, 20%, 19%, 11% and 2% respectively as shown in figure 4.4.

Figure 4.2.5 ***Types of equipment used in Bollore Africa Logistics Nairobi***



Source: Research Data (2014)

The extensive use of mechanical devices as opposed to automatic devices allows flexibility in warehouse design as well as cut operational costs.

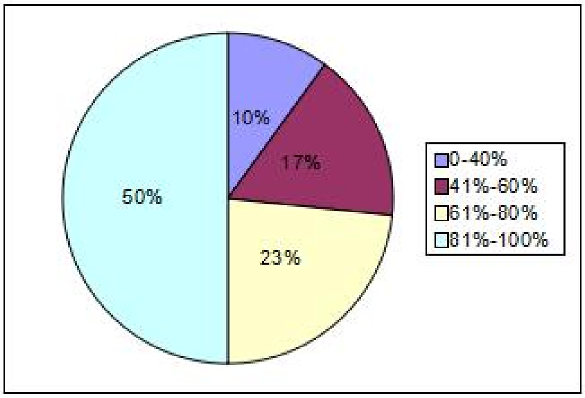
4.3 The Optimization Strategies Employed in Bollore Africa Logistics Ltd

The objective of the study was to find out the optimization strategies employed by third party warehouses in Nairobi. Using Bollore Africa Logistics Ltd as the case study, The research sought information on warehouse dimension, machine utilization and labour productivity from the respondent and then calculated the level of layout optimization, capacity utilization, level of labour productivity and machine utilization rate in Bollore Africa Logistics Ltd Nairobi using efficiency and productivity ratios as shown in appendix 3.

4.3.1 Level of Layout Optimization

The research sought to find out the level of warehouse layout optimization by investigating the level of storage space utilization in order to link the layout design strategies in Bolllore Africa Nairobi with the level of optimization attained. In order to do so the study compared the total storage space in use against the total storage space available. The study found that 50% of the warehouses had over 81% storage space utilization, and 23% of the warehouses were between 61% and 80% space utilization. 17% of the warehouses had between 41 and 60% level of storage space utilization with only 10% of the warehouses achieving below 20% storage space utilization at the time of the study as shown in diagram 4.5.

Figure 4.5: Storage Space utilization in Bollore Africa Nairobi



Source: Research Data (2014)

Overall, the storage space utilization for the entire Bollore Africa Ltd Nairobi warehouses was found to be 71.52% which statistically is very good. The research found that though Bollore used traditional layout in all its warehouses, they have managed to utilize their storage system through the use of mixed storage methods to attain high level of layout optimization. The optimization strategy used by Bollore Africa Nairobi is through the use of combined storage system to attain high level of storage space optimization.

4.3.2 Level of Machine Utilization

In order to assess the level of machine utilization in Bollore Africa Logistics Ltd Nairobi, the research adopted Overall equipment effectiveness (OEE) metric which examines the capacity utilization rate of the equipment in the warehouse in a holistic and multifaceted way. OEE measures total utilization and effectiveness of warehouse equipment in a calendar year. The measure breaks the performance into three separate but measurable components: loading, availability, productivity and quality.

The loading metric represented the percentage of time that an operation is scheduled to operate compared to the total calendar time that is available. The Loading Metric is a pure measurement of schedule effectiveness and is designed to exclude the effects how well that operation may perform. The research established that Bollore warehouses operated on an eight hour shift in weekdays and four hour shift on Saturdays (44 hours).

*Loading = [(5days*8 hours) + (1 day*4 hours)] / (7 days*24 hours) = 26%*

Availability portion of the OEE Metric represented the percentage of scheduled time that the equipment is available to operate. The Availability Metric is a pure measurement of Uptime that is designed to exclude the effects of Quality, Performance, and Scheduled Downtime Events. Bollore warehouse equipment are scheduled to operate 8 hours daily (480 minutes) with 60 minutes scheduled break. The research also assumed an unscheduled break of equipment of 60 minutes daily. The operating time was therefore found to be: *420 Min Scheduled – 60 Min Unscheduled Downtime = 360 Minutes* and the availability metric of Bollore equipment was thus: *360 minutes/ 420 minutes = 85.7%*

The Performance portion of the OEE Metric represented the speed at which the warehouse equipment runs as a percentage of their designed speed. The Performance Metric therefore measures equipment operation speed excluding the effects of Quality and Availability. To enable calculation of this metric, research assumes that all the warehouse equipment are driven at a constant speed and adopts the speed of the fastest equipment in the warehouse; folk lift. Bollore warehouses are scheduled to operate on an 8-hour (480 minute) shift with a 60-minute scheduled break. Therefore, Operating Time is 360 minutes. The research uses the recommended formula in the ASME B56.1-2000 Safety Standard For Low Lift and High Lift Trucks to approximate the standard rate of operating equipment in the warehouse and establish to be 20 trips per hour or 3 minutes per trip (http://gauthierlift.com retrieved on 22nd September 2014).

The research established that the warehouse equipment handles on average 9 metric tons daily of inventory per warehouse and assuming that the folk lift can handle one ton of inventory per trip, then the maximum time it can take to perform the task is 9* 3 minute per trip = 24 minutes. *Performance (productivity) therefore was 24 minutes / 360 minutes = 6.66%*

Quality performance of the warehouse equipment was another metric used to measure the overall equipment effectiveness. The measure assessed the percentage of unit safely handled compared to the total units handled assuming that the damage was not as a result of the operator. The research established that Bollore Africa Nairobi warehouses handled 80,305 MT of inventory in the year 2013 out of which 120MT were damaged. Handling quality therefore is *(80,305- 120) / 80,305 = 99.85%*

Overall the study established that on average the level machine utilization in Bollore Africa Logistic Ltd Nairobi was; *Loading (26%)*availability (87.5%)* productivity (6.667%)* quality (99.85%) = OEE of 1.5%.* The level of machine utilization was found to be very low and the research contributed it to the fact that the aisles were narrow to enable efficient use of the machines.

4.3.3 Labour Productivity

The research further investigated the level of labour productivity. Labour productivity was measured by the amount of output that could be attributed to one employee. The research calculated the output produced annually in all warehouses and compared it to the man hours spent in producing that output. For the purposes of this research the output was taken to be the number of goods handled in tons in each warehouse in a year and the man hours were measured in hours. The result is as shown in table 4.3.3.

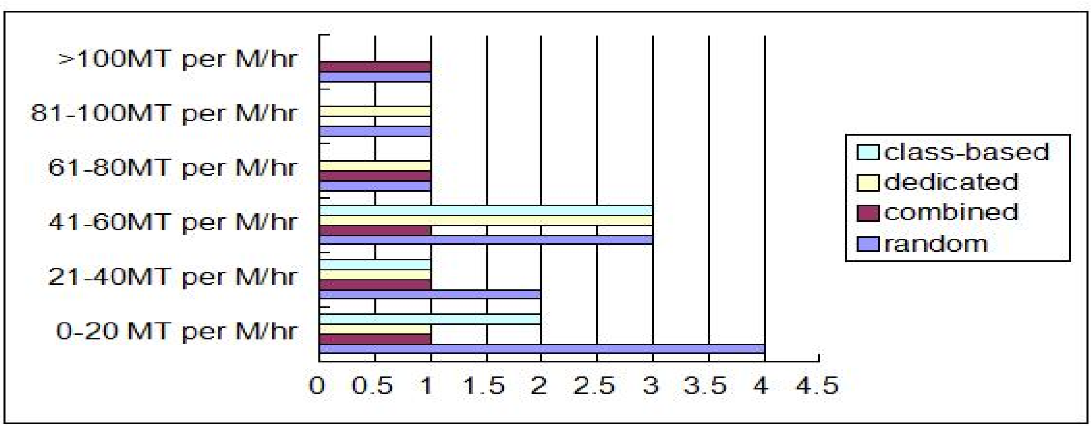
Table 4.3.3: Summary of the labour productivity in Bollore Africa Logistics Ltd.

Productivity	Warehouses	percentage (%)	random	combined	dedicated	class-based
0-20 MT per M/hr	8	26.67	4	1	1	2
21-40MT per M/hr	5	16.67	2	1	1	1
41-60MT per M/hr	10	33.33	3	1	3	3
61-80MT per M/hr	3	10.00	1	1	1	
81-100MT per M/hr	2	6.67	1		1	
>100MT per M/hr	2	6.67	1	1		
Total	**30**	**100.00**	**12**	**5**	**7**	**6**

Source: Research Data (2014)

Based on table 4.3.3.1, majority of the warehouse move 41-60 metric tons per man hour which represent 33% of the total warehouses viewed. The mean average for the level of labour productivity is 51.84 metric tons per man hour. The research further compared the level of labour productivity with the type of storage system and established a relationship as shown in figure 4.6.

Figure 4.3.3 Labour productivity and storage designs in Bollore Nairobi



Source: Research Data (2014)

The research found that there was an inverse relationship between random storage and labour productivity while the research established a positive relationship between dedicated and class based storage system and level of labour productivity. Those warehouses that adopted random storage had low labour productivity compared to warehouses that adopted dedicated and class-based storage system.

4.4 Relationship between Warehouse Storage Design and the Level of Optimization

The research set to investigate the relationship between warehouse storage design and the level of warehouse optimization. The levels of optimization in all the thirty warehouses were analyzed against the type of storage each warehouse used and using SPSS system pearsonian correlation was derived. The association was also tested for significance at 5% level of significance with a 2-tailed test. Thus, the critical values were set at 0.025 beyond which the association was concluded as being statistically insignificant or vice versa as shown in table 4.4.

Table 4.4: Correlation between Warehouse storage design and the level of optimization in Bollore Nairobi

		warehouse storage design	level of optimization
warehouse storage design	Pearson Correlation	1	.829**
	Sig. (2-tailed)		0.006
level of optimization	Pearson Correlation	.829**	1
	Sig. (2-tailed)	0.006	
	N	30	30

**. Correlation is significant at the 0.05 level (2-tailed).

Source: SPSS (2014)

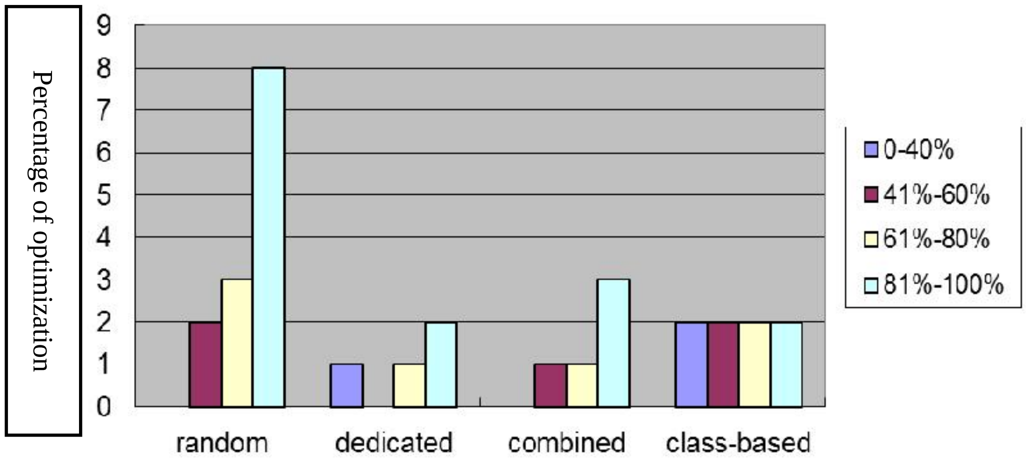
Table 4.4 presented the analysis results giving the correlation coefficient (testing association) and the significant value of the association (testing significance). The significance testing was critical in analyzing the correlation further by showing whether the correlation was purely due to chance factors or not.

From table 4.4, the correlation coefficient value obtained was 0.829. This indicated that the two variables had a positive and strong correlation. The strength of the coefficients was measured using the Pearson correlation scale where a correlation value in the interval 0 - 0.3 indicated no correlation, 0.3 – 0.5 weak correlation, 0.5 – 0.7 fair correlation and above 0.7 a strong correlation. Since the correlation coefficient was above 0.7, then the study concluded that there was a strong and positive association between warehouse layout design and the level of optimization.

The significance of the association was further tested at 5% level with a 2-tailed test showing a significance value of 0.006. The significance value (0.006) obtained was less than 0.025 which is the critical value at 5% level conducting a 2-tailed test. Thus the association was confirmed to be statistically significant and therefore, it is improbable that we would get correlation this big if there was not a relation between the variables.

Further, to establish whether there was a relationship between the level of warehouse optimization and the storage system applied, the research analyzed the storage design against the level of optimization and found that majority of the warehouses with over 81% storage optimization used random storage system as shown in figure 4.6.

Figure 4.4 Level of warehouse optimization and storage designs in Bollore Nairobi



Source: Research Data (2014)

Comparatively, the research established that for those warehouses that used random storage the level of optimization was higher compared to the other storage systems. Class based system was found to be presented equally in all levels of optimization and therefore can be said to be indifferent to the level of optimization.

4.5 The Challenges that Bollore Africa Ltd Faces as they Optimize their Warehouses

The research also asked the respondents to rank the challenges that third party warehouses face as they strive to optimize their warehouses in a 5 likert scale. To identify the challenges, the research posed twelve questions as shown in the Table 4.5. For each question a mean and corresponding standard deviation was calculated.

The score of ‘strongly disagree’ and ‘disagree’ was taken to represent a no extent (N.E) equivalent of mean score of 0- 2.5 on the continuous likert scale. The score of ‘not sure’ was taken to represent a small extent (S.E) equivalent of a mean score of 2.5- 3.75 on the continuous likert scale and a score of ‘agree’ and ‘strongly agree’ represents a large extent (L.E) equivalent of 3.75-5.0 on a continuous likert scale. A standard deviation of

>1 implied a significant variation in the response to a variable by the respondent while a standard deviation of <1 signified uniformity or little variation in respondents' replies.

Table 4.5 Perception of respondents on challenges experienced

CHALLENGE	MEAN	STD DEV
I find it difficult to store or retrieve goods because the racks are too high	1.97	0.68
The Loading and offloading space is too small	2.00	0.80
I find it difficult to locate goods in the warehouse	2.37	0.89
There is no sufficient equipment for loading and offloading goods	2.55	1.30
The equipment faults easily	2.55	0.99
The warehouse management system is hard to understand and use	2.70	1.09
I am unable to use the equipment because i am not trained on how to use them	2.90	1.09
I find it difficult to store or retrieve goods because the paths are blocked	3.17	1.04
The quantities in the warehouse system does not always match the physical count	3.24	1.21
It takes time to retrieve an order because they are not arranged in a systematic manner	3.28	1.07
The process of loading and offloading goods is too long and time consuming	3.30	1.09
It is difficult to conduct a stock take because the goods are not palletized	3.48	1.18

Source: research data

The data showed that to a small extent, the warehouse operators and supervisors found a challenge to conduct stock take because the goods are not palletized (3.48). This challenge can be attributed to the fact that floor storage is a predominant feature in Bollore Africa Nairobi warehouses. The research also found that loading and offloading goods is a challenge (3.30) due to reliance on manual system despite presence of warehouse management system. The use of random storage system also contributes to the delay as goods have to be allocated to the available space despite the distance and frequency of usage. Random storage also contributes to the challenge of quantities not matching the physical count (3.24) as well as difficulty in storage and retrieval (3.17).

The respondents also expressed to a small extent the challenge of equipment usage due to poor or no training (2.9 and 2.7) which can to some extent explain the challenge of equipment faulting easily (2.55). In addition, majority of the respondent express a challenge of few handling equipment (2.55) and this challenge can also contribute to delays expressed earlier as challenges. However, the issues of locating goods in the warehouse (2.37), space (2.0) and rack size (1.97) were not found to be a challenge in Bollore Africa Ltd Nairobi. It is worth noting that despite majority of the respondents expressing these challenges, their levels of agreement were found to have huge variance which means that there is no overwhelming consensus on these challenges and a significant number of respondents disagree with these challenges.

CHAPTER 5: SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter summarizes the findings gathered with the analysis of the data. The findings have being summarized in the context of the objectives of the study and conclusions drawn. The recommendations have also being given out and inferred from the findings and conclusion.

5.2 Summary of Findings and conclusion.

The purpose of this research was three fold; to establish the optimization strategies currently employed by third party warehouses in Nairobi, to investigate the relationship between warehouse storage designs and the level of optimization as well as to investigate the challenges that third party warehouses in Nairobi face as they optimize their warehouses. A case study of Bollore Africa Logistic Ltd Nairobi was carried out and the research interviewed thirty warehouse supervisors on different aspects of warehouse layout and operation management with a view to identify different warehouse strategies employed in each of the warehouses as well as identify the challenges that the warehouse supervisors face as they optimize their warehouses. The data collected was analyzed using single factor productivity ratios, descriptive statistics and correlation.

The research established that majority of the respondents were skilled enough in warehouse management and were actively involved in warehouse management decisions. The findings proved that the respondent were a good source of information as they had enough experience to provide reliable and accurate information for analysis. The research can therefore conclude that the information derived from the respondent is valuable, reliable and timely and can reliably represent the situation in the warehouse industry in Kenya.

Moreover, the research established that Bollore did not own all its warehouses rather were on capital lease. This kind of arrangement meant that Bollore did not have a luxury of space and was therefore keen in ensuring that they optimize their operation so as to minimize wastage and costs. It is therefore not surprising that the research found that Bollore preferred random storage above the rest of the storage system. Random storage helped Bollore to utilize every available space irrespective of the type and ownership of goods. Goods were therefore stored according to the available space as they arrive at the warehouse. This storage system was also complemented by the fact that majority of the warehouses in Bollore were under general warehouse as opposed to either contract or private. This kind of arrangement meant that it was onus on the Bollore management to decide where to store the goods as opposed to contract arrangement where the goods have to be stored in a fixed space. The former arrangement guarantee higher level of optimization as opposed to the latter in a commercial warehouse as the customers only pay for the storage space occupied by goods compared to contract arrangement where the space is fixed whether occupied or not.

The research further deduced that random storage guarantee higher level of storage space utilization as opposed to the use of class-based and dedicated storage designs as found out by the analysis of Bollore warehouses. The research performed correlation analysis where a strong positive relationship was found between level of optimization and the storage system adopted. The research can thus infer that third-party warehouses stand to gain huge savings through minimizing storage costs if they adopt random storage. It is however important to point out that this analysis and inference does not contradict the argument by Hausman et.al., (1976) rather provides an insight into the advantages of using random storage as opposed to dedicated or class based system. Hausman et.al., (1976) found dedicated storage system to be superior to random and class based system when dealing with many classes of inventory by reducing storage and retrieval time, though his findings were silent on the implication of dedicated storage on the level of space utilization.

The research found that dedicated and class based storage system guarantee high level of labour productivity compared to random storage affirming Hausman et.al., (1976) findings. The reason that warehouses with dedicated and class based storage system exhibit high level of labour utilization can be attributed to reduction in travel time which according to Frazelle (1996) account to 55% of the warehouse operation costs. The research can therefore deduce that by adopting dedicated or class based storage system, third party warehouses can greatly improve labour productivity which can help warehouses make huge cost savings.

However it is simplistic to adopt either dedicated or class based system as an optimization strategy without taking into account other factors such as level of storage optimization. It is worth noting that in some warehouses where dedicated and class based storage system was adopted, storage space utilization was found to be low despite increase in labour productivity. The scenario presents another view that previous researchers never explored. The layout and operation optimization strategies are contingent on several factors key among them is space verses time costs.

The research has therefore qualified the findings of Hausman et.al., to include the fact that in as much as the dedicated storage system saves warehouse storage and retrieval time, and therefore can be a good source of operational optimization, it has been found to offer very poor storage space compared to random storage. The research can therefore conclude that in situations where space is expensive compared to labour and thus space utilization is of essence compared to time, then it is essential to adopt random storage as opposed to dedicated storage. In situations where labour is expensive compared to warehouse space, or in situations where the warehouse is owned by the third party provider and the fixed cost has been recouped, then dedicated storage system is superior to random storage in optimizing the warehouse operations.

The fact that Bollore Africa Ltd Nairobi has a very high level of storage space utilization as well as labour utilization is an indicator of an organization that has mastered the art of maximizing the available resources to deliver value to its stakeholders. However high level of optimization pose a challenge as it results in narrow aisles, small staging area which impedes smooth flow of workforce and materials across the warehouse. Difficulty in conducting stock take, retrieving and storing the goods, as well as time wastage in loading and offloading of inventory are the most outstanding challenges posed by the respondent. These challenges can be attributed to the layout strategies adopted which on one hand results in high storage space utilization while on the other results in overcrowding and impede movement. The research would recommend adoption of contemporary layout designs such as fishbone and flying V, which Gue and Meller (2009) found to offer 10-20% reduction of travel time without reducing the storage space capacity.

Training on the use of machines and warehouse management systems has also been cited as a challenge by the respondents and can be attributed to the extensive use of contractual or casual labour in Bollore Africa Ltd Nairobi and in inference all third-party warehouses in Nairobi. This challenge has also been affirmed by the research data which shows machine utilization of 1.5% in Bollore Africa Nairobi. The low level of machine utilization is an indicator of lack of knowledge in machine usage and points to the fact that the employees do not have enough time to learn how to use the machines as they are on contractual basis. The research therefore recommends review of this strategy to ensure that the permanent- casual composition in labour is harmonized so that there is enough and experienced workforce through-out in the warehouses. Increase of permanent workforce will result in higher machine utilization as well as higher labour utilization. However, the increase of permanent labour should be done carefully to safeguard against huge increment of labour costs without commensurate increase in output.

5.3 Recommendations

The level of warehouse optimization in Bollore Africa Logistics Ltd Nairobi is very high which can be attributed to the fact that they are bent on maximizing input against output. However high level of optimization (above 70%) results in disequilibrium due to overcrowding and narrowing of aisles. The scenario results in serious challenges of operation and can be a security and accident risks. The research therefore recommends to Bollore Africa, to review its operation strategies and balance its storage across the warehouses so that it does not over stock in some warehouses while under-stocking others.

The research also recommends the review of labour policies to ensure that there is adequate workforce working under permanent terms who will train the casuals on the use of machines and warehouse management systems. The adoption of a balanced and representative number of workforce in all areas will result in higher level of machine utilization, higher level of labour utilization and consequently higher level of warehouse optimization.

5.4 Limitations of the study

The results obtained and analyzed were as a result of a case study conducted on a short span of time which can be biased based on the level of activity during the data collection period. The research therefore recommends more research to be conducted on a time series approach to establish the behaviour and the level of optimization across a given period of time as opposed to at a point in time. The research further recommends that the findings of this research should be compared against those from other organizations so as to validate the findings as to whether they represent the situation in all third-party warehouses across the world.

The research also adopted a number of assumptions so as to calculate the level of optimization, level of machine utilization and level of labour utilization. It is therefore imperative that future research review these constraints and assess their practicality in influencing the outcome of the findings and whether by not relaxing them the level of optimization would change.

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APPENDICES

APPENDIX 1

QUESTIONNAIRE

This questionnaire is designed to collect data on the level of warehouse optimization, the challenges and benefits of further optimization in Bollore Africa Logistics Ltd Nairobi. Kindly respond to the questions honestly by ticking the most appropriate responses. The information you provide will be treated with high degree of confidentiality.

SECTION A: DEMOGRAPHIC INFORMATION.

1. For how long have you worked in Bollore Africa Logistics Ltd Nairobi?

   Less than 1 year [ ] 1-2 year [ ] 3-5 years [ ]

   More than 5 years [ ]

2. The Location of the Warehouse: Mugoya [ ] North Airport Road [ ]
3. Who owns the building? Bollore [ ] Rented [ ]
4. Type Of warehouse: Public [ ] contract [ ] both [ ]
5. Total number of staff in the warehouse: permanent [ ] casuals [ ]
6. Normal hours of operation: ....
7. Total square foot of the warehouse..
8. What is the layout of the warehouse?

   Traditional [ ] fishbone [ ] chevron [ ] none [ ]

9. Which storage system is being applied?

   Class based [ ] Random [ ] Dedicated [ ]

10. Kindly indicate the type of equipment used in the warehouse

Equipment	Yes	No	Equipment	Yes	No
Trolley			Conveyors		
Folk-lift			Carts		
Picking bins			cranes		
Pallets			robots		
Racks			Automatic storage retrieval system (AS/AR)		

SECTION B: WAREHOUSE OPTIMIZATION

Kindly fill the gaps appropriately

Dimension	Measurement	comments
Warehouse total area		
Total staging area		
Total storage space available		
Total storage space in use		
Storage area dedicated to handling		
Total number of items in the warehouse		
Average time it takes from receiving to storing goods		
Total number of orders processed annually		
Annual inventory holding costs		
Sum of all capital and non-capital costs		
Total costs of fulfilling orders		
Total value of items distributed annually		
Average value of inventory		
Average time products are stored in the warehouse		
Total number of inventory received in a year		
Total warehouse cost		
Quantity of stocked units		

SECTION C: CHALLENGES IN BOLLORE AFRICA LOGISTICS LTD NAIROBI.

To what extent do you agree with the following statements concerning the challenges that Bollore Africa Logistics Ltd Nairobi faces as it optimize its warehouses?

Use the scale of:

1. Strongly disagree
2. Disagree
3. Not sure
4. Agree
5. Strongly Agree

No		1	2	3	4	5
1	I find it difficult to locate goods in the warehouse					
2	I find it difficult to store or retrieve goods because the paths are blocked					
3	I find it difficult to store or retrieve goods because the racks are too high					
4	It is difficult to conduct a stock take because the goods are not palletized					
5	It takes time to retrieve an order because they are not arranged in a systematic manner					
6	The Loading and offloading space is too small					
7	The quantities in the warehouse system does not always match the physical count					
8	The process of loading and offloading goods is too long and time consuming					
9	There is no sufficient equipment for loading and offloading goods					
10	I am unable to use the equipment because i am not trained on how to use them					
11	The equipment faults easily					
12	The warehouse management system is hard to understand and use					

APPENDIX II

WAREHOUSE OPTIMIZATION RATIOS

i. Storage space utilization

This measure indicates the percentage of the total space actually being used out of the total storage space available. This indicator helps in assessing the space utilization and optimization of the warehouse.

Formula:

$$\frac{\textit{Total storage space in use } (M^3)}{\textit{Total storage space available } (M^3)} \times 100$$

ii. Labour Productivity

Labour productivity is a measure of the amount of output that could be attributed to one employee. The measure compares the output produced against the man hours spent in producing that output. This measure helps in assessing the operation optimization of the warehouse.

Formula:

$$\frac{\textit{Output (Amount handled annually in MT)}}{\textit{No of Man hours (Hrs)}} \times 100$$

(Man hours = Hrs worked * Number of employees)

iii. Machine Utilization Rate

Machine Utilization rate is measured using Overall equipment effectiveness (OEE) metric which examines the capacity utilization rate of the equipment in the warehouse in a holistic and multifaceted way. OEE measures total utilization and effectiveness of warehouse equipment in a calendar year. The measure breaks the performance into four separate but measurable components: loading, availability, productivity and quality.

OEE= Loading* Availability* Productivity* Quality

a) The loading metric represents the percentage of time that an operation is scheduled to operate compared to the total calendar time that is available. The Loading Metric is a pure measurement of schedule effectiveness and is designed to exclude the effects how well that operation may perform.

Formula: $$\frac{\textit{Scheduled time}}{\textit{Available time}}$$

b) Availability portion of the OEE Metric represents the percentage of scheduled time that the equipment is available to operate. The Availability Metric is a pure measurement of Uptime that is designed to exclude the effects of Quality, Performance, and Scheduled Downtime Events.

Formula: $$\frac{\textit{Uptime}}{\textit{Available time}}$$

c) The Performance portion of the OEE Metric represents the speed at which the warehouse equipment runs as a percentage of their designed speed. The Performance Metric therefore measures equipment operation speed excluding the effects of Quality and Availability.

Formula: $$\frac{\textit{Maximum Operating time}}{\textit{Available time}}$$

d) Quality performance of the warehouse equipment measures the overall equipment effectiveness. The measure assesses the percentage of unit safely handled compared to the total units handled assuming that the damage was not as a result of the operator.

Formula: $$\frac{\textit{Goods Stored- Defects}}{\textit{Goods stored}}$$