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# Role of Quantitative Methods of Decision Making On Port Performance at the Kenya Ports Authority

(RESEARCH PROJECT)

ORWA EUGENE MANASE

JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY

***Abstract:*** Quantitative modelling is a scientific approach applied to decision making. Includes use of logic and mathematics in such a way as to not to interfere with common sense. It can also be described as the use of mathematical and statistical techniques, mathematical programming, modelling, and computer science to solve complex operational and strategic issues.

The aim of this research was to determine the role of quantitative aspects of decision making on performance of container ports and terminals. Port operations involve multiple parties such as ship owners, crane operators, port management and government officers. By its nature each party has its own concerns and requirements that need to be addressed in a decision making process. Thence the decision makers must always consider multiple objectives at a time, which adds to the complexity of the problem. An essential concern to deliberate is the fact that objectives such as minimizing vessel service time and maximizing crane utilizations frequently conflict with each other and a decision maker is forced to attain a balance among those conflicting objectives.

Line items under study included but weren't limited to the problem of berth allocation with a priority service by presenting a model of priority, crane allocation problems; and the application of data envelopment analysis as a way of streamlining decision making units in container ports.

Both descriptive and exploratory research designs were used. The target population being the 12 gantry cranes and their operators, line supervision staff with tactical functions in decision making and senior management staff at the port bestowed upon the task of strategic decision making. Stratified random sampling and judgemental sampling techniques were utilized; data for statistical inference being both primary and secondary data. Data collection modes included observations, interviews and surveys of the existing operation records. The data acquired was then analyzed using SPSS and further presented in tabular and graphical formats to illustrate the relationships between different variables.

The findings of the study suggest need in the contemporary to integrate quantitative aspects of decision making processes in port operations if competitive advantage is to be achieved. Out of the 160 questionnaires sent out 122 were returned in a usable form indicative of a response rate of 76.25%. The operations department respondents that which this research considered as key stakeholders it was determined; were moderately satisfied with decision making with reverence to quantitative aspects inclusion. It was also determined that there is room for growth and as such this research was generally welcome as a positive impact on the operations of the port authority. It was further recommended that new aspects like transhipment, multivariate consideration of berth and crane allocations and position formulation approach for crane allocation be considered fundamentally to be well equipped for competition as a way forward.

Simulations showed some improvement especially the minimization of the total waiting time of the vessels, and the improvement of the availability of the berths, reduced costs of operations, improved customer service and improved TEU's all in a bid to improve the ports efficiency.

***Keywords:*** **Decision making, Model of priority, Ports efficiency.**

**ABBREVIATIONS:**

**AHP** Analytic Hierarchy Process

**BAP** berth allocation problem

**CAP** Crane Allocation Problem

**GoK** Government of Kenya

**KPA** Kenya Ports Authority

**MBS** State commendation meaning Moran of the Order of the Burning Spear

**MERCOSUR** Mercado Común del Sur comprising Argentina, Brazil, Paraguay, and Uruguay) trading bloc

**MS** Mess Management

**QCAP** quay crane allocation problem

**QCSP** Quay Crane Scheduling Problem

**TEU's** Twenty Feet Equivalent Unit

**DEFINITION OF TERMS:**

**Heuristics;** refers to experience based techniques for problem solving, learning, and discovery that give a solution which is not guaranteed to be optimal **(**Pearl, 1983)

**Meta-heuristic;** within the confines of computer science and mathematical optimization definitive's, it refers to higher-level procedure designed to find, generate, or select a lower-level procedure (partial search algorithm) that may provide a sufficiently good solution to an optimization problem, especially with incomplete or imperfect information or in circumstances where we have limited computational capacity (Blum, 2003)

**Modelling;** a representation of reality to be of use to someone in understanding, changing, managing and controlling that reality (Sokolowski *et al*, 2009)

**Quantitative techniques;** refers to the systematic empirical investigation of social phenomena via statistical, mathematical or numerical data or computational techniques (Jayathilake *et al*, 2011)

**Seat off the pants decision making;** rapid decision-making based on intuition, with no real attempt to think through the consequences (Jayathilake *et al*, 2011).

## 1. INTRODUCTION

### 1.1 Background of the study:

As important gateways to trade, seaports play a critical role in determining a country's competitiveness and economic health. In 1990, 185 U.S. commercial deep draft ports handled approximately 1.5 billion short tons of domestic and overseas commerce. The value of U.S. waterborne foreign commerce (imports and exports) for 1990 reached $438 billion. The value and magnitude of commerce that passes through a country's ports are determined by how well a port's resources; labour, port terminals, wharves, equipment, real estate, etc. are managed (Stromberg, 1992)

Both industrial engineering and operations research have their roots in logistics. Fredrick Taylor, who wrote ''*The Principles of Scientific Management*'' in 1911 and is considered the father of industrial engineering, focused his early research on how to improve manual loading processes. Operations Research began when scientists demonstrated the value of analytics in the study of military logistics problems in the 1940s as a result of the complex requirements of World War II. While Industrial Engineering and Operations Research have each tried to maintain separate identities, many of their biggest successes have occurred when used in an integrated framework to address supply chain and logistics issues. Increasingly this is referred to by industry as "Supply Chain Engineering."(Kalluri & Kodali, 2009)

Derewecki (2008) iterates that ''in today's environment speed through distribution centres is critical. He adds that we've moved out of the age of warehousing into the age of throughput centres.'' Whether they're called throughput centres, distribution centres, or warehouses, effective operations use best practices within the four walls of the facility and beyond.

With the global economy's rapid development and the enhancement of international foreign trade, the ports throughput in the world develops rapidly. Ports are the backbone of international trade, providing direct linkages from international to regional or local transport systems and trade chains (Briano *et al*, 2005)

### 1.1.2 The Kenyan Perspective:

Between 2004 and 2008 the port of Mombasa has seen an increase of about 3.5 million tons in total cargo throughput. From 12.9 million tons of cargo handled in 2004, the port handled over 16.4 million tons in 2008 a 27% growth in five years. This improvement is attributable to focused management, robust regional economic growth and modernization programs that have significantly improved performance to internationally acceptable standards. The Mombasa container terminal has a design capacity of 250,000 TEU's and handles 40% of the ports total traffic. This capacity is now saturated with container throughput exceeding 500,000 TEU's mark in 2007 reaching 615,733 TEU's in 2008. This has necessitated rehabilitation of a further 50,000 sq meters space at the former container freight station to create more room for the growing container traffic (Blouin & Njoroge, 2008).

Today in the era of globalization and competition, industrial companies focus more and more on their heart activity and outsource other tasks out of their areas of expertise. Hence flows of goods have increasingly exhibited growth and development towards international and intermodal transport networks. With the arrival of container handling and standardization transit time from one mode of transport to another has significantly decreased. However, passage through the port container terminal remains the weakest link in the intermodal transport chain, hence the need to optimize port management in order to accelerate and reduce the cost of moving the goods through the port. Optimization of operations within the port container terminal is very important, because the charging time has a great impact on the economic viability; hence the importance for the efficiency and effectiveness of the identification and location of containers inside the port area (Wua & Goh, 2010)

### 1.1.3 Background Information on KPA:

Gichiri Ndua the incumbent Managing Director at KPA states that, ‘‘despite the many achievements so far realized the KPA board and management remain visionary. To ensure that the port of Mombasa is responsive to current and future global and regional developments KPA plans to expand the existing container handling facilities as well as construct a second container terminal to cater for present and expected traffic growth; dredge the channel and widen the turning basin to accommodate larger vessels; enhance the role of private sector participation in the provision of port services and other institutional efficiency related programs’’ (Kenya Ports Authority [KPA] Handbook, 2012).

Recent Capacity expansion and the handling of increased traffic volumes have propelled the port of Mombasa to the ranks of top world container ports. Having handled 903,000 TEU's in 2012 coupled with the prediction to break 1 Million TEU's mark this year, the port of Mombasa has been ranked 117th out of the leading 120 container world ports and 5th in Africa. According to the current (July /August) issue of *Container Management* Magazine, front runners on the Africa front are Port Said of Egypt at 39th position, Port of Durban in South Africa at 51, Port of Tanger Med in Morocco at 73 and port of Alexandria in Egypt at 84.The magazine's detailed

Chronology of the World Top Container Ports 2013 has attributed the impressive port performance to various efficiency interventions instituted by the management. Major attribute is the dredging of the main entrance channel to minus 15m and the widening of the turning basin to 500 meters which has enabled larger vessels to call at the port (KPA Handbook, 2012).

Also attributed to the success of the port of Mombasa is the newly completed 240m long berth 19. Deeper and longer, the new berth has an additional stacking yard of 15 acres; increasing the port's capacity by 250,000 TEU's annually. The berth was commissioned by His Excellency Hon. Yoweri Museveni the president of the Republic of Uganda. Uganda is the biggest port user among the landlocked countries in the region. He was flanked by His Excellency Hon. Uhuru Kenyatta of the republic of Kenya and His Excellency Hon. Paul Kagame of the republic of Rwanda. These are heads of states for the member nations of the East African Community (KPA Handbook, 2013).

The ongoing construction of the 1.2 M capacity second container has also been cited as one of the attributes that influenced the ranking of the port. The first phase involves construction of initial three berths scheduled for completion in 2016.The new berths will have an additional capacity of 450,000 TEU's, with two further expansion phases running through to 2020. The Shipping Magazine *Container Management* also reported on the port's investment in new and modern cargo handling equipment which has greatly improved efficiency. The equipment includes ship to shore gantry cranes terminal tractors and reach stackers. With the developments and progressive developments it is envisaged that, the port of Mombasa will reach greater heights (KPA Handbook, 2013).

**1.2 Statement of the problem**:

Port operations involve multiple parties such as ship owners, crane operators, port management and government officers. By its nature each party has its own concerns and requirements that need to be addressed in a decision making process. Hence, the berth allocation and crane scheduling problem, requires the decision makers to consider multiple objectives at a time, which again, adds to the complexity of the problem. An essential concern to deliberate is the fact that objectives such as minimizing vessel service time and maximizing crane utilizations frequently conflict with each other. That is, the decision maker is forced to attain a balance among those conflicting objectives (Cordeau *et al*, 2005)

However, recent literature on berth and crane scheduling problem do not provide adequate support to resolve the issue of multiplicity of objectives. With that in mind, this study made an attempt to simultaneously determine the berthing and crane allocations under multiple objectives. In principle, with the existence of more than one objective, we would expect to have a set of optimal solutions instead of a single optimal solution. Therefore, an approach to determine these set of solutions was made, also referred as Pareto optimal solutions, in order to determine Pareto efficient frontier. Following this multi- solution approach, the aim was to offer the decision maker the flexibility of adjusting the balance within conflicting objectives (Bierwirth & Meisel, 2010).

The opening up of countries such as China and Eastern European nations has intensified the need for international trade. As a result, the requirement for sea transportation has been growing fast due to the cost-effectiveness of sea transportation. Mombasa Port, as one of the world's major ports specifically serving the East African Coast, handles a tremendous amount of cargo annually. Shipping companies in the East African region that offer short-distance feeder services seek to coordinate their ship routing and berthing operations, so as to reduce the operating costs and improve the efficiency (Wang, 1999).

However, the coordination between ship routing and berth operations increases the complexity of the operations substantially. Because those shipping companies often operate multiple cargo terminals in different locations, their terminals often serve as consolidation facilities where containers can be unloaded from one feeder vessel and reloaded onto another one. This transhipment operation option further increases the complexity of berthing decision making processes of KPA's Mombasa Port. With the unveiling of the berth 19 the logistical challenges at the Kenya Ports Authority are expected to get even worse since the assignment models for the existing cranes cannot cope with if not managed scientifically the new 750,000 TEU's that the berth is expected to introduce. With the current institutional goal to be the leading ports service centre in the East and Central African region and with the complaints abound so far from the cross border trading partners it is needful to say that there should be a workable strategy to manage the foreseeable crisis which is the bedrock of this research (KPA Handbook, 2013).

This research project sought to investigate why KPA's ship-to-shore gantry cranes only handle up to 15 containers abreast, each with a capacity to make 25 moves per hour. The strategic decisions that have been made to date are more on dredging to increase berth space that which this research work seeks to question as the most optimal decision premised on the fact that this might only cure the symptoms and not the disease itself. Port efficiency according to empirical studies depend on numerous quanta and universal suffrage of applying only a single solution to the infinite challenges of ports it has been observed limits greatest potential (Wua & Goh, 2010).

Systematic examination of the observed information was done to find answers to research questions and to offer insight as to what measures could be put in place to optimize the port's efficiency.

**1.3 Research Objectives:**

**General Objective:**

The aim of this research is to evaluate the role of quantitative methods of decision making on port performance at Kenya Ports Authority.

**Specific Objectives:**

1) To determine the role of Quay Crane Scheduling on port performance

2) To investigate the influence of Berth Allocation on port performance

3) To determine the effects of Data Envelopment Analysis on port performance

**1.4 Research Questions:**

This proposal seeks to answer the following questions

1) What is the role of Quay Crane Scheduling on port performance?

2) How does Berth Allocation influence port performance?

3) What is the effect of Data Envelopment Analysis on port performance?

**1.5 Justifications of the study:**

The nature of operations at the port of Mombasa is not only the lifeline of more than 40 million Kenyan citizens but also the economic lifeline of the neighbouring landlocked countries like Uganda, Rwanda and Sudan who all depend on the cargoes that are received there from. The logistical operations costs are on the rise as machines undergo wear and tear and purchases of new ones translate into billions of shillings an expense the Board and Management of KPA would not want to incur in the near future (Njoroge, 2008).

Transportation via sea continues to rise as a result of the increasing demand due to its advantages over other transportation modes in terms of cost and security. Actually, as of 2006, seaborne trade accounted for 89.6% of global trade in terms of volume and 70.1% in terms of value. Subject to this trend, demand towards sea transportation and expectations for high efficacy deliverables for port management has become major issues for the port owners and shipping companies (Rodrigue et al, 2009).

This research work is expected to benefit Kenya Ports Authority in terms of alternate ideologies to logistical operations improvement driven towards improving port efficiency. Practioners in the field of maritime logistics are also expected to benefit from this work. The general population served in one way or the other by Kenya Ports Authority is equally a beneficiary. I will depict the contributions of this paper as twofold. First, I will extend the existing literature by embracing more practical assumptions to better represent the real world implementation. Second, I will formulate a bi-objective integer problem and propose an epsilon-constraint method based solution algorithm to acquire the non-dominated berth-crane assignments and schedules as Pareto optimal front.

**1.6 Scope of the study:**

This research work is geographically scoped to cover ship-to-shore gantry cranes port operations in general with a keen focus in the Mombasa port manned by the Kenya Ports Authority. I propose to use a rough set theory method for data pre-processing, which can avoid drawbacks of not being objective enough in the evaluation of results due to the subjective factors influenced in Analytic Hierarchy Process (AHP).

Therefore, it will filter out the high value logistics indicators. The weights of rough set shall be based on measurement, experimental data and mining the data itself. So it will be more objective than the subjective weighting method and shall improve the authenticity of the evaluation results.

It can be a good screening and quantification of treatment with performance indicators of port logistics by constructing a rough set model. Finally, the key indicators of port logistics enterprises shall be focused on monitoring by ABC management method, thereby reducing the operating cost of logistics, improving the efficiency of the logistics operation and further increasing profits of the port enterprises

**1.7 Limitations of the study:**

During the research, information gathering was conducted by interviews on KPA staff members who operate the cranes. They have a busy schedule and at times making good on their appointments was expected to face some challenges. I had to reschedule as much as possible and apply alternative media like telephone interviews to get their responses.

Unwillingness to reveal information by respondents was also anticipated. However, this was mitigated by sensitizing the respondents via presentation of an introductory letter with an explanation on the purpose of the research and declaration of confidentiality of information to be collected being solely used for academic purposes before administering the interviews.

Cases of respondents lacking interest in being interviewed was another expected challenge. A pilot study was conducted in terms of a brief interview to reduce chances of lack of cooperation. Research instruments were also structured in a user-friendly and simplified manner.

In addition, financial hindrances occasioned by extensive travels to the field site in the process of conducting my research were experienced. The number of times of visit to the project site had to be reduced to accommodate the budget I had.

## 2. LITERATURE REVIEW

### 2.1 Introduction:

The entails of this chapter include: three theoretical models that put into perspective the research problem, a conceptual framework illustrating the relationship between the dependent and independent variables under study and some empirical studies on this research topic. It shall then detail a summary of literature and the research gaps in this research work for purposes of advancement in the future.

### 2.2 Theoretical Review:

Many research models have been developed to tackle various kinds of ship routing and scheduling problems. However, most of these models have focused only on the optimization of travel distance and/or minimization of fleet size, without taking into consideration the capacity, availability, and transhipment capability of terminals. This group of studies originated from the pioneering work of Dantzig and Fulkerson (1954), who considered the problem of minimizing the required number of tankers to perform a given set of delivery schedules. In the last decade, more research has been devoted to studying the planning of fleet sizes and the scheduling of ships (Cho & Perakis, 1996).

Theoretical models advanced that provide insightful information on how to undertake acquisition of solutions to this research problem are many. However, the most significant of them are three namely: Berth allocation problem model [BAP], Quay Crane Scheduling Problem model [QCSP] and Data Envelopment Analysis models [DEA]. This shall each be explained in details.

#### 2.2.1 Berth Allocation:

Berth allocation problem also known as berth scheduling problem is an NP-Complete problem in operations research regarding the allocation of berth space for vessels in container terminals. Vessels arrive over time and the terminal operator needs to assign them to berths to be served (loading and unloading of containers) as soon as possible. Different factors affect berth and time assignment of each vessel (Bierwirth & Meisel, 2010).

Among the models found in literature there are four most frequently observed scenarios namely: Discrete Vs Continuous berthing space, Static Vs Dynamic vessels arrival, Static Vs Dynamic vessel handling times and Variable vessels arrival scenario. In the discrete problem the quay is viewed as a finite set of berths. In the continuous problem vessels can berth anywhere along the quay. In the static arrival problem all vessels are already at the port whereas in the dynamic problem only a portion of the vessels to be scheduled are present. It is the major focus area for many researches. In the static time handling problem, vessel handling times are considered as input whereas in the dynamic handling they are decision variables. Finally in the last case the vessel arrival times are considered optimized (Bierwirth & Meisel, 2010)

Berth and crane allocation problems aim to display the berthing position and service sequence of all the vessels; hence it denotes an assignment and scheduling problem structure. In most of the studies in literature, crane allocation is planned after berthing the ship, which results in suboptimal solutions. My focus in this review process will put an emphasis on studies that simultaneously tackle both problems. Review work provided by Bierwirth and Meisel (2010) presents state-of-art research on the topic that jointly tackles berth allocation and crane scheduling.

The berth allocation and scheduling problem is one of the critical issues for port management and has been widely discussed in literature through several research and has mainly been approached from two slightly different names: Berth allocation problem (BAP) and Berth scheduling problem (BSP), but the principal goal is the same, as in the goal in the two problems is to exploit in an efficient manner the berth length available for berthing the maximum possible ships for a given time interval (Meisel, 2009).

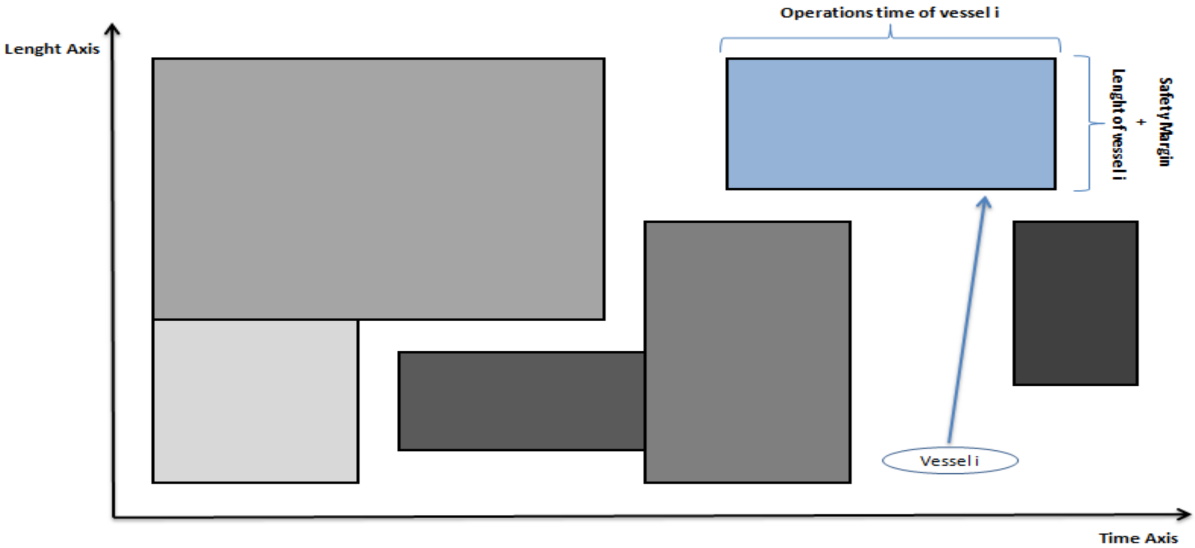


**Figure 2.1: Representation of the Berth Allocation Process (Bierwirth Et Al. 2009)**

The process of berth allocation is to allocate a berth to a ship in order to ensure her berthing operation while respecting a number of technical standards, including draft (depth), berthing priority, operation time involved, and specific needs of the vessel (bunker). There are two scenarios: berth discrete distribution ( berth positions are known in advance) or berth continuous distribution (the distribution of the quay is as required in need of the terminal and this scenario is the most used), this process is extremely important, especially at multi-users ports, because the position assigned to a ship can significantly impact the productivity of the terminal and the productivity of the ship as well, as poor planning can cause an unnecessary delay for some ship and thus cause dissatisfaction of the ship-owners (Meisel and Bierwirth, 2009).

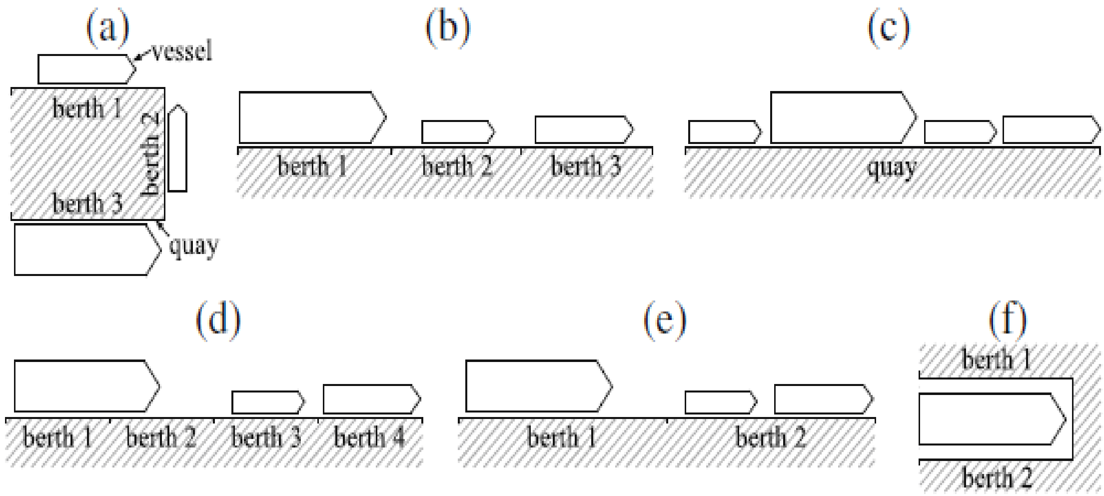


**Figure 2.2: Presentation of Possible Berth Configurations (Bierwirth Et Al. 2009)**

Fig 2.2 can be deduced as follows: (a) represents berths that are known in advance; (b) berths that are defined depending on the position occupied by vessels; (c) berths that are defined by the number of cranes for ships; (d) berths that are defined according to the schedule of operations and cranes assigned to ships; (e) is a model combination of b, c and d (Bierwirth *et al*, 2009*)*

Berth scheduling aims to provide a fast and reliable service to vessels wishing to do commercial operation. The problem is generally treated by different objective functions according to the approach adopted, for example minimizing the waiting time or minimizing the time handling vessels. The port container terminal handles a huge number of operations which essentially is work planning and scheduling characterized by a decision level ranging from strategic to the operational level via the tactical level (Bierwirth & Meisel, 2010). *Figure 2.3: Planning Levels in a Port Container Terminal (Günther et al. 2006)*

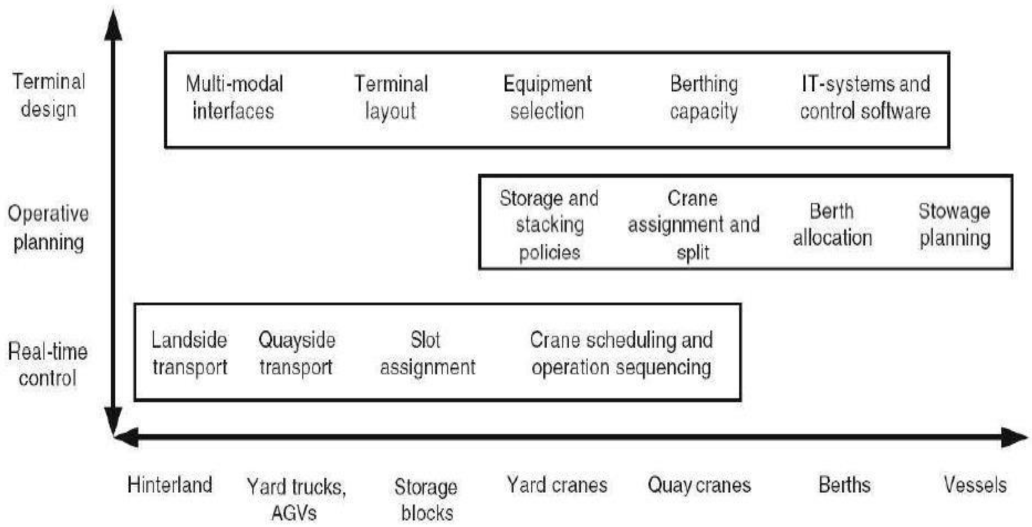


**Figure 2.3 shows and gives a decision level for each activity of the port environment, e.g. determining berthing capacity decided before the terminal layout, which stems from a strategic decision; the choice of an information system for the management of the terminal is a strategic choice, but it can also be done after the construction of the terminal.**

### 2.2.2 Data Envelopment Analysis models:

These are of two basic types DEA-CCR and DEA-BCC additive models. Tongzon (2001) in the article *decomposing Growth in Portuguese Seaports: A Frontier Cost Approach* chose the DEA-CCR and DEA-additive models to study the efficiency of four Australian and 12 other international container ports, and tested if the differences in output affected the performance and efficiency of the ports. Other studies used both the CCR and BCC models to analyze the efficiency of two Greek and four Portuguese ports (Barros & Athanassiou, 2004) and to evaluate the world's top 30 container ports to determine if container port privatization benefits efficiency.

In the context of *emerging economies*, Chudasama and Pandya (2008) investigated 12 major ports in India adopting the DEA-CCR and DEA-BBC models, identifying sources of inefficiency to port authorities. Rios and Ma (2006) established a model to measure the relative efficiency of the MERCOSUR using the DEA-BCC model. They concluded that DEA is useful for both governmental regulatory bodies and port managers in analyzing operational efficiency. Kumar and Kumar (2009) proposed to use fuzzy AHP method to achieve a fixed base evaluation of third-party logistics enterprises and compare the third-party logistics enterprises in western area of India with four other logistics enterprises by the critical success factors and obtained the rankings of their level of performance. Junco (2009) reached the following conclusions by in-depth study of the fuzzy evaluation method and principal component analysis and applied the research results to the evaluation of logistics performance. The conclusions were: fuzzy evaluation method could solve the vagueness and uncertainty of judgment effectively and could make the factors which were hard to be quantitative and whose boundaries were unclear to be quantitative.

Bowersox (2008) concluded through research that the performance of enterprise logistics could generally be measured within external and internal confines. The external performance was usually evaluated by best practice benchmarks and customers' satisfaction, and internal performance was primarily from the five indexes of productivity indexes namely: asset measure, customer service, cost and quality to measure. Meichilai (2011) proposed to use the DEA method to evaluate the port logistics performance from the level of financial, logistics operation, and customer service. It drew out that it should analyze specifically based on the characteristics of enterprises themselves during logistics performance evaluation and pointed out which indicators were important for the impact of logistics performance.

### 2.2.3 QCSP Quay Crane Scheduling:

The QCSP can be formally defined as a scheduling problem on parallel uniform machines with precedence constraints, denoted in the classic three fields notation as Pm|prec|Cmax. The QCSP also possesses non-standard characteristics: ready times on machines and explicit non- simultaneity constraints. It is well known that Pm|prec|Cmax is strongly NP-hard unless the precedence constraints graph is an out tree or an in-tree; other polynomially solvable cases of the above problem arise when the number of machines is one or greater than the number of jobs. Thus the QCSP is at least as

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difficult as Pm|prec|Cmax since it reduces to this problem when rk = 0, √k=є K, and ψ = ϕ. The QCSP can also be viewed as a vehicle routing and scheduling problem consisting of two sub problems. There exist two scenarios representative of this namely: a routing problem, which determines the sequence of tasks on each machine; and a scheduling problem, which determines, for each sequence, the starting handling time (or equivalently the completion time) of the tasks belonging to that route (Pinedo, 1995)

Quay Crane allocation and scheduling problem is widely discussed in literature across multiple researches. This problem has been addressed in two different sub-problems Quay Crane Allocation Problem (QCAP) and Quay Crane Scheduling Problem (QSCP). QCAP is that which is allocated a number of quay cranes to incoming ships, so the goal is to determine the number of quay crane to allocate for each vessel. Otherwise QCSP is set to determine the work schedule for each quay crane by elaborating and editing a schedule work (Bierwirth & Meisel, 2009).

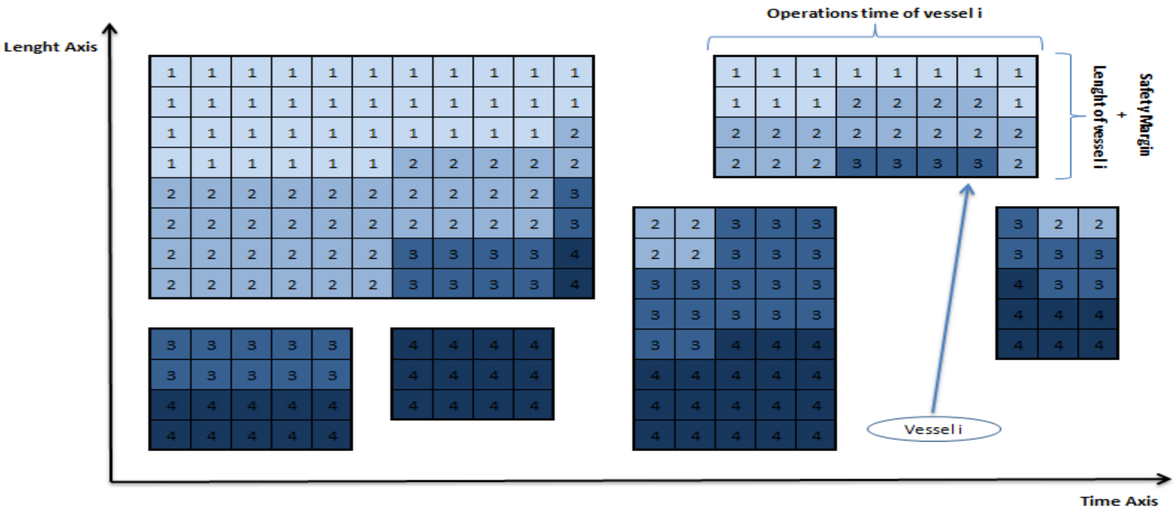



**Figure 2.4: Representation of the process of Cranes Scheduling (Bierwirth et al, 2009).**

Figure 2.4 above represents a summary of the container port terminal activity; which consists primarily of vessels berthing from any destination to another and requires a number of services namely: the unloading and loading containers. This operations of loading and unloading are carried out by specialized handling equipment we call Quay Crane, which moves on rail throughout the quay and is characterized by a definite productivity depending on several parameters such as: the crane driver, the availability of containers handled, availability of containers transport vehicle to and from storage areas on the one hand and on the other hand inside the port area we find also yard crane, internal tractor, the storage areas, etc (Bierwirth *et al*, 2009).

The objective addressed by literature in most cases is maximizing use time of quay crane in order to obtain the maximum profitability and productivity of handling facilities because they are the most expensive handling equipment at the port container terminal; and are usually the neck position at the import and export process in the port area (Song *et al*., 2011).

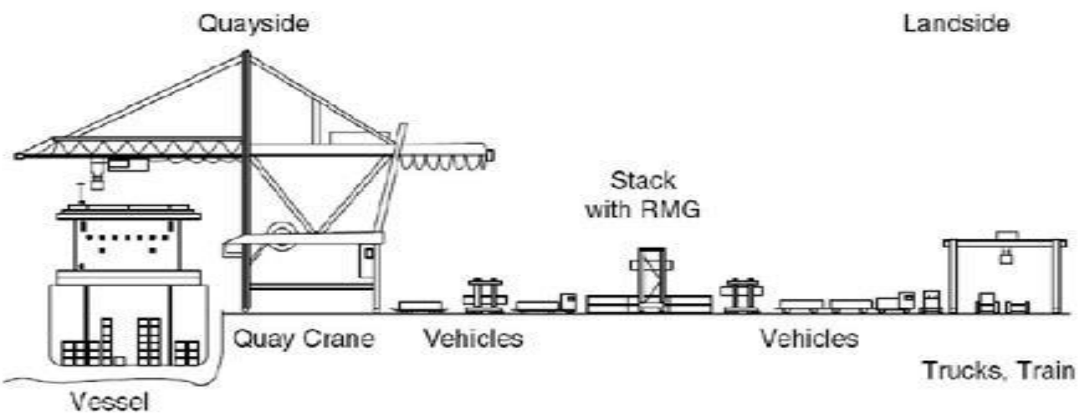



**Figure 2.5: Schematic representation of the Port Container Terminal (Steenken et al. 2004).**

The problem of scheduling quay cranes has been studied before in many different settings. Daganzo (2006) considers both the static problem of assigning cranes to a set of vessels present at port at the time of decision making to minimize total weighted vessel completion time, as well as a dynamic extension in which vessels arrive over time.

**2.3 Conceptual Review:**

A conceptual framework is a logically developed, described and elaborated network of interrelationships among variables integral in the dynamics of a situation being investigated. It explains the theory underlying these relationships and describes the nature and direction of these relationships. A variable is a measurable characteristic that assumes different values among the subject. It is therefore a logical way of expressing a particular attribute in a subject (Mugenda & Mugenda, 2003).

A dependent variable is the variable of primary interest to the study and is affected by independent variable. Decision making in a qualitative manner doesn't adduce as much benefits as when made quantitatively via models like AHP for example. Imagine a port system that has quantitatively integrated decision making mechanisms in place, it can't be false to deduce from that that the port would be very efficient. Logistic costs are a measure of port efficiency. When the logistical costs of port operations are high, it is said that the port isn't efficient whereas when they are low it is said to be very efficient. Port throughput measurements in specific quanta like TEU's per year determine scales of efficiencies of any port. Higher TEU's can be achieved quantitatively and when they are high a port is considered efficient; whilst low a port is considered less efficient. An independent variable is the one that influences the dependent variable in either a positive or negative way (Mugenda & Mugenda, 2003).

The relationship of all variables in this study is as shown below;

**Independent Variable Dependent Variable**

Quay Crane Scheduling

Data Envelopment Analysis

Berth Allocation

Port Performance

 Bottlenecks in operations

 Logistic Costs

 Port Throughputs

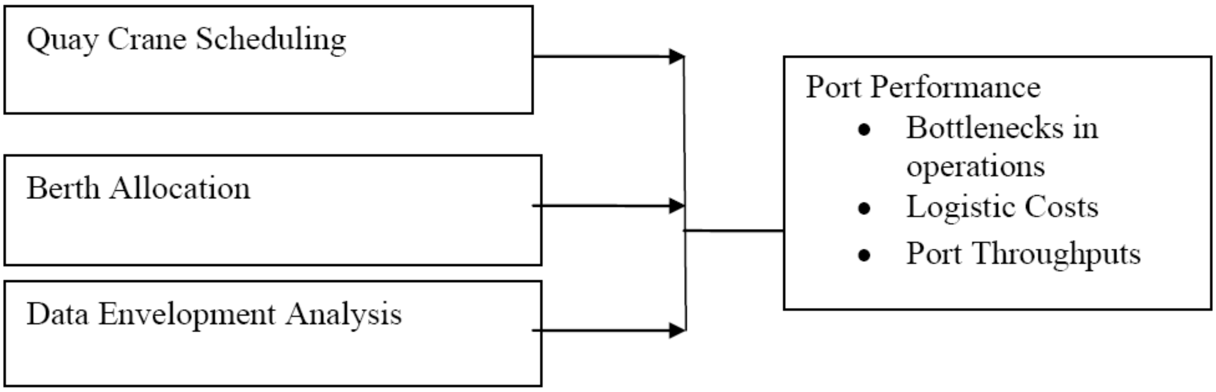



**Fig 2.6 Conceptual Framework**

**2.3.1 Analytical Hierarchy Process (AHP):**

The most creative task in making a decision is to choose factors that are important for that decision. AHP technique facilitates arrangement of a these selected factors in a hierarchical structure descending from an overall goal to criteria, sub-criteria and alternatives in successive levels (Saaty, 1990). As stated by Cheng *et al.* (1999), AHP enables the decision maker structure a complex problem in a simple hierarchy which is then used to evaluate a large number of quantitative and qualitative factors in a systematic manner under multiple criteria environment in confliction.

There are four main steps involved in (Cheng *et al,* 1999): breakdown the complex problem into a number of small constituent elements and then structure the elements in a hierarchical form; make a series of per wise comparisons among the elements according to a ratio scale; use the eigenvalue method to estimate the relative weights of elements; aggregate these relative weights and synthesize them for a formal measurement of a given decision alternative. Now using these steps, a decision maker specifies judgment by inserting an entry aij (aij > 0) stating how much more attribute *i*-is in the attribute *j* (Anderson *et al.* 2003). An expert judgment is then used giving cardinal values rather than ordinal numerals. That which was adopted for the impetus of this research had the following notations:

A = (aij) = a11 a12 .......... a1n

a21 a22 …….. a2n

an1 an2 …….. ann

Where aij = relative importance of attribute ai and aj. In this respect matrix pair wise comparison (MPC) would be a square matrix **‘‘A**’’ embracing **‘‘n’’** number of attributes whose relative weights are ‘‘w1 ……………….wn’’ respectively. This can be expresses in an equation format as:

aij = wi/wj where w = {w1 , w2 , ……………wn}T

i,j = 1,2 …………n and T being a transpose matrix

**2.3.2 Proposed Mixed Integer Program and tabu search Models:**

In practice, berth scheduling and quay crane scheduling problems are generally considered sequentially by terminal operators. They first determine a berth schedule using estimates of the duration of berthing for each vessel. Then, they try to split quay cranes efficiently between the vessels that are planned to moor simultaneously at the same berth. Such sequential planning can be achieved using the models developed in this thesis:

The number of cranes that a terminal operator can assign to a vessel depends on the number of cranes used by other vessels simultaneously moored at the berth. Assigning a crane to a vessel is equivalent to reducing the number of cranes that can be assigned to other vessels. Naturally, the total number of cranes that a terminal operator can utilize at each time period cannot exceed the total number of cranes on hand. This limitation can cause an inferior crane allocation for some vessels compared to what is projected in the berth scheduling phase, and thus vessels may be forced to stay longer than expected at berth. Such delays then may affect vessels to be moored later. A terminal operator may be able to determine a better and more accurate operational plan if actual crane requirements are considered while determining berth schedules, which is the motivation behind simultaneous berth and quay crane scheduling.

The problem of simultaneously scheduling berth and quay cranes was first introduced in Park & Kim (2003). The authors formulate an integer programming model which determines the berthing position on a continuous berth and the berthing time of each vessel, as well as the number of cranes assigned to each vessel at each time period. However, the paper assumes that vessel processing times decrease linearly with the number of quay cranes assigned to a vessel. The authors agree that this assumption is not realistic, and does not agree with the models used by other studies on crane scheduling (including the simple one used in Daganzo, 1989). This is because of the fact that the work required on a vessel is generally not evenly distributed on the vessel.

Researchers in Chen *et al.* (2008) also draw attention to the relationship between berth allocation and quay crane scheduling. The problem they define considers a discrete berth structure where each berth can serve one vessel at a time and a number of quay cranes which can be moved from one berth to another when required. Vessel handling time is dependent on the berth where it is assigned; however, the number of cranes required by each vessel is known, and hence the impact of crane assignment on handling time is not considered. In a simplification, the paper assumes that vessel handling does not begin until the predetermined numbers of cranes are available at the corresponding berth. The objective of the problem considered is to minimize the total time spent by vessels at the port. They present a mixed integer program, and introduce a solution method based on a genetic algorithm.

The problem variant adopted for my thesis is defined for a long continuous berth which can handle multiple vessels simultaneously. On this berth, a number of identical quay crane operate on a single set of rails for container loading and unloading. Also considered was a case where vessel processing time depends on the number of quay cranes assigned to the vessel, where a ship is considered processed once cranes have completed the work. In this model, each vessel is divided along its length into holds of 3 or 4 container rows where at most one quay crane can work on a hold in a time period. I also assume that once started, work needs to continue on a hold until completion. Note that these assumptions do not prevent assigning more than one crane to a vessel, and cranes can be shifted from hold to hold both within ships and between ships, as long as cranes are not allowed to pass one another. Consequently, the model developed determines the berthing position and berthing time of each vessel while simultaneously determining when to assign a quay crane to each hold of each vessel for container loading and unloading. The primary contributions of this study include: the introduction of a BQCSP variant which considers a continuous berth structure and detailed crane assignments to vessel holds; the introduction of a lower bound that can be found in polynomial time for any instance of the BQCSP, where the bound is provably tighter than the linear programming relaxation bound for a standard integer programming model for the problem; and the development of an effective tabu search algorithm which utilizes a nested neighborhood search procedure.

The research concentrates on the dynamic version of the problem where we have a set *V* of vessels with known arrival times, where *n* = | V |. For each vessel *k* Є V, I define:

*h k*: number of holds of vessel *k* ,

*pi k*: processing time of hold *i-of* vessel *k*,

*pmax k*: maximum hold processing time for vessel *k* [*pmax k* = maxi {*pi k*}],

*a k*: arrival time of vessel *k*,

*d k*: due time of vessel *k* (where *d k* ≥ *a k* + *p* k*),

*f k*: lateness penalty of vessel *k*,

*b k*: planned berthing position of vessel *k*,

*t k*: berthing time of vessel *k*,

*c k*: the earliest time that vessel *k* can depart.

The objective function which represents the sum of the dwell times and the total penalty accrued by tardy vessels is to minimize:

**Σ k Є V ( c k − a k ) + Σ k Є V *f* k (c k − d k ) + ………………………….. (i)**

Subject to:

**xℓk + xkℓ + yℓk + ykℓ ≥ 1 …………………………………………………. (ii)**

**xℓk + xkℓ ≤ 1 ……………………………………………………….. (iii)**

**yℓk + ykℓ ≤ 1 ……………………………………………………….. (iv)**

**t ℓ ≥ c k + (xkℓ − 1) M ……………………………………………….. (v)**

**b ℓ ≥ bk + hk + (ykℓ − 1) M ………………………………………….. (vi)**

**t k ≥ ak ……………………………………………………………….. (vii)**

**t k ≤ t z tk i + (1 − z tk i ) T …………………………………………….. (viii)**

**c k ≥ t z tk i + *pi k* …………………………………………………….. (ix)**

**c k ≥ t k + *pmax k* …………………………………………………….. (x)**

**Σ T t=1 z tk i = 1 ………………………………………………………. (xi)**

***b k* ≤ B − hk + 1 ……………………………………………………. (xii)**

***b k* ≥ 1 ………………………………………………………………. (xiii)**

**x ℓ k Є { 0, 1}, yℓk Є { 0, 1} ………………………………………… (xiv)**

**z tk i Є { 0, 1} ……………………………………………………… (xv)**

**Algorithm:**

Begin

| Arrival of the ship

| Priority measurement (algorithm for priority measurement)

| Display the new classification

| *If* (Berth empty) *then* Replacement vessel used by the first of the list *else* Awaiting release to another location

| Allocation of the berth

| Gain calculation (calculation algorithm)

| *If [* (a vessel leave) *Or* (a vessel arrive)] *then* Update of priority list *else* ( )

| Display of the new priority list End

**2.4 Empirical Review:**

There are other numerous studies on BAP: The work of Zhen *et al*. (2011). , *A priority decision model for berth allocation and scheduling in a port container terminal*, addressed the issue of BAP. His article discussed the berth allocation problem in an uncertain environment where he noted previous authors didn't take into consideration cranes allocation problem, for which he suggested a Meta heuristic. The goal was to answer the question where and when a ship has to berth while minimizing latency and reducing the overall distance travelled by the vehicles at the loading and unloading operations of a ship. Hence he proposed a model on Meta heuristic and numerical results validation.

However, Dongsheng *et al*. (2002), in their journal, *Berth allocation with time-dependent physical limitations on vessels*, studied the same problem of berth allocation BAP taking into account the constraints of draft and tidal, the authors neglected the problem of cranes allocation. The goal of their work was to test if it was necessary to consider the tidal conditions when making berth decision assignment. Their paper proposed a heuristic approach to the treatment of static and dynamic case. The model they developed showed that the port terminal operators could make better decisions, taking into account the depth variation in berth allocation. However, their model assumes that a berth supports only one ship when in fact, a berth can accommodate two small ships; they also divided the time horizon of only two periods: high tidal period and low tidal period when in fact it is cyclical.

In addition, and always with the BAP; Barros *et al*. (2010) proposed a model that gives berthing priority to the ship with the most critical level of stock in order to regulate the flow in the terminal, and also decides what sequence of vessels in planning at given time horizon. This problem is modelled as a heuristic algorithm to solve it. In the 1940s and 1950s, the focus of logistics research was on how to use mechanization (e.g., pallets and pallet lifts) to improve the very labour intensive processes of material handling and how to take better advantage of space using racking and better warehouse design and layout. The "unit load" concept gained popularity and the use of pallets became widespread. In the mid 1950s, this concept was extended to transportation with the development of intermodal containers together with ships, trains, and trucks to handle these containers. This was a prerequisite for the supply chain globalization that was to come much later. Although the terms "warehousing" and "materials handling" were used to describe many of these efforts, this work could be viewed as fundamental applications of industrial engineering rather than as a discipline of its own (Xiaohong *et al*, 2010). By the 1960s, a clear trend had developed in shifting more time-dependent freight transportation to truck rather than rail. This led to the need for joint consideration of warehousing, material handling, and freight transportation, which emerged under the label of "Physical Distribution." The National Council of Physical Distribution Management was formed in 1963 to focus industry attention on this area and quickly became the predominant organization in the field. Academic research and education followed this trend to satisfy the growing industry recognition of the needs in this area. This area gained much wider recognition in both industry and academia due in large part to the fundamental paradigm change that occurred during the 1960s and 1970s with regard to computers (Xiaohong *et al*, 2010)

Lee *et al* (2006) studied gantry cranes scheduling with non-interference constraints. The study is motivated by the problems studied in Kim & Park (2003). The objective is the minimization of the make span for a single container vessel, and the paper develops a genetic algorithm approach that obtains near optimal solutions for the proposed MIP model. Quay crane scheduling for a given berth schedule is first mentioned in Liu *et al* (2006). The objective of the problem considered in that reference is to minimize the maximum relative tardiness of vessel departures. The authors propose a heuristic decomposition into a vessel level model and a berth level model. The vessel level model provides the optimal processing time for any given number of quay cranes assigned to each individual vessel. The berth level model considers the entire set of vessels. Quay cranes are assigned among the vessels using the results from the given berth allocation and from the vessel level model. Since a gantry crane assigned to a vessel cannot be redeployed to another vessel until all cranes assigned to the first vessel have completed their work, this model reduces to a simplified problem that which I call dedicated crane allocation in this thesis. In practice, better solutions can be found that do not impose this restriction.

From the empirical results, one can conclude that when quay cranes setup costs are ignored, the total service time of vessels decreases. A decision maker might choose to prefer a solution closer to the left hand side of the Pareto efficient frontier. On the other hand, in case of extreme setup costs of quay cranes, the decision maker is directed towards the solutions in the right hand side. The Pareto efficient frontier in this case may be used as an efficient decision support tool for decision makers.

**2.5 Critique of Literature:**

Recently, Pang *et al.* (2009) considered a ship routing problem with time clash avoidance constraints at the pickup and drop-off points. However, their model implicitly assumes that a cargo terminal is either the origin or the final destination of a container. In accordance with empirical reviews, no study has been conducted on integrating ship scheduling and berthing time assignment decisions which also considers the transhipment option. There is also no considerable amount of research on the allocation of berths at container terminals to minimize the waiting time of ships or to maximize the utilization of berths. In the above studies, the authors assume that the berths are discrete resources along a quayside and that each ship occupies a discrete number of berth locations. However, in some studies, the quayside of the berth is treated as a continuous resource, (Lim, 1998)

Technical restrictions such as berthing draft and inter vessel and end berth clearance distance are further assumptions that have been adopted in some studies dealing with berthing allocation problems bringing the problem formulation closer to real world conditions (Bierwirth & Meisel, 2010). Introducing technical restrictions to existing berth allocation models is rather straight forward and it may increase the complexity of the problem but simplify the use of Meta heuristic (decrease in the feasible space). Some of the most notable objectives addressed in literature are: Minimizing of vessel total service times (waiting & handling times), Minimization of early and delayed departures, Optimization of vessel arrival times and Optimization of emissions and fuel consumption. This traditional approach may lead to serious congestion of the vessels at some terminals, as many vessels may be assigned to berth at the same terminal to perform the loading/unloading of the container batches at the same time period, some of these vessels are then needed to wait at the sea until the berth is available to service them. In such case, the operating cost will be higher when compared with the integrated model that I shall be proposing, because the operating time of the vessels becomes longer as they have to wait at the sea until the berth is available (Wang & Lim A, 2007). Besides, a transhipment operation is currently not possible as the routing and berthing time of the vessels are determined individually. Such that the arrival time of the vessels at a terminal is not coordinated. In fact, the pickup and drop-off operations of a container batch are assigned to two vessels only. When the routing of the vessels are determined separately the container batch will only be loaded to a vessel which will then transport the batch to its drop-off location and unload the batch. There is therefore no consideration on the consolidation option, which leads to longer total travel distances of the vessels. It is because two vessels are responsible for both the pickup of a container batch from its origin and drop-off to its destination that the vessel has to travel to more terminals to perform the loading/unloading of the container batches. In contrast, if transhipment option is possible, the vessel may pick up some containers batch at their origins, and transport and unloads some of them at a consolidation facility before transporting the remaining batches to their destinations. In such case, the distance travelled by the vessel is shorter in general (Wang & Lim A, 2007).

The berth structure is discrete, and the whole quay area is partitioned into 4 berths. There are seven quay cranes, with a handling rate equalled to 40 TEUs / hour. Due to the lack of available accurate data, the cranes are taken as identical in terms of their handling rates. That, in fact, is a generalization of my model structure, as I allow for variable quay crane handling rate specification. With more realistic crane specifications my model can be used much more efficiently. Maximum allowable number of cranes assigned to a vessel is 4. In order to show the impact of portable and static cranes, crane id 6 and 7 are assumed to be portable, i.e. move among the berths while 5 of the 7 cranes are assumed to be static.

**2.6 Summary of Literature:**

This thesis provides a comprehensive study on planning problems related to berth and quay cranes which are the most important resources in container terminals at seaports. It contributes to filling many of the gaps in the literature that appear due to recent trends and changes in maritime logistics, like the introduction of mega-ships and increasing popularity of flexible continuous berth structures. In this chapter, a variant of berth allocation problem (BAP) which considers dynamic arrival of vessels and a single berth having a long continuous structure that can serve multiple vessels simultaneously is considered. Two different mixed integer programming (MIP) formulations are provided, and a meta-heuristic algorithm based on tabu search which employs a novel nested neighbourhood structure to solve large problems is developed (Wang & Lim A, 2007).

A polynomially computable lower bound is also introduced which can be computed quickly in polynomial time, and is provably tighter than the bound generated by solving the LP relaxation of the associated MIP. Computational experiments show that the algorithm is able to provide high quality solutions in relatively short computation times. Instances with 10 to 14 vessels were solved optimally by the nested tabu search algorithm under 4 seconds, whereas, for some of these instances, it took days to solve with the MIP. More realistic instances with 20 to 30 vessels were also solved within 100 seconds. For those instances, I will be able to reduce the optimality gap to a reasonable initial solution by 70% on average (Pang *et al*, 2009).

Earlier studies concerning gantry crane scheduling focus on detailed models applicable to either one vessel or a set of vessels docked at the time of decision making. In this thesis, a QCSP variant defined for a given berth schedule is analyzed. Hence, in the problem variant studied, not only are the vessels that are present at the berth at the time of decision making considered but also vessels planned to arrive later. Concepts of crane blocking and crane shifting are defined, and two crane scheduling methods; dedicated crane scheduling and roaming crane scheduling are introduced. Exact optimization models are developed for each crane scheduling method under both blocking and shifting assumptions. These models are used to analyze the methods computationally using a set of small instances. It is shown that roaming crane scheduling with crane shifting can provide significantly better operational plans by increasing crane utilization. A tabu search algorithm to solve realistic instances under this scenario is designed. The individual crane assignment problem (CAP) is also introduced and a polynomial time solution method is provided. Computational experiments indicate that the tabu search algorithm designed is able to find optimal solutions almost instantaneously for small problems with 10 to 14 vessels and 6 cranes (Xiaohong *et al*, 2010).

For larger problem instances with 20 to 30 vessels and 10 cranes, the optimality gap was improved by approximately 68% within 5 to 15 seconds respectively. Designing fast search algorithms for the case with no crane shifting or crane roaming may be an interesting subject for future research activities. With the global economy rapid development and the enhancement of international foreign trade, the ports throughput in the world develops rapidly. Ports are the backbone of international trade, providing direct linkages from international to regional or local transport systems and trade chains. The container throughput of the Shanghai Port in China was 31.74 million TEU's in 2011, on the top 1 container port in the world. The annual average growth rate of container throughput was 8.8% from 2006 to 2011 of the Shanghai Port. The throughput of China's container port is growing fast, but the earnings of inland port enterprises are not so good. This shows that there are some problems on the management of the port enterprises.

**2.7 Research Gaps:**

Many research models have been developed to tackle various kinds of ship routing and scheduling problems (Christiansen *et al.* 2004). However, most of these models have focused only on the optimization of travel distance and/or minimization of fleet size, without taking into consideration the capacity, availability, and transhipment capability of terminals.

This group of studies originated from the pioneering work of Dantzig & Fulkerson (1954), who considered the problem of minimizing the required number of tankers to perform a given set of delivery schedules. In the last decade, more research has been devoted to studying the planning of fleet sizes and the scheduling of ships including the work of Cho & Perakis (1996).

There is also a considerable amount of research on the allocation of berths at container terminals to minimize the waiting time of ships or to maximize the utilization of berths. In the above studies mentioned in detail both in the theoretical review and in empirical studies, the authors assume that the berths are discrete resources along a quayside and that each ship occupies a discrete number of berth locations. However, in some studies, the quayside of the berth is treated as a continuous resource (Lim, 1998).

Recently, Pang *et al.* (2009) considered a ship routing problem with time clash avoidance constraints at the pickup and drop-off points. However, their model implicitly assumes that a cargo terminal is either the origin or the final destination of a container. To the best of our knowledge, no study has been conducted on integrating ship scheduling and berthing time assignment decisions which consider also the transhipment option.

## 3. RESEARCH METHODOLOGY

### 3.1 Introduction:

This section of the research work answers the question *how* the desired objects of this research work were obtained. It stipulates the research methodology framework to be used to gather requisite data necessary for interpretation and analysis. It introduces the research design used; it defines the target population to generalize findings on; the sample frame and the sampling technique; a detailed structure of data collection instruments; pilot study and data processing and analysis mechanisms.

### 3.2 Research Design:

Phillips (1979) noted that a research design should constitute the blue print for the collection, measurement and analysis of data. To meet the desired objects of this research both descriptive and exploratory research designs were used to gather and interpret data owing to the fact that phenomena under study depicted both qualitative and quantitative aspects. A descriptive study is concerned with determining the frequency with which something occurs or the relationship between variables (Churchill, 1991).

A descriptive study is one in which information is collected without changing the environment; that is nothing is manipulated. Sometimes these are referred to as “correlational” or “observational” studies. The Office of Human Research Protections (OHRP) defines a descriptive study as “Any study that is not truly experimental.” In human research, a descriptive study can provide information about the naturally occurring health status, behaviour, attitudes or other characteristics of a particular group. Descriptive studies are also conducted to demonstrate associations or relationships between things in the world around us.

Descriptive studies are usually the best methods for collecting information that will demonstrate relationships and describe the world as it exists. This is the case for the situational analysis existent at KPA in the contemporary with reverence to port performance consequent of decision making mechanisms over port performance improvement. These types of studies are often done before an experiment to know what specific things to manipulate and include in an experiment. Brickman and Rog (1998) suggest that descriptive studies can answer questions such as “what is” or “what was.” Experiments can typically answer “why” or “how.”

### 3.3 Target Population:

Saunders, Thorn hill & Kothari (2007), described a population as the total collection of elements about which one wishes to make inferences. The target population refers to the entire group of individuals or objects to which a researcher is interested in generalizing the conclusions. The study population was the accessible population at KPA in which the researcher applied the conclusions. For purposes of this study the target the target population was the 2 ship-to-shore & 10 rubber tiered gantry cranes and their operators, line supervision staff with tactical functions in decision making and senior management staff at the port bestowed upon the task of strategic decision making.

The total population of staff currently employed in KPA is over 7,000. However, the target population only included respondents from the mechanical and user departments who are 1,600 in total (KPA Handbook, 2010-2011) as shown in table 3.1.

**Table 3.1: Stratification of sample frame for the respondents**

| Staff level | **No in Position** | **Percentage of Total Population.** |
|---|---|---|
| Senior Management | 104 | 6.5% |
| Tactical Level Management | 592 | 37% |
| Mechanical Dept Staff | 904 | 56.5% |
| **Total** | **1,600** | **100%** |

**3.4 Sampling Design:**

**3.4.1 Sampling Technique:**

Stratified sampling and convenience sampling techniques were used to select the subjects to be interviewed. In a stratified random sampling approach, the population was divided into three relevant and significant strata based on area operations and significance of improved processes to this operational area. For example, the population of this study was first divided into disjoint groups of users; procurement department, suppliers, senior management, other affiliate departments like finance and customers. These subgroups, called strata, together they compromise the whole population, so that N1+N2+...NL=N. From each stratum, a sample, of pre-specified size, will be drawn independently using stratified sampling. The convenience sampling technique was used because as it allows the freedom to choose whoever else shall be deemed as convenient to include in the sample based on need basis. It was also chosen because it is the easiest and cheapest method and can be adopted for early stages of research (pilot study).

According to Lenth (2001), the sample size should be of adequate size and relative to the goals of the study. This research used a sample size formula of 1/3 of the target population to construct the stratus representative of the whole population of user departments, customers, suppliers and top management. A confidence level of 95% and a standard error of estimate of 5% were allowed.

**3.4.2 Sample size determination:**

The sample size was determined using a formula of 1/3 of each of the independent stratus earlier identified (Lenth, 2001).

**Table 3. 2: Relationship between sample frame and sampling size**

| Level | Sample frame | Sample ratio | Sample size |
|---|---|---|---|
| Top level management | 104 | 0.1 | 11 |
| Middle level management | 592 | 0.1 | 59 |
| Low level management | 904 | 0.1 | 90 |
| **Total** | **1,600** | **0.1** | **160** |

**3.4.3 Construction of research materials:**
An interviewer administered questionnaire that had open, closed ended, contingency and matrix questions was used. It was further divided into several sections of; the first part constituted the particulars of respondent; the second part questions on effect of quantitative methods of decision making on bottlenecks associated with port performance; the third part questions about influence of quantitative methods of decision making on logistics costs; the fourth part focussed on key indices of port throughputs like TEU's per year with regard to effects of quantitative methods of decision making

**3.4.4 Pilot study:**

The pilot study consisted of one member from each strata of the target population being interviewed; to confirm practicability of the research; to test the research materials and processes evaluation.

**3.5 Data Collection:**

According to Ngechu (2004), ''the choice of a tool and instrument depends mainly on the attributes of the subjects, research topic, problem question, objectives, design, expected data and results.'' This was because each tool and instrument collects specific data. The study employed a survey questionnaire for data collection. Primary data is information gathered directly from respondents (Kombo & Tromp, 2006) and for this study the study administered questionnaires and interviews. Secondary data was collected from published material and information from other sources such as annual reports, journals websites, articles etc.

Data collection modes were observations and interviews for the primary data and surveys of the existing operation records to support secondary data acquisition. The interviews were structured to provide for open and closed ended questions. The structure of the interview comprised four parts; the first part constituted the particulars of respondent, the second part questions on general information, the third part questions about specific areas of berth and gantry crane allocation that can be changed to improve the ports throughputs and lastly the fourth part focused on key implications of a more scientific approach to managing performance of the gantry cranes.

The interviews were developed on the basis of the research hypothesis and were self-administered by the researcher through face-to-face or via telephone. Data was collected at the offices of the respective respondents by well trained assistants, who interviewed respondents using a pre tested interviewer administered questionnaire, to avoid errors and biases.

### 3.6 Data Analysis:

This study used the quantitative and qualitative methods of data analysis. To facilitate the analysis, the data collections tools were coded according to each variable of the study to ensure accuracy and minimal error margin during analysis. Descriptive statistics such as mean and standard deviation were used to describe the basic features of the data and to provide simple summaries about the sample and the measures. Together with simple graphics analysis, this formed the basis of virtually every aspect of quantitative analysis of data.

Data analysis was facilitated by Statistical Package for Social Sciences (SPSS) program version 20 which has Automated Data Preparation feature (ADPF), can provide multiple comparisons and allows table customization. Regression analysis was further used to show the relationship between the dependent variable and the independent variables .Then data was presented using tables and charts to give a clear picture of the research findings at a glance.

#### 3.6.1 Validity and reliability of data:

There was a random call back of five percent of the subjects, and the questionnaire was re administered to check the consistency of the answers given. The questionnaire was standard for all respondents. The Cronbach's Alpha Test of Reliability was used to test the reliability of the constructs describing the variables of the study and the results. Implementation was then allocated alpha scores.

#### 3.6.2 Data entry and analysis:

Data was examined for completeness, comprehensibility, consistency and reliability before coding. Data was then fed into SPSS from where it was to be analyzed. Data comparison and validation was conducted to limit data entry errors. Frequencies and proportions were then used for the descriptive analysis. Differences in proportions was compared for significance using Chi-squire tests and where a P- Value of $<0.005$ was considered significant. Results were then presented in the form of tables and figures.

## 4. RESEARCH FINDINGS AND DISCUSION

### 4.1 Introduction:

This chapter presents the findings of the study as per questionnaires distributed for data collection. It shows the response rate and further presents the analyzed data using the SPSS version 20 software. The data was gathered exclusively from the questionnaire and observation as the research instruments. The questionnaire was designed in line with the objectives of the study.

#### 4.1.1 Pilot test results:

Reliability is a measure of the degree to which a research instrument yields consistent results or data after repeated trials (Mugenda & Mugenda, 2003). Validity is the extent to which a test measures what it claims to measure. It is vital for a test to be valid in order for the results to be accurately applied and interpreted. Validity isn't determined by a single statistic, but by a body of research that demonstrates the relationship between the test and the behaviour it is intended to measure. During the pilot study, two repeat mailings of the instrument were carried out to improve the overall response rate before sending the actual instrument to allow for pre-testing of the research instrument. Cronbanch's alpha for each value was established by the SPSS application and gauged against each other at a margin value of 0.7 which is acceptable according to Cooper and Schindler (2008). The findings established that all the values were above 0.7 which concludes that the data collection instrument was reliable.

**Table 4: 1: Data reliability test**

| Variable | Cronbach's Alpha | No of Items |
|---|---|---|
| Quay Crane Scheduling Problem | .8002 | 7 |
| Berth Allocation Problem | .7184 | 10 |
| Data Envelopment Analysis | .8981 | 8 |

### 4.1.2 Response Rate

One hundred and sixty (160) questionnaires were sent to top, middle and lower level management staff at various user departments of Kenya Ports Authority (KPA). Out of the 160 questionnaires sent, 122 were considered to be legitimate for this research. With 122 returned and useable questionnaires out of 160, the response rate was 76.25%. This commendable response rate was made a reality after the study made several follow-ups to remind the respondent to fill-in and return the questionnaires. According to Kothari (2004) a response rate of above 60% is acceptable.

The table below shows the departments where the respondents work. 19.7% of the respondents work at the Electrical Engineering Department, 14.8% work at the Logistics Department, 12.3% work at Container Terminal Department, 15.6% work at the Marine Operations Department while the majority (37.6%) worked at the Procurement Department.

**Table 4. 2: Department where the respondents worked**

| | Frequency | Percentage |
|---|---|---|
| Electrical Engineering Department | 24 | 19.7 |
| Logistics Department | 18 | 14.8 |
| Container Terminal Department | 15 | 12.3 |
| Marine Operations department | 19 | 15.6 |
| Procurement Department | 46 | 37.6 |
| **Total** | **122** | **100** |

## 4.2 Respondents information:

### 4.2.1 Gender of the Respondent:

The study sought to find out the gender of the respondents. From the findings, 54% of the respondents were male while only 46% of the respondents were female. This implies that there is equal distribution of gender.

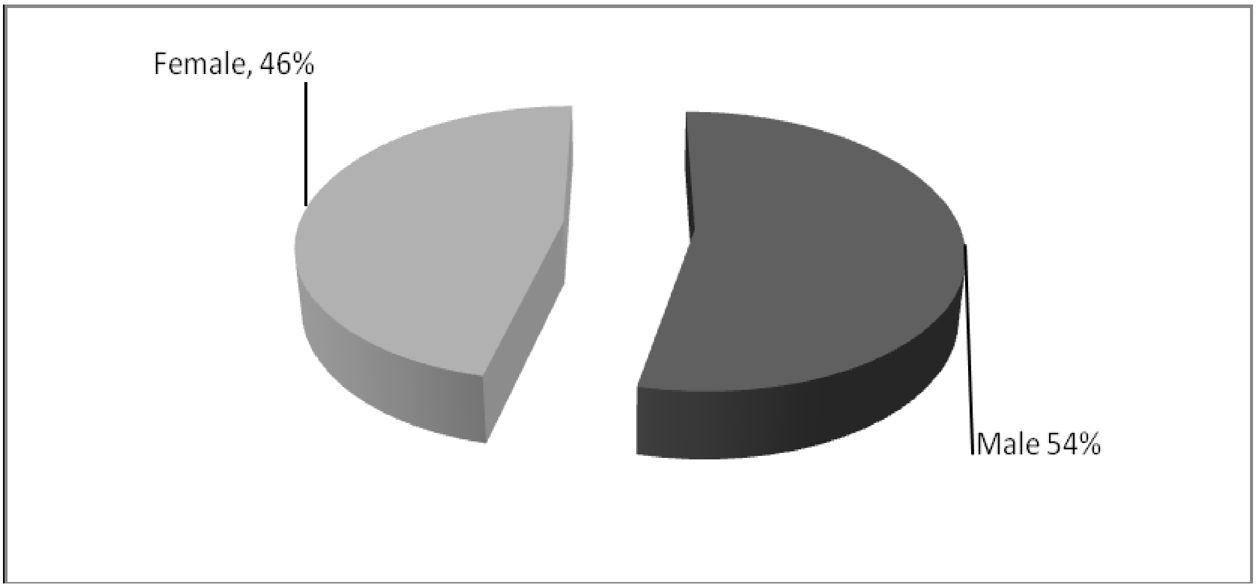



**Figure : 4.1: Gender of the Respondent**

**4.2.2 Employee's age:**

The study sought to find out the age of the respondents. According to the findings, 28.6% of the respondents were over 46 years old, 28.5% of the respondents were between 26-35 years old, and 23.1% of the respondents were between 18-25 years old, while 19.8% of the respondents were 36-45 years old. This implied that most employees are almost attaining their retirement age while the level of work experience may be high. This is collaborated by studies done by Larsen (2012) where he indicated that work related experiences are important in developing motivation of becoming good.

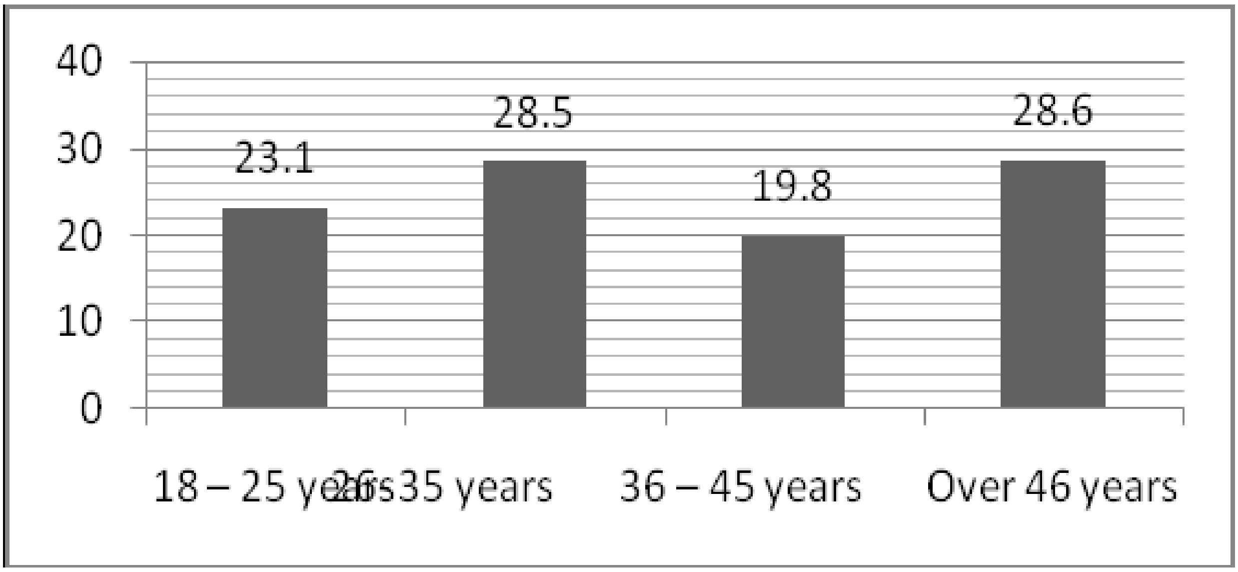



**Figure 4.2: Age of the respondents**

**4.2.3 Highest education attained:**

The study sought to find out respondents' level of education. As per the findings, 46% of them were higher national diploma holders which are the majority, 27% had attained first degrees, 15% were certificate holders, 9% were advanced degree holders while only 3% were PhD holders. This implied that the education level for most staff is fairly low and thus knowledge in strategic perspective of decision making premised on quantum aspects may also be rated as low. This may affect port performance with respect to bottlenecks in decision making, high logistic costs due to lack of costing processes skills and lower port throughputs evidenced by low TEUs. This notion is supported by studies done by Kim & Staw (1991) and Katz (1992) which indicate that those with higher education are more successful as they have more knowledge and have modern managerial skills making them more conscious of the reality of the business work.

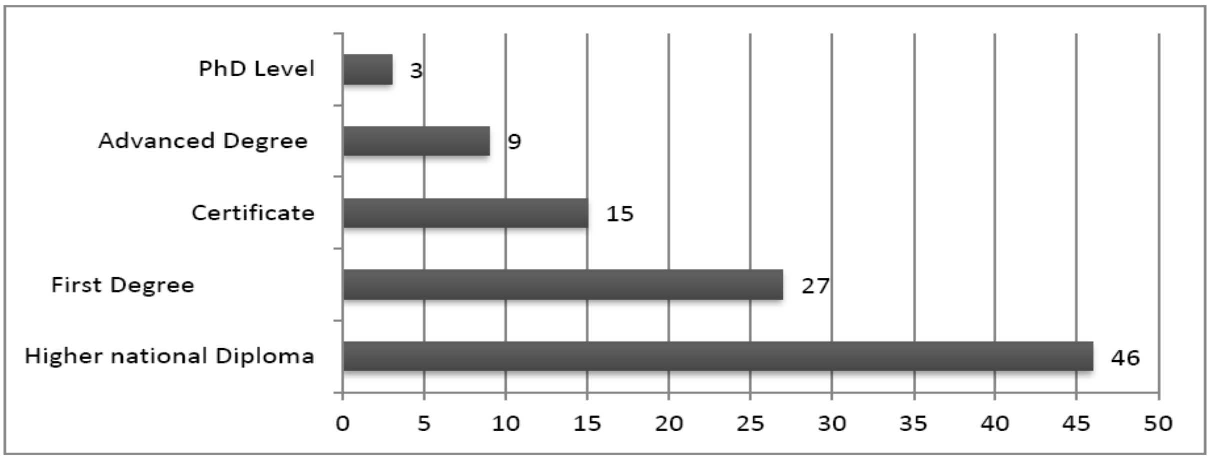



**Figure 4.3: Highest education attained**

### 4.2.4 What is the number of years in terms of experience with KPA:

The study sought to find out respondents' level of experience working at KPA. As per the findings, 46% of them had over 10 years experience, 27% of the respondents had between 7-10years of experience, 15% had between 3-6 years of experience whilst the remaining 12% had less than two years of experience. This is collaborated by studies done by Larsen (2012) where he indicated that work related experiences are important in enabling technical input of an employee in decision making processes which thence develops their motivation of becoming better at it

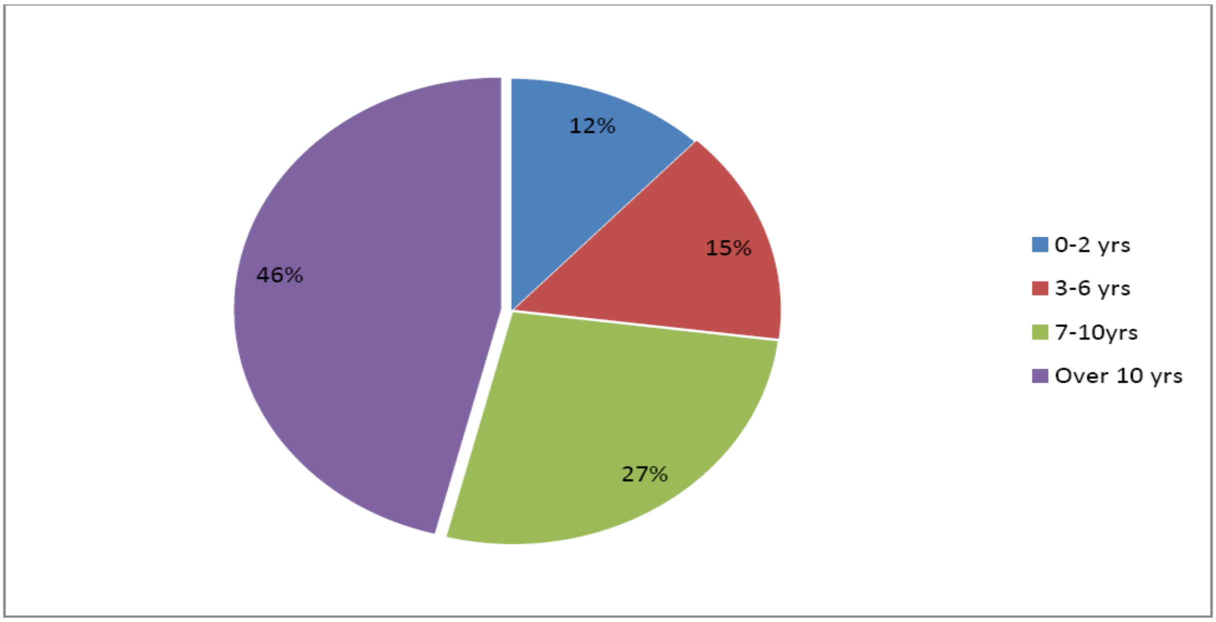



**Fig 4.4: Number of years in terms of experience with KPA**

### 4.2.5 What is the respondents' category of basic salary scale?

On their salary category, 45% of the respondents indicated that they earned between Kshs 20,000 - 50,000, 32% of the respondents indicated that they earned between Kshs 51,000 - 100,000, 12% of the respondents indicated that they earned between Kshs 101,000 - 150,000, 6% of the respondents indicated that they earned between Kshs 151,000 - 200,000, while the rest (5%) of the respondents indicated that they earned between Kshs above Kshs 201,000. This implies that staffs at operations level are not well remunerated reducing their job satisfaction levels that would encourage creativity, innovativeness and technical input in arriving at better decisions made. This is supported in an article in Nguzo za Haki, issue 3, (2005) where it states that Public office is abused when private agents actively offer bribes to circumvent public policies and processes for competitive advantage and profit. Corruption increases the cost of public services, lowers its quality and distorts government's priorities as its beneficiaries give preference to those programs that offer the greatest opportunities for self-enrichment.

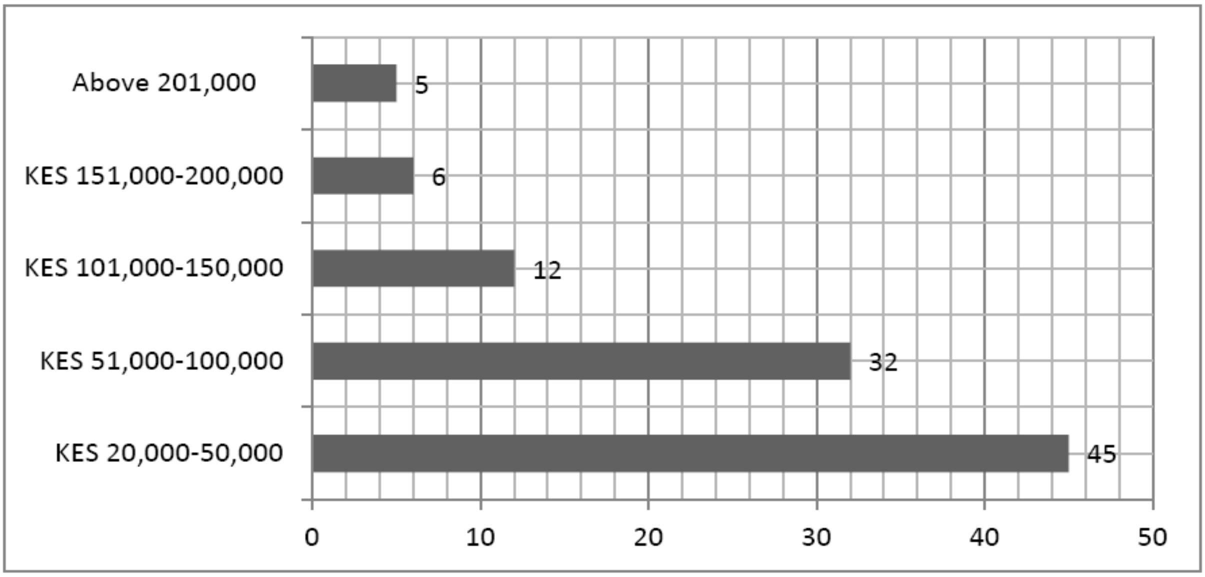
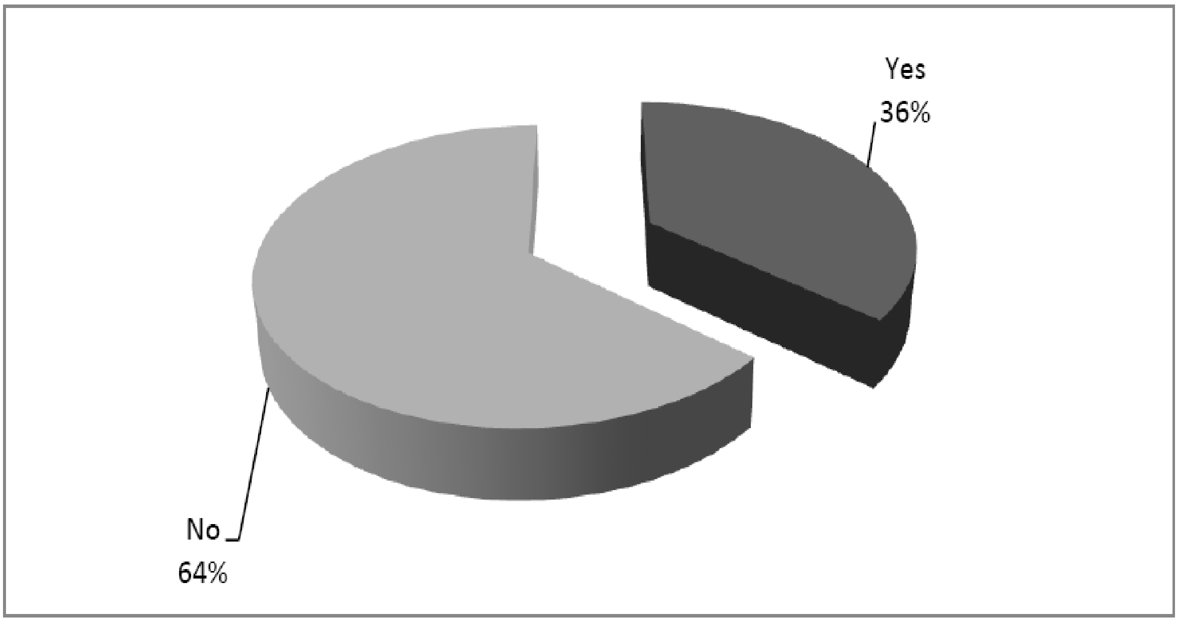



**Figure 4.5: Respondents' salary category**

### 4.2.6 Are the respondents' a member of any professional body?

Figure 4.6 below shows results from the question "Are you a member of any professional body?" It indicates that 64% of the respondents indicated that they were not members of any professional body, while the rest (36%) were members of a professional body. This implies that most staff members are not adequately trained on the metrics composite of any efficient port terminal and their tactical and strategic managers haven't undergone any contemporary strategic management training and this may impact negatively on the decisions made. This is supported by studies where it is stated that the shortage of proper know-how among professionals about quantitative methods for fulfilling desired objects of any strategic decision making process that may be made from time to time seems to be a global phenomenon (Brammer & Walker, 2007).




### 4.2.7 Have the respondents' been promoted in the last two years?

On whether respondents had been promoted in the preceding two years, 32% of the respondents had been promoted in the past two years while the rest (68%) of them had not been promoted over the same period. This implies that staff motivation and career development is low at KPA. To support this, according to Vroom (1994), people will be motivated if they believe that strong effort will lead to good performance and good performance will lead to desired rewards.

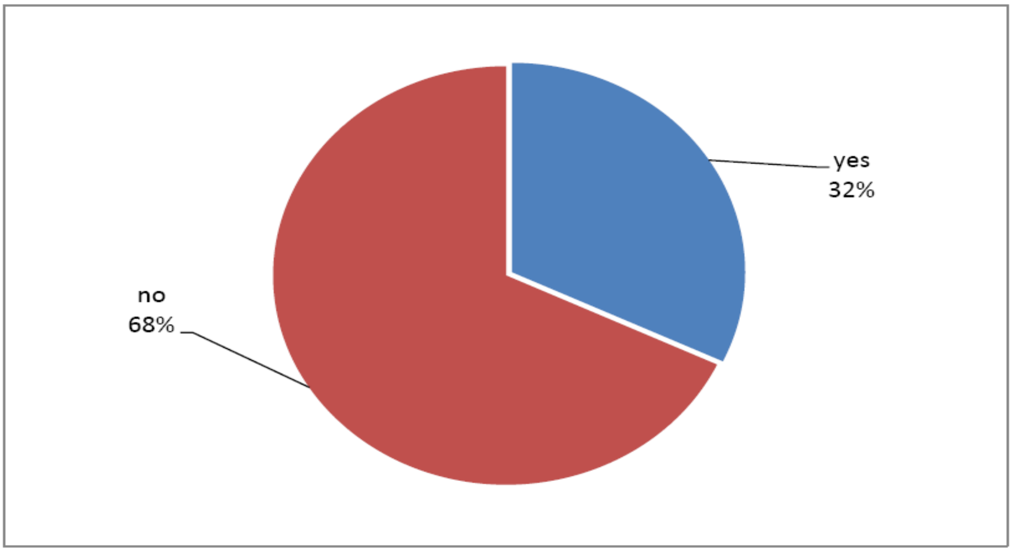



**Figure 4.7: Whether respondents had been promoted in the last two years**

**4.3 Effects of Quantitative Methods of decision making on bottlenecks in Port Performance:**

**4.3.1 How respondents are satisfied with decision making processes in operations:**

These were findings from respondents from mechanical departments on how satisfied they are with decision making processes with respect to inclusion of quantitative aspects driven at improving port performance. The study observed that 32% of the respondents were neither satisfied nor dissatisfied, 29% of the respondents were satisfied, 16% of the respondents were very satisfied, 12% of the respondents were very dissatisfied while only 11% of the respondents were dissatisfied. This implied that most decisions made may not meet the expectations of the operations team in terms of their influence on logistics costs, flexibility bent on reducing bottlenecks, and their reflection on port throughputs. Previous research has shown that satisfaction with decision making of the operations staff by their incumbent top tier managers is important for stimulating and sustaining competitive and innovative firms (Porter, 1990; Anderson, 2007). Vinnova (2009) further suggested that this competence includes technical competence of the innovation as well as competence to manage strategically any operations management even if it implies involvement of quanta. This whole process is usually left to strategic level managers. However, in many cases decisions are qualitative in nature with little or no quantitative aspects inclusion; in the process of making these all important decisions many managers may not fully understand the impetus of such an undertaking. This may result in less competitive and intuitive decisions amounting to inefficiencies in systems or processes.

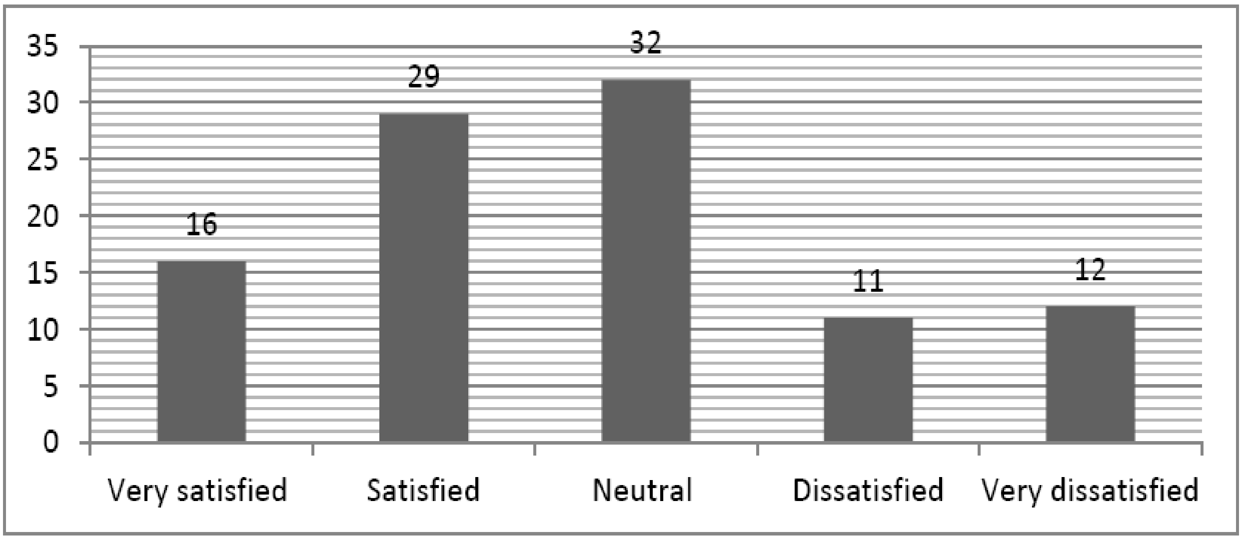



**Figure 4.8: How respondents are satisfied with decision making processes in operations**

### 4.3.2 Whether respondents were satisfied with items reflective of efficiency in port performance:

The study aimed at establishing if the respondents were satisfied items reflective of efficiency in port performance. The findings were that inclusion in decision making had a vast majority of 60% being very dissatisfied as compared to 2% very satisfied and 5% neutral. This goes to show that top tier managers need to incorporate more input of their operations level staff in decision making processes. It was also found out that respondents in a general sense were satisfied with preparation of vessels set to arrive form sea at 55% with only 5% being very dissatisfied. This indicates that this item reflective of efficiency in port performance is generally good and as such can only be improved. User experience with equipment was another area the research wanted to establish as being satisfactory to meet the requirements of an efficient port. The findings were that 60% were very satisfied, 30% being satisfied with only 2% being dissatisfied. Experientially the respondents are well but this translates probably into a lot of routine experiences and calls for a need for job rotation supported by studies of Kauffman (2006).

**Table 4.3: Whether respondents were satisfied with items reflective of efficiency in port performance**

| | Very Satisfied | Satisfied | Neutral | Dissatisfied | Very Dissatisf | Mean | Stdev |
|---|---|---|---|---|---|---|---|
| Inclusion in decision making. | 2 | 3 | 5 | 30 | 60 | 4.6 | 0.4 |
| Preparation of vessels set to arrive from sea | 20 | 55 | 10 | 10 | 5 | 3.70 | 0.14 |
| The current allocation mechanism for the cranes | 3 | 30 | 60 | 5 | 2 | 3.27 | 0.2 |
| User experience | 60 | 30 | 5 | 3 | 2 | 4.43 | 0.42 |

### 4.3.3 Whether in the opinion of the respondent's quantitative methods of decision making affect port performance:

The study aimed at establishing whether in the opinion of the respondents quantitative methods of decision making affected port performance. The findings were that 63% were of the opinion that they do whilst 37% were of the opinion that they don't. This is indicative of an expectation gap between input and output variables surrounding operations t the port. This is supported by studies by Esig & Arnold (2001) whereby they found out that expectation gaps usually are a consequence of too much emphasis on qualitative rather than quantitative aspects of decision making by decision makers.

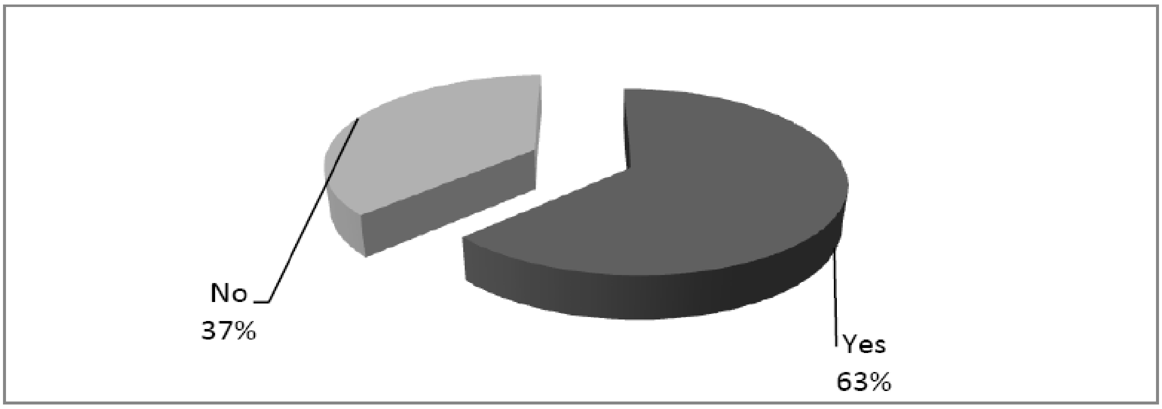



**Figure 4.9: Whether in the opinion of the respondents' quantitative methods of decision making affect port performance**

### 4.3.4 To what extent quantitative methods of decision making affect port performance:

The research wanted to establish the extent to which quantitative methods of decision making affect port performance. The findings indicated that 33% of respondents thought they affect to a very great extent, 15% to a great extent, 36% to a moderate extent, 9% to a little extent and 7% of the respondents thought they do not affect at all. This is interpreted to mean that quantitative methods of decision making do indeed have a play in the results of port performance easily supported by studies of Bierwirth & Meisel (2010).

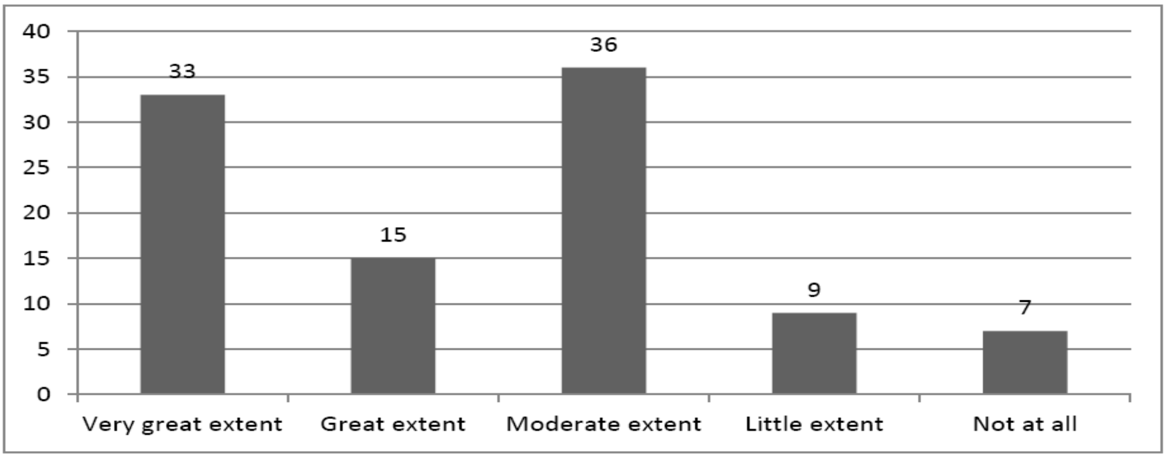



**Fig 4.10: Extent to which quantitative methods of decision making affect port performance**

**4.3.5 Whether mechanical operations staffs have the ability to challenge tactical and strategic decisions of superiors when they are aware of them not being optimal:**

The study sought to find out whether respondents had the ability to challenge tactical and strategic decisions made by their superiors more so when they were aware they were not optimal. The findings were that the ability to challenge such decisions always was at 6%, Often 8%, sometimes 14%, infrequently at 2% and never at a 70% majority. This is indicative of inflexibility of top tier management to incorporate input of lower cadre employees even though empirical studies related to value chain and core competency concepts urge this (Porter, 1990). There is need therefore on the part of these top tier managers to allow input of lower cadre employees for functional and fulfilling work environment tantamount to synergetic advantages that relate to the same.

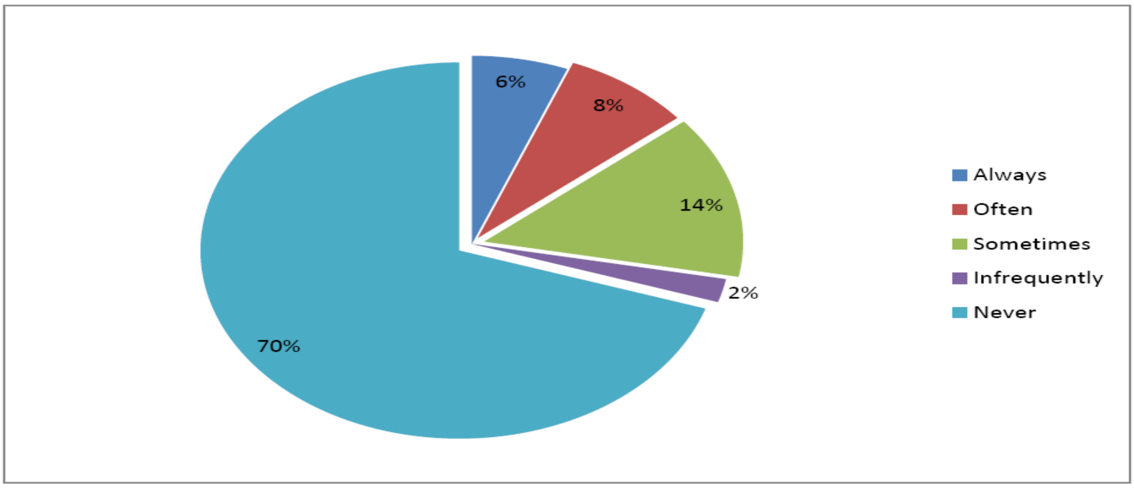



**Fig 4.11: Ability to challenge tactical and strategic decisions made by superiors**

**4.3.6 Level of agreement with statements on effects quantitative methods of decision on port performance:**

The study sought to find out whether respondents agreed with provided statements on effects of quantitative methods on port performance. Findings were that there is no proper ICT infrastructure to handle the movement of the cranes efficiently as shown by a mean of 4.6 which corresponds to strongly disagree; that most of the staff in mechanical operations departments are not properly trained and lack skills requisite skills that enable them to make tactical decisions as shown by a mean of 3.70; that there exists no proper quantitative models like crane assignment models that guide decision making as shown by a mean of 3.27; that there exists no scientific approach to managing performance of ports' infrastructure attributable to the fact that the strategic significance of the port and the need for more robust management in the strategic sense is still at its beginning stages as shown by a mean of 4.43; that lack of quantitative methods is the biggest contributor to the contemporary low port throughputs as shown by a mean of 3.75. These findings indicate the need for more to be done with respect to reasoning quantitatively in managing infrastructure of the port to in essence achieve strategic objects (Christiansen *et al*, 2004).

**Table 4.4: Level of agreement with statements relating to effect of quantitative methods of decision making on port performance**

| | Strongly agree | Agree | Neutral | Disagree | Strongly disagree | Mean | Stddev |
|---|---|---|---|---|---|---|---|
| There is no proper ICT infrastructure to handle the movements of the cranes properly and efficiently. | 60 | 30 | 5 | 3 | 2 | 4.6 | 0.4 |
| All the staffs in mechanical operations department aren't professionally qualified to make tactical decisions | 20 | 55 | 10 | 10 | 5 | 3.70 | 0.14 |
| There exists no proper quantitative models like crane assignment models that guide decision making | 3 | 30 | 60 | 5 | 2 | 3.27 | 0.2 |
| There exists no scientific approach to managing performance of the ports infrastructure | 60 | 30 | 5 | 3 | 2 | 4.43 | 0.42 |
| Lack of quantitative methods is the biggest contributor to the contemporary low throughput port efficiency metrics | 20 | 55 | 10 | 10 | 5 | 3.75 | 0.43 |

### 4.4 Influence of quantitative methods of decision making on logistics costs

#### 4.4.1 How generally respondents are satisfied with listed items affecting port performance

The study sought to find out whether respondents were satisfied with items affecting port performance. Findings were that costs for cargo handling, transfer and storage had an average effect on port performance as shown by a mean of 3.5 which corresponds to being generally satisfied; that efficiency of inland transport mechanisms are generally satisfactory as shown by a mean of 3.27; that waiting time for service by vessels from time of arrival as shown by a mean of 3.32 is also generally satisfactory but is subject to further improvement to maintain competitive advantage; that ownership for costs of damages within the loading and unloading areas are satisfactory as shown by a mean of 3.75 indicative of professionalism in handling of work allocated; that any other related levies for cargo handling charged to port users as shown by a mean of 3.63 is also close the desirable margins of equal costs to service delivery. These findings indicate the need for more to be done with respect to reasoning quantitatively in managing infrastructure of the port to in essence achieve strategic objects (Christiansen *et al*, 2004).

**Table 4.5: General level of satisfaction with items affecting port performance**

| | Very Satisfied | Satisfied | Neutral | Dissatisfied | Very Dissatisfied | Mean | Stdev |
|---|---|---|---|---|---|---|---|
| Costs for cargo handling, transfer and storage. | 10 | 30 | 20 | 30 | 10 | 3.5 | 0.18 |
| Efficiency of inland transport mechanisms | 5 | 35 | 20 | 30 | 10 | 3.27 | 0.2 |
| Waiting time for service by vessels from time of arrival | 15 | 20 | 30 | 20 | 15 | 3.32 | 0.32 |
| Ownership for costs of damages within the loading and unloading areas | 20 | 30 | 10 | 20 | 20 | 3.75 | 0.43 |
| Any other related levies for cargo handling charged to port users | 10 | 35 | 40 | 5 | 5 | 3.63 | 0.39 |

**4.4.2 Level of agreement with statements on influence of quantitative methods of decision making on logistics costs:**

The study sought to find out whether respondents agreed with provided statements on influence of quantitative methods of decision making on logistics costs. Findings were that indeed quantitative methods of decision making influence logistics costs as shown by a mean of 2.3 which corresponds to agree; that nature of infrastructure such as having a bigger container yard, more cranes influence level of logistics costs as shown by a mean of 3.20; that adequate intermodal links and land transport systems are two of the most important criteria in determining logistics costs in ports as shown by a mean of 3.27; that vessel waiting times and delays influence amount of logistics costs as shown by a mean of 2.43; that level of logistics costs is closely associated with level of customer service as shown by a mean of 3.75. These findings are a clear indication of shifts that have been made over time to more time dependent freight transportation handling with combined consideration of warehousing, material handling and freight transportation which emerged under the label physical distribution management (McKinnon *et al*, 2010).

**Table 4.6: Level of agreement with statements on influence of quantitative methods of decision making on logistics costs**

| | Strongly agree | Agree | Neutral | Disagree | Strongly disagree | Mean | Stddev |
|---|---|---|---|---|---|---|---|
| Quantitative methods of decision making influence level of logistics costs | 50 | 35 | 10 | 5 | 2 | 2.3 | 0.76 |
| The nature of infrastructure such as having a bigger container yard, more cranes and berths influence level of logistics costs | 20 | 55 | 10 | 10 | 5 | 3.2 | 0.2 |
| Adequate intermodal links and land transport systems are two of the most important criteria in determining logistics costs in ports | 3 | 30 | 60 | 5 | 2 | 3.27 | 0.2 |
| Vessel waiting times and delays influence amount of logistics costs | 60 | 30 | 5 | 3 | 2 | 2.43 | 0.65 |
| Level of logistics costs is closely associated with level of customer service | 20 | 55 | 10 | 10 | 5 | 3.75 | 0.43 |

**4.5 Effect of quantitative methods of decision making on port throughputs:**

**4.5.1 Is there a system that determines measurements like coefficient of crane productivity?**

The study sought to find out whether there exists a system that determines measurements like coefficient of crane productivity. The findings were that 80% of the respondents intimated that there exist no such systems whilst 20% of the respondents' intimated otherwise. This interpreted implies that KPA need to develop such models that will enable roaming crane scheduling with crane shifts that provide significantly better operational plans that in essence increase or otherwise improve crane utilization (Zsidisn & Smith 2005).

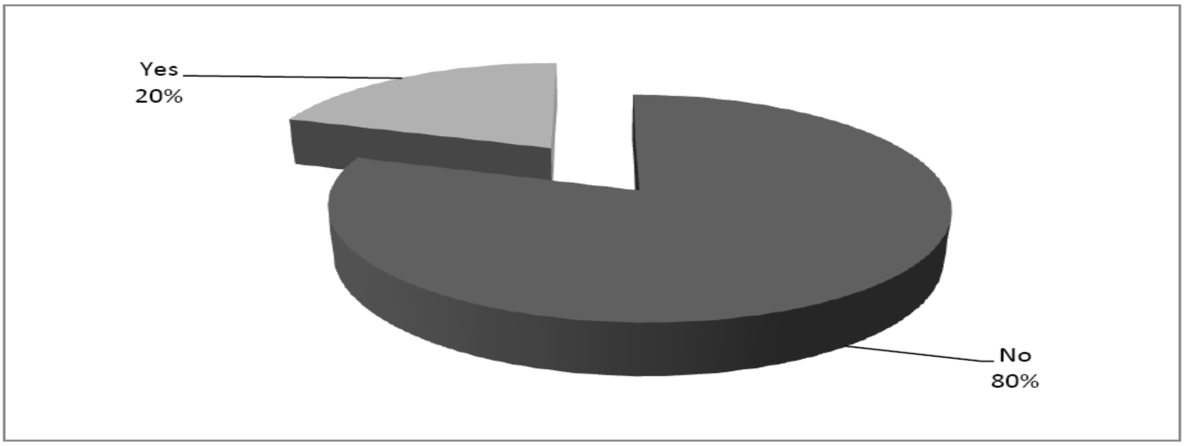



**Figure 4.12: Whether respondents are aware of existence of a system that determines measures like coefficient of crane productivity**

### 4.5.2 Whether there exist records kept on metrics such as annual growth rate on TEUs per year:

The study sought to find out the there exist records on metrics such as annual growth rate on TEUs per year. The findings of this question were that 88.2% of respondents agreed that there existed such records whilst 11.8% indicated that there exist no such kept records. The analysis of this data reveals that this good practice is kept by KPA and it is an encouraging thing. However, those who responded as to not being aware of the existence of such records imply a breakdown in communication processes either vertically or horizontally and it a gap that would be very necessary to bridge going forward to enable KPA achieve its strategic objects premised on perfect flow of information very necessary for growth as supported by empirical studies (Bekov *et al*, 2002).

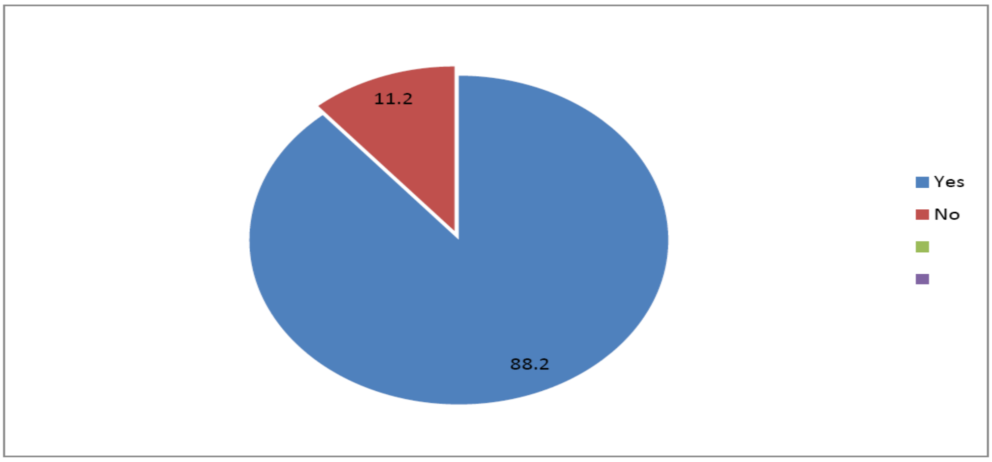



**Figure 4.13: Whether there exist records kept on metrics like TEUs per year**

### 4.5.3 Level of agreement with statements that relate to effect of quantitative methods of decision making on port throughputs:

The study sought to find out whether respondents strongly agreed, agreed, were neutral, disagreed, or strongly disagreed on a scale of 1-5 whereby 1 represented strongly agreed, 2 agreed, 3 neutral, 4 disagreed and 5 strongly disagreed. The results of the findings were as shown below. The implications of these findings are that there is general consensus on the fact that there is a relationship between the number of operational cranes and their productive capacity; that decisions regarding operations of cranes require multiple attribute decision making model; that there is a relationship between port throughput metrics and its earnings; and that a scientific approach to managing port operations can improve productive capacities of port infrastructure like cranes and berth space (Loukis et al, 2009).

**Table 4.7: Level of agreement with statements that relate to effect of quantitative methods of decision making on port throughputs**

| | Strongly agree | Agree | Neutral | Disagree | Strongly disagree | Mean | Stddev |
|---|---|---|---|---|---|---|---|
| There is a relationship between number of operational cranes and their productive capacity | 78 | 14 | 6 | 2 | 0 | 4.7 | 0.1 |
| That the operations of cranes decision making requires a multiple attributes decision making model | 24 | 66 | 8 | 2 | 0 | 4.1 | 0.1 |
| That there is a relationship between port throughputs metrics and its earnings | 60 | 30 | 5 | 3 | 2 | 4.43 | 0.42 |
| That a scientific approach to managing port operations can improve productive capacities of cranes | 60 | 30 | 5 | 3 | 2 | 4.43 | 0.42 |
| That there are very many variables that affect crane scheduling decisions | 20 | 55 | 10 | 10 | 5 | 3.75 | 0.43 |

**4.5.4 Whether the strategic decisions made by senior management affected decision making with regard to operational processes.**

The study sought to find out whether decision made by senior management affected operational processes decision making whereby respondents were expected to answer either a **Yes** or **No**. **Yes** being representative of those who thought they affected whilst **No** being representative of those respondents who thought they don't affect. According to the findings Yes had 94% whereas No had 6%. This translates into general consensus that indeed strategic decisions made by senior management affect operational processes and as such should be as optimal as possible to avoid misdirection of effort. This was also supported by Tan et al. (1999).

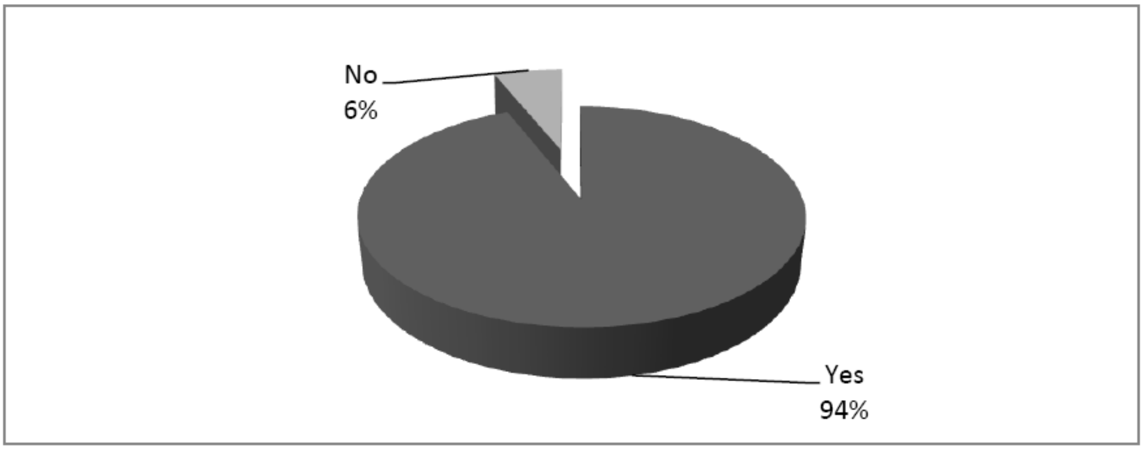



**Fig 4.14: Whether the strategic decisions made by senior management affect operational processes**

**4.5.5 Extent to which decision made by senior management affect decision making with regard to operational processes:**

It was observed that senior management make contributions in decision making processes at operational level of the organization by way of influence. This was shown by 34% of respondents opining that to a very great extent decisions made by senior management affect decisions made at operational level. 36% thought they affect to great extent, 26% supported moderate extent, 4% little extent and 0% thought they don't affect at all. Moreover, some studies state that decision making at senior management level is the key driver of decision making at all other levels of the organization and they should therefore be as intuitive as they are expeditious (Schapper et al 2006). This study is therefore a support to studies done by other scholars.

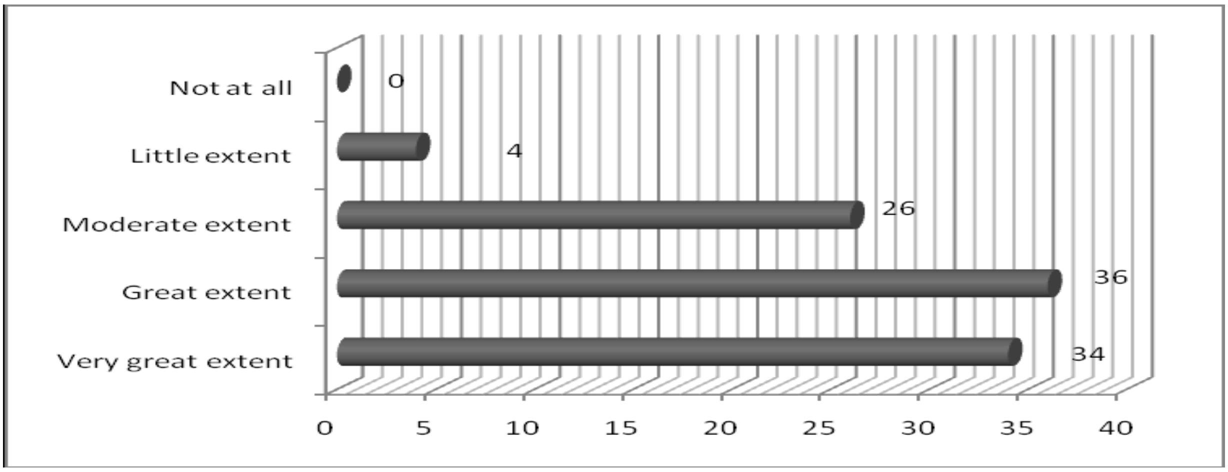



**Fig 4.15: Extent to which senior management decision making affects operational level decision making**

**4.5.6 Level of agreement with statements on effect of strategic decisions made by senior management on operational efficiency:**

The study sought to find out whether respondents strongly agreed, agreed, were neutral, disagreed, or strongly disagreed on a scale of 1-5 whereby 1 represented strongly agreed, 2 agreed, 3 neutral, 4 disagreed and 5 strongly disagreed. The results of the findings were as shown below. The implications of these findings are that there is general consensus on the fact that there is a commitment on the part of senior management to develop junior staff and that they enhance their careers; that senior management influence board decisions on capital acquisition issues; that senior management encourages collaboration with suppliers of machinery equipment to improve on their productivity; that senor management have made efforts to apply quantitative methods of decision making in the operational policy guidelines although there exists room for improvement; and that senior management are willing to take responsibility for low metrics in port throughputs whenever such occur. These findings are supported by studies made by Bowersox (2008) which concluded that the performance of an enterprise logistics could generally be measured within external and internal confines.

**Table 4.8: Level of agreement with statements on effect of strategic decisions made by senior management on operational efficiency**

| | Strongly agree | Agree | Neutral | Disagree | Strongly disagree | Mean | Stdev |
|---|---|---|---|---|---|---|---|
| Senior management are committed to staff development and career enhancement | 65.3 | 22 | 4.1 | 6.1 | 2.0 | 4.4 | 0.3 |
| Senior management influence board decisions on capital acquisition issues. | 40.8 | 35 | 8.2 | 14.3 | 2.0 | 4.0 | 0.2 |
| Senior management encourages collaborative relationships with suppliers of crane infrastructure to improve their productivity. | 55.1 | 2.9 | 8.2 | 6.1 | 2.0 | 4.3 | 0.3 |
| Senior management make effort to apply quantitative methods of decision making in their daily operational policy guidelines | 34.7 | 29 | 14.3 | 18.4 | 4.1 | 3.7 | 0.3 |
| Senior management are willing to take accountability for low metrics in port throughputs. | 73.5 | 16 | 6.1 | 2.0 | 2.0 | 4.6 | 0.1 |
| Senior management make efforts to streamline record management systems | 56 | 6 | 16 | 5 | 17 | 3.84 | 0.8 |

According to Mugenda and Mugenda, 2003, one cannot determine the significance of a study by trial and error. Therefore, to determine the significance of this research, ANOVA and Coefficient of determination were used.

### 4.6 Analysis of Variance (ANOVA):

**Table 4.9: Analysis of Variance (ANOVA)**

| Model | | Sum of Squares | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|---|
| 1 | Regression | 11.534 | 5 | 2.878 | 52.400 | .0003 |
| | Residual | 186.555 | 27 | 2.129 | | |
| | Total | 198.089 | 32 | | | |

According to Mugenda and Mugenda (2003), ANOVA is a data analysis procedure that is used to determine whether there are significant differences between two or more groups or samples at a selected probability level. `An independent variable is said to be a significant predictor of the dependent variable if the absolute t-value of the regression coefficient associated with that independent variable is greater than the absolute critical t-value. The regression analysis also yields an F-statistic where if the calculated F-value is greater than the critical or tabled F-value, the prediction will be rejected. In this study, the significance value is .0003 which is less that 0.05 thus the model is statistically significant in making predictions. The F critical at 5% level of significance was 3.23. Since F calculated is greater than the F critical (value = 52.400), this shows that the overall model was significant.

## 5. SUMMARY OF THE FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

### 5.1 Introduction:

The chapter provides the summary of the findings from the previous chapter. The chapter also gives the conclusions and recommendations of the study based on the overall objective of the study.

### 5.2 Summary of the Findings:

The overall objective was aimed at investigating the role of quantitative aspects of decision making on port performance. This thesis provides a comprehensive study on planning problems related to berth and quay cranes which are the most important resources in container terminals at seaports. It contributes by filling many of the gaps in the literature that appear due to recent trends and changes in maritime logistics, like the introduction of mega-ships and increasing popularity of flexible continuous berth structures.

A multivariate QSCP and BAP which considers dynamic arrival of vessels and a single berth having a long continuous structure that can serve multiple vessels simultaneously is considered. A mixed integer programming (MIP) formulation is provided, and a meta-heuristic algorithm based on tabu search which employs a novel nested neighbourhood structure to solve large problems is developed. A polynomially computable lower bound is also introduced which can be computed quickly in polynomial time, and is provably tighter than the bound generated by solving the LP relaxation of the associated MIP. Computational experiments show that the algorithm is able to provide high quality solutions in relatively short computation times. Instances with 10 to 14 vessels were solved optimally by the nested tabu search algorithm under 4 seconds, whereas, for some of these instances, it took days to solve with the MIP. More realistic instances with 20 to 30 vessels were also solved within 100 seconds. For those instances, I was able to reduce the optimality gap of a reasonable initial solution by 70% on average.

A mixed integer program and a two phase tabu search heuristic are provided. Two polynomially-computable lower bounds are also introduced. Computational experiments show that the algorithm designed can reduce the optimality gap of a reasonable initial solution by 66% within 1 minute for moderate size instances with 10 to 14 vessels and 6 cranes. The algorithm provided even better improvement for larger instances with 20 to 30 vessels and 10 cranes. An average of 77% reduction in the optimality gap of the initial solution in 3 to 30 minutes is observed. This thesis also shows that simultaneous scheduling of berth and quay cranes may yield savings as large as 35% over the hierarchical planning approach used by terminal operators. The simultaneous scheduling approach can easily be extended for the multiple berth case in a future study. The nested neighbourhood structure and the two stage search procedure provided can be utilized efficiently to design a solution method for such extensions that are time bound.

A model based on multi-commodity network flow is presented. It is proven that when only dedicated terminal capacities are relaxed, the model can be decomposed for each route and an optimal integer flow can be found by an improved version of the LP relaxation with the help of additional valid inequalities. This result is used to reduce the problem size. Methods to handle transhipments, terminal time windows and service level requirements are provided. Ideas to improve the reliability of schedules are also discussed. The efficiency of the model and the ideas presented in this thesis can guide a smooth integration of crane scheduling problem and berth scheduling problem.

The research had a primal focus on an *NP*-hard berth allocation problem (BAP) which is the problem of assigning ships to berthing positions within a seaport to optimize some performance metric. It considered the dynamic variant of the BAP, whereby it modelled the dynamic arrival of vessels during the planning horizon. It then used a model that treats the berth as a continuous facility where a vessel can moor anywhere along the berth simultaneously with other vessels. Further, the research provided mixed integer programming (MIP) formulations, and then developed a meta-heuristic algorithm based on tabu search which employs a novel nested neighbourhood structure to solve large problem instances. Also it introduced a lower bound which can be computed quickly in polynomial time, and is provably tighter than the bound generated by solving the LP relaxation of the associated MIP. Computational experiments showed that the algorithm was able to provide high quality solutions in relatively short computation times. Instances with 10 to 14 vessels were solved optimally by the nested tabu search algorithm in less than 4 seconds, whereas, for some of these instances, it took days to solve with the MIP. More realistic instances with 20 to 30 vessels were also solved within 100 seconds. For those instances, we were able to reduce the optimality gap of a reasonable initial solution by 70% on average.

**5.3 Conclusions:**

Container terminals are more and more automated and as a result optimization technologies are needed to solve efficiently the numerous logistics problems arising. This is also reflected in the operations research literature where recent works try to solve these integrated problems. This thesis has shown that operational and realistic constraints for port performance can be successfully addressed in the context of a quantitative techniques approach. This approach is modular in the sense that each set of operational constraints can be separated. The key idea is to use a mixed integer problem entailing QSCP, CAP and DEA by applying AHP as the main component, and view it as a resource. Other side constraints can be integrated around this basic model. Experiments show that these models can produce solutions close to 1/5th to 1/10th from an ideal operational world. Overall, this works shows that quantitative techniques could be a modular choice challenging problems in the maritime industry considered "out of scope" for the current approaches, even under complex operational and scale constraints.

The financial impact of the improvement resulting from the dual loops is based on the arguments forwarded by Goodchild and Daganzo (2007). The drop in completion time by executing dual loops has positive as well as negative financial consequences for several parties involved. A reduction in handling time at the port, accords them the opportunity to increase their productive time. The cranes can handle all containers of a vessel in less time when using double cycling. Therefore, the gained time can be used to serve another vessel. Terminals are mostly paid per container handled. The average rate amounts $200 per handled container. Consequently, it is possible to generate $33000 within 5 hours. This comes down to $22 per container. The terminal operator therefore benefits from the increase in crane productivity.

The vessel operator has to pay two fees in return for berthing space. The first one is the dockage fee. This fee is paid to the port authority on a daily or hourly basis. As a result, the cost for the vessel operator decreases, because the vessel stays a shorter period of time at the port. The revenue of the port authority stays the same, assuming that there is always another vessel waiting for that berthing space. It is estimated that the dockage fee can be reduced by $2400, or $1, 60 per container handled at the port. The second fee is the wharf age fee. These wharf age fees are paid on container basis and average $200 per container. They are paid to the port authority or the terminal operator. This comes down to a benefit of $22 per handled container.

It is obvious that implementing the recommended formulations of the postulated models herewith provided has positive overall financial, decision making and port performance consequences. Now the most important questions that can be posed is the possibility of implementation of such a multiple attribute decision model that is a change processes having in mind the fact that change is usually resistance bound. The complexities of such a model implementation can also not be ignored.

**5.3.1 QSCP:**

Quay cranes are very important resources at container terminals. They are used to load containers onto and discharge containers from vessels at the quayside of terminals. Quay cranes along the same berth are mounted and operate on a common set of rails. This prevents quay cranes from passing each other at any time. In this research we focused on the problem of scheduling quay cranes at container terminals for a given berth schedule, namely the Quay Crane Scheduling Problem (QCSP).

The problem of scheduling quay cranes has been studied before in many different settings. The research considered both the static problem of assigning cranes to a set of vessels present at port at the time of decision making to minimize total weighted vessel completion time, as well as a dynamic extension in which vessels arrive over time. The paper develops a mixed integer program for the static problem, and provides scheduling principles that are then used to produce heuristic solutions to both the static and dynamic problems. Researchers also study the static quay crane scheduling problem with no berth length limitation. The developed model uses an objective of minimizing weighted tardiness, and is solved via a branch and bound method.

The primary contributions of this research with regards to QSCP is the classification and analysis of different crane scheduling methods; the development of an effective tabu search algorithm designed for the most realistic crane scheduling model that allows crane roaming and shifting; and the introduction of the crane assignment problem and a polynomial time method for its solution. The QCSP variants that were considered in this thesis use the output of the berth allocation problem (BAP) as input. The resultant BAP can therefore be expressed on a time- space diagram. In practice, many terminal operators use a hierarchical approach for scheduling berths and quay cranes. They first determine a good berth schedule using estimates on total processing (berthing) time for each vessel by solving the BAP. The resultant berth schedule specifies the berthing position and an estimated berthing time for vessels considered in the planning horizon. Once a reasonable berth schedule is determined, port operators attempt to allocate available quay cranes to vessels that are planned to berth simultaneously. Once cranes are assigned, the actual berthing and completion times of vessels are determined with more precision.

The positive outcome therefore becomes the decreased container processing time of a vessel when more quay cranes are assigned to it as long as there is no interference between the assigned quay cranes and other relevant resources are allocated accordingly. This is deemed as a positive outcome as it is expected it shall influence positively the nature of operations at the port going forward.

#### 5.3.2 BAP:

The objective of this research work was to establish the benefits derived from simultaneous scheduling of berth and quay cranes. In practice, berth scheduling and quay crane scheduling problems are generally considered sequentially by terminal operators. They first determine a berth schedule using estimates of the duration of berthing for each vessel. Then, they try to split quay cranes efficiently between the vessels that are planned to moor simultaneously at the same berth. Such sequential planning can be achieved using the models developed in this thesis. The key is to first solve the BAP, and then use its output as an input to solve the QCSP namely the simultaneous berth and quay crane scheduling. The number of cranes that a terminal operator can assign to a vessel depends on the number of cranes used by other vessels simultaneously moored at the berth. Assigning a crane to a vessel is equivalent to reducing the number of cranes that can be assigned to other vessels. Naturally, the total number of cranes that a terminal operator can utilize at each time period cannot exceed the total number of cranes on hand. This limitation can cause an inferior crane allocation for some vessels compared to what is projected in the berth scheduling phase, and thus vessels may be forced to stay longer than expected at berth. Such delays then may affect vessels to be moored later. A terminal operator may be able to determine a better and more accurate operational plan if actual crane requirements are considered while determining berth schedules, which is the motivation behind simultaneous berth and quay crane scheduling.

#### 5.3.3 DEA:

In container port performance evaluation, the heterogeneity of input or output measures often exist owing to non-controllable external factors such as geographical location, regional economy, political systems and so on. It therefore becomes imperative to investigate the individual input or output measures so as to identify their specific impact on the efficiency of a port. In addition, the purpose of performance evaluation cannot be a mere exercise of candidate ranking. The purpose of this research was to study ways of retaining and improving on efficiency. The conventional Data Envelopment Analysis model was utilized to test the sensitivity of the individual input and output variables of decision making. For the impetus of efficiency in decision making, there must be a measure of how much an input can be increased, or an output decreased, without changing its efficiency status. Postulated results are indicative of a situation whereby the number of berths and the capital deployed are the most sensitive measures impacting performance of most container ports.

### 5.4 Recommendations:

The research was aimed at conceptualizing the quantum aspects of decision making and their relative influence on port performance. It was established that for better output multivariate considerations be made to decision making at the port with reference to BAP, QSCP and DEA modelling decision making. A clear overview is given of both the practical concerns, as well as the possible benefits consequent of such considerations. Given the fact that those benefits are greater with better TEU's per year (Goodchild & Daganzo, 2007) and given the current trend towards larger container vessels, it is worthwhile to further investigating this promising technique. In order to demonstrate the efficiency gains associated with the aforementioned, models and corresponding solution methods are proposed.

The proposed models incorporate many real-life operational issues that are often neglected in existing papers, such as multivariate concerns for berthing, transhipment as an increasing new trend considered more by maritime players and postulated formulations like position allocation formulation for crane allocations considered very necessary for competitive advantage. The models are solved using a good mix of intelligent decision rules, together with heuristic optimization methods. More particularly, a hybrid genetic algorithm is presented, providing near-to-optimal solutions to the models within an acceptable time periods. As such, the proposed models can be used operational decision support tools, providing a good compromise between solution quality and computation time. Therefore, if decisions should be made fairly quickly, the extended constructive heuristic can be used stand-alone, whereas the incorporation of the hybrid genetic algorithm yields better solutions even though they are more technical.

Furthermore, the proposed heuristics are tested on real-life data, showing that indeed there can be reduced vessel turn-around time by more or less 10%, reduced operational costs for all players by 30% and reduced bottlenecks in operations. A future study can be conducted on the problem of determining vessel routes considering berth resource limitations. The study was only carried out at the Kenya Ports Authority thus the same study should be carried out in the other government departments to find out if the same results will be obtained. Equally there is room for further research on external factors that affect these models in any other public corporate body in Kenya.

Future research includes using alternative, profile-cantered, labelling or additional quantitative technique variables beyond those covered in this study. The resource view of the models used opens the possibility to use many scheduling tools from the maritime community to improve performance or to integrate new types of side constraints. Integrating the yard management aspect by computing the ideal positions together with the scheduling would extended the integrated approach, for which quantitative techniques may be the right optimization tool.

As with many models, a trade-off had to be made in this paper as well. On the one hand, the proposed model attempts to integrate several planning issues into one and the same model, while on the other hand, the level of detail that can be obtained of each considered element should also be taken into account. Therefore some decisions had to be made, resulting in a number of topics not discussed within this paper. More particularly, the proposed model now assumes that all crane operators work at the same efficiency rate, although this is often not the case in reality.

Further, the presented model is based on vessels' stowage plans on arrival and departure that are assumed to be known on beforehand. A second recommendation for research would be to investigate how stowage planning could be optimized on a simulated basis. Lastly, the proposed model does not penalize for spreader travel time along the width of the vessel, therefore, the time gain remains the same, which is not in line with reality. Further research would be appropriate, penalizing for the *row distance* between consecutively scheduled containers. Such an extension would be a useful refinement of the obtained results and might lead to new insights.

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## APPENDIX I: SAMPLE INTRODUCTORY LETTER

Orwa Eugene Manase

P.O BOX 778-40610

Yala, KENYA.

Date……………………….

Dear Respondents,

**RE: DATA COLLECTION:**

I am a student at the Jomo Kenyatta University of Agriculture And Technology. I am currently doing a Research study to fulfil the requirements of **AWARD OF MSc. PROCUREMENT AND LOGISTICS**.

You have been selected to participate in this study and I would highly appreciate if you assisted me by responding to all questions as completely, correctly and honestly as possible. Your response will be treated with utmost confidentiality and will be used only for research purposes of this study only.

Thank you in advance for your co-operation.

Yours Faithfully,

Orwa Eugene Manase

**HD311-C005-2739/12**

## APPENDIX II: SAMPLE QUESTIONNAIRE

**Part I: Particulars of Respondents**

Below is a questionnaire you are required to fill read carefully and give appropriate answers by ticking or filling the blank spaces.

√

The information obtained in this questionnaire will be treated with utmost confidentiality.

Department: ……………………………………………………………………………….

1. Gender Male Female

2. Employee's age

18 – 25 years

26- 35 years

36 – 45 years

Over 46 years

3. Professional title (e.g. clerk)…………………………………………….

4. Academic qualifications

Diploma

First Degree

Advanced Degree (Masters Level)

PhD Level

ii) Kindly give qualification name (e.g. Bachelors in Commerce)

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………......

5. Years of experience working with KPA (Tick appropriate criteria)

Less than 2 years

3-6 years

7-10 years

Over 10 years

6. Which category is your basic salary scale?

KES 20,000-50,000

KES 51,000-100,000

KES 101,000-150,000

KES 151,000-200,000

Above 201,000

7. Are you a member of any professional body? If YES please indicate:

Yes

No

8. Have you been promoted in the last two years?

Yes

No

**Part II: Effects of Quantitative Methods of Decision making on bottlenecks in Port Performance**

1. On overall, how satisfied are you with the decision making processes in operations?

Very satisfied

Satisfied

Neutral

Dissatisfied

Very dissatisfied

If you are dissatisfied, briefly state why? ………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

2. How satisfied generally are you with the following items affecting port performance?

| | Very atisfied | Satisfied | Neutral | Dissatisfied | Very lissatisfied |
|---|---|---|---|---|---|
| a) Inclusion in decision naking for operations persons | ○ | ○ | ○ | ○ | ○ |
| b) Preparation for vessels set to arrive from sea | ○ | ○ | ○ | ○ | ○ |
| c) The current allocation mechanism for the cranes | ○ | ○ | ○ | ○ | ○ |
| d) User experience | ○ | ○ | ○ | ○ | ○ |

3. In your opinion, do quantitative methods of decision making affect port performance?

Yes

No

ii) Kindly explain your answer ………………..……………………………………..

…………………………………………………………………………………………

4. In your opinion, to what extent does quantitative methods of decision making affect port performance?

Very great extent

Great extent

Moderate extent

Little extent

Not at all

5. Do you as a mechanical operations staff have the ability to challenge tactical and strategic decisions of your superiors if you at any point in time know they are not the most optimal?

Always

Often

Sometimes

Infrequently

Never

6. What is your level of agreement with the following statements that relate to the effect of quantitative methods on port efficiency? Use a scale of 1-5 (1- Strongly agree; 2-Agree; 3-Neutral; 4- disagree; 5- strongly disagree)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| a) There is no proper ICT infrastructure to handle the movement of cranes efficiently. | | | | | |
| b) All the staffs in mechanical operations departments aren't professionally qualified to make tactical decisions | | | | | |
| c) There exists no proper quantitative models like crane assignment models that guide decision making processes | | | | | |
| d) There exists no scientific approach to managing performance of the ports infrastructure | | | | | |
| e) Lack of quantitative methods is the biggest contributor to the contemporary low throughput port efficiency metrics | | | | | |

7. In your opinion, how else do quantitative methods of decision making affect port performance?

………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………………….

**Part III: Influence of quantitative methods of decision making on logistics costs**

**1.** How satisfied generally are you with the following items affecting port performance?

| | Very atisfied | Satisfied | Neutral | Dissatisfied | Very lissatisfied |
|---|---|---|---|---|---|
| a) Costs for cargo handling, transfer and storage | ○ | ○ | ○ | ○ | ○ |
| b) Efficiency of inland transport mechanisms | ○ | ○ | ○ | ○ | ○ |
| c) Waiting time for service by vessels from time of arrival | ○ | ○ | ○ | ○ | ○ |
| d) Ownership for costs for damages within the loading and unloading bay | ○ | ○ | ○ | ○ | ○ |
| e) Any other related levies for cargo handling charged to port users | ○ | ○ | ○ | ○ | ○ |

2. What is your level of agreement with the following statements that relate to the influence of quantitative methods of decision making on logistics costs? Use a scale of 1-5 (1- Strongly agree; 2-Agree; 3-Neutral; 4- disagree; 5- strongly disagree)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| a) Quantitative methods of decision making influence level of logistics costs | ○ | ○ | ○ | ○ | ○ |
| b) The nature of infrastructure such as having a bigger container yard, more cranes and berths influence level of logistics costs | ○ | ○ | ○ | ○ | ○ |
| c) Adequate intermodal links and land transport systems are two of the most important criteria in determining logistics costs in ports | ○ | ○ | ○ | ○ | ○ |
| d) Vessel waiting times and delays influence amount of logistics costs | ○ | ○ | ○ | ○ | ○ |
| e) Level of logistics costs is closely associated with level of customer service | | | | | |

3. In your opinion, how else do quantitative methods of decision making influence logistics costs?

…………………………………………………………………………………………………………………………

**Part IV: Effect of quantitative methods of decision making on port throughputs a key index of port performance**

1. Currently is there a system that determines measurements like coefficient of crane productivity?

Yes

No

2. Are there records kept on metrics such as annual growth rate of TEU's per year?

Yes

No

3. What is your level of agreement with the following statements that relate to the effect of quantitative methods of decision making on port throughputs? Use a scale of 1-5 (1- Strongly agree; 2-Agree; 3-Neutral; 4- disagree; 5- strongly disagree)

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| a) There is relationship between number of operational cranes and their productive capacity | ○ | ○ | ○ | ○ | ○ |
| b) That the operations of cranes decision making requires a multiple attribute decision making model | ○ | ○ | ○ | ○ | ○ |
| c) That there is a relationship between port throughputs metrics and its earnings | ○ | ○ | ○ | ○ | ○ |
| d) That a scientific approach to managing port operations can improve productive capacities of cranes | ○ | ○ | ○ | ○ | ○ |
| e) That there are very many variables that affect crane scheduling decisions | | | | | |

4. Do the strategic decisions made by senior management affect decision making with regard to operational process?

Yes

No

5. In your opinion, to what extent do decisions made by senior management affect decision making with regard to operational process?

Very great extent

Great extent

Moderate extent

Little extent

Not at all

6. In your own opinion, how would you rate the following statements on the effect of strategic decisions made by senior management on operational efficiency? Use a scale of 1-5 (1- Strongly agree; 2-Agree; 3-Neutral; 4- disagree; 5- strongly disagree).

| Statements on effects of strategic decisions by senior management | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| a) Senior management are committed to staff development and career enhancement | ○ | ○ | ○ | ○ | ○ |
| b) Senior management influence board decisions on capital acquisition issues | ○ | ○ | ○ | ○ | ○ |
| c) Senior management encourages collaborative relationships with suppliers of cranes infrastructure to improve their productivity. | ○ | ○ | ○ | ○ | ○ |
| d) Senior management make efforts to apply quantitative methods of decision making in their daily operational policy guidelines | ○ | ○ | ○ | ○ | ○ |
| e) Senior management are willing to take accountability for low metrics in port throughputs | ○ | ○ | ○ | ○ | ○ |
| f) Senior management make efforts to streamline record management systems | ○ | ○ | ○ | ○ | ○ |

**APPENDIX III: WORK PLAN**

**Time in Weeks (Yr 2014)**

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| A- Identification of target population | ✓ | | | | | | |
| B- Development and adoption of data collection instruments | ✓ | ✓ | | | | | |
| C- Seeking appointments with respondents | | ✓ | | | | | |
| D- Observations at the port side with cranes | | ✓ | ✓ | | | | |
| E- Survey of existing operational records | | | ✓ | ✓ | | | |
| F- Data analysis | | | | | ✓ | ✓ | |
| G- Data presentation | | | | | | ✓ | |
| H- Publication of research | | | | | | | ✓ |
| | **0** | **1** | **2** | **3** | **4** | **5** | **6** |

## APPENDIX IV: SAMPLE BUDGET

The proposed budget for this research activity is provided as follows:

| EXPENDITURE CATEGORY | AMOUNT REQUESTED(KSHS) | TOTALS(KSHS) |
|---|---|---|
| Printing Costs | 3,000.00 | 3,000.00 |
| Publication costs | 100,000.00 | 100,000.00 |
| Transportation | 40,000.00 | 40,000.00 |
| Research Materials costs | 8,000.00 | 8,000.00 |
| Data Analysis Costs | 10,000.00 | 10,000.00 |
| TOTALS (KSHS) | 161,000.00 | 161,000.00 |